Cooperation in Weed Control Research 1/

At a conference such as this there is little need to emphasize the widespread and increasing interest in weed control research. The fact that at present there are four large and well organized Weed Control Conferences in the United States and one in Canada clearly illustrates the general interest in the problem among scientists working in the field. New information is being developed so rapidly that it is a real task to keep abreast with the latest findings.

This widespread interest in weed control is pleasing to research workers but it must have a sobering effect as well. Farmers are clamoring for answers to their problems. Many are completely sold on the results of agricultural research. This means that each and every worker has a special responsibility to see that he neither oversells nor sells the wrong package. This was pointed out so clearly in two of the general talks given at this conference last year. In many cases application has gone far beyond research. Research must catch up and go ahead, so that safe, practical methods may be recommended without fear of seriously unfavorable results.

Weed control research is being conducted by State and Federal agencies, and by commercial companies. In this paper an attempt will be made to show how much of this work is now correlated and offer some suggestions as to how this cooperation may be enlarged and improved in the future.

Early History

In order to develop a clear picture of the present program, a brief historical sketch will be given. As early as 1902 experimental work on weed control was started in the Department of Agriculture. This work was in the Division of Agrostology of the Bureau of Plant Industry and had to do with Johnson grass in Texas. From 1906-1915 important studies were made by the Office of Farm Management on the relation of weeds to intertillage and methods were developed for controlling quackgrass and wild onion. From 1915-1920 limited weed studies were handled by the Office of Forage Crops and some progress was made with chemical weed killers and on nutgrass control. In 1920 the work was transferred to the Office of Economic and Systematic Botany, and in 1933 to the Division of Forage Crops and Diseases. From 1920-1935 no funds were available for weed research, activities being limited to general observations and answering routine correspondence.

Work of Recent Years

The present research project was initiated in 1935 when a special appropriation was made by the Congress. The work was organized as a project in the Division of Cereal Crops and Diseases so that administrative

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overhead could be held to a minimum and a large part of the available money devoted to research. The first appropriation specified that work was to deal with the control of bindweed. Later the authorization was broadened to include whitetop and other noxious weeds, but since the program had been organized to work primarily on bindweed and funds were reduced rather than increased, it obviously was not possible to make significant advances with other weeds. In the cooperative bindweed research program, however, some very significant progress has been made. It is no exaggeration to say that as a result of this work bindweed is no longer feared as it once was. Cultural methods including cropping and intensive cultivation have been devised which make it possible for any farmer anywhere to keep bindweed under control and in some cases eradicate this pest with a fraction of the cost formerly thought necessary. Much basic information has been accumulated especially as regards root reserves, time, depth, and frequency of cultivation and crop competition. This has made it possible to devise effective, economical control methods for new areas and new situations with a minimum of field experiments. It has also provided many valuable leads for the control of other noxious weeds. In fact, the same principles have been found to apply to other perennial weeds so that here also effective methods of control can be devised with less expense for field trials.

This work did not start from scratch. In developing the program in cooperation with various states, advantage was taken of much valuable experimental work conducted by State agricultural experiment stations previous to 1935. That of the Kansas, Nebraska, Minnesota, Utah, California, and Idaho Stations especially should be mentioned. Root reserve studies with other plants, especially alfalfa, indicated the role of reserves in regeneration and the maintenance of stands and played an important role in setting the pattern of the weed program.

The discovery of the herbicidal value of 2,4-dichlorophenoxyacetic acid and other chemicals inaugurated another phase of research. Unfortunately from some points of view this discovery coincided with World War II and with the reduction in funds and personnel, so that research progress for a time was not so rapid as might be desired, although the pace is now accelerating. As a result, information now available is not always complete and is in some cases contradictory. Because of the great promise and in many cases spectacular results from this method of weed control, application has gone far ahead of research, usually with satisfactory results, but in some cases resulting in failure or even serious damage to the crops in or near the treated field. Consequently, there is still a great need for more work including fundamental studies to determine how and why these chemicals kill plants, and how they may be applied with minimum danger to adjoining crops.

Aquatic Weed Work

In December 1945, the Department of Agriculture was directed by Congress to cooperate with the Office of the Chief of Engineers, War Department, on a study of the control of water hyacinth in the Gulf Coastal area. The project was financed by the War Department.

Water hyacinths have been a serious problem in rivers, reservoirs, and canals of the Gulf Coastal area for many years. The weed is a menace to navigation, clogs canals, and may seriously endanger fish and wildlife interest. Hundreds of thousands of dollars have been spent annually for more than 40 years merely to keep open channels through the dense masses of these plants. Lack of funds limited the research to a single year; but the results were so promising the War Department has undertaken control programs using 2,4-D and has requested funds for putting them into effect on an extensive scale. There are some problems yet to be solved. For example, the dead hyacinth plants constitute a serious obstacle to navigation until they decompose. It is possible that other weeds such as Alligator weed and certain aquatics that are not easily killed by 2,4-D will take the place of the water hyacinths. But there seems no reason to believe that 2,4-D will not play an important role in water hyacinth control in the immediate future, and that practical solutions will be found for problems for which 2,4-D is not the answer.

Southern Weed Work

Nutgrass (Cyperus rotundus) is one of the serious weeds of the Southeastern States and so far has not been brought under control. In 1946 the Congress voted a modest appropriation for a study of the control of this weed and as a result cooperative work was started in Mississippi and Georgia.

This project is only well started, but some worth-while results have been obtained. Nutgrass can be effectively controlled with soil fumigants, ethylene dibromide and chloropicrin being the most effective of this group of chemicals. Soil fumigants are too expensive to use on large areas and more economical herbicides are being sought. It has been discovered that the key to successful control seems to be in breaking the apical dominance, either by chemical or cultural methods, and the forcing of all tubers into production of leafy shoots.

Weed Work in the West

In 1946 funds were appropriated by the Congress for the study of the control of weeds on ditchbanks, in irrigation canals and reservoirs, and on irrigated lands of the West. It is doubtful if there is any situation in the United States where weeds are a more serious menace than on the irrigated farms of this area. The appropriation was obtained at the request of and with support from the Bureau of Reclamation of the Department of the Interior, and the research work is conducted in cooperation with that Department.

This project has now been in operation during two seasons with work located in Arizona, Colorado, Utah, Idaho, and Washington, all in cooperation with the State experiment stations in the area. Within the limits of available funds a good start has been made on several serious weed problems.

Tests with the "Electrovator," a portable machine designed to apply a high voltage low amperage current to weeds in the field, on whitetop and bindweed disclosed that top growth is readily killed, but root systems are not seriously affected, even after repeated application. This work was done at Meridian, Idaho, in cooperation with the Ada County Weed Control Supervisor.

In a joint discovery by personnel of our Bureau and the Bureau of Reclamation at the Power Generation Laboratory of the latter Bureau, it was found that the carrier used in one of the proprietary 2,4-D compounds was toxic to aquatic weeds. When the carrier was analyzed, the toxic constituent proved to be a coal-tar naphtha. Later a cheaper petroleum naphtha was found to be just as effective as coal-tar naphtha and much less expensive than present chemical control methods. Preliminary data show little or no danger from using the contaminated water for irrigation purposes. It is considered sufficiently promising to justify commercial use on a limited scale.

In tests conducted in Washington and Idaho, certain of the aromatic oils satisfactorily controlled cattails and other emergent aquatics which infest water delivery systems. These same oils were found to be effective as general weed killers on ditchbanks and other non-cropped land in Arizona. Johnson grass was controlled by one-half the usual number of applications when the aromatic oils were used. Substituted phenol compounds are used as fortifying agents for the purpose of increasing the toxicity of diesel oil.

New York

With the passage of the Research and Marketing Act of 1946, new funds were made available for weed research work. A project entitled "To establish a cooperative national statistical program to develop practical methods and equipment for weed control" was approved, and in 1947 funds were allotted for its support. As the title indicates, a national cooperative, coordinated weed research program is being developed. As yet, the funds available will not permit doing this on an entirely adequate scale. Some of the money has been allotted to work on weed control equipment. The original allotment was increased this year, and the plans call for additional requests so that an adequate program may be developed.

This new appropriation has made possible considerable new work in the Middle West. Projects have been started in North Dakota and Michigan where the emphasis is being placed on weed control in sugar beets. In Minnesota the new work includes studies on the control of leafy spurge and the effects of 2,4-D on various inbred lines of corn. In South Dakota the emphasis is being placed on new phases of bindweed control in dry areas, including the use of 2,4-D in combination with tillage and cropping practices. In Nebraska a study of weeds common to grasslands and pastures is planned, including the ecology of weeds in competition with various crop plants. Farther south in Oklahoma and Texas studies are contemplated on the control of sagebrush, and

mesquite on range lands. The mesquite problem has been found to be so complex and difficult that some physiological studies are contemplated to determine the underlying principles affecting translocation of herbicides in woody tissue.

In the eastern area only a limited amount of work is started. In New Jersey a cooperative project on pre-emergence weed control in crops, especially corn, is underway. It has been possible to provide an assistant to the project leader in Beltsville. Also at Beltsville certain physiological studies are being initiated, especially with the use of radioactive materials to determine the physiological mechanisms involved in the toxic action of herbicides on plants. Plans are going forward on a project to screen the new herbicides that are coming out with such rapidity.

Studies of mechanical problems are covered in Iowa, Minnesota, and Mississippi. Problems dealing with nozzles, pumps, tanks, cultivators, and burners will be stressed in these projects. The performance characteristics of commercial spray nozzles are being determined in order to develop the most effective spacing and placement of nozzles for specific crops. Spray equipment is being evaluated to eliminate inherent functional deficiencies through improvements in design.

Last spring the Congress passed House Resolution 452, requesting the Secretary of Agriculture to obtain certain information on the use of 2,4-D. The weed project was instructed to make studies to ascertain whether 2,4-D in any form may be used safely in areas where cotton, vegetables, and other broad-leaved plants are grown, and to investigate the methods that are being employed in applying 2,4-D, including application by airplane, and to determine whether proper precautions are being taken to protect against injury to valuable crops. This resolution was brought about because of damage to cotton by weed killers used on rice fields in Texas, Louisiana, and Arkansas. In order to carry out these instructions, an RMA project to study the drift of 2,4-D when released from aircraft was submitted and approved. The work was done at Beaumont, Texas, in cooperation with the State experiment station. The project was started late in the season, and only a limited number of flights could be made before the end of the fiscal year. From these tests it was found that under climatic conditions prevailing at Beaumont, 2,4-D spray when released from an airplane flying at an altitude of 10 feet in a 5 mile an hour cross wind may drift 1,000 feet. When discharged at 20 feet elevation, the spray drifted 2,000 feet. The spray may drift still farther when flying at higher altitudes or in stronger winds.

The findings also emphasized the need of daily maintenance and inspection of airplane spray equipment to avoid accidental discharge from faulty equipment.

Cooperative Research

For more than 50 years the Division of Cereal Crops and Diseases has operated on the basis of cooperative effort, believing that the most progress can be made that way. This is also the accepted policy of the Bureau. Most problems are extremely broad and must be attacked from many angles if the proper solution is found. Whether a State, Federal, or commercial agency helps to do the work is not important in the end, so long as the job is done.

Most progress can be made by all working together, yet there will always be plenty of credit for the individual worker, as long as credit is given where credit is due.

Within the United States Department of Agriculture weed control research is conducted by a number of agencies, such as the Bureau of Plant Industry, Soils, and Agricultural Engineering; Entomology and Plant Quarantine; Animal Industry; the Forest Service; and the Soil Conservation Service. Each agency is interested in certain phases only and often to the exclusion of others. This means that care must be exercised to assure a balanced program and also that unnecessary duplication and overlapping be avoided. An attempt to do this is being made, but due to the recent rapid expansion of the work, this has not been accomplished as completely as desired.

In the Bureau of Plant Industry, Soils, and Agricultural Engineering, weed control research is conducted by the Divisions of Agricultural Engineering; Fruit and Vegetable Crops and Diseases; Forage Crops and Diseases; and Cereal Crops and Diseases; all in cooperation with State experiment stations in the various areas. In this case the work is rather well-coordinated so that each organization knows what is being done by others.

With the discovery of the herbicidal value of certain chemical compounds, many commercial companies organized research programs. Most of this work has liberal support, is well-planned and conducted by competent scientists. These programs have contributed much useful information, but many people feel that at times the research is biased. The company may be set up so that it can manufacture a certain type of product profitably, and naturally the research is directed at finding the best way to use this product. Thus, much is learned about the material, but competitive products often are not included, or if included, may not be reported. For these reasons, additional comparisons by State and Federal agencies are desirable. Incidentally, bias is not limited to commercial companies, which is an additional reason for constant checking and re-checking experimental results.

The Research and Marketing Act of 1946 provides for research by State, as well as Federal, agencies. Numerous weed control research projects have been submitted by individual States, and some of these have been approved. Under other provisions of the Act, cooperative research undertaken by two or more States is made possible. In the North Central Region a research committee has proposed a project for weed control research in which thirteen States and the Bureau of Plant Industry, Soils, and Agricultural Engineering will cooperate. In June 1948, the research committee of the Southern States met and made real progress in developing a cooperative project for that area. In October 1948, a similar committee met here in New York to draft a project for the Northeastern States. In the Western Region progress on a cooperative project is well underway. When completed these projects will be submitted through the proper channels for consideration and allotment of funds. Our Bureau is much interested in these programs and is participating in the planning and will cooperate when the work is actually started.

Need for Basic Research

Basic research is a primary function of our weed control project---research that is expected to provide a better understanding of principles and thereby lead to more effective, economical, safe, and practical methods of control. Usually such basic research is carried on at the same laboratory or experimental field as is the so-called practical research and by the same personnel. This means that any discoveries relating to principles are immediately put to practical use and likewise, any practical problems that require more basic information are immediately given attention. For example, knowledge of why 2,4-D kills some plants under certain conditions and not under others, would be of great assistance in devising better methods for using 2,4-D, or point the way to more effective herbicides. The demand for practical answers to immediate problems has sometimes led to over-emphasis of problems that may not be the most important. Efforts are being made to avoid this in developing a long-term program. While most of the examples cited have had to do with the use of chemical methods of weed control, it should not be assumed that good cultural and cropping practices are being neglected, because it is felt that these are still essential to good farming.

Federal-State Cooperation

How do the cooperative programs operate? First of all, it must be emphasized that organization and operation are absolutely voluntary on the part of all concerned. Due to limitations of funds, most State scientists must work within the boundaries of their respective states. They are, therefore, in a position best to attack problems of immediate concern to their own states, yet their findings may be applicable in other areas. Federal appropriations are usually not so restricted as to locality, and for this reason Federal men may work on problems of a broader geographic coverage and are likewise obligated to do fundamental work which may have a wide application. By invitation a Federal man may often function effectively as coordinator in helping to synthesize Federal and State work in an area. This is not done in any way to dominate the picture, but rather to serve in bringing work and workers together and through suggestions, to make the total work more effective. As a service the coordinator may assemble annual data accumulated by cooperators, summarize these data, and make them available to all concerned in the program. Such a clearing house for information may advance progress materially, as has been shown so clearly in a number of crop improvement projects.

Without question weed control research is national, and even international, in scope. The foundation for a national program, in which State, Federal, and commercial agencies will participate, is now being laid, and each one of us must do his part to insure a broad and firm foundation, one capable of supporting the work to be done. Great care must be exercised in the planning so that principals and fundamentals are obtained as efficiently as possible. Since so many are engaged in the work, unnecessary duplication should be avoided and necessary replication encouraged. It is most stimulating, encouraging, and interesting to see a research program develop along such broad lines, and if it progresses as it should, it will supply much information and be a real example of the value of cooperation in agricultural research.

SOME EFFECTS OF HERBICIDAL OILS ON THE PHYSIOLOGY OF PLANTS(1)

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Certain oil fractions have been used extensively to control weeds in crops of carrots and of parsnips. Oils have also been used to kill weeds selectively in lawns, in grapevine nurseries, in cranberry bogs, and in conifer seedling nurseries. Because of the importance that oils are assuming in the herbicidal field, it would appear that a brief discussion of their herbicidal action merits consideration. The subject will be discussed under the headings: the penetration of oils, the distribution of oils within the plant, the effect of oils on the physiology of the plant, and the mechanism of selective action of herbicidal oils.

The Penetration of Oils into the Leaves of Plants

According to Knight et al. (6), the resistance offered to the penetration of oils deposited on leaves is with the epidermis. The xerophytic leaves of stonecrop (Sedum sp.) showed no visible penetration of kerosene after eight hours of exposure, but, when the epidermis was punctured, penetration was very rapid. Tugwell (12) studied the stomatal shape and pore size of citrus leaves and concluded that citrus stomata may be penetrated by oil.

Kerosene-like oils penetrate very rapidly the leaf epidermis of herbaceous plants with stomata. The penetration of oils is not, however, confined to stomata, as the cuticle may be penetrated to some extent (1, 7, 8, 11). Knight and Cleveland showed (9) that surface tension and viscosity determine the rate of oil penetration.

Following the penetration of the leaf epidermis, the oil spreads out and fills the intercellular spaces more or less completely (7, 11). This displacement of the air in the intercellular spaces renders the leaves translucent.

The Distribution of Oil following Penetration

Oils that penetrate into plant leaves may remain in the leaf indefinitely, may evaporate into the surrounding air, or may move out into other parts of the plant. No information on the rate of disappearance of herbicidal oils from leaves, or on the amounts of oil that may disappear by evaporation or transport to other plant parts, has been found in the literature. Fourbaugh (11) found that from two-thirds to three-quarters of the lighter insecticidal oil emulsions applied to leaves of the orange disappeared during the first three months after treatment and that very little was left after six months. Young (14) reported that kerosene disappeared from potato leaves in from 1 to 24 hours but that lubricating oils remained in the leaves for

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the remainder of the growing season. The evaporation of insecticidal oils from leaves into the surrounding air is considered negligible (7, 8, 13) and, with certain insecticidal oils, at least a part of the oil remains in the leaf through the whole of its lifetime (8, 11, 13).

There is considerable evidence that, for certain plants at least, oils will move out of the leaves to other parts of the plant. Knight et al. (8) were of the opinion that this movement was through the vascular system, the oils being translocated to the storage tissues. Rohrbaugh (11) and Young (13,14), however, found that the major portion of the oil moved by way of the intercellular spaces while it was being transported out of the leaves. Reports that at least a part of the oil enters the living cells are to be found (8, 10, 13, 14), but, in most of these reports the evidence is not too definite. Rohrbaugh (11) could find no evidence that oil entered plant cells that contained living protoplasm.

At Ottawa, the movement of kerosene-like oils has been studied in dandelions, carrots, and parsnips. By the use of Sudan IV dissolved in the oil, it has been found that, when the oil is applied to the leaves of the dandelion plant, it travels from the leaves to the roots; and that, if the oil is applied to the cut surface of the root, it travels up to and spreads throughout the leaf blades. During transport, the oil is confined to the intercellular spaces of parenchyma tissue in the midrib and petiole of the leaves and to the intercellular spaces of the phloem parenchyma tissue of the root. This transport of oil is not associated with either the xylem vessels, the sieve tubes, or the latex system. The diffusion of the oil within the root is not confined to any one direction but may take place up or down the root, in a radial direction, or tangentially around the root. In large turgid dandelion roots, the rate of diffusion is from four to five centimeters per hour.

In carrots and parsnips, kerosene oils will also travel from the leaves to the roots, or vice versa, by means of the intercellular spaces of the parenchyma tissue. Oil has been found in an occasional tracheae of the xylem of both leaves and roots, but the major portion of the oil that appears in roots travels between the cells of the parenchyma tissues.

In all three plants, carrots, parsnips, and dandelions, no oil has ever been found inside living parenchyma cells.

The Effect of Oils on the Physiology of Plants

Addicott (1) studied the effects of oils on the cells of guayule leaves. He found that injury was evident within 30 minutes and that, at the end of this period, the palisade cells were in the early stages of collapse. The leaf tissues most affected were in those areas that came in direct contact with the oil. Injury was characterized first by a callapse and shrinkage of the entire cell, including the cell wall, and later by a more or less complete cytolysis.

Following the application of a highly refined undiluted white oil to citrus leaves, Knight et al. (8) found that transpiration was sharply decreased, respiration was enormously increased, and photosynthesis was temporarily inoperative. Kelley (6) applied oil emulsions to leaves of apple, pear,

peach, plum, and sour cherry and found that the transpiration rate was retarded as much as 75% when the spray was applied to the lower surface of the leaves, but had no effect when it was applied to the upper surface. The retarding of the transpiration rate was noticeable within 30 minutes after application of the oils. Green (4) studied the effect of petroleum oils on the respiration of the leaves of beans, apples and barley seedlings. In the majority of tests the rate of respiration was increased, but in an occasional test the respiration was retarded. No explanations could be found for this discrepancy. Large quantities of oil sprayed on barley seedlings produced the same change in the respiration rate as did small quantities of oil. It has been reported that the respiration rate of apple leaves (5) and apple twigs (5, 10) decreased following the application of insecticidal oil emulsions.

Investigations were initiated at Ottawa to study the effect of herbicidal oils on the physiology of Umbelliferous crop plants and some of the weeds commonly associated with these crops. By means of an infrared absorption apparatus a study was made of the time course of photosynthesis, transpiration, and respiration for leaves of carrot, parsnip, common mustard, lamb's quarter, and common chickweed following the application of a petroleum naphtha (boiling range 300-400°F).

By means of readings taken at 10-second intervals, the immediate effect of the petroleum naphtha on photosynthesis was determined for single attached leaves sprayed with the oil. Treatment was made with the leaf in the apparatus leaf chamber and the apparatus in operation. For all the plants studied, photosynthesis ceased abruptly and completely immediately following the application of the oil.

With the infrared apparatus the recovery of photosynthesis in parsnip and common mustard leaves has also been followed after treatment with the oil. To make certain of uniform conditions during the application of the oil to the leaves, the attached leaf was removed from the leaf chamber, plunged into the oil and held there for 4 seconds. It was then removed from the oil, the excess oil blotted off, and the leaf was replaced in the leaf chamber.

With parsnip, true photosynthesis started to recover within 30 minutes after the immersion, and was almost one-third of the original rate at the end of 3 hours. The photosynthetic rate of parsnip continued to increase until at the end of 48 hours it was approaching normal. There was no sign of wilting of parsnip leaves following treatment. With mustard, there were indications of a slight temporary recovery of true photosynthesis starting within 30 minutes after the immersion and continuing for approximately one hour. Following this temporary recovery, however, true photosynthesis completely ceased and did not recover. The leaves of mustard were definitely wilted within one hour after the immersion.

From an experiment investigating the effect of different rates of application it was apparent that the amount of oil applied per unit area of leaf affected the degree of recovery of photosynthesis. With light applications of oil the photosynthetic rate, at 48 hours after treatment, had recovered to at least 90% of normal. With the heaviest applications, however, the photosynthetic rate, at 48 hours after treatment, had recovered to only 60% of normal.

The respiration rate of the parsnip leaf continued with no significant change for at least 3 hours after being immersed in the oil. With mustard, the respiration continued at the original rate for approximately one hour after the immersion into the oil. It then gradually decreased until it reached zero some 2 hours after the oil was applied.

The effect of the petroleum naphtha on the transpiration of attached leaves of parsnip and mustard has also been determined with the infrared apparatus. With the leaf in the apparatus leaf chamber, the oil was applied as drops in sufficient quantity to cover the dorsal surface of the leaf. A decrease of from 25 to 40% occurred in the transpiration rate of parsnip leaves within 10 minutes after the application of the oil. Transpiration then continued to decrease at a steady but slower rate until, at approximately 90 minutes after the oil was applied, it levelled off at 20% of maximum transpiration (about double the rate of cuticular transpiration for this species). Transpiration then remained at the 20% level until, at approximately 3 hours after the oil was applied, it started to recover and, 5 hours after the application, it had increased to one-half the original rate. It then continued to increase but at a very slow rate. With mustard leaves, the immediate effect of the oil on transpiration was similar to that for parsnip in that a rapid initial drop of approximately the same extent occurred within 10 minutes, followed by a steady but slower rate of decrease. Transpiration of mustard leaves, however, continued to decrease until cuticular transpiration was reached at approximately 90 minutes after the oil was applied. Thereafter no indication of any recovery occurred. The length of time required for the transpiration rate of an oil-treated attached mustard leaf to be reduced to the cuticular level was approximately the same as that for an untreated detached leaf.

Indications have been obtained that the amount of oil applied per unit area of leaf and the age of the leaf at the time of application affect the amount of the decrease of the transpiration rate of parsnip leaves when treated with the petroleum naphtha. The greater the amount of oil applied and the older the leaf at the time of application the greater was the amount of the decrease in the transpiration rate.

The Mechanism of the Selective Action of Oils

It has been suggested that oils may kill plant cells by means of suffocation. There has been no attempt, however, to relate this theory to the selective action of petroleum oils on plants, nor in fact is there experimental evidence to prove that any plant cells are killed by this means under the ordinary circumstances of herbicidal or insecticidal spray treatments.

Crafts (2) has suggested that plants differ in the reactivity of their protoplasm to herbicidal oils. The protoplasm of some plants is considered susceptible and as a result is denatured by the oils; the protoplasm of other plants is considered resistant and, with the oil concentrations used, is not affected. There is likewise no clear cut experimental evidence to support this theory.

From the results obtained at Ottawa, it is evident that the application of a petroleum naphtha disrupts completely and immediately

the photosynthesis of all plants tested, regardless of whether the plants were susceptible or not susceptible to injury from this oil. This disruption of photosynthesis, although permanent for mustard a species rather easily killed by applications of herbicidal oils, was however, temporary for parsnip, a species not readily injured. Parsnip, therefore, was apparently able to survive the application of oil while the weed, i.e., the mustard, was killed.

It is further evident from these results that, when a petroleum naphtha is applied to the leaves, transpiration ceases permanently in mustard, but, in parsnip, it recovers after a temporary reduction. The transpiration results suggest that an interference with or a stoppage of the water supply to the leaf cells may be the factor responsible for the sudden disruption of photosynthesis and for the difference in the recovery of the photosynthesis in parsnip and mustard. Before the mechanism of selective action of herbicidal oils can, however, be fully explained considerably more experimental work is required on the effect of these oils on the physiology of plants.

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"Comparative Activity of Hormone-like Substances as Herbicides and Their Future Possibilities with Special Reference to Water Weeds"

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Recent work dealing with the eradication of water plants in Louisiana was started in April, 1948, as a cooperative project between the Army Corps of Engineers of the New Orleans District, Tulane University, and Boyce Thompson Institute. The work involves laboratory and field studies relating particularly to the growth and reproductive habits of water hyacinth (Eichornia crassipes) and alligator weed (Alternanthera philoxeroides) and their practical eradication by treatment with chemicals of a hormone-like or caustic nature. The present report is concerned primarily with the eradication of hyacinth and alligator weed.

Field Plots. Most of the treatments were applied to plants growing in 108 pits located at Norco, La., near the Bonnet Carre Spillway. Each pit was approximately 15 X 30 feet at the top, 10 feet deep, and 10 X 10 feet at the bottom. During dry periods the water level was maintained at one to two feet below ground level depending upon the size of the plants. In addition to rain water, the pits contained natural seepage and the water pumped from the Mississippi River. The growth and appearance of the hyacinths were similar to those of plants growing under natural conditions.

Hyacinths growing under natural conditions in canals or borrow pits served also for experimental work. Areas of about 50 sq. ft. were sprayed with a Hudson Junior sprayer having the same type of nozzles as those used for spraying plants in the pits. A Bean gun operated at a pressure of 400 lbs. was also used for spraying hyacinths.

Equipment, methods and materials. Most of the test solutions were applied to plants in the pits at a pressure of 25 to 30 lbs. at rates of 6 to 150 gal./acre by means of a 4-nozzle boom which delivered from each nozzle a flat fan-shaped spray pattern. The numbers of the tips of Spraying Systems' Teejet nozzles were as follows for the lowest to the highest rate of delivery: 650067 (200-mesh screen), 6502 (50-mesh screen), 8006, 8010, and 8020. An area of about 100 sq. ft. at the ends of the pits was treated, the middle portion of the pit serving as a non-treated control. In some tests all plants in a pit were treated.

The low volume low pressure spraying equipment consisting of a boom, a gasoline-powered compressor, and a storage tank with a reducing valve were mounted on a rubber-tired wheelbarrow which facilitated moving from place to place. Treatments applied by means of this equipment are listed in Table 1. The schedule of treatments for the alkanolamine salt of 2,4-D (2,4-Dow-40) is shown in Table 2. In addition, there were 247 tests in which individual hyacinths were sprayed with a DeVilbiss No. 114 atomizer or the Hudson Junior sprayer.

An efficient spreader is considered essential for obtaining good coverage on the dense smooth-surfaced foliage of hyacinths. When a spreader was omitted, a lower percentage kill resulted. Since Nekal NS (General Dyestuff Corp.) proved to be an effective spreader when used at a concentration of 0.25 per cent, it was used in most of the tests. Most sprays were applied

when the foliage was not noticeably wet and when it appeared unlikely that rain would fall within two hours after treatment. However, the effectiveness of a 2,4-D treatment was not reduced when the sprays were applied to wet hyacinth foliage, but a marked reduction occurred if it rained within two hours after the spray was applied. In some cases particularly with the low volume nozzles it appeared that the sprays were more effective if applied to foliage which was wet as a result of a previous rain or dew.

Table 1. Number of treatments applied to plants growing in pits.

Principal spray ingredients	Hyacinth		Alligator weed		Totals
	Ends of pits	Entire pits	Ends of pits	Entire pits	
Alkanolamine salt of 2,4-D	67	11	7	—	85
Sodium salt (different spreaders)	8	—	—	—	8
Esters of 2,4-D	11	—	7	—	18
Alkanolamine salt of 2,4,5-Cl3POA	7	—	4	1	12
Esters of 2,4,5-Cl3POA	3		4	1	8
Non-hormone toxicants	9	1	2	—	12
Mixtures (hormone + toxicant)	15	1	7	—	23
Successive (hormone, toxicant)	6	—	—	—	6
Mixtures (two hormone types)	7	—	1	—	8
Total number of pit treatments	133	13	32	2	180

Table 2. Number of treatments with alkanolamine salt of 2,4-D applied to hyacinths according to time of year and rate of application.

Month	Lbs./acre			Totals
	1 - 2	3 - 4	5 - 8	
June	13	8	10	31
July	0	5	7	12
August	1	6	7	14
Total	14	19	24	57

Killing hyacinths. Unless otherwise specified, killing means death of the entire plant, including all under-water parts. The alkanolamine salt of 2,4-D killed 90 to 100 per cent of the hyacinths during the months of June to October inclusive and irrespective of flowering cycles when the concentration of 2,4-D was 0.5 per cent or higher, the rate of application 2 lbs./acre or higher, and the rate of delivery 18 to 150 gal./acre. In some cases a concentration of less than 0.5 per cent 2,4-D or a rate of less than 2 lbs./acre was effective in killing most of the hyacinths. Results for treatments applied June 24 are shown in Table 3, and the results for sprays applied August 17 appear in Table 4.

Table 3. Relation between concentration of 2,4-D amine salt (0.25 per cent total spreader) and the rate of application and delivery for killing and stalling bracken growing in pits. Plants treated June 24, 1948. Results 47 days later.

Concn. %	Gal./acre*	Calculated lbs./acre	No. plants present**	% Plant material sunk In each	Av. for group
0.16	70	0.9	3	25	
0.30	57	1.[illegible]	1	25	33
0.32	70	[illegible]	2	50	
0.52	43	[illegible]	14	85	
0.60	57	2.5	0	50	73
0.64	70	3.8	2	85	
1.04	43	3.7	3	90	
1.20	57	5.6	0	98	83
1.28	70	7.6	0	95	
1.28	18	2.0	0	90	
2.08	43	7.4	0	95	
2.40	57	11.2	0	98	96
2.56	18	4.0	8	95	
[illegible]	—	—	[illegible]	[illegible]	

* Based on measured delivery at rate of 3 m.p.h. from 4-nozzle boom.
** Area treated was 100 sq. ft., containing approximately 2,000 plants.

Table 4. Relation between concentration of 2,4-D amine salt (0.25 per cent total spreader) and the rate of application and delivery for killing and stalling bracken growing in pits. Plants treated August 17, 1948. Results after two months.

Concn. %	Gal./acre	Lbs./acre	% Plant material sunk* After 55 days	After 64 days	No. new plants after 64 days
0.68	70	4	90	95	0
0.84	57	4	25	90	0
1.12	43	4	60	95	0
3.72	18	4	70	100	0
7.80	6	4	10	90	8
1.36	70	8	70	95	0
1.68	57	8	60	100	0
2.24	43	8	20	100	0
3.44	18	8	80	95	0
15.60	6	8	90	95	0

* The 6 gal./acre rate with 7.8 per cent 2,4-D caused 95% kill and all other treatments caused 100 per cent kill.

Results obtained with the lowest volume nozzle (6 gal./acre) were more variable than those obtained with the higher volume nozzles. Spray drift was noticeable with the 6 and 18 gal./acre nozzles and varied with wind conditions. A minimum effective rate of delivery appears to be between 18 and 43 gal./acre.

Esters of 2,4-D were of about the same effectiveness as the alkanolamine salt in causing 90 to 100 per cent killing of hyacinths. When used at the rate of 4 to 8 lbs./acre and at a concentration of about 1 per cent, the alkanolamine salt and isopropyl ester of 2,4,5-trichlorophenoxyacetic acid (2,4,5-Cl_3POA) (Dow Chemical Co.) were about equal to 2,4-D. The allyl ester of 2,4-D (Carbide and Carbon Chemicals Corp.) appeared to be more effective than the isopropyl or butyl ester (Sherwin-Williams Co.). At lower rates, 2,4-D was more effective than the trichlorophenoxy compounds. Any difference in effectiveness of the 2,4,5 compounds for killing hyacinths was in favor of the salt which is in contrast to the higher effectiveness of the 2,4,5 ester for killing alligator weed.

Ten non-hormone toxicants were used alone and in combination with 2,4-D. All of these were less effective or ineffective for killing hyacinths when used at the approximate minimum effective dose of 2,4-D. None of the toxicants, except possibly sodium trichloroacetate, caused additive effects when used in sub-lethal quantities in combination with 2,4-D. In fact, a lower percentage kill generally resulted from the use of this type of mixture, indicating that the toxicant may have reduced the transport of 2,4-D to underwater parts. Killing of above-water parts was frequently more rapid with these mixtures than with 2,4-D used alone. In contrast, mixtures of 2,4-D and 2,4,5-Cl_3POA were of equal or slightly greater effectiveness than the same quantity of 2,4,5-Cl_3POA used alone.

Sinking of treated hyacinths. A higher dose of 2,4-D and a longer time period were required to cause sinking of hyacinths than for merely killing the plants (Tables 3, 4, and 5). There was an indication that hyacinths treated in June sank less readily than those treated during the period July to October. This applied particularly to rates of application less than

Table 5. Relative effectiveness of different formulations for killing and sinking hyacinths. Plants treated at rate of 8 lbs./acre July 20, 1948. Results after 41 days.

Formulations containing 1.2% 2,4- or 2,4,5-chlorophenoxy compounds	No. of plants present	% Plant material sunk
2,4-D isopropyl ester	0	60
2,4-D butyl ester	1	60
2,4-D allyl ester	0	95
2,4-D alkanolamine salt	0	85
2,4-D isopropyl ester + 1% Na-trichloroacetate	0	75
" " " " 3.2% " "	0	100
" " " " 10.0% " "	0	100
2,4,5 isopropyl ester	0	50
2,4,5 alkanolamine salt	2	50

8 lbs./acre. Mixtures of either the isopropyl ester (Table 5) or the alkanolamine salt of 2,4-D and sodium trichlorophenate appeared to be more effective for sinking hyacinths than the ester used alone, even though both treatments caused 100 per cent killing. Treatments with 8 lbs./acre of the salt and ester of 2,4,5-Cl$_3$PO4 which caused 99 to 100 per cent killing, resulted in sinking 50 per cent of the plants which is less than the percentage for the corresponding 2,4-D salt and ester (Table 5).

Relationship of hyacinths in control and treated areas. Some knowledge of the growth rate of growth per unit of time of hyacinths at different times of the year is necessary in order to appreciate the pronounced differences in maintenance following of control and ineffective treatment with 2,4-D. For example, three hyacinths placed in pit on May 11 produced approximately 1,000 new plants in 50 days and about 5,500 at the end of three months. (Appendix 16) This is in contrast with the production of 32 new plants in 50 days from three hyacinths planted on August 23. About August 15 the older extensively developed roots up to 4ft and sometimes feet long began to die on plants growing under natural conditions. By October 1 the root systems of most plants were greatly reduced in size and poor in appearance. It was noticed that the rate of growth of hyacinths and their vegetative reproduction were reduced at least 50 per cent after August 16. Consequently, any of the treatments applied during the period August 16 to October 15 which caused less than 100 per cent killing appeared more effective than they actually were due to the relatively slow rate of growth and growth of new plants during late August and later.

Ineffective treatments causing less than 50 per cent killing permitted various amounts of regrowth or reinfestation to occur, ranging from a complete filling in of the treated area in the course of two to three months. This type of growth consisted of a resumption of growth and the production of new leaves and new plants from surviving parts of plants (old rhizomes) even though most or all of the above-water parts had been killed. In many instances, part of the newly developed leaves were spotted. In the case of effective treatments causing 99 to 100 per cent killing, the surviving plants were very small and grew at a slow rate. These small plants were recognized as evidenced by the piece of attached stolon and the presence of leaves having normal characteristics of established plants. No seedlings were found in any of the 100 pits during the period May to October inclusive. Apparently these "plantlets" which are formed at or slightly above ground level had not received an effective dose of 2,4-D as a spray or by transport from the parent plant through the stolon. The surviving plantlets did not exhibit any typical herbicide response other than a retarded growth.

In special tests with individually treated hyacinths there was little or no transport of 2,4-D from parent to daughter plants, or vice versa, in the case of low concentrations (less than 0.5 per cent), but there was some transport with 1 per cent, although in these particular tests not enough to cause killing. It has not been fully established whether the failure of plantlets to survive in areas where 100 per cent killing occurred is due to direct killing by the spray or from transport of 2,4-D through stolons.

Alligator weed. The most effective sprays applied to the ends of pits containing alligator weed caused considerable damage but failed to kill the plants. Since some of these same treatments were effective in killing and sinking hyacinths, it was apparent that the alligator weed was going to be

much more difficult to kill than the hyacinth. A possible clue to an effective treatment on alligator weed was obtained from the results of a test in which all of the plants in a pit were sprayed on August 31 with a 17.5 per cent solution of the isopropyl ester of 2,4,5-Cl_3POA applied at the rate of 8 lbs./acre with the 6 gal./acre nozzle. Within one month most plants were badly damaged and many had sunk below the surface of the water. In three months all plants had sunk without exhibiting any signs of regrowth. It is not certain whether the effectiveness of this treatment is due to the time of year or to the fact that all plants were sprayed, including those anchored to the banks of the pit. Results with hyacinths treated after July also indicated that spraying entire pits was more effective than treating the ends. Sprays delivered by the lowest volume nozzle (6 gal./acre) appeared to be more effective on alligator weed than those delivered by higher rate nozzles. The reverse was true for hyacinth.

In contrast to the effectiveness of the ester, the alkanolamine salt of 2,4,5-Cl_3POA was less damaging to the above-water parts of alligator weed and failed to cause sinking of the plants.

Practical applications. Since complete killing and sinking of all hyacinths resulted from certain treatments with 2,4-D under conditions where good coverage was obtained, it seems likely that with the development of special spray equipment and the use of proper methods of application the large scale practical eradication of hyacinths in Louisiana may be accomplished. Sprays applied on October 15 with a Bean gun sprayer operated from a boat indicated that only about 70 per cent adequate coverage was obtained on an irregular fringe growth of hyacinths covering an estimated 16 acres along the borders of a canal (borrow pit). In this case a 1 per cent solution of 2,4-D salt delivered at the rate of about 100 gal./acre caused killing and at least 80 per cent of all plants adequately covered sank by the end of six weeks. On the basis of the results obtained to date, it appears that practical eradication of water hyacinth in areas which are inaccessible to boat-mounted cutting machines might be accomplished by a system of patrol maintenance whereby the plants not previously contacted by an effective dose of spray could be killed by a second spray applied before any large scale reinfestation had occurred. This would necessitate the use of two or more sprays each year. Considering the marked seasonal differences in the rate of growth and reproduction of hyacinths, the timing of spray applications would no doubt be important.

Factors Effecting the Action of 2,4-D

The development of 2,4-D as a selective herbicide has been rapid and significant. If a basic understanding could be found of how 2,4-D kills plants, its use and effectiveness as an herbicide might be further increased.

Since 2,4-D in very minute amounts produces symptoms in plants somewhat similar to those caused by diseases, one may wonder whether there may not be substances which act as antitoxins to overcome the effect of 2,4-D and also whether there may be other compounds which might act as synergistic agents in increasing or promoting its toxic action.

The fact that 2,4-D is so effective in such small quantities suggests the possibility that there might be some key mechanism upset in the plant. For example, an enzyme might be either stimulated or depressed. With this in mind, experiments were conducted with enzymes. Various enzymes in solution with 2,4-D were tested on bean plants using the drop test which consists of applying 1 drop (.05 ml) of solution to one of the primary leaves of young red kidney bean plants and measuring the new growth above the primary leaves after ten days. The degree of inhibition of new growth is in direct proportion to the strength of the 2,4-D solution. (1).

The enzymes tested were diastase, lipase, maltase, invertase and trypsin. None of the enzymes had any effect on either increasing or decreasing the action of 2,4-D.

Tests were then made using various amino acids in solution with 2,4-D, these included tryptophane, glycine, alanine, valine, leucine, isoleucine, aspartic acid, glutamic acid, serine, phenylalanin, tyrosine, cystine, methinine, lysine, arganine, histidine, proline. These amino acids failed to affect the action of 2,4-D.

The selective action of 2,4-D indicates that some plants are less responsive to it. In fact most of the grasses are not seriously affected. One might then be led to believe that the grasses and other resistant plants might contain some mechanism for inactivation of 2,4-D.

To test this theory extracts from over eighteen plants were used in combination with the salt of 2,4-D. Of the many extracts tested, only two showed any affect on modifying the action of 2,4-D. The combination of onion extract and the salt of 2,4-D increased the action of 2,4-D at the concentration used. In one case the extract of (red beet) a rather significant reduction in activity of 2,4-D was noted (2).

Many unrelated chemicals were then tested and it was observed that ascorbic acid (vitamin C) at pH 4.5 tended to increase the action of 2,4-D. However, this stimulating effect was lost when the solution was brought to the neutral point. This suggested that the acidity of the solution might be a factor in increasing the action of 2,4-D. Experiments were then conducted using solutions of the salt of 2,4-D at various acid levels. The results showed that the herbicidal action of the salt of 2,4-D could be greatly increased by using it in an acid solution. The greatest activity of 2,4-D, as measured by the inhibition of growth was obtained when the pH value of the acid solutions was held between 2.0 and 3.0. (3).

The next step was to determine whether the action of 2,4-D in acid solution was due to pH or titrable acidity. Accordingly various buffer solutions containing the sodium salt of 2,4-D were prepared at pH levels of from 2 to 7. When 2,4-D was applied in these buffered solutions a far greater activity was exhibited than when dissolved in unbuffered solutions at pH 4, pH 5, pH 6, and pH 7. At pH 2 and pH 3, the growth inhibiting effect was at maximum effeciency (4). In other words buffered solutions were equally effective at a pH of from 2 to 7. Unbuffered solutions were most effective at pH 2 to 3.

The question has often been asked "why should acid solutions or buffer solutions increase the action of 2,4-D?" It is time that some effort at least should be made to explain it. It is known that acid solutions affect certain colloids. For example if gelatin is placed in various acid solutions, the gelatin will swell or imbibe water to a much greater extent at between pH 2 to 3 than at any other pH (Fig. 1). This pH range corresponds to the effective range of acid solutions in increasing the action of 2,4-D, which indicates that the acid solutions may cause the cellular colloids of treated plants to swell and thus exert a greater imbibing force for the intake of the spray solution.

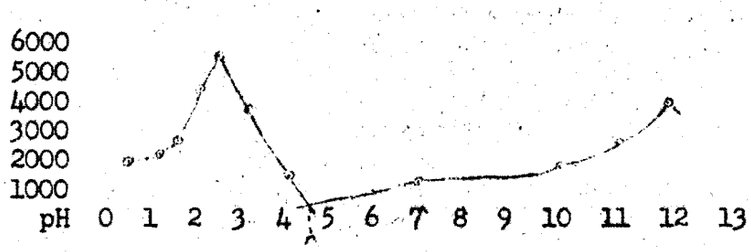

Fig. (1) Swelling of gelatin in solutions of hydrochloric acid (pH 0-6) or sodium hydroxide (pH 7-13). The ordinate represent the weight of 100 parts of dry gelatin after 48 hours at 18°.

(From Jordan Lloyd Biochem Journal 1920)

Another possible explanation of how acid solutions may aid in increasing the action of 2,4-D is primarily based upon a mechanism of entry through a semi-permeable membrane (Donnan's theory of equilibrium). According to Jordan Lloyd (5). The theory of membrane equilibrium is based upon the following consideration, that if a non diffusible ion is present in a system bounded by a membrane it will exert an electrostatic repulsion on the diffusible ion of the same sign leading to the expulsion of these to the opposite side of the membrane. Meyer and Anderson (6) state that cytoplasm is usually on the alkaline side of its iso electric range and therefore, it should be expected that the constituent micelles (or non diffusible ions) are negatively charged. The 2,4-D molecule of Na - 2,4-D is also negatively charged and hence would be repulsed by the cytoplasm. By lowering the pH of the solution, of 2,4-D the cytoplasm would change from the alkaline side of the iso electric range to the acid side and hence the micelles would attract the 2,4-D molecule and 2,4-D would enter.

The explanation of how buffer salts effect the action of 2,4-D would be somewhat similar. Crafts (7) reported that non polar compounds can pass through the cuticle of leaves readily whereas polar compounds enter with difficulty. It is quite possible that buffer salts would lower the polarity of 2,4-D and hence permit its more rapid entry.

One rather interesting development in connection with the use of 2,4-D is the increased action of 2,4-D when it is combined with a plastic material called Geon 31X latex which is a vinyl resin latex (8). By the addition of this plastic

material, the amount of 2,4-D salt necessary to kill plants is greatly reduced. Experiments on a golf course showed that as low as amount as ½ pound of 2,4-D could be used per acre to produce a permanent kill of dandelions without injury to the grass when it was combined with a 10% solution of Geon. With other commercial formulations it was necessary to use 1 ½ pounds of 2,4-D per acre to obtain similar results. At present it would not be practical to use Geon with 2,4-D because of the expense of the Geon.

In the course of the studies on 2,4-D several compounds were found that completely or partially inactivated the sodium salt of 2,4-D. These materials were activated carbon (9), potassium ferro cyanide and triphenyltetrazolium chloride.

Apparently activated carbon adsorbs the 2,4-D molecule, takes it out of solution and hence makes it inactive.

Potassium ferro cyanide may be effective in preventing entry of 2,4-D into the plant. This compound is a tetra valent ion that may give the protein ion a negative charge which would tend to repel the negative 2,4-D ion according to Donnan's equilibrium. It has been shown for example, that a related compound sodium ferro cyanide may produce a negative electrical potential by 30 millivolts (Fig. 2).

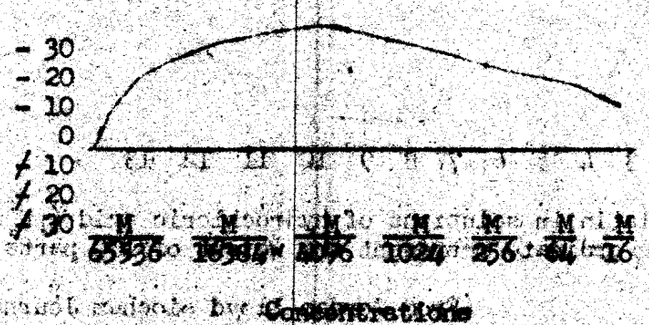

Fig. 2 Influence of salts on the surface potential of denatured egg albumin at its iso-electric point.

(From Loeb Journal of Gen. Physiology 1922-1923)

Triphenylulrazolium chloride appear to completely inactivate 2,4-D salt. No explanation of how this is accomplished is now offered.

Reports have been received that some weeds are more palatable to animals a week or so after having been sprayed with 2,4-D. This indicates that the nutritional value of the plants has been changed by the 2,4-D treatment.

Sell et al have shown that certain amino acids in treated bean plants are two to three times as great as in untreated stems. The total protein in treated plants is greatly increased and the percentage composition of constituent amino acids is changed.

The treatment of plants with 2,4-D to change the nutritional value of plants mig ht some day have far reaching effects in agriculture.

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EFFECT OF TEMPERATURE, ORGANIC MATTER, pH AND RATES OF APPLICATION ON PERSISTENCE OF 2,4-D IN SOIL

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Several workers have reported the effect of organic matter, temperature, rate of application, and addition of lime or pH on the persistency of 2,4-D in the soil.

Brown and Mitchell(1) found that the addition of cow manure up to 4000 pounds per acre reduced persistency markedly whereas 8000 pounds per acre markedly reduced the rate of inactivation.

They also found that for temperatures of 36°, 50° and 70° F. stored soils to which had been added 0, 2, 4, 10, 30 and 100 lbs. per acre of 2,4-D, the length of persistency decreased at the higher temperatures and at the lower rates of application.

Kries(3) found that the addition of lime to soil increased the persistency of 2,4-D in soil plots which contained the rate of 200 ppm of 2,4-D. This worker also found that the addition of organic matter in the form of leaf mold markedly decreased persistency.

Jorgensen and Hamner(2) found that pH had a negligible influence on the loss of toxicity but there was a tendency favoring dissipation or inactivation at neutral or slightly alkaline pH. They also found that high temperatures, 80°-105° F. increased the rate of toxicity loss over freezing or sub-freezing temperatures.

In view of the above observations we thought it pertinent to determine the effects of those factors individually and their effect upon one another.

Materials and Methods

A factorial experiment was set up in order to determine the effect of (1) pH; (2) organic matter; (3) rate of application; and, (4) temperature, on the persistency of 2,4-D in the soil.

Two soils having a pH of 5.0 were used, one being a Dunkirk fine sandy loam; the other peat.

These soils were mixed in proportions to give organic matter content of 0%, 25% and 50%, and pH of 5.0, 7.0 and 9.0 by the addition of a predetermined amount of hydrated lime. The mixed soils were then put into 6-inch painted clay pots which were placed in temperature controlled houses of 60°-70° and 70°-80° F. The experiment contained four replications which were randomized.

The sodium salt of 2,4-D mixed with sand was then applied at four rates: (1) "0" pounds per acre; (2) one pound per acre; (3) five pounds per acre; and, (4) nine pounds per acre. The 2,4-D-sand mixture was mixed thoroughly with the top inch of soil.

Plantings of five seeds each of beans and corn were made and the pots watered once daily throughout the growing period, precautions being taken that no leaching occurred. After 20 days of growth the plants were counted and growth measurements were taken in the form of fresh weights, these data being used as a criterion of presence or absence of 2,4-D.

Two successive plantings of corn and beans were made and three plantings of beans alone. The toxicity of 2,4-D to corn had disappeared at the second planting. These plantings were made at approximately one month intervals, beginning February 3, 1948. The last two plantings of beans were made without temperature control.

The data were transformed by the addition of 0.5 to each observation and the square root extracted. This was necessary due to the large number of "0" readings.

Results

pH - This factor had no significant effect at 60-70° and only at the 5% level at 70-80°. Under the latter condition this difference was only evident for bean weights and counts at the first planting and for weights only at the second planting.

In table I which presents weights for both plantings, it will be found that pH 7 gave significantly less growth than pH 9. At the second planting this effect had reversed.

Table 1. 70-80°.

Bean weights - First planting				Bean weights - Second planting			
pH	5.0	7.0	9.0	pH	5.0	7.0	9.0
Means	1.340	1.240	1.398	Means	2.503	2.591	2.393
L. S. D.	.05=0.121	.01=0.160		L. S. D.	.05=0.154	.01= 0.205	

Organic Matter

With a few exceptions this factor was significant at the 1% level for both counts and weights of both corn and beans at each temperature and planting.

Table 2 gives weights at 70-80° for both plantings and it will be seen that in general each higher rate of organic matter gave better growth at either the 5% or 1% level.

Table 2. 70-80°.

Bean weights - First planting				Bean weights - Second planting			
O. M.	0%	25%	50%	O. M.	0%	25%	50%
Means	1.097	1.427	1.155	Means	2.010	2.656	2.820
L.S.D.	.05=0.121	.01=0.160		L.S.D.	.05=0.154	.01=0.205	

Rate of 2,4-D

At the first planting for both temperatures this factor was significant at the 1% level for beans and corn for both weights and counts. At the second planting, however, rate was significant only at 70-80°.

Table 3 gives the weights at 70-80° for both plantings of beans and shows thatat the second planting there was significant difference between each rate.

Table 3.

Bean Wts.-First planting 70-80° Rate lbs./Acre				Bean Wts.-Second planting 70-80° Rate lbs./Acre			
0	1	5	9	0	1	5	9
2.701	1.181	0.707	0.718	—	2.792	2.536	2.308
L.S.D.	.05=0.135	.01=0.179		L.S.D.	.05=0.178	.01=0.237	

Second Order Interactions

Organic Matter X Rate

At the first planting this interaction was significant at the 1% level for both temperatures except for bean weights at 60-70° there being significance at the 5% level.

Table 4 which includes weights for corn and beans at 70-80° is representative of these results for both counts and weights at both temperatures. These data show that as rate increases and organic matter decreases greater toxicity is experienced.

Data from the second planting of beans gave the same general results as from the first planting with the exception that significant toxicity was evident only at the high rate of 2,4-D and low rate of organic matter as is shown in Table 5 which contains bean weights at 70-80°.

Table 4.

First Planting 70-80° - Corn Wts.

Rate	Organic Matter 0%	25%	50%
0	2.218	3.032	2.854
1	0.771	1.280	1.491
5	0.700	0.700	0.721
9	0.700	0.700	0.753
L.S.D.	.05=.240	.01=0.318	

Table 5.

Second Planting 70-80° - Bean Wts.

Rate	Organic Matter 0%	25%	50%
0	--	--	--
1	2.218	3.031	3.127
5	2.030	2.788	2.788
9	1.597	2.763	2.566
L.S.D.	.05=0.420	.01=0.558	

pH X Rate

This interaction was significant at the 5% level for bean counts and weights on the first planting at 70-80° and for bean counts on the second planting at the 1% level at 60-70°.

For the first planting of corn there was the same trend for weights at 60-70°, being significant at the 5% level.

Table 6 which gives data for bean counts and corn weights at 60-70° indicates that better germination and growth was attained at the high pH in the 2,4-D treated plots. In the check plots for growth the reverse was true.

Table 6.

First Planting 60-70°- Corn Wts.

Rate	pH 5	7	9
0	2.561	2.443	2.378
1	2.112	2.045	2.032
5	1.145	1.163	1.365
9	0.937	1.041	1.019
L.S.D.	.05=0.164	.01=0.218	

Second Planting 60-70°- Bean Counts

Rate	pH 5	7	9
0	2.075	2.027	2.213
1	2.056	2.193	2.134
5	1.966	2.009	1.976
9	1.666	1.997	2.120
L.S.D.	.05=.327	.01=0.434	

pH X Organic Matter

This interaction was significant only at 70-80° for beans and Table 7 will show that there is a differential response of pH on growth between the different levels of organic matter. With organic matter levels 25% and 50% better growth was attained at pH 5. The reverse was true of the 0% organic matter.

Table 7. Second Planting - Bean Wts.

Organic Matter	pH 5	7	9
0%	1.782	2.018	2.295
25%	2.840	2.743	2.384
50%	2.948	3.012	2.502
L. S. D.	.05=0.267	.01=0.356	

Conclusions

Under the conditions of this experiment it may be concluded that of the factors studied, organic matter is the most important. This is evidenced from the fact that the inhibitory effect of 2,4-D had practically disappeared from the two high organic matter series on the second planting for beans. Symptoms remained in the low organic matter level through the fourth planting and were still apparent in the low pH series at the high 2,4-D level on the fifth planting.

Rate of application was second in importance and gave more prolonged toxicity under the conditions as stated above.

pH ranks third and was of greater importance in the organic matter series where the lower pH increased the length of persistency. There was some indication that the high pH in the 50% organic matter series gave greater toxicity as is evidenced in Table 1 (second planting) and in Table 7. Subsequent plantings however gave no significant difference for the higher organic matter levels.

Temperature was not included in the analysis of variance as observations of 2,4-D symptoms showed that the general trend was the same under the two levels studied. It must be noted, however, that there was no significant first order interactions of pH at 60-70°.

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The Role of Physiological Research in Chemical Weed Control

John W. Mitchell[1]

Physiological research has long been considered as one means of learning how weeds can be most efficiently controlled. But in developing the various methods of control used today -- cultivation, the use of chemicals as contact poisons, or the use of chemical stimulators -- relatively little attention has been directed toward answering the question, How do these methods work? Instead, we have spent practically all of our effort in answering the question, Where do they work?

When we analyze these different methods of weed control it appears that an understanding of how they cause the death of a weed is of considerable importance, for interpretation of the results and improvement of the methods you use in the field depend upon this basic information. For example, in our attempt to control certain perennial weeds through cultivation, the objective is to limit top growth of the plant and in this way cause the weed to exhaust its reserve food materials and die. Knowledge as to when these reserve materials in the plant can be most readily exhausted is of importance if our aim is to obtain most efficient weed control through cultivation.

The contact poisons, such as volatile oils, arsenites, and chlorates, that are used as herbicides present a special problem from the standpoint of physiological research. These substances for the most part kill plants because they have the power to break down the protoplasm or disorganize the contents of many of the living cells in the plant. This disorganization or poisoning of plant cells happens so quickly and completely that apparently many of the physiological processes in the plant are stopped soon after the poison is applied. But physiological problems present themselves even in the use of these powerful contact poisons. Some of the questions most of you have asked yourselves or someone else are: Why is it that you can spray certain volatile oils on a carrot patch and kill the weeds and not the carrots? What is the basic difference between carrots and weeds that makes carrot resistant? Are some parts of plants more sensitive to these contact poisons than others? Little is known of how these contact poisons affect the plant physiologically, so this field of research is still wide open and should indeed prove to be a fertile one. If we knew more about how the oils kill plants, we could surely use them more widely and intelligently as selective herbicides.

We have known for more than 15 years that some organic chemicals act as stimulators when applied to plants. These substances are generally called plant growth regulators. About 5 years ago it was discovered that some of these compounds could be used to over-stimulate some kinds of weeds and cause them to die. This was the beginning of the use of 2,4-D as an herbicide. In using this new method of killing weeds, you are using a chemical to accelerate or over-stimulate certain physiological processes in the plant to the point where the plant is killed.

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Instead of breaking down the contents of living cells as the contact poisons do, growth regulators, such as 2,4-D, leave the cells organized and functioning, but the rate at which certain growth processes occur is greatly changed. Most of you realize that the process by which these chemicals kill plants is a very complicated one. Since the killing process is a complex one it is not surprising that it is readily affected or altered by various external factors, so that even though it appears that we spray the same kind of plant in the same way and with the same 2,4-D preparation, we do not always get the same result.

Some of us have wondered why physiologists have not already answered some of the more obvious questions concerned with the use of 2,4-D so that this method of weed control could be used more effectively. We should remind ourselves that the basic problems which the physiologists have tackled in studying 2,4-D are similar to others which the botanists have been trying to solve for many years. For instance, we have wondered for years how a tree can continuously absorb water into its roots and readily translocate it to the uppermost leaves. Scientists have worked intensively for years trying to learn exactly how a plant makes sugar, but so far no one has been able to completely understand or duplicate the process outside of the plant. Some of the problems with which we are concerned in using 2,4-D are of this nature -- they can not be solved immediately.

It is time, however, that we try to sum up results of our efforts, learn more about some of the physiological effects involved in the use of 2,4-D, and take account of the progress we have made so that you will have results of this more basic type of research before you. Physiological research on the effects of 2,4-D might be divided into 4 fields and I would like to point out as best I can where we stand in each of these lines of work.

Absorption and Translocation of 2,4-D

We have learned that 2,4-D is very readily absorbed by practically all living surface cells of mesophytic plants. The compound is very effectively absorbed by the root system, and the results obtained through the use of a test plant as snap bean indicate that developing seeds may absorb a sufficient amount of the chemical to prevent their subsequent germination. We know that the coats of some kinds of seeds are impermeable to 2,4-D but that these seeds become very sensitive to the chemical as they germinate.

We have learned that, when applied to a leaf of a plant, 2,4-D is readily absorbed, is translocated from the leaf to the stem where it is moved both upward and downward, and finally accumulates in developing buds, leaves, and root tips. This movement of 2,4-D from the leaves to the stem of a plant takes place most readily when the plant is translocating carbohydrates in the same direction.

Results so far indicate that plants of the grass type are somewhat less efficient in absorbing 2,4-D through their leaves than are plants of the broad leaf type. In the plants studied so far, this difference in rate of absorption does not, however, account for the marked difference in the sensitivity of grasses and broad-leaved plants to 2,4-D.

Specificity

One of the most striking features in the use of 2,4-D is that it will readily kill one species of plant and at the same time have practically no effect upon

another species even though the two plants are in our estimation very closely related. Not only has this striking specificity been noted in connection with weed control but it also stands out very clearly in connection with the use of 2,4-D in preventing preharvest drop of fruit. For instance, 2,4-D at a very low concentration of 10 p.p.m. will keep Winesap and Stayman Winesap apples from dropping off of the trees at harvest time but it has practically no effect on many other apple varieties even when applied very much stronger.

So far we do not have an explanation of why plants vary so widely in their sensitivity to 2,4-D. It is safe to say that the question of specificity will probably remain unanswered until we learn a lot more about the way 2,4-D affects physiological processes in plants.

Mechanism of Action

How does 2,4-D kill plants? This question was asked just as soon as it was learned that 2,4-D held promise as an herbicide. We have made some progress in gaining an understanding of the physiological processes involved when plants are killed with 2,4-D but we do not have the complete picture.

Results so far indicate that after 2,4-D is absorbed the chemical unites with some plant constituent. Once a unit of 2,4-D has been absorbed by a plant and has brought about a specific response, then that unit of 2,4-D is apparently bound up and no longer is effective in bringing about any additional response on the part of the plant. Regarding the way in which 2,4-D kills plants, it has been reported by several investigators that the chemical affects the rate at which plants use up their reserve food supply. Reserve carbohydrates are rapidly depleted in plants treated with 2,4-D. The fact that such carbohydrate reserves as starches and dextrins were rapidly hydrolized or broken down in the plants studied indicates that enzymes concerned in this process were very active. So far as I know we do not now have direct evidence that enzyme systems in plants are accelerated by the application of 2,4-D. All the indirect evidence, however, points toward the probability that this is the case; and before long we may obtain direct evidence to show whether or not certain enzymes are more active in plants treated with 2,4-D than they are in untreated ones.

To return to the utilization of reserve carbohydrates, in some of the plants studied reserve materials were used up rapidly and the plants apparently reached a point where they starved for the lack of these materials. How, then, does the plant deplete itself of reserve food materials so rapidly when treated with 2,4-D? Several investigators have reported that the rate of respiration of test plants treated with 2,4-D was much higher than that of untreated plants. In recent experiments the respiration of treated plants increased noticeably within an hour and a half after 2,4-D was applied and it continued to increase for a day or two, reaching a rate 85% above that of untreated plants; but after 5 days the plants had apparently exhausted their reserves and their respiration had dropped almost to zero (figure). In these experiments plants treated with 2,4-D failed to synthesize solid matter after treatment. In other words, they failed to grow following treatment, but at the same time their respiration rate, or that at which they burned up reserve food materials, was almost doubled. It was also determined that these treated plants used more oxygen than did untreated ones, which indicates that oxidative processes in the treated ones were relatively intense. These findings indicate that rapid utilization of reserve materials was associated with an excessively high rate of respiration and a lack of growth by the

plant. The effect is like fanning a fire withour adding more fuel, and it is doubtful that any plant or animal could survive very long when affected in this way. Although we do not know just why the respiration of plants is accelerated by 2,4-D, we feel that this effect may be an important factor in explaining why plants treated with 2,4-D die.

Molecular Structure of a Chemical and its Weed-Killing Properties

There is one important question which most all people working with biological chemicals would like to have answered. It is : How can I judge whether a chemical will be active, on the basis of the molecular structure of the substance? The answer to this question would be welcomed by entomologists, by pathologists, by those engaged in medical research, as well as by those interested in killing weeds.

It seems that this may be one of our most difficult problems. In fact it appears that we are still a long way from finding a means of predicting whether a substance will be active or inactive biologically. In this problem we are confronted with a wide range of variables that effect the activity of the chemical, not only differences in chemical and physical characteristics of the substance itself, such as its molecular configuration, solubility, or the kind of atoms it contains, but also the kind of physiological processes that occur in the organism, the stage of development of the organism, and the conditions under which it is growing. Some questions regarding the activity of substances involve a type of chemistry which is not too well understood from either the plant or the animal side and which involves physiological reactions that we are just now beginning to study.

Some progress has been made, however, toward an understanding of why one chemical is very potent while another closely related one is not. Dr. Zimmerman has shown that the number of carbon atoms in the side chain of esters of 2,4-D is related to their activity on plants. The activity of compounds closely related to 2,4-D is being very carefully determined under controlled conditions, and attempts are being made to measure certain physical and chemical characteristics that might be involved in this question of herbicidal activity.

These are some of the things that have been learned as the result of basic physiological research on 2,4-D. It is hoped that more intensive work of this kind can be directed toward a study of some of the other chemicals now used to kill weeds and by thus gaining a better understanding of how all of these chemicals work we will be able to do a better job of weed control.

A New Chemical for Use in Pre-emergence Weeding.

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Sodium 2-(2,4-dichlorophenoxy) ethyl sulfate (Experimental Herbicide No. 1) is a germinative toxicant for weed seeds when applied to the soil. Although its chemical relationship to 2,4-D is apparent, its physiological effects when applied to plant foliage are entirely different. Spray or dust applications of this chemical to the foliage of sensitive plants result in no epinastic responses and only slight 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. Sodium 2-(2,4-dichlorophenoxy) ethyl sulfate (formerly coded as No. 5264) is a free-flowing white powder. It offers no formulation difficulties since it is freely soluble in soft water.

Table 1. Seed Germination Test Conducted in 4" Pots (40 ml. per pot of aqueous solution added three hours after planting)

Chemical	Concn. %	Germination as % of check		
		lettuce	radish	ryegrass
Exp. Herb. No. 1	0.1	0	0	17
	0.01	0	26	83
	0.001	0	84	100
	0.0001	100	100	100
Na 2,4-D	0.1	0	5	12
	0.01	0	24	45
	0.001	23	53	100
	0.0001	82	100	100

Laboratory tests with various concentrations of Experimental Herbicide No. 1 in water solution applied to pots which had been planted with small seeds revealed the highly toxic nature of this compound to germinating seeds in the soil. The similarity of its action to that of 2,4-D in this type of test is evident. It is probable that No. 1 is toxic only to germinating seeds and not so to dormant seeds. This is also true

for 2,4-D. Thus this type of toxic action on seeds is more precisely defined with the use of the term "germinative toxicant". Field tests showed that at rates of 3 lbs./acre germinating seeds of crabgrass, purslane, carpet weed, and low ragweed were killed.

Table 2. Hormonal Responses of Potted Tomato Plants. Three different modes of application.

Chemical	Foliage Spray Increase in height as % of ck. after application of sprays foliage			Soil Watering Growth in ht. as % of ck. after application to soil as aqueous solution, lbs./acre				Soil Dusting Dry wt. of tops as % of ck. after 33 days. Dust applications to soil surface, lbs./acre			
	0.1	0.01	0.001	62.5	6.25	0.63	0.063	10	5	1	0.5
E. H. No. 1	92	111	117	0	34	76	115	69	72	76	91
Na 2,4-D	3	29	73	0	0	133	134	17	55	92	51
Check		- 100 -			-	100 -			-	100	-

Since No. 1 is chemically related to 2,4-D, it might be expected that it would show some of the hormonal characteristics of the latter. The chemical per se shows almost none of the usual hormonal responses shown by 2,4-D on sensitive plants. A number of experiments have been conducted to demonstrate the differences between No. 1 and 2,4-D. These differences are striking when the chemicals are applied to the surfaces of such sensitive plants as tomatoes as shown in Table 2 when they were applied as foliage sprays. Reduction in growth with No. 1 was minor while it was severe with 2,4-D. However, when this chemical is applied to the soil, its action on growing plants is more nearly similar to 2,4-D, though even then it is less hormonal. (Compare 2,4-D and 5264 in sections on soil watering and soil dusting in Table 2)

When a single leaf of a potted tomato plant was dusted with a 1.0% preparation of 2,4-D Na salt in pyrophyllite, a profound epinasty of the treated leaf and other leaves, and a strong distortion of the plant occurred within 24 hours after treatment. When 5264 was applied in the same manner and at the same concentrations, no such responses were noted. If clipped tomato leaves were immersed in 1.0% solutions of 2,4-D, strong epinasty was noted within 24 hours, and growth in the apical region practically ceased. Similar tests with 5264 showed none of these typical hormonal responses.

Table 3. Weed Control and Yield in Snapbeans, and Small Seeded Lima Beans.* (Chemical applied three days after planting)

Treatment	Lbs/A	Snap beans: Fresh weed wt. gms/3 sq. ft.	Snap beans: Fresh bean wt. lbs/10 row ft.	Lima beans: Weed Control	Lima beans: Ave. pod wt. in lbs/80 row ft.
E.H. No. 1	3	384	10.5	good	9.2
Na 2,4-D	1.5	204	10.6	good	8.8
Uncultivated check		1939	10.5	none	5.8
Cultivated check		-	11.5	good	8.5
					100 sq. ft.
E.H. No. 1	1	-	-	fair	11.0
E.H. No. 1	2½	-	-	good	11.8
E.H. No. 1	5	-	-	good	12.2
Uncultivated check	-	-	-	none	5.5

* Data of Dr. Benjamin Wolf, Seabrook Farms, New Jersey.

The results of some field tests conducted by Dr. Benjamin Wolf on small seeded lima beans and snap beans are presented in Table 3. It is evident that good weed control was obtained with Experimental Herbicide No. 1 in the range 2½ to 3 lbs./acre. There is also an indication of some stimulation in the yields of the lima beans, especially at the higher rates. No epinastic or formative effects were noted on the lima beans. Slight formative effects on the young leaves of the snap beans were noted early in the growth period, but these effects did not persist and did not interfere with yield.

The single dose oral toxicity to rats of Experimental Herbicide No. 1 is approximately the same as the sodium salt of 2,4-D. 2,4-D is not considered a hazardous material in regard to mammalian toxicity.

CHEMICAL WEED CONTROL IN HORTICULTURAL CROPS AT THE PENNSYLVANIA STATE COLLEGE

Charles J. Noll and Martin L. Odland

Weed control experiments using chemical herbicides were carried out this year on asparagus, lima bean, string bean, beets, spinach, and sweet corn. The chemicals used included differen forms of 2,4-D, 2,4,5-T, dinitro, petroleum products, cyanamid and some miscellaneous materials.

The sprays were applied with a large nozzeled knapsac sprayer at a rate of from 50 to 100 gallons per acre. Low volumn spraying was attempted and discarded because of the high percent of drift off of the small plots. All applications were pre-emergence except with the late applications on asparagus.

ASPARAGUS WEED CONTROL

A well established field of asparagus was utilized for this study. The field plot layout was a randomized block arrangement with four replications. Each plot represented by a single row eight seven feet long, was 1/100 of an acre in area. The field was disked and harrowed on the 19th of April which was approximately ten days prior to the emergence of the first shoots.

The materials used were Defoliant Cyanamid, 2,4-D Acid, 2,4-D Sodium Salt, 2,4-D Butyl Ester, 2,4,5-T Butyl Ester, Dow Selective and Stoddard Solvent. Defoliant cyanamid was applied at 2 rates, 200 and 400 pounds per acre, and three applications were made. 2,4-D was applied at 3 rates, 1, 2, and 4 pounds per acre and two applications were made. Two applications were made with 2,4,5-T but rates per acre were ½, 1, and 2 pounds. Stoddard Solvent was applied at one rate only, 100 gallon per acre, and applied two times.

The first application of 2,4-D and of 2,4,5-T were made on the 23rd of April prior to the emergence of the first asparagus shoot. The second applications were applied on May 19 during the cutting season. The first application of Cyanamid, Dow Selective and Stoddard Solvent were made on April 29 when the first shoots were emerging. The Cyanamid plots were dusted again on the 28th of May and on the 9th of June. The second applications of Dow Selective and Stoddard Solvent were made on May 18. It should be noted that on this date many shoots not yet of harvestable size were covered by the spray.

Eighteen cuttings were made during the season and yield records were taken. Analysis of varience showed no significant differences in yield treatments. No check plot was included in the randomized block arrandement so direct comparison of yield of treated and untreated asparagus cannot be made. From observations it appeared as if the treated plots yielded fully as much asparagus on the surrounding untreated areas.

Good weed control was secured by all treatments as compared to the untreated areas surrounding the plots. The untreated areas were green with rabbit eared chickweed, smart weed, purslane and other weeds. Probably the best weed control was with 2,4-D and Dow Selective at the heavier concentrations and with Stoddard Solvent.

Table I. Yield of asparagus obtained from eighteen different chemical weed control treatments.

Treatments	Rate per Acre	Number of Applications	Total Yield four Replications
1 Defoliant Cyanamid	200 lbs.	3	84.9 lbs.
2 Defoliant Cyanamid	400 lbs.	3	70.7 lbs.
3 2,4-D Acid	1 lb.	2	71.1 lbs.
4 2,4-D Acid	2 lbs.	2	69.8 lbs.
5 2,4-D Acid	4 lbs.	2	77.1 lbs.
6 2,4-D Sodium Salt	1 lb.	2	65.8 lbs.
7 2,4-D Sodium Salt	2 lbs.	2	83.7 lbs.
8 2,4-D Sodium Salt	4 lbs.	2	74.2 lbs.
9 2,4-D Butyl Ester	1 lb.	2	67.2 lbs.
10 2,4-D Butyl Ester	2 lbs.	2	68.9 lbs.
11 2,4-D Butyl Ester	4 lbs.	2	77.4 lbs.
12 2,4,5-T Butyl Ester	½ lb.	2	80.1 lbs.
13 2,4,5-T Butyl Ester	1 lb.	2	81.2 lbs.
14 2,4,5-T Butyl Ester	2 lbs.	2	73.8 lbs.
15 Dow Selective (100 gal. water)	1 gal.	2	73.8 lbs.
16 Dow Selective (" " ")	2 gals.	2	67.1 lbs.
17 Dow Selective (" " ")	3 gals.	2	71.0 lbs.
18 Stoddard Solvent	100 gals.	2	71.9 lbs.
Significant Difference			Not significant

LIMA BEAN WEED CONTROL

Sixteen 32 foot single row plots replicated four times were sprayed or dusted with 2,4-D Acid, 2,4-D Sodium Salt, 2,4-D Butyl

Ester, 2,4,5-T Butyl Ester, Carbide 5264, Defoliant Cyanamid, Dow Selective, Aramatic H.B., and Stoddard Solvent. All applications were made after planting and prior to the emergence of the lima beans. The different forms of 2,4-D were sprayed on the plots at the rate of 1 and 2 pounds per acre; 2,4,5-T at ½ and 1 pound per acre, Carbide 5264 at 5 pounds per acre, Aramatic H.B. at 50 gallons per acre, Dow Selective at 2, 4, and 6 quarts per acre. One plot was left untreated.

The land was prepared on the 19th of May and planted the next day. A day later, the 21st, plots receiving 2,4-D, 2,4,5-T, and Carbide were treated. On the 28th, 8 days after planting, plots receiving Cyanamid, Aramatic H.B., and Stoddard Solvent were treated. Some beans emerged on the 9th day after planting.

Weed control was rated in each plot from 1 to 10, 1 being good weed control and 10 no apparent weed control. With the exception of 5 plots weed control was poor. These five plots in order of weed control were 2,4-D Butyl Ester at 2 lbs. per acre, Aramatic H.B. at 100 gallons per acre, Carbide 5264 at 5 lbs. per acre, 2,4-D Sodium Salt at 2 lbs. per acre and 2,4-D Butyl Ester at 1 lb. per acre. There was significant difference between the first three and the last two in weed control.

Records were taken on plant stand in all treatments. No significant differences found. Yield records (two pickings) were taken of the best five in weed control. The differences in yield were not significant.

Table II. Yield and relative weed control in lima beans obtained from fifteen different chemicals weed control treatments.

Treatment	Rate per Acre	Stand of Plants	Weight of Total Yield	Weed Control (1-10) +
1 2,4-D Acid	1 lb.	136		31
2 2,4-D Acid	2 lbs.	119		25
3 2,4-D Sodium Salt	1 lb.	98		30
4 2,4-D Sodium Salt	2 lbs.	128	22.7	19
5 2,4-D Butyl Ester	1 lb.	119	20.1	19
6 2,4-D Butyl Ester	2 lbs.	104	23.8	11
7 2,4,5-T Butyl Ester	½ lb.	116		29
8 2,4,5-T Butyl Ester	1 lb.	116		31
9 Carbide 5264	5 lbs.	107	19.4	13
10 Defoliant Cyanamid	200 lbs.	95		33
11 Defoliant Cyanamid	400 lbs.	106		30
12 Dow Selective	1 gal.	114		35
13 Dow Selective	2 gals.	135		29
14 Aramatic H.B.	100 gals.	110	24.0	12
15 Stoddard Solvent	100 gals.	112		32
16 Untreated		134		36
Significance	5%	not significant		1.50
	1%	" "		1.97

+ Weed control of all 4 replications. Rate 1, good; to 10 none.

DELAYED PLANTING - PRE-EMERGENCE WEED CONTROL

Sixteen plots planted with single rows 30 foot long of Beets, Lima Bean, String Bean, and Spinach, replicated four times, were sprayed with 2,4-D Acid, 2,4-D Sodium Salt, 2,4-D Butyl Ester, 2,4,5-T Butyl Ester, Carbide 5264, Aramatic H.B., Stoddard Solvent, and Dow Selective. All applications were pre-emergence.

The land was prepared on the 20th of May and planted on the 1st of June. Only one light rain occured between these two dates. Two days after planting, the plots receiving 2,4-D and 2,4,5-T were sprayed, while the other chemicals were applied 4 days after planting.

Records were taken of beet stand of plants, weight of plants and early yield; lima bean stand of plants and weight of plants; string bean stand of plants, weight of plants, and early yield; spinach weight of yield and weed control rated 1 to 10.

The beets, lima bean, and string bean were harvested on the 27th of July, prior to full maturity. The spinach reach full maturity on the 8th of July and was harvested at that time.

In beets a significant difference in stand of plants over the check was obtained with Stoddard Solvent at 50 gallons, and 100 gallons and Dow Selective at 2 quarts. The best stand was obtained with Stoddard Solvent at 50 gallons. The difference in the stand obtained from this treatment and the second best was significant. Significant differences in weight of plant over the untreated was obtained with Dow Selective at 2, 4, and 6 quarts, Stoddard Solvent at 50 and 100 gallons, Aramatic H.B. at 50 gallons, and 2,4,5-T at 1 pound per acre. The highest weight of plants was with Dow Selective at 2 quarts, a weight of plants that is significant at the 5% level over all other treatment. Significant differences in early yield over the untreated were secured with the chemicals: Dow Selective at 2, 5 and 6 quarts, Stoddard Solvent at 50 and 100 gallons, Aramatic H.B. at 50 gallons, 2,4,5-T at 1 lb. and 2,4-D Acid at 1 lb. The best three treatments were Dow Selective at 4 quarts and Aramatic H.B. at 50 gallons and Dow Selective at 6 quarts. There was no significant differences between the three.

In lima bean stand of plants no significant difference was found between the check and best three treatments. These were Stoddard Solvent at 50 gallons, Dow Selective at 4 quarts, and Aramatic H.B. at 50 gallons. The untreated was significantly better than all other treatments. In weight of plants a significant difference over the check was obtained from Dow Selective at 4 and 6 quarts, Aramatic H.B. at 50 gallons, and Stoddard Solvent at 50 gallons. There was significant difference in favor of Dow Selective at 4 quarts over all other treatments.

With string beans significant differences in stand of plants when compared to the untreated was obtained with Dow Selective at 2 and 4 quarts, and Aramatic H.B. at 50 gallons. Dow Selective at 4 quarts gave significant differences over all other treatments. Significant differences in plant weight was found with Dow Selective at 2, 4, and 6 quarts, Stod ard Solvent at 50 and 100 gallons, Aramatic H.B. at 50 gallons, and 2,4,5-T at ½ lb. Dow Selective at 6 quarts gave significant differences over all other treatments. Significant differences in favor of the following materials was recorded for early yield: Dow Selective at 2, 4, and 6 quarts, Stoddard Solvent at 50 and 100 gallons, Aramatic H.B. at 50 gallons, and 2,4,5-T at ½ lb. Again Dow Selective at 6 quarts gave significant differences over all other treatments.

With spinach significant differenc in favor of the chemically treated as compared to the check was secured only when Stoddard Solvent was used at 100 gallon per acre. A yield of 25 pounds as compared to 16 pounds was recorded.

The best weed control was not associated with the best stand of plants, weight of plants or yield. Weed control was significantly better than the check with all chemicals used. The best weed control was with 2,4-D Butyl Ester at 2 lbs. per acre. Weed control in order of control is as follows: 2,4-D, Carbide 5264, Aramatic H.B., Stoddard Solvent, 2,4,5-T, and Dow Selective.

SWEET CORN WEED CONTROL

Thirty-two 60 foot plots replicated six times were treated with the following chemicals: 2,4-D Acid, 2,4-D Sodium Salt, 2,4-D Butyl Ester, and 2,4,5-T Butyl Ester. The chemicals were used at the rate of 1½, 2, 2½, and 3 pounds per acre. The chemicals were applied by two methods; over the row for a width of eight inches and broadcast over the entire surface area. Every fifth row through the field was untreated and served as a check.

The check rows and the rows receiving only 8 inches of coverage were cultivated at regular intervals. The rows receiving broadcast application were cultivated at regular intervals after the corn reach 2 feet in height.

The heavier concentrations of 2,4-D gave good control of the broad leaf weeds and a fair control of the annual grasses. Quack grass was in the field and no visable control was secured at any dosage. The light applications of 2,4-D and all concentrations of 2,4,5-T failed to give adequate weed control.

Yield records showed no significant differences in yield between the untreated and the treated or between any two treatments.

Table III. The results obtained from fifteen different chemicals weed control treatments on four vegetable crops, beets, lima beans, string beans, and spinach, when applied as a pre-emergence treatment.

Treatments	Rate per acre	BEETS			LIMA BEAN		STRING BEAN			SPINACH	
		Stand of Plants	Wt. of Plants	Early Yield	Stand of Plants	Wt. of Plants	Stand of Plants	Wt. of Plants	Early Yield	Total Yield	Weed Control * (1-10)
1 2,4-D Acid	1 lb.	190	16.8	4.7	68	4.2	259	16.5	4.4	6.6	23
2 2,4-D Acid	2 lbs.	75	8.5	1.5	57	3.7	240	15.1	4.1	2.4	11
3 2,4-D Sodium Salt	1 lb.	88	9.4	2.2	46	2.7	240	14.9	3.4	4.1	16
4 2,4-D Sodium Salt	2 lbs.	53	4.2	1.3	31	1.7	207	7.7	1.3	0.3	8
5 2,4-D Butyl Ester	1 lb.	122	8.9	0.7	66	5.2	279	17.8	4.3	1.7	11
6 2,4-D Butyl Ester	2 lbs.	35	3.0	0.9	51	2.5	207	9.2	1.4	0.4	4
7 2,4,5-T Butyl Ester	½ lb.	609	26.0	2.1	55	3.7	315	31.5	10.6	10.1	30
8 2,4,5-T Butyl Ester	1 lb.	390	28.8	5.7	49	4.2	261	27.0	9.3	14.7	26
9 Carbide 5264	5 lbs.	57	3.3	0.6	38	2.8	197	13.4	2.8	0.4	19
10 Aramatic H.B.	50 gals.	541	38.5	6.3	84	8.3	339	40.2	15.1	11.7	22
11 Stoddard Solvent	50 gals.	1037	36.6	3.5	89	5.9	295	32.2	11.4	18.3	24
12 Stoddard Solvent	100 gals.	796	41.5	4.8	70	4.7	314	33.6	12.1	25.3	27
13 Dow Selective	2 qts.	821	44.1	5.3	71	5.3	315	32.6	11.0	15.5	37
14 Dow Selective	4 qts.	433	35.1	6.5	87	9.8	359	41.4	12.9	9.7	30
15 Dow Selective	6 qts.	376	34.5	5.8	62	7.6	399	54.1	16.7	2.6	29
16 Untreated		638	24.5	1.9	84	4.8	314	26.3	9.4	16.5	34
Significant Difference	5%	41.58	3.05	.73	6.59	.79	17.16	2.13	.89	2.03	2.5
	1%	54.58	4.01	.96	8.64	1.03	22.52	2.80	1.18	2.67	3.3

*

* Weed control of all 4 replications rate 1 - good weed control. To 10 - no weed control.

Control of Woody Plant Weeds in Blueberries with 2,4-D Materials

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Many of the weeds infesting blueberry fields are woody like the crop plants and some are closely related to them. These facts together with the one that blueberries are essentially wild plants, which have been favored by repeated burning, makes weed control somewhat difficult. Burning blueberry land every three years is commonly practiced because it definitely stimulates the production of a better crop. This burning usually does not eradicate the weed species, it merely keeps them in a sprout stage. Some growers have been very successful in clearing their lands of competing species by burning and cutting while others have found this more difficult.

Considerable work was done experimentally on weed control in blueberries by Chandler and Mason (1) in Maine between 1930 and 1940. They found that alders would not sprout as much if cut during July and August and that sweet fern can be nearly eradicated by three years of successive cutting. Several chemicals were tried, the more effective were sulphuric acid, and ammonium sulfamate.

With the introduction of the 2,4-D materials, new hope and renewed vigor was given this weed control work. In 1946 Dr. Steinbauer (2) and myself tried four 2,4-D materials on some of the more common weeds and on some blueberry plants to determine the feasibility of using these materials. We had misgivings because of the close relationship of the crop plants and weeds. It was found that the four materials tried might seriously injure blueberries and would kill some of the weeds. Following burning, many of the weed species appear before the blueberry plants. It was found that the young shoots of the weeds were far more susceptible than the older plants. During this period which includes late June and early July, the young sprouts can be spot treated without causing unnecessary injury to the blueberries. The 2,4-D materials used in 1946 were an ethyl ester, methyl ester, butyl ester and two amine salt formulations. Of these materials the ammonium salt materials were the least injurious to the blueberries.

Because of this difference in the effect of the above herbicides on blueberry plants without apparent reduction in their effectiveness on the 2,4-D susceptible weeds it was decided to try several formulations in 1947. About 10 acres of blueberry land burned during that spring were used for this work. Seventeen materials listed in Table 1 were used.

Table 1.
Materials Used in Blueberry Weed Control Experiments 1947

Trade Name	Manufacturer	Formulation
Weedanol 70	Associated Chemists N. Collins, New York	70% sodium salt 2,4-D
Weedanol 40	Associated Chemists	40% morpholine salt 2,4-D
Chipman Weed Killer Powder	Chipman Chemical Co.	Sodium salt 2,4-D 60% 2,4-D acid
Chipman 5% Weed Killer Dust	" " "	5% 2,4-D acid equivalent
Chipman 15% Weed Killer Dust	" " "	15% 2,4-D acid equivalent
Chipman 27-D Dust	" " "	5% 2,4-D acid equivalent plus 2% oil
Chipman 33-D Dust	" " "	15% 2,4-D acid equivalent plus 2% oil
Chipman 31-D Dust	" " "	5% 2,4-D acid equivalent plus 2% non-volatile solvent
Esteron 44	Dow Chemical Co.	44% isopropyl ester 2,4-D
Dow 2,4-D Dust	" " "	5% methyl ester dust
DuPont 2,4-D Weed Killer	DuPont Co.	83.5% ammonium salt 2,4-D
Weed-No-More 40	Sherwin Williams Co.	40% butyl ester 2,4-D
2,4-D Dust	" " "	5% butyl ester 2,4-D
Stantox 2,4-D	Standard Agricultural Chemicals, Inc.	33% triethanolamine salt 2,4-D
Ammate	DuPont Co.	Ammonium sulfamate
Handy Killer	Ralph Adams	23% sodium arsenite
Varsol	Esso Standard Oil	Stoddard solvent

Differences in reaction of these materials on weeds and blueberries were marked. The 2,4-D dusts have been eliminated because of the difficulty in applying them and because drift of these materials caused injury to blueberry plants some distance from the weeds treated. The ammonium sulfamate was used on certain 2,4-D resistant woody weed species, the sodium arsenite was applied to brake fern and the Stoddard solvent was tried on grasses with variable results from all of them.

Many individuals of most of the weed species under consideration were treated with nearly every herbicide, and at least three plants were marked by wire stakes with a numbered tag attached for reference. Notes were taken in the late summer of 1947 and again

in the spring of 1948. Some individuals listed as dead in 1947 were found sprouting in 1948 and some which were apparently only slightly injured in 1947 were dead the next July. Conditions similar to this were found in 1946 and 1947.

For the 1948 experiments an attempt was made to select formulations which seemed to give the better results and to try new ones. Those used in 1948 are listed in Table 2.

Table 2.
Materials Used in Blueberry Weed Control Experiments in 1948

Trade Name	Manufacturer	Formulation
Baker #4	J. T. Baker Chemical Co.	99% morpholine salt 2,4-D
DuPont 83% Sodium 2,4-D Weed Killer	DuPont de Nemours Co.	83.5% sodium salt 2,4-D
DuPont 2,4-D Weed Killer	" " " "	83.5% ammonium salt 2,4-D
Powco Brand Mixed Isopropanolamine Salts of 2,4-D	John Powell and Co.	65.1% isopropanolamine salts 2,4-D
Stantox 66	Standard Agricultural Chemicals, Inc.	67% triethanolamine salt 2,4-D
Weedone Concentrate	American Chemical Paint Co.	39% ethyl ester 2,4-D
Ammate	DuPont de Nemours Co.	Ammonium sulfamate

The above 2,4-D materials that were applied as a spray were used at a concentration of 2000 parts per million 2,4-D acid equivalent. The leaves of the treated plants were made thoroughly wet with the spray material. As indicated, nearly all of the above materials were used on most of the weed species and blueberries that are listed in Table 3 along with their relative susceptibility to the 2,4-D materials.

Table 3.

A List of Plants Treated With 2,4-D Herbicides in Blueberry Weed Control Experiments and Their Relative Susceptibility.

Scientific Name	Common Name	Relative Susceptibility 1/
Acer rubrum	Red maple	R
Alnus rugosa	Alder	S
Amelanchier laevis	Serviceberry	I
A. stolonifera	Sugar plum	I
Apocynum androsaemifolium	Dogbane	S
Aronia melanocarpa	Chokeberry	I
Betula papyrifera	White birch	S
B. populifolia	Gray birch	S
Comptonia peregrina	Sweet fern	S
Cornus canadensis	Dwarf cornel	R
Diervilla lonicera	Bush honeysuckle	I
Gaultheria procumbeus	Wintergreen	R
Kalmia angustifolia	Sheeplaurel	I
Nemopanthus mucronatus	Mountain holly	I
Populus tremuloides	Small tooth aspen	I
Prunus pensylvanica	Pin cherry	S
Pteridium aquilinum	Brake fern	R
Rhododendron canadense	Rhodora	I
Rosa sp.	Wild rose	R
Rubus hispida	Swamp dewberry	R
Rubus sp.	Blackberry	R
Rubus sp.	Raspberry	R
Salix bebbiana	Bebb willow	I
Salix discolor	Pussy willow	S
Salix humilis	Prairie willow	S
Salix petiolaris	Willow	S
Sorbus americana	Mountain ash	I
Spiroala latifolia	Meadowsweet	I
Ulmus americana	American elm	S
Vaccinium spp.	Blueberry	I
Viburnum cassinoides	Witherod	S

1/ S = Susceptible, I = Intermediate, R = Resistant

Although much more data are needed before a definite statement can be made, it seems that all of the 2,4-D materials do not affect all weed species in the same way. This is definitely true on the blueberry plants and it is probably true on the weed species as well. Two examples of this may be cited. The sheeplaurel is killed by the isopropyl ester, butyl ester, and the morpholine salt, but is not killed by the ammonium salt, triethanolamine

salt, and the sodium salt. Rhodora is killed by the ammonium salt, sodium salt, isopropyl ester and butyl ester but is not killed by the triethanolamine salt or the morpholine salt. In contrast to this, sweet fern is very susceptible to the materials tried while red maple seems nearly immune to all 2,4-D materials used.

The effect of these materials on blueberries is of considerable importance. It seems that the upright stems of the low-bush blueberries may be killed by all of the materials tried if the dose is heavy enough but at concentrations of 1000 or 2000 parts per million of 2,4-D acid equivalent, there are definite differences as to the reaction of the low sweet blueberry, Vaccinium angustifolium to the various materials tried. This species is the most susceptible to the ethyl ester, methyl ester, butyl ester, sodium salt, morpholine salt and isopropanolamine salt while it is more resistant to the ammonium salt and triethanolamine salt. While the upright blueberry stems may be killed back the horizontal underground rhizomes may not be severely injured. The third season after treatment the plants seem to have almost completely recovered from the ammonium salt, ethyl ester and methyl ester while there has been only slight recovery from the butyl ester. The plots treated with these four materials in June 1946 will be burned next spring. It will be interesting to see how many blueberries will be produced in 1950, and not until then will we know definitely the effect of these materials on the blueberry plants.

Because alders are sometimes more of a problem than other weeds, trials have been made combining what is already known about cutting practices and the use of 2,4-D materials. Plants three feet tall or less can be easily killed by these materials when sprayed until the leaves are thoroughly wet with a concentration of 2000 parts per million 2,4-D acid equivalent. If the plants are much over three feet tall sprouts may appear from the roots and it takes much more material to cover the whole plant.

In one experiment large bushes were cut in July and some of the stumps treated at the time of cutting. Some of the sprouted stumps were treated the following September and others the next July. A complete kill was obtained on both dates where the sprouts were treated, but treating the stumps after cutting has been unsatisfactory. In another experiment some bushes were cut in March while they were still frozen. They cut much easier at this time of year than during the summer. Some stumps were treated right after they were cut with a spray and with the concentrated powder and other stumps were treated before they began to sprout. Still more were sprayed and some were dusted with 5% and 15% 2,4-D acid equivalent materials. The dusts were not effective, and neither were the stumps killed that were treated at cutting time or later. Complete kill was obtained when they were allowed to sprout and then sprayed with the 2,4-D materials.

Acknowledgements

Considerable credit is due Ramond Buck, now a graduate assistant at the University of Maryland, for carrying out much of the field work done during 1947 and 1948.

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PROGRESS REPORT ON WEED CONTROL IN STRAWBERRIES

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The preliminary tests conducted in 1947 to determine the feasibility of using various chemicals for the control of weeds in strawberries were sufficiently promising to continue this investigation in 1948.

The phases which were investigated to a limited extent were:

1. Control of weeds in a fruiting field by the use of chemical sprays applied in the spring of the fruiting year.

2. Reduction of labor costs by the use of weed control sprays in a newly planted field.

Phase 1

Problem:

Pussy or rabbit clover (Trifolium arvense) was a major weed pest causing as much as 80% reduction in yield in a three acre field of Blakemore strawberries in Cape May County. Other weeds present were spurry (Spergula arvensis), sheep sorrel (Rumex acetosella), chickweed (Stellaria media), dandelion (Toxicum officinale), and wild carrot (Daucus carota).

Sprays applied:

February 26, 1948 - Growth starting-one new leaf.
Butyl ester of 2,4-D at the rate of ¼, ½, 1, 2, and 4 lbs. of actual acid per acre.

March 20, 1948 - Plants making active growth.
Isopropyl ester of 2,4-D at the rate of 1, 2, and 4 lbs. of actual acid per acre.

Dinitro (1 qt.), diesel oil (30 gal.), and water (100 gal.) per acre.

Dinitro (3 pts.) and water (100 gal.) per acre.

Results:

1. There was relatively little lasting injury to the strawberry plants with as much as 4 lbs. of 2,4-D applied on February 26, 1948.

2. At concentrations below 1 lb. 2,4-D per acre, the clover was not controlled adequately. Concentrations of 1 lb. and

above gave very good control of this weed.

3. Weeds which were not adequately controlled by the 2,4-D sprays were spurry, chickweed, sheep sorrel, and wild carrot. In the plots where the clover was controlled, these plants (weeds) were more abundant than in the check plots where clover over-ran the entire row.

4. Concentrations of 2 lbs. of 2,4-D and above applied on March 20, 1948 retarded plant growth considerably.

5. The Dinitro sprays burned most of the exposed leaves of the weeds and strawberries very soon after application. However, both the weeds and strawberries recovered very quickly.

Note:

No yield records were obtained from these plots but the fruit was not deformed. However, observation of the amount of fruit during the harvest season indicated that a much larger crop was harvested in the plots where the clover was eliminated than in the comparative check plots.

Conclusions:

Sprays of 2,4-D at a concentration of 1 lb. of actual acid per acre applied during early spring just as growth is starting seems practical where the major problem is one in which the weeds are susceptible to this spray. However, where the weed population consists of grasses and weeds not eliminated by the use of 2,4-D, sprays applied at this time will be very disappointing.

Phase 2

Problem:

One of the major expense items in the growing of strawberries during the first season in the field is the removal of weeds by hoeing, hand weeding and cultivation. In the particular field in which the following sprays were applied the grower paid $5.00 to have rows 200 yards long weeded one time. This, of course, was not the only time that weeding was necessary, although it was probably the most expensive weeding of the season. With costs of this nature cutting into the net profit, it was the object of this study to ascertain whether or not a portion of this cost could be eliminated by the judicious use of weed control sprays.

Sprays applied:

On July 24, 1948, 2,4-D (Amine salt) at the rate of 1 lb. per acre was applied to a small plot of Redwing. At this time the plants were actively growing and producing numerous runners

and runner plants. Five days prior to the application of the spray, the field had been thoroughly cultivated and hoed so that it was entirely free of weeds except for a few which had just begun to germinated.

On August 10, 1948 the same rate of 2,4-D was applied to a larger plot adjacent to the earlier sprayed plots. At this time a large number of weed seeds and crab grass had reached a height of 1 to 3 inches.

Results:

1. The day after the strawberry plants were sprayed, practically all of the plants were quite severely wilted and some of the runner tips were slightly twisted. This condition persisted for approximately three to seven days.

2. The sprays applied on July 24, 1948 gave excellent weed control for the remainder of the growing season.

3. The sprays applied on August 10, 1948 gave good control of the broadleafed weeds present, but the crab grass soon over-ran the rows.

4. The field was checked on October 19, 1948, with no visual difference in the number of plants in the sprayed plots as compared with the unsprayed plots.

Conclusions:

Excellent control of weeds was obtained with 2,4-D (Amine salt) at the rate of 1 lb. per acre applied five days after cultivation with the strawberry variety Redwing. This spray was applied just as the weed and grass seed was germinating with the result that all weed growth was controlled.

When the spray was applied after approximately 20 days had elapsed following cultivation and hoeing crab grass became a major problem.

SUMMARY

From these limited tests it appears that the use of 2,4-D for the control of weeds in strawberries is feasible under special conditions with proper management. However, it must be remembered that the work herein reported is with 2 varieties of strawberries only.

A PROGRESS REPORT ON CHEMICAL WEED CONTROL IN VEGETABLE CROPS

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The work presented here is that which has been accepted or shows promise of being accepted in the near future for commercial field practice in the Tidewater area of Virginia.

Strawberries

Experimental results with the Blakemore variety suggests the possibility of using chemicals for control of weeds in this crop for the major part of the year with a reduction of present weeding costs of $100 to $150 per acre per year to about $20. The use of 1.4 pounds of the 2,4-D acid equivalent per acre in the form of the sodium or trielthanolamine salts applied in 100 gallons of water per acre after the berries have been harvested has proved satisfactory as a weed controlling measure. Serious reductions in yield and quality of fruit have resulted from treatments applied during flowering or fruiting. Timing the treatment to accomplish the desired result is important. Such weeds as pigweed (Amaranthus retroflexus), curley dock (Rumex crispus), purslane (Portulaca oleracea), lamb's quarters (Chenopodium album), ragweed (Ambrosia artemisiifolia) and knotweed (Polygonum aviculare) have been controlled by this method. In addition, such grasses as crab grass (Digitaria sanguinalis) and bull grass (Eleusine indica) have also been controlled by treatments applied when these grasses were germinating. In our area, applications are made in June for crab grass control and July for bull grass control. Through grower and custom spray operator cooperation, it has been possible to extend our summer field treatments from the 27 acre experiment of last year to approximately 600 acres in the present year. We consider this work as experimental at the present time, although it is on a semi-commercial basis.

Work with winter weeds such as chickweed (Stellaria media) and henbit (Lamium amplexicaule) in Blakemore berries have shown that the same amount of 2,4-D as used in summer treatments, when applied at the time of germination of the above weeds, gave satisfactory control.

It should be understood that the above treatments are all essentially soil treatments which depend for their effectiveness on the weed seed being in the germinating stage sometime during a 2 to 3 week period following application. A soil moisture level which allows for good germination has been found to be a necessity as applications made during extended dry periods have given variable results. The sodium and triethanolamine salts of 2,4-D have given consistantly good results without injury to the berry plants. The butyl ester applied in a concentration of 1000 ppm using 100 gallons per acre has also been satisfactory. Low gallonage treatments with the butyl ester have been under investigation and a report will be made on this subject in the coming year.

Experiments on the use of Sinox General (dintro ortho secondary amyl Phenol) for the control of established stands of chickweed and henbit in Blakemore strawberries have shown this material to be very effective. The spray solution found most satisfactory for small weeds is prepared by mixing one quart of chemical with

100 gallons of water. For large weeds, one quart of Sinox General mixed with 15 gallons of kerosene or diesel fuel and the addition of this mixture to 85 gallons of water makes a satisfactory preparation. Rate of application must be determined by the amount required to give a satisfactory coverage of the weed foliage. This will ordinarily be in the range of 100 to 150 gallons per acre of actual area sprayed. This material is being recommended for the spraying of the middles and shoulders of the strawberry beds. Weeds in this area usually grow over the margins of the beds and reduce the yields of early berries. Sprays over the beds are still limited to a small experimental trial basis, though 100 acres have been treated this winter in field trials of the method. It has been found that treatments during dormancy have not injured the berry plants in 3 years of trials. Considerable caution must be exercised in over-all sprays applied in the late winter as severe injury can result from treatments applied after the berry plants have begun to make rapid growth in the early spring.

Sweet Corn

Pre-emergence spray applications of 1.4 pounds of the 2,4-D acid equivalent per acre using the triethanolamine and sodium salts in 100 gallons of water immediately after planting Norfolk Early Market sweet corn have given satisfactory weed control during the early growth of the corn when it is often impossible to cultivate either because of the size of the corn or because of wet weather.

Spray applications of the sodium and triethanolamine salts and the butyl ester of 2,4-D when the corn was 12 inches or more in height have given good weed control without damage to the crop when rates of 1.0 pound of the acid equivalent of the salts and 0.35 pound of the acid equivalent of the butyl ester per acre were used in 100 gallons and 5 gallons of water, respectively.

Approximately 600 acres of sweet and field corn was treated in pre-emergence trials by farmers during the past season. Post-emergence use has been almost unlimited. In spite of this, we are still avoiding a recommendation as more evidence in seasons of varying climatic conditions must be obtained before the effect on yield can be clearly demonstrated. The question of omission of mechanical cultivation and its effect on various soil types is also important and must be studied.

Parsley and Carrots

The use of Stoddard's Solvent type oils at rates of 80 to 100 gallons per acre for weeding parsley and carrots has been very successful in Virginia and is now on a commercial basis. Experience has shown that ragweed (Ambrosia artemisiifolia) and Galensoga (Galensoga parviflora) are not affected by this type of treatment. It has been found, however, that Galensoga in parsley can be killed where it emerges before the crop and is sprayed with a mixture of one pint of Sinox General to each hundred gallons of oil. The same is true of ragweed under the same conditions. This work has been merely the introduction of methods already established by Sweet of the New York Station and Lachman of the Massachusetts Station.

Onions

Preliminary experiments involving the use of Santobrite (sodium pentachloro phenate), Sinox Selective (sodium dinitro ortho cresylate) and aero cyanate (potassium cyanate) for the control of weeds in seedling San Joaquin onions have indicated that Aero Cyanate is superior to the other two materials if applied when weeds such as chickweed and henbit are less than 2 inches tall. Best results on these weeds in later stages of growth are obtained with Santobrite and Sinox. Aero Cyanate in 0.5% concentration has been used satisfactorily on very small onion seedlings (up to 3 leaf stage) and at 1.0% concentration in later stages at rates up to 100 gallons per acre with only slight injury to the onions. Sinox Selective used at concentrations of 1 to 120 on onions up to the 3 leaf stage and 1 to 80 at later stages has given good weed control at 100 gallons per acre with noticeable injury to the onions at times. Santobrite used at a 0.5% concentration up to the 3 leaf stage and at 1.0% later using 100 gallons per acre has given good weed control with noticeable injury to the onions at times. In 3 seasons of trials, the onions have outgrown these injurious effects produced by treatment.

We feel that this work is still in the early experimental stage, though approximately 100 acres of onions have been treated with Aero Cyanate in our territory due to the enthusiasm of the growers. Acknowledgement is made of the ground work laid in this field by Hedlin of the New York Station, Bakke of the Iowa Station, and Fink of the American Cyanamid Company.

Asparagus

Experimental results of treatments for the control of winter weeds such as chickweed and henbit in asparagus have given excellent results during the past 2 years and at present. The most satisfactory treatment used has been Sinox General, using one quart of this chemical mixed with 15 gallons of diesel fuel or kerosene and added to 85 gallons of water. 100 gallons of the mixture will cover an acre satisfactorily if the weeds are less than 3 to 4 inches high. Later growth stages will require additional spray. This spray is recommended for trial after the asparagus has completed its growth in the fall and after the weed has been harvested, if this is to be done. Treatments through the winter and spring before emergence have produced no symptoms of injury to the crop.

True annual winter growing grasses have been a problem in some areas and it has been found that the above mixture does not kill these weeds. These grasses have been killed by spraying them with a mixture of one pint of Sinox General to 100 gallons of Stoddard's Solvent, kerosene, or diesel fuel.

Summer weed control in this crop has not been attempted in our trials to date.

Irish Potatoes

Trials on Irish Cobbler potatoes using the sodium salt and butyl ester of 2,4-D at rates of 1.4 pounds of the acid equivalent in 100 gallons of water and 0.7 pound of the acid equivalent in 5 gallons of water per acre, respectively, in pre and post-emergence sprays have indicated the need for caution in the use

of 2,4-D on this variety. Pre-emergence treatments applied at the time the rows were dragged off did not affect yields, whereas, post-emergence applications made when the potato plants were 6 inches high reduced yields as much as 50% in both the ester and salt treatments. Other workers, principally Shuel and Thompson of the Ontario Canada Station, have indicated differences in Irish potato varietal responses to 2,4-D.

Conclusion

Chemical weed control appears to have great possibilities in vegetable crop production. It is felt that great stress is often put on the possibility of offering not only complete control of weeds, but also the elimination of mechanical cultivation, and that this leads to many disappointments and retards grower acceptance of proven methods. If the grower understands that there are limitations, he will not be too disappointed if results are somewhat less than perfect.

Preliminary Notes on Chemical Weeding of Asparagus, the Temperature-Moisture Index and Sunshine

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Introduction

The need is generally recognized for definition of environmental conditions which prevail during experiments in chemical weed control. Until many experiments under well defined conditions are analyzed, environmental effects on chemical weeding may remain poorly understood.

This paper describes preliminary tests of various chemicals on 6 year-old asparagus beds in Sassafras sandy loam at the Vegetable Research Farm of Rutgers University, New Brunswick, N. J., during the spring and summer of 1948. The experiments were accompanied by measurements of temperature, rainfall, evaporation and sunshine, in an attempt to define the environment at least partially. Data of temperature, rainfall and evaporation have been combined into a single index according to the principles set forth by Livingston (4,5), for the periods between chemical treatment and final weed count. Integrated values of sunshine for the same periods in terms of gram calories per square centimeter are presented.

The limitations emphasized by Livingston to the use of such environmental indices are, of course, implied here. It is also to be understood that much other desirable information has not been obtained, such as, for example, measurement of wind velocity at time of spraying, the amount of material actually received per unit area of soil or lost by wind drift, or details of microclimate. Other phases of the work with asparagus in New Jersey in 1948 were summarized elsewhere (10).

Equipment, Materials and Procedure

Sources of air temperature data were (a) a J. P. Friez recording thermograph which was mounted inside a standard wooden weather shelter about 500 feet north of the asparagus with the thermo-sensitive Bourdon bulb 6 inches above the soil surface, or (b) maximum and minimum thermometers mounted 12.5 feet above the soil surface inside the standard wood instrument shelter of the U. S. Weather Bureau Station at New Brunswick and about 1.5 miles northeast of the asparagus plots.

Rainfall data were taken from a standard U. S. Weather Bureau rain gage and a recording rain gage, supplied by the U. S. Soil Conservation Service, mounted about 700 feet north of the asparagus.

Evaporation data are averages from three Livingston standard spherical radio atmometers (6) located in the open about 1 foot above the soil surface and from about 350 to 650 feet northeast of the asparagus plots.

Radiation totals were obtained from a Kipp & Zonen integrating solarimeter mounted horizontally in the open about 4 feet above the soil surface and about 500 feet northeast of the plots. This device, a thermopile, is stated by the manufacturer* to integrate approximately 9 gram cal. of radiant energy/cm^2 per solarimeter unit. Solarimeter units were summed for the experimental periods and converted into gram calories per square centimeter without further calibration.

Data resulting from the use of the various instruments and from weed counts are given in Tables 1 to 4.

Pre-emergence Treatment Before the Asparagus Cutting Season

2,4-D as the triethanolamine salt** was applied at rates of 1 and 3 pounds 2,4-Dichlorophenoxyacetic acid equivalent in 5 gallons of water per acre to the soil on April 26, four days after fertilization with 1500 lbs./Acre of 5-10-10 and after discing of the asparagus beds. Unsprayed plots served as controls.

Each treatment was triplicated on segments of asparagus row about 25 feet long and five feet wide. Wind movement was roughly estimated to be about 10 miles per hour at time of spraying, and air temperature was about 60° F. Only 17 asparagus spears were observed three inches or less above the soil surface in 225 feet of row at this time. The soil was moist on April 26 from rain of 0.22 inch April 24, 25.

The total number of asparagus spears and also the number curled on April 26 and 10 and 21 days thereafter are shown in the following tabulation:

Number of spears per 75 feet of asparagus row

Lbs/Acre 2,4-D	Day April 26	Day 10th, May 6 Total	Day 10th, May 6 Curled	Day 21st, May 7 Curled Spears
0	2	14	1	7
1	6	17	2	5
3	9	19	3	9

*The U.S.A. distributer is James G. Biddle Co., Phila., Pa.

**The use of G.L.F. weedkiller "66" is acknowledged.

Table 1. Weeds in asparagus beds, 10 and 21 days after spraying 2,4-D on soil, and data on climate from April 26 to May 6 or 17, 1948, New Brunswick, N.J.

	Number of weeds/ft.^{2}			
2,4-D lbs/Acre April 26	May 6		May 17	
	Mean	Range	Mean	Range
0	5	0-20	35	11-67
1	3	0-9	9	3-18
3	3	0-7	9	3-22
I_t, Physiological temperature index, summation from April 26		110.*		433.*
Rain, total inches		1.40		4.56

Rain log:

April 25	-	0.21 in.
28	-	0.02 "
29	-	0.05 "
May 3	-	0.48 "
5	-	0.92 "
7	-	0.72 "
12-13	-	1.57 "
14	-	0.16 "
16-17	-	0.71 "

*Based on U.S. Weather Bureau data, N. J. Experiment Station, sheltered thermometers 12.5 ft. above soil surface.

Table 2. Weeds in Asparagus beds 12 days after spraying 2,4-D on soil, and data on climate from July 14 to 26, 1948, New Brunswick, N.J.

2,4-D Lbs./Acre July 14	No. weeds/ft.^{2} July 26 Mean	Range	I_t	Rain inches
0	44	15-61	950*	1.21
1	21	0-50		cm.
3	8	1-13	914**	3.07

Evaporation corrected loss, Livingston black sphere atmometer, ml. = 442.

Sunshine, Solarimeter gram cal/cm.^{2} = 6574.

Sunshine, Radio-atmometer corrected loss, B-W, ml. = 156.

Temperature-moisture index $I_{tm} = 950.^{*} \left(\frac{3.07}{442}\right)$ or $914.^{**} \left(\frac{3.07}{442}\right)$

$I_{tm} = 6.6^{*}$ or 6.3^{**}

Rain log: July 13 - 1.28 in.
18 - .02 "
22-23- .53 "
23-24- .66 "

* Based on U.S. Weather Bureau data, N.J. Experiment Station, sheltered thermometers 12.5 ft. above soil surface.

**Based on thermograph record from instrument shelter, Bourdon bulb 6 inches above soil surface.

Table 3. Weeds in asparagus beds 17 days after application of calcium cyanamid during the cutting season, and data on climate from May 23 to June 9, 1948, New Brunswick, N.J.

Lbs/Acre cyanamid	No. weeds/ft.^{2} Mean	Range	Physiological temperature index summation, 18 days	Rain inches
0	210	110-460		2.55
Dust 75	300	120-680	652.*	cm.
Dust 100	190	80-260	964.**	6.48
Granular 800	50	20-80		

Evaporation, corrected loss, Livingston black sphere atmometer, ml. = 553.

Sunshine, Radio-atmometer, corrected loss, B-W, ml. = 232.

Temperature-moisture index $I_{tm} = 652.^{*} \frac{6.48}{553} = 7.7$

or $I_{tm} = 964.^{**} \frac{6.48}{553} = 11.3$

Rain log:

May	21	-	0.09 in.
	25	-	0.76 "
	30	-	0.54 "
	30-31	-	0.52 "
June	1	-	Trace
	4	-	0.01 "
	5-7	-	0.26 "
	7	-	0.25 "
	7-8	-	0.21 "

* Based on U.S. Weather Bureau data, N.J. Experiment Station, sheltered thermometers 12.5 ft. above soil surface.

**Based on thermograph record from instrument shelter, Bourdon bulb 6 inches above soil surface.

Table 4. Weeds in asparagus brush 8 days after treatment with potassium cyanate, calcium cyanamid and di-nitro ortho secondary butyl phenol, and data on climate integrated from June 30 to July 8, 1948, New Brunswick, N.J.

Treatment per acre	No. weeds/ft^2 Mean	Range	Physiological temperature index	Rain inches
0	150	80-260	687.*	0.93
$CaCN_2$ granular 400 lbs.	150	70-270	654.**	cm.
Dinitro. (Dow Selective) 3 pints/200 gal. water	130	60-180		2.36
KOCN, 2% 200 gal.	14	4-56		

Evaporation, corrected loss, Livingston black atmometer sphere, ml. = 386.

Sunshine, solarimeter, gram calories/cm.^{2} = 5232.

Sunshine, Radio-atmometer, corrected loss, B-W, ml. = 132.

Temperature-moisture index $I_{tm} = 687.^{*} \frac{2.36}{386} = 4.2$

or $I_{tm} = 654.^{**} \frac{2.36}{386} = 4.0$

				Hour of fall
Rain log:	June	27 - 1.20	in.	0310-0420, 1635-1650
		28 - 0.08	"	1930-2100
		30 - 0.51	"	2050(6/30)-0330(7/1)
	July	6 - 0.26	"	0410-0545
		7 - 0.16	"	0515-0900

* Based on U.S. Weather Bureau data, N.J. Experiment Station, sheltered thermometers 12.5 ft. above soil surface.

**Based on thermograph record from instrument shelter, Bourdon bulb 6 inches above soil surface.

Weed counts were made on May 6 and 17, three areas of 1 square foot being selected at random in each of the triplicate plots of a treatment. Results are presented in Table 1. On May 17 the weeds were generally less than 1/4 inch high. The weed population consisted chiefly of Pigweed (*Amaranthus* spp.), ragweed (*Ambrosia* spp.), and lambsquarters (*Chenopodium album*). There were relatively few grasses observed. Scattered plants of Canada thistle (*Cirsium arvense*) were slightly damaged by 2,4-D but were not eliminated by any treatment.

Pre-emergence treatment after the asparagus cutting season and before emergence of the brush

The area used for the 2,4-D experiment on April 26 was disced again on July 13 before the heavy rain of 1.28 inches of that day. On July 14, 2,4-D as the alkanolamine salt* of 2,4-Dichlorophenoxyacetic acid, was sprayed upon the moist soil, which was saturated to 10 cm. below the surface, at 1 pound acid equivalent in 5 gallons water per acre, unsprayed plots serving as controls. A third treatment, namely three pounds 2,4-D was applied in 15 gallons of water per acre. All treatments were triplicated and were applied between 3 and 5 p.m. under an overcast sky and in a light wind estimated to be about 10 miles per hour while thermograph records indicated air temperature ranging from about 82 to 78° F. Weed counts of July 26 and data on climate for the intervening period are shown in Table 2. On July 26 *Amaranthus* and grass species were dominant and weeds were generally no taller than 3 inches.

On July 14, an adjacent area of tall asparagus brush infested with pigweed, lambsquarters and grass about 1 foot high was sprayed with 3 pounds 2,4-D in 15 gallons of water under the conditions just described. Fifteen hours after the treatment, curling of pigweed shoots was observed, but no damage to asparagus canes was noted. On July 26, twelve days later, the pigweed and lambsquarters were observed to have been killed, the grasses to have survived. Extensive death of asparagus fern was ascribed to direct spraying of the fine, tender foliage with 2,4-D.

Calcium cyanamid during asparagus cutting

Three treatments in quadruplicate consisting of pulverized Aero cyanamid** (dust) at 75 and 100 pounds per acre and of granular Aero cyanamid** at 800 pounds per acre were applied broadcast to dewy asparagus and weeds in plots 25 feet long and 5 feet wide on the morning of May 23 from 6 to 7 a.m. Four control plots were left untreated.

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* Use of Dow Weed Killer Formula 40 is acknowledged.

**Acknowledgement is made to the American Cyanamid Co.

Asparagus shoots ranged up to about 18 inches tall; most weeds, pigweed, lambsquarters, chickweed (unidentified) and ragweed were one inch tall or less. There were also a few scattered plants of Asclepias (milkweed) up to 18 inches tall, Ipomea (Morning Glory) up to 2 feet and a localized stand of Canada thistle up to 9 inches tall. The thermograph recorded air temperatures from 48 to 51° F. at the time of treatment. Wind was light, estimated at about 10 miles per hour.

Surface soil moisture was probably rapidly depleted on May 23, 24, sunny, warm days, with temperature maxima about 77° F. and minima 46-50° F. Tensiometers buried 10 cm. deep (porous region of cup extended from 7 to 13.5 cm. below soil surface) at two stations about 350 and 650 feet respectively from the cyanamid plots but in the same general soil type, indicated an increase in soil moisture capillary tension (11) from about 16 inches Hg on May 23, 6:30 a.m., to about 22 inches Hg on May 24, 3:45 p.m. However, on May 24 from 3-4 p.m. the upper layers of soil beside the tensiometers were probably adequately moist for plant growth since initial water-supplying power of the soil 2-4 cm. below the surface ranged from .074 g. to .097 g. per cm^2 per first hour exposure of the Livingston soil point, at a soil temperature of 77° F. This value corresponds to about 1 gram per point per hour. The soil point method has been useful in numerous studies of soil moisture in relation to plant vigor (2,7,8,9,12,14).

After the rain of 0.76 inch on May 25, the tensiometers indicated, on the morning of May 26, a zero value of capillary tension. This fact suggested that the soil was generally saturated to a depth of 7 to 13.5 cm.

On June 9, weed counts were made in triplicate on each plot. Data are given in Table 3 with information on climate for the period from May 23. Dominant weeds were pigweed, grass and lambsquarters. Canada thistle was not eliminated by the treatment of 800 lbs/Acre Aero cyanamid, although chickweed and lambsquarters were practically eliminated by this means. No damage to asparagus was observed.

Treatments during brush growth

When asparagus brush was about 5 feet tall and weeds (dominantly pigweed and grass) were 1 to 2 inches tall, a comparison of five treatments was begun, on quadruplicate plots, segments of row 19.4 feet long and 5 feet wide, as follows:

1. No material,
2. Granular cyanamid*, 400 lbs/Acre.
3. Potassium cyanate*, 2%, 200 gallons/Acre**.
4. Potassium cyanate, 4%, 200 gallons/Acre.
5. Dow Selective Herbicide***, 3 pints per 200 gal. water/Acre.

The granular cyanamid was broadcast. Solutions of potassium cyanate and Dow Selective were applied as a coarse spray from a knapsack sprayer.

Treatments were made between 2 and 4 p.m. on June 30, 1948 under relatively warm, dry, sunny atmospheric conditions. Air temperatures recorded by the thermograph were 89-90° F. Mean daily corrected evaporation from Livingston standard atmometer spheres between June 28 and July 1 was 63.2 ml (Black sphere). The difference between the losses from Black and White spheres Black minus White (B-W), representing the effect of radiation was 23.7 ml between June 28 and July 1. The Kipp & Zonen solarimeter integrated sunshine from 2 p.m. until sunset on June 30 of approximately 306 gram calories per cm^2. Average daily radiation received by the solarimeter from June 28 to July 1 was about 1136 gram calories per square centimeter. Thermograph air temperature ranged between 69° and 90° F. for 24 hours following the treatments.

When these measurements on evaporation and sunshine are compared with those of other workers and places, the relative order of magnitude can be appreciated. For example, data of Wilson (13) summarizing 10 years of evaporation studies at Wooster, Ohio, show that mean daily evaporation from the standard black atmometer ranged from a high of about 64 ml. per day in July, 1930 to a low about 40 ml. per day in 1937. Wilson found that B-minus W (evaporation due to radiation) ranged from about 18 to 13 ml. per day. Furthermore, the highest daily value of solar radiation shown by Briggs and Shantz (1) for Akron, Colorado, July, 1915 was 1132 gram calories per cm^2.

Soil moisture was relatively abundant at the time of treatment. The upper 10 cm. of soil surface had been generally saturated on June 24 to 29th, (tensiometers showing no capillary tension) but had dried enough by the evening of June 30 to exert capillary pull from 7 to 20 cm. Hg just before the rainfall at 8:20 p.m. which again saturated the upper 10 cm. of surface soil.

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* Acknowledgement is made to The American Cyanamid Co. for these materials.

** It should be noted that only 50-80 gallons per acre is the customary rate of application.

***Acknowledgement is made to the Dow Chemical Co. for this material.

Within 2 hours or less after the potassium cyanate solutions were sprayed upon weeds on June 30, pigweed and grasses were showing leaf burn. Data of weed counts made July 8 are given in Table 4. Potassium cyanate 2% and 4% spray at 200 gallons per acre were of equal effectiveness and data on the weed counts after the 4% solution, omitted from Table 4, ranged from 0-52 weeds/ft^2 with a mean of 20/ft^2.

Treatments other than those involving potassium cyanate were relatively ineffective in reducing weed population under these conditions. Potassium cyanate, 200 gallons per acre of 2% water solution, cut the average weed count to about 0.1 the mean value found in other treatments. Since potassium cyanate has shown promise for weed control in onions (3) the tolerance of asparagus for the material seemed worth examination. Under the conditions of the New Brunswick tests with the excessive application of 200 gallons of 2% solution (about twice the recommended gallonage) some bleaching or "burning" of the epidermis of the woody stalks was observed. Tender tissues of the "fern" or asparagus leaves were killed. However, no extensive general damage on the brush was observed when the bases of the stalks were sprayed. In the writer's opinion, the material deserves further trial in old asparagus brush to ascertain the effects of lighter applications than those described here.

Summary

A description of preliminary trials of chemical weed control on 6 year-old asparagus beds with 2,4-D, calcium cyanamid, potassium cyanate and Dow Selective Herbicide at New Brunswick, N. J. in 1948 is accompanied by data on indices of temperature-moisture conditions, and sunshine which prevailed during the experiments.

Materials which appeared worth further trial for weed control were 2,4-D as a pre-emergence spray at one to three pounds per 5 gallons water per acre, calcium cyanamid (granular Aero cyanamid) at 800 pounds per acre during the cutting season and potassium cyanate in water solution during growth of asparagus brush.

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Chemical Weed Control in Sweet Corn and Asparagus

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In a sweet corn experiment on Sassafras silt loam at the Delaware Agricultural Experiment Station, at Newark, in 1948, equally good weed control was obtained with 1½-pound pre-emergence 2,4-D applications of any of four 2,4-D forms - acid, sodium salt, ethyl ester, and alkanolamine salt. Use of the ester form did, however, result in some seedling injury which disappeared within a week. A comparison of 1½, 3, and 6 pound pre-emergence applications of 2,4-D indicated that the 1½-pound rate was sufficient for weed control. A comparison of pre-emergence applications made one and five days after seeding resulted in no significant difference. A 3/4-pound post-emergence application when the corn was a foot tall resulted in good weed control except for crab grass while a similar 2,4-D application in a 1:4000 solution of PMAS (phenyl mercuric acetate) resulted in good control of crab grass but did some injury to the lower leaves of corn. Although the corn appeared to outgrow this injury, further research on the possible use of PMAS is necessary. Pre-emergence applications of 2,4,5-T.C.P. (2,4,5-Trichlorophenoxyacetic acid) at 1½ and 3-pound rates gave slightly better weed control, especially of crab grass, than did equal applications of 2,4-D. They caused more seedling injury, however, which soon disappeared.

In an asparagus experiment on Sassafras loamy sand at the Delaware Agricultural Substation, at Georgetown, a 2-pound pre-emergence application of actual 2,4-D in the sodium salt form gave very good weed control throughout the harvesting season. Additional treatments were applied after the harvesting season when crab grass was most prevalent. The only effective treatment was a 4 pound 2,4-D application made five days after discing and after a 2½-inch rain had compacted the soil. When this application was made, however, a few asparagus spears were severely injured but were soon replaced by other healthy shoots. Further research will be necessary to determine whether this injury will affect subsequent yields. Other chemicals used on asparagus were: Dinitro ortho secondary butyl phenol, N.I.X. (Sodium isopropyl xanthate), Stoddard Solvent, and I.P.C. (Isopropyl phenyl carbamate). Yields were not significantly affected this first year by any treatment.

Productivity of Cultivated and Uncultivated Golden Cross Bantam Sweet Corn Weeded With Post-emergence Sprays of 2,4-D.[1]

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Evidence has been presented (1), (2), (3) to show that sweet corn weeded with 2,4-D will produce as good a yield of marketable fresh corn as sweet corn grown by conventional methods where some weeds persist throughout the growth of the crop. Some growers would not hesitate to refrain from all cultivation of sweet corn if sufficient evidence was available to justify such a departure in the culture of corn.

The purpose of this study was to ascertain if the productivity of Golden Cross Bantam sweet corn weeded with 2,4-D but not cultivated would equal or exceed that of sweet corn sprayed and cultivated, or cultivated and hoed.

Materials and Methods

Four experiments were conducted in cooperation with two sweet corn growers. Experiments 1 and 2 were located in the same field of corn but on very different soils. A dry, gravelly knoll was chosen for the site of the first experiment while a moist flat silty area of Ontario soil was selected for the second experiment. In each of these two experiments there were six replicates of 3 treatments. The treatments were (1) sweet corn sprayed with 0.5 lbs. of 2,4-D and cultivated, (2) sweet corn sprayed with 0.5 lbs. of 2,4-D and never cultivated and (3) sweet corn cultivated and hoed.

In contrast to the location of the first two experiments the sites for experiments 3 and 4 were chosen on what appeared to be a uniform Ontario Loam soil. Four treatments, 0.0, 0.5, 0.7 and 1.0 pound per acre of 2,4-D acid equivalent, were replicated four times in each experiment.

Only one spray of 2,4-D was applied on any plot in any of the four experiments, and this spray was delivered from a tractor mounted spray boom designed to cover the entire area of a 4 row plot. Thirty to thirty-five pounds pressure on the boom was used throughout. Where cultivation was practiced it followed the spraying within 72 hours. Experiments 1 and 2 were cultivated twice while 3 and 4 were cultivated 3 times. In experiment 3 all treatments were cultivated while in experiment 4 only the check plots were cultivated. Whatever weeds that remained in the check plots in experiments 3 and 4 after cultivation were hoed out or pulled by hand. In all experiments when the sweet corn was about 4 inches tall the treated plots were sprayed with 20 gallons per acre of water containing the proper amount of triethanolamine salt of 2,4-D to supply the desired acid equivalent of 2,4-D.

All plots of a given experiment were harvested the same day and as near the prime canning stage of maturity as possible. Yield records were taken of

1. Contributions from the Division of Vegetable Crops Journal Paper No. of the New York State Agricultural Experiment Station.

the number of ears of corn, and the weight in pounds of unhusked ears from two 30-foot rows in experiments 1 and 2 and from two 50-foot rows in experiments 3 and 4. In addition, the weight of husked marketable corn-on-the-cob was obtained from experiments 1 and 2. The method of analysis of variance was used in the interpretation of the data.

Results

Although the 0.5 pound per acre rate of 2,4-D killed the initial stand of 2,4-D sensitive broad-leaved weeds such as, lambs quarter, amaranthus, ragweed and mustard it did not prevent the seeding of some of these weeds that germinated late in the season. These weeds did not develop seeds on the 0.7 and 1.0 pound rates of 2,4-D. In fact, these weeds were practically non-existant on these two treatments. Grasses such as yellow foxtail, broom grass and barn yard grass were common on all treatments in experiments 1 and 2 and particularly so in the sprayed and uncultivated plots. In the sprayed and uncultivated areas of experiment 2 the corn out-grew the grasses because of ample moisture in this low area.

The average number of ears of sweet corn per acre and the average tonnage per acre of marketable husked corn-on-the-cob is presented in Table 1 for experiments 1 and 2.

Table 1. Efect of three methods of weeding sweet corn on the number and weight of ears of marketable husked corn-on-the-cob produced per acre.

Treatment	Experiment I No. Ears/Acre	Experiment I Tons/A.	Experiment II No. Ears/Acre	Experiment II Tons/A.
(1) 0.5 lbs. 2,4-D + Cult.	8,600	1.5	13,000	2.7
(2) 0.5 lbs. 2,4-D	3,700	0.2	11,100	2.2
(3) Cult + Hoed	8,800	1.6	11,900	2.6
L.S.D. 5%	2,800	0.4	1,600	0.3

The significantly lower yield of corn produced on the 2,4-D sprayed and uncultivated plots (treatment 2) is attributed to the failure of this cultural practice to prevent grasses from competing with the corn for moisture and nutrients. The differences in yield in either experiment 1 or 2 between the sprayed and cultivated plots and the cultivated and hoed plots are not statistically significant at the 5 per cent level. Thus, at this location the spray-cultivation practice was as satisfactory as the cultivation-hoe method of weed control.

The growing conditions for the corn in experiments 3 and 4 were quite different from that just described. Grasses were not common and, consequently, the corn in the sprayed plots was practically free of weeds except on the ½ pound rate of 2,4-D where some broad-leaved weed seeds germinated late in the growth of the corn. Some bending of the young corn plants took place

following the 1.0 pound application of 2,4-D but these plants recovered their upright position within three weeks. At harvest time there were no visible differences in the plants on the several treatments. The yield data from experiments 3 and 4 are summarized in Table 2.

Table 2. Effect of post-emergence sprays of 2,4-D and of cultivation on the yield of Golden Cross Bantam sweet corn.

Treatments	Experiment 3 All treatments cultivated & hoed		Experiment 4 Only checks cultivated & hoed	
2,4-D lbs./A.	No. Ears/A.	Tons/A.	No. Ears/A.	Tons/A.
0.0	9,300	2.8	10,500	3.1
0.5	9,200	2.7	10,500	3.1
0.7	9,300	2.6	10,300	3.0
1.0	11,300	3.1	9,800	2.6
L.S.D. 5%	900	.2	N.S.	.5

The number of ears and the tonnage per acre is shown in columns 2 and 3, respectively, for experiment 3. Cultivation was practiced on all treatments in this experiment so that any significant differences between treatments is presumed to be due to treatment or soil heterogeneity. Although treatments 0.0, 0.5 and 0.7 pound of 2,4-D per acre produced a similar number of ears, the tonnage on the 0.7 pound treatment was less than that of the zero treatment. Both the number of ears and the tonnage of corn on the 1.0 pound 2,4-D treatment were significantly higher than the untreated check. This increased tonnage was due to the larger number of ears, since the ear size decreased with the higher rates of 2,4-D.

In experiment 4 where only the check plots were cultivated the yield of ears per acre did not differ significantly among the four treatments. However, the tonnage of corn on the 1.0 pound per acre 2,4-D treatment was less than either the check or the 0.5 pound treatment when compared at the 5 per cent level of significance. If the average weight per ear is calculated it will be found to be smaller than that of the 0.0, 2,4-D plots. This is in agreement with the results of experiment 3. In viewing the results of the two experiments, it is interesting to note that the tonnage of corn produced on the 1.0 pound 2,4-D treatment that was not cultivated (column 5, table 2) is not only lower than the yield of the cultivated check but also lower than the yield of the 1.0 pound treatment that was cultivated in experiment 3. In this connection, both the writer and other research workers in the state observed a commercial field of sweet corn in which one half of the field had been cultivated several days after a uniform post-emergence spray of 2,4-D had been applied. In the cultivated area all corn plants, including some near the tassel stage of development, appeared normal while the leaves of similar corn plants on the uncultivated portion of the field were badly rolled.

In conclusion the results of four experiments show that cultivation in conjunction with a 2,4-D spray is necessary in the production of sweet corn where grasses and other weeds persist after spraying with 2,4-D. There is some indication that the productivity of sweet corn is improved by a cultivation

to break up the 2,4-D layer on the surface of the ground when the post-emergence treatment exceeds 0.7 of a pound per acre of 2,4-D acid equivalent.

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RESPONSE OF EIGHT VARIETIES OF SWEET CORN TO POST-EMERGENCE TREATMENT OF 2,4-D

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There has been some inconsistency in results obtained from weeding sweet corn with 2,4-D in the different sections of the country. Thus, it is evident that research must be done to determine the influence of the important variable factors before 2,4-D can be used safely to weed sweet corn on a wide scale. One important factor may be differential varietal response.

The object of this investigation was to determine the response of several varieties of sweet corn to 2,4-D post-emergence spray.

Method

The varieties and sources of seed used were: North Star (Joseph Harris Co., Inc.), Seneca Dawn (Robson Seed Farms), and Spancross, Marcross, Carmelcross, Golden Cross, Lincoln, Ioana (G.L.F.). The above varieties were chosen because they are the leading varieties grown for market in the Northeast.

A single 33 foot row of each variety was planted in each of six randomized blocks. The distance between rows was 3 feet. A guard-row was planted on each side of the experimental area. Several seeds were planted in hills one foot apart. At come-up the hills were thinned to 2 plants each.

On July 14, when the sweet corn was approximately 6 inches high, each block was divided into two 16 foot sections, one of which was treated. Sodium salt of 2,4-D at 1 pound per acre was sprayed over the tops of the corn at 100 gallons per acre. At the time of treatment the soil was moist, and conditions were favorable for rapid growth. Many grasses and broadleaved weeds had emerged. Some were two inches high.

Untreated plots were cleaned of weeds July 17 by use of a wheel-hoe with knife attachments. Ten days following treatment, July 25, broadleafed weeds in the treated plots were either already dead or severely stunted and dying. There were, however, considerable annual summer grasses in the plots. To

avoid variations due to competition, all plots were hoed clean of weeds and grasses. Plots remained clean for the remainder of the season.

Results

The malformed plants were counted on July 31. The results expressed as percentage of treated plants malformed are presented in table 1 along with the data obtained in 1947 using the same varieties and same rate of NH_4 2,4-D (1).

Table 1. Varietal response to 2,4-D spray as indicated by foliage malformation

Variety	Percentage of treated plants malformed	
	1947[1]	1948[2]
Seneca Dawn	65.0	80.8
North Star	65.2	75.0
Carmelcross	43.2	46.7
Spancross	35.8	45.0
Golden Cross	24.8	30.8
Marcross	15.0	15.8
Lincoln	0.0	15.8
Ioana	0.0	5.0
Least significant difference 5%	22.8	9.0

[1] Observations made three weeks after treatment.

[2] Observations made 17 days after treatment.

The consistency in the order of susceptibility for the two years is striking. Seneca Dawn and North Star varieties had the highest percentage malformed plants. Marcross, Lincoln and Ioana showed the least response. Carmelcross, Spancross, and Golden Cross were intermediate.

Reports have been made of 2,4-D treatments preventing lodging of sweet corn following heavy wind storms (2). On August 28 a heavy wind and rainstorm blew down a considerable amount of the sweet corn being studied in these investigations. An opportunity was thus given to observe whether there were differences in lodging between treated and untreated plants. A rating was given each variety of corn by replicates on the

the following basis: 1 = no lodging, 3 = up to 50% lodged, 5 = more than 50% lodged. The ratings were compared by analysis of variance and the data are presented in table 2.

Table 2. Varietal response to 2,4-D spray as indicated by lodging and yield per acre of marketable ears

Variety	Treatment	Lodging[3] (rating)[1]	Marketable Ears/A. Number[2]	Marketable Ears/A. Wt. in tons[2]
Seneca Dawn	Treat.	3.33	18,150	3.63
	Check	3.67	17,696	3.75
North Star	Treat.	2.67	23,595	4.47
	Check	4.67	21,145	4.12
Carmelcross	Treat.	3.0	14,702	3.65
	Check	4.0	15,881	4.02
Spancross	Treat.	3.67	15,881	3.93
	Check	3.33	15,155	3.76
Golden Cross	Treat.	1.0	19,058	4.16
	Check	1.67	17,061	3.93
Marcross	Treat.	3.33	17,424	3.81
	Check	2.67	16,063	3.76
Lincoln	Treat.	3.0	16,154	3.95
	Check	2.33	9,347	2.48
Ioana	Treat.	2.33	13,612	3.47
	Check	1.0	11,344	3.52

[1] 1 = No lodging, 3 = up to 50 lodging, 5 = more than 50% lodging.

[2] There was no significance for treatment within any of the varieties.

[3] North Star and Ioana were the only varieties within which there was significance for treatment.

The analysis showed a highly significant variation due to varieties and the variety x treatment interaction was significant at the 5% level. The variation due to treatment, however, was not significant.

When the varieties were considered singly, less lodging was found in the treated rows than in the untreated rows of North Star. On the other hand, there was less lodging in the untreated rows of Ioana. For the other varieties there was no significant difference between treated and untreated rows.

The ears were harvested at the fresh market maturity stage. One or two pickings per variety was made. The number and weight of marketable ears are presented in table 2. The treated plots yielded significantly more ears than the untreated plots when all varieties were considered. The variance for treatment based on weight of ears, however, was not significant. There was no significance for treatment within any of the varieties either for weight or number of ears.

The varieties used in these tests showed a marked variation in foliage response to 2,4-D. There was no yield reducation, however, for even the most responsive varieties. Higher rates or different environmental conditions might cause yield reduction of sweet corn.

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Pre-emergence Chemical Weeding of Lima Beans and Cauliflower on Long Island.

Walter C. Jacob and Walter T. Scudder(1)

The major weed in summer crops on Long Island is crabgrass. Other weeds of consequence are purslane and carpet weed, with a smaller number of lamb's quarters, smartweed and pigweed (Amaranthus). The time of year when crops are sown determines to a large extent the characteristics of the weed population.

To obtain some information on the tolerance of lima beans for various chemicals and the effectiveness of these chemicals on controlling different kinds of weeds, three different plantings of lima beans were made and two concentrations of five materials were applied as pre-emergence weed control agents.

In connection with a study of direct seeding of cauliflower, various chemicals were used in an attempt to control weeds at least until the cauliflower was large enough to permit the use of mechanical cultivation equipment. A previous experiment had indicated that weed control early in the season was the major problem involved in direct seeding of cauliflower.

Material and Methods

In all experiments the land was prepared, the fertilizer applied and the rows marked 10 to 14 days prior to seeding. The weed control materials were applied 7 days after seeding for the first planting, 6 days after seeding for the second planting and the same day as seeding for the third planting of lima beans and for the cauliflower. Observations as to plant response and weed control were made two weeks after applying the materials. All experiments had four replications arranged in four randomized blocks. All plots were four rows wide, 19 feet long in the case of lima beans and 18 feet long for cauliflower. Stand counts were taken on the middle two rows of each plot. Weed counts were taken on a square foot area in each aisle of the plot. Thus 3 counts were made for each plot.

All data were analyzed by the analysis of variance procedure, and weed counts were first transformed to square root of x plus 0.5.

For lima beans five materials were used at two concentrations each. Two forms of 2,4-D, the triethanolamine salt and a material known as L.F.N. 472 containing 97% 2,4-D acid, were used. An unsaturated hydrocarbon, H.A.N. 132, a dinitro, Dow Contact weed killer, and granular cyanamid were the other three materials. The rates of application for these materials will be given in each table for the various planting dates. In the cauliflower experiment five materials

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100 Gal/A

at one rate each were used. The materials and rates were: H.A.N. 132 at 35 gallons per acre made up to 100 gallons with water; granular cyanamid at 400 pounds per acre; Dow Contact at 2 gallons per acre in 98 gallons of water; 2,4-D acid (97% material L.F.N. 472) at 1-1/2 pounds per acre; and sodium isopropyl xanthate at 15 pounds per acre plus 1 pint Triton spreader in 100 gallons of water. All sprays were applied at the rate of 100 gallons per acre with small hand operated compressed air sprayers.

No yield records were taken as these experiments were primarily designed to estimate weed control and immediate crop responses to the various materials.

The variety of lima beans used was Fordhook Bush and though four varieties of cauliflower with seed normal and pelleted were used, no distinction will be made between cauliflower varieties in this report.

Results and Discussion

Lima Beans

The observations from the first planting of lima beans are given in table 1.

Table 1. Influence of various weed control treatments on the stand of Lima Beans planted May 21, 1948 and ratings for weed control.
(Observations on June 16, 1948)

Material	Rate of Appli.	No. of plants in 38' of row: Good Plants	Bald* Heads	Crooks**	Weed Control Ratings***
T.E.A. Salt of 2,4-D (1)	1 lb.	22	7	14	7.5
	2 lb.	15	7	24	8.2
L.F.N. 472 (2)	1 lb.	21	6	12	7.8
	2 lb.	10	6	26	8.8
H.A.N. 132	25 gal.	35	8	2	6.5
	35 gal.	22	4	3	7.0
Dow Contact	2 gal.	22	11	6	6.2
	4 gal.	33	7	2	8.0
Cyanamid (granular)	200 lbs.	28	13	4	5.7
	400 lbs.	33	7	6	8.2
Untreated	- -	22	7	2	1.2
Least Sig. Dif. at P=.05		11	N.S.	7	2.1

* Plants with injured growing points or one or both cotyledons missing.
** Plants with hypocotyl out but cotyledons still underground.
*** Key to weed control ratings
0 = No weed control - same as weediest plot.
9 = No weeds present.
(1) Triethanolamine salt of 2,4-D.
(2) 97% 2,4-D acid.

It is apparant that the germination was very poor in this planting. The beans were planted about 4-1/2 inches apart so there should have been at least 100 plants in 38' of row. It can be seen that the high rates of 2,4-D significantly reduced the number of good plants and increased the number of "crooks". The lower rates actually increased the number of "crooks" but had no influence on the stand of good plants. There was a significant difference between treated and untreated plots with respect to weed control but no significant differences among the treatments.

The data from the second planting (table 2) indicate better germination in general, but here also 2,4-D at either concentration reduced the number of good plants and increased the number of "crooks".

Table 2. Influence of various weed control treatments on the stand of Lima Beans planted June 18, 1948 and associated ratings for weed control.
(Observations on July 13, 1948)

		No. of plants in 38' of row			
Material	Rate of Appli.	Good Plants	Bald* Heads	Crooks**	Weed Control Ratings***
T.E.A. Salt of 2,4-D (1)	1 lb.	46	5	48	5.7
	1.5 lb.	32	4	60	6.0
L.F.N. 472 (2)	1 lb.	37	4	55	6.0
	1.5 lb.	36	4	53	6.2
H.A.N. 132	25 gal.	73	5	17	7.0
	35 gal.	86	6	11	7.2
Dow Contact	2 gal.	77	7	12	6.5
	4 gal.	75	7	14	7.5
Cyanamid (granular)	200 lbs.	73	4	15	4.5
	400 lbs.	68	6	17	5.5
Untreated	- -	71	6	16	1.0
Least Sig. Dif. at P=.05		15	N.S.	14	0.8

*Plants with injured growing points or one or both cotyledons missing.
**Plants with hypocotyl out but cotyledons still underground.
***Key to weed control ratings
0 = No weed control - same as weediest plot.
(1)Triethanolamine salt of 2,4-D
(2)97% 2,4-D acid.

All treatments gave better weed control ratings than the untreated and all other treatments were better than 200 pounds of cyanamid. The weed control can be seen more clearly in the counts presented in table 3. All treatments reduced the weed count significantly compared to the untreated.

Table 3. Average number of weeds per square foot on plots treated with various weed control chemicals. (Lima Beans planted June 18, 1948.)
(Observations on July 12, 1948)

Material	Rate of Appli.	Total No. of Weeds No.	Total No. of Weeds Sq.Root*	Crabgrass No.	Crabgrass Sq.Root*	Broadleaved Weeds No.	Broadleaved Weeds Sq.Root*
T.E.A. Salt of	1 lb.	14	3.67	6	2.48	8	2.67
2,4-D (1)	1.5 lb.	10	3.05	5	2.21	5	1.88
L.F.N. 472 (2)	1 lb.	10	3.30	5	2.20	6	2.53
	1.5 lb.	10	3.11	5	2.34	5	1.84
H.A.N. 132	25 gal.	8	2.82	2	1.65	5	2.33
	35 gal.	7	2.75	2	1.46	5	2.35
Dow Contact	2 gal.	7	2.67	4	2.07	3	1.67
	4 gal.	4	1.96	2	1.46	2	1.44
Cyanamid	200 lbs.	17	4.16	6	2.52	11	3.29
(granular)	400 lbs.	8	2.89	5	2.28	3	1.73
Untreated	- -	38	6.18	8	2.72	28	5.32
Least Sig. Dif. at P=.05			0.64		0.54		0.73

* For purposes of analysis data were transformed to square root of x + 0.5.
(1) Triethanolamine salt of 2,4-D
(2) 97% 2,4-D acid.

Dow Contact at four gallons per acre was considerably better than any other treatment in reducing the total number of weeds. This low number was obtained by excellent control of both crabgrass and broadleaved weeds. Other treatments reduced either the grass or broadleaved weeds, but Dow Contact at 4 gallons per acre reduced both types markedly.

There was a rain the evening of the same day that the chemicals were applied at each of the first two plantings. This may account for the amount of injury and the rather poor weed control from some of the treatments. The third planting was put in after a very light shower and no rain fell for three days after application. As may be seen in table 4 there was no influence of treatments on the stand of good plants or number of poor plants.

These treatments were applied on the same plots as the first planting. Since Cyanamid and a low amount of 2,4-D salt gave no better weed control rating than the untreated plots, evidently there was no carry over effect from the treatments applied in May. The actual weed counts are given in table 5.

Here it can be seen that although there were actual reductions in weed population by the treatments, the reductions were mostly found in the broadleaved weeds, purslane being the predominate one present. The excellent control given by Dow Contact should be noted. High concentrations of 2,4-D also gave a marked reduction in broadleaves. Except for Cyanamid, all other treatments had significantly fewer broadleaved weeds than did the untreated plots.

Table 4. Influence of various weed control treatments on the stand of Lima Beans planted July 28, 1948 and associated ratings for weed control.
(Observations on August 11, 1948)

Material	Rate of Appli.	No. of plants in 38' of row: Good Plants	Bald* Heads	Crooks**	Weed Control Ratings***
T.E.A. Salt of 2,4-D (1)	.50 lb.	83	6	3	3.5
	.75 lb.	87	4	3	6.2
L.F.N. 472 (2)	.50 lb.	81	6	7	6.2
	.75 lb.	72	7	8	5.7
H.A.N. 132	25 gal.	82	4	3	7.5
	35 gal.	86	5	3	8.2
Dow Contact	2 gal.	85	7	1	7.2
	4 gal.	87	5	0	7.0
Cyanamid (granular)	200 lbs.	85	5	2	3.0
	400 lbs.	82	8	3	3.0
Untreated	- -	81	6	2	3.0
Least Sig. Dif. at P=.05		N.S.	N.S.	N.S.	2.1

* Plants with injured growing points or one or both cotyledons missing.
** Plants with hypocotyl out but cotyledons still underground.
*** Key to weed control ratings
0 = No weed control - same as weediest plot
(1) Triethanolamine salt of 2,4-D
(2) 97% 2,4-D acid

Table 5. Average number of weeds per square foot on plots treated with various weed control chemicals. (Lima Beans planted July 28, 1948.)
(Observations on August 11, 1948)

Material	Rate of Appli.	Total No. of Weeds: No.	Sq.Root*	Crabgrass: No.	Sq.Root*	Broadleaved Weeds: No.	Sq.Root*
T.E.A. Salt of 2,4-D (1)	.50 lb.	6	2.34	4	1.91	2	1.44
	.75 lb.	4	1.97	3	1.74	1	1.11
L.F.N. 472 (2)	.50 lb.	9	2.57	5	1.92	4	1.79
	.75 lb.	4	2.04	3	1.62	1	1.35
H.A.N. 132	25 gal.	3	1.69	1	1.08	2	1.47
	35 gal.	4	1.67	2	1.29	2	1.33
Dow Contact	2 gal.	1	1.43	1	1.24	0	0.87
	4 gal.	4	1.89	4	1.80	0	0.87
Cyanamid (granular)	200 lbs.	10	3.16	4	1.90	6	2.54
	400 lbs.	7	2.62	2	1.62	5	2.12
Untreated	- -	11	3.19	3	1.69	8	2.68
Least Sig. Dif. at P=.05			0.91		N.S.		0.64

* For purposes of analysis data were transformed to square root of x + 0.5.
(1) Triethanolamine salt of 2,4-D.
(2) 97% 2,4-D acid.

In this third planting Cyanamid showed considerable injury to the crop, but this was not found in either of the other two plantings. There was practically no injury from 2,4-D in the third planting.

The main point to be observed from these three plantings is the importance of the influence of rain on the injury of the chemicals to the crop and on the effectiveness of the weed control. In none of the plantings did any treatment give commercial control of weeds for more than a month after application. Even the last planting had considerable weed growth after three weeks.

Cauliflower

The influence of various weed control treatments on the germination of cauliflower seed is given in table 6.

Table 6. Influence of various weed control treatments on the germination of normal and pelleted cauliflower seed sown on July 27, 1948.
(Observations on August 10, 1948)

Treatment Material	No. of plants per yard Normal Seed	Pelleted Seed	Average
H.A.N. 132	12	9	10
Cyanamid (granular)	11	6	8
Dow Contact	11	9	10
L.F.N. 472 (1)	0	0	0
N.I.X. (2)	9	10	9
Untreated	11	9	10
Average omit L.F.N. 472	11(3)	9(3)	10

(1) 97% 2,4-D acid.
(2) Sodium isopropyl xanthate plus Triton.
(3) Difference between these two averages is significant.

Except for the complete prevention of germination by 2,4-D, there was no effect of treatments on the number of plants per yard. The significant difference in number of plants from pelleted and normal seed was due to the fewer seeds sown on pelleted plots. This was no influence of weed control treatment. The reduction in weed population by the treatments can be seen in table 7.

Cyanamid failed to reduce the weeds below the number on the untreated plots. All other treatments significantly reduced the number of weeds. The most common of the broadleaved weeds was purslane, and this was significantly reduced by all chemicals except Cyanamid. Crabgrass was no problem, because the land used for this experiment had been kept fallow and free from weeds all summer, until the fertilizer was applied for cauliflower on July 15.

Table 7. Average number of weeds per square foot on plots treated with various weed control chemicals. (Cauliflower planted on July 27, 1948.)
(Observations on August 10, 1948)

Treatment Material	Total No. of Weeds No.	Total No. of Weeds Sq.Root*	Crabgrass No.	Crabgrass Sq.Root*	Broadleaved Weeds No.	Broadleaved Weeds Sq.Root*
H.A.N. 132	3	1.88	1	1.29	2	1.42
Cyanamid (granular)	10	3.12	2	1.49	8	3.07
Dow Contact	5	2.20	2	1.36	3	1.81
L.F.N. 472 (1)	4	1.94	1	1.35	3	1.59
N.I.X (2)	4	2.13	3	1.70	1	1.44
Untreated	12	3.44	3	1.61	9	3.12

Least Sig. Dif. at P=.05

* For purposes of analysis data were transformed to square root of x + 0.5.

(1) 97% 2,4-D acid

(2) Sodium isopropyl xanthate plus Triton

The Cyanamid plots were weeded the same time as the untreated ones on August 10th. The other treatments had to be cultivated on August 23rd. and normal cultivation was practiced for the rest of the season. From the results this year it is apparant that 2,4-D cannot be used for cauliflower as a pre-emergence application. Sodium isopropyl xanthante, Dow Contact, and H.A.N. 132 were all equal in suitability, but none of them provided more than one month of adequate weed control.

Summary

1. Pre-emergence application of 2,4-D on large seeded lima beans resulted in crop injury if more than 3/4 of a pound per acre was used and rain fell within 24 hours after the time of application.

2. Cyanamid at rates in excess of 200 pounds per acre may cause injury to lima beans.

3. Dow Contant at 2 or 4 gallons per acre gave excellent weed control with no injury to lima bean plants.

4. H.A.N. 132 at 35 gallons per acre was satisfactory for pre-emergence application to lima beans.

5. Cauliflower seed was inhibited in germination by 1.5 pounds of 2,4-D per acre.

6. Dow Contact at 2 gallons, sodium isopropyl xanthate at 15 pounds and H.A.N. 132 at 35 gallons per acre provided one month of weed control with no injury to cauliflower when applied the same day the seed was sown.

7. None of the materials used provided more than a month of adequate weed control during the past summer on Long Island.

Effects of Weed Control Sprays of Salt and Salt Plus Sodium Nitrate on the Stand and Yield of Canning Beets[1]

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One of the most expensive operations to the grower of canning beets, is the removal of weed competition within the beet row. It has been reported that beets can be weeded with salt (1), (2); however, it is pointed out that the use of this material is limited by its failure to kill lambs quarter (Chenopodium album) and purslane (Portulaca oleracea), and by the time required for dissolving a large amount of salt. Some further objections to its use are the time required for hauling water and the soil compaction resulting from the heavy equipment necessary to transport and disperse 200 gallons of solution per acre. In spite of these limitations some growers are adopting the practice because of the apparent savings in cost of production. In order to determine the effectiveness of a weed control spray, considerations must be based not only upon the completeness of weed control, but also on the productivity of the crop. Since the canners who contract beets are primarily interested in roots 3/4" to 3" in diameter, growers make an effort to get a stand thick enough so that most beets come within this size range. Therefore, any treatment which directly or indirectly reduces stand may increase root size and decrease cash returns.

The purposes of the experiments conducted in 1948 were to determine the effects of concentrated sprays of sodium chloride and of a mixture of sodium chloride and sodium nitrate on the stand and yield of beets, on the stand of weeds and on the quality of the canned beets. Unpublished results from studies conducted in the greenhouse at Geneva in 1947 in search of a more soluble weedicide indicated that a mixture of sodium chloride and sodium nitrate would be more satisfactory than salt alone, because the mixture is more soluble. In addition the sodium nitrate in the spray might add sufficient nitrogen to increase the yield of beets.

Materials and Methods

In cooperation with four beet growers[2], four experimental sites were selected in what appeared to be uniform stands of Detroit Dark Red beets growing on Ontario silt loam soils. The beet fields had been fertilized in the usual manner including 400 or 500 pounds of sodium chloride as a soil amendment drilled in several days before seeding. The beets were drilled in rows 24 inches apart. All plots were 4 rows wide by 30 feet long, alternated with check plots

[1]Contribution from Division of Vegetable Crops Journal paper No. of the New York State Agricultural Experiment Station.

[2]The author wishes to express his appreciation to A. Rilands, Wm. Tichnor, H. Turnbull and H. Utter on whose farms these studies were conducted and to Ivan Head who assisted in the field work.

in a systematic design to facilitate the growers in applying the sprays. There were 8 replicates of two sprays with their checks at locations 1 and 2. At locations 3 and 4 there was a salt spray and a check treatment replicated six times. The spray treatments were composed as follows: (a) 200 pounds of fine granulated sodium chloride dissolved in 100 gallons of water and (b) 160 pounds of sodium chloride plus 120 pounds of sodium nitrate dissolved in 100 gallons of water. Even though two different tractor-mounted sprayers with different pressure capacities were used the sprays were applied at the rate of 200 gallons per acre.

Treatments (a) and (b) were applied at 50 pounds pressure at location 1 and at 100 pounds pressure at location 2. The salt spray was applied at location 3 at 50 pounds pressure and at location 4 at 100 pounds pressure. The mixture of salts was not used at sites 3 and 4. All sprays were applied when the beets were in the 3 to 5 true leaf stage of growth.

Since it was only the weeds within the beet rows that could not be removed by cultivation, two nozzles delivering a flat fan spray were used on a row. The boom carried 4 pairs of nozzles arranged over 4 rows and set at diagonals with their respective rows to cover a band 8 inches wide. On this basis 200 gallons of spray solution would cover the beet rows in a 3 acre block because only 1/3 of the area of land drilled to beets 24 inches between rows was actually in the path of the spray. In all cases the grower cultivated all beets and in addition, hand-weeded the unsprayed plots.

When the crop was mature the beets in the two center rows, less a foot on either end for border effect, were pulled and topped with the mechanical roll-topper. Records were taken of the total number and total weight of beets topped from each plot. Weed counts were made at location 1 sixteen days after spraying. Beets from unsprayed, salt sprayed and salt plus nitrate sprayed plots were prepared by treatments, diced, packed in a salt brine, sealed in tin[1] and processed in accordance with commercial practice.

Results

The foliage of beets and the foliage of weeds that were sensitive to these concentrated salt solutions became flaccid within 20 minutes after spraying. The beets recovered their turgidity within a few hours, although the margins of some leaves developed irregularly as a result of the spray burn. Water-soaked areas appeared in the beet leaves shortly after spraying with pressures of 100 pounds or greater. As the beet crop matured the foliage of the beets on the plots receiving the salt plus sodium nitrate remained erect and greener than did beets growing on either the salt or the check plots.

The average stand of beets as measured by the number which developed to marketable size, that is 3/4 inch or over, and the average yield in tons per acre is presented for the four locations in Table 1.

[1]Assistance from the Division of Food Science and Technology at this Station is gratefully acknowledged.

Table 1. Effect of Salt Sprays at 50 and 100 lbs. Pressure on Final Stand and Yield of Beets.

Treatment Gallons Per Acre	LOCATIONS I 50 lbs. Pressure		II 100 lbs. Pressure		III 50 lbs. Pressure		IV 100 lbs. Pressure	
	Count(1)	Tons	Count(1)	Tons	Count(2)	Tons	Count(2)	Tons
Not sprayed	77,600	11.8	96,100	18.8	163,500	15.2	85,200	11.4
Salt Spray, 200	72,300	12.0	100,600	20.0	159,600	15.2	87,500	13.3
Not Sprayed	76,600	10.2	100,500	20.5				
Salt & nitrate Spray, 200	77,800	11.5	89,800	20.2				

(1) Average stand and yield per acre of beets from 8 plots at harvest.

(2) " " " " " " " " " 6 " " "

Within a given location the small differences between the means for the unsprayed and the sprayed plots are not statistically significant. This statistical interpretation is based on the assumption that the systematic design did not introduce an unusual bias. The fact that the stand and yields for the sprayed and unsprayed beets were similar at the four locations and at two different pressures of spray application indicates that the crop was not adversely affected by the salt spray. Although the salt plus nitrate spray mixture was only tested at locations 1 and 2, the data indicate that the beets responded the same as they did with the salt spray. There was no evidence of increased tonnage as a result of the 19.2 pounds of nitrogen added by the 120 pounds of sodium nitrate. Even though the actual tonnage was not increased by the salt plus nitrate mixture, it appeared on several strips sprayed with this mixture adjacent to the plots that the mechanical harvester picked up a higher percentage of the beets because of the erectness of the tops.

Since the beet yields were not adversely affected by the sprays, any material reduction in the weed population should be highly important. The average weed count for 8 plots of each of 2 spray treatments and their respective checks, together with the least difference necessary for significance, is presented in Table 2.

Table 2. Effect of Salt and Salt Plus Sodium Nitrate Sprays on the Control of Weeds Other than Lambs Quarter and Purslane in Beets.

Treatments Gallons Per Acre	Location I - Weed Count Per Acre Before Hand Weeding
Not sprayed	10,900
Salt Spray, 200 gal., 50 lbs. Pressure	400
Not sprayed	10,300
Salt and Nitrate Spray, 200 gal., 50 lbs. Pressure	200
L. S. D. 5 per cent	3,300

The high weed count on the unsprayed plots represents a stand of ragweed, red-root, mustard and smartweed that was typical over the beet field. Obviously it was not necessary to hand weed the sprayed plots. Even when hand weeding must be practiced in conjunction with spraying to control lambs quarter, the problem is greatly simplified by the removal of the salt sensitive weeds. In addition, weeds sprayed with salt die rapidly; whereas, many weeds that are pulled and dropped between the beet rows soon become re-established and produce seed.

Beet samples which had been held in tin for about seven weeks were rated by a panel of food tasting experts at the Geneva Station. In no case, were there differences between the unsprayed and sprayed samples that could be attributed to the spraying with salt or salt plus sodium nitrate.

In conclusion, the data gathered in 1948 indicate that the canning type of beet being grown on heavy soils in Western New York can be weeded with concentrated salt sprays of either sodium chloride or a mixture of sodium chloride and sodium nitrate without impairing the stand or yield of the crop. The completeness with which sensitive weeds including very young grasses were killed by sprays applied at 50 lbs. pressure has made it seem doubtful if higher pressures are necessary, except where weeds are large and coverage cannot be obtained with the lower pressures. These findings are in accord with observations made in 1947 and 1948 on commercial beet plantings sprayed experimentally with 200 gallons per acre of water containing 400 pounds of sodium chloride.

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Weed Control In Onions Grown From Sets*

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It has generally been considered that the principal job in the culture of onions between planting time and harvest is weed control. For generations this has been accomplished by hand labor in some form or another; usually this meant a combination of hand weeding and cultivation with wheel or shove hoes. On this basis it has been estimated that cultivating and weeding made up nearly 40 percent of the total labor cost (5) in growing onions.

Although chemicals have been used for centuries to control weeds it is only within the last 50 years that their potential selective action was recognized. Within the last 25 years experimenters in Europe (1,3,4) and the United States (14,15) found that dilute sulfuric acid was of value as a selective herbicide in onion fields. Recently Hedlin (11) and Carew and Hedlin (6) demonstrated that dilute solutions of potassium cyanate are selective for onions grown from seed and provide a toxic agent for killing annual weeds. The purpose of the experiments reported here was to study the effect of several chemicals on weed control and the yield of onions grown from sets.

Materials and Methods

Experiments with Ebenezer onions were conducted on a Scarborough very fine sandy loam with an impervious subsoil in 1947 and 1948. The soil was moderately fertile and the pH ranged from 5.7 to 6.0.

The various chemicals used in these experiments were kindly submitted by the following: American Cyanamid Company, Dow Chemical Company, Pittsburgh Plate Glass Company and Standard Agricultural Chemicals, Inc.

A Hauck "Little Giant" flame gun was used for flaming weeds and this was carried at a rate of approximately 2.5 miles per hour. The Cyanamid dust treatment was with the material known as Aero Cyanamid Special Grade and in post-emergence treatments no special effort was made to keep the dust off the plants.

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* Contribution No. 692 of the Massachusetts Agricultural Experiment Station.

The Sinox used was of the old formulation with sodium dinitro-ortho cresylate as the active ingredient. A 1% spray of Sinox with 1 pound of ammonium sulfate to 100 gallons of water was used as a direct spray on the onion plants as were Dow Selective Herbicide (2 pints to 100 gallons) and sodium pentachlorophenate (0.5% soln.). 2,4-D was applied at the rate f 2.0 pounds (acid equivalent) in 100 gallons of water using the 80.5 percent sodium salt. Several strengths of potassium cyanate (KOCN) were used both as direct foliar and as side sprays. The brand name of this material was Aero Cyanate Weedkiller. Isopropyl phenyl carbamate (IPPC) was used as a pre-emergence application at the rate of 5 pounds per acre with sand as the diluent and Stoddard Solvent with Tributyl phosphate as the co-solvent as a second treatment. The Stoddard Solvent, IPPC mixture was applied at the rate of 100 gallons per acre. A few exploratory treatments were given but these were not replicated. The sprays were applied with a Brown Open-Hed No. 4 hand pressure sprayer fitted with a No. 8004 Spraying Systems fan-type nozzle and the speed of application was regulated so that the plots were covered twice at any given application to assure as uniform coverage as possible.

In 1947 five replications and in 1948 three replications were used for each treatment and were laid out in randomized blocks. The plot size used was 6 rows, 15 feet long, with rows spaced 15 inches apart. The onion sets were spaced 3 inches apart in the row.

The following weeds were present abundantly and more or less uniformly throughout the experimental area: purslane, chickweed, shepherd's purse, smartweed, lamb's quarters, pigweed, galinsoga and wiregrass. Cultivation and hand weeding were not practiced on the chemically treated plots at any time during the season.

Yields of 1948 were considerably lower than those of 1947 and this might be expected in view of the inclement weather experienced during the first half of the growing season in 1948. Commercial fields experienced a considerable amount of onion blast (12) but the experimental plots were free from this trouble. It is not suggested that this was the result of any of the herbicidal treatments.

Table I - The Effect of Several Weed Control Agents On The Yield Of Set Onions in 1947 (Planted Apr 17, Harvested July 20)

Treatments (5 replications)	Rate Per Acre	Number of Applications	Yield of U.S. No. 1 Onions (Bu. per A.)
1. Flamed with Weed Burner		2	535
2. Sodium Pentachlorophenate 0.5% soln.	90 gals.	2	424
3. Cultivated		4	679
4. Stoddard Solvent pre-emerg followed by scraping	100 gals	1 4	607
5. Dow Selective Herbicide (2 pints to 100 gals.)	100 gals	2	479
6. Cyanamid Dust	50 lbs.	5	562
7. 1% Sinox + 1 lb. $(NH_4)_2 SO_4$ to 100 gals.	100 gals	2	501
L.S.D. 5 percent			107
1 percent			146

Table 2 - The Effect of Several Weed Control Agents On The Yield Of Set Onions in 1948 (Planted Apr. 22, Harvested July 29)

Treatments* (3 replications)	Rate Per Acre	No. of Applications	Weeds Per Sq. Ft. July 14	Yield of U.S. No. 1 Onions (Bu. per A.)
1. Cultivated		3	0	420
2. Cyanamid Dust (pre-emerg) ✓	75 lbs.	1	14	392
KOCN 1%	80 gals.	4		
3. Cyanamid Dust (pre-emerg) ✓	150 lbs.	1	7	413
KOCN 2%	80 gals.	4		
4. IPPC in sand (pre-emerg) ✓	5 lbs.	1	16	388
KOCN 1%	80 gals.	3		
5. Na salt of 2,4-D (pre-emerg) ✓	2 lbs.	1	2	287
KOCN 1.5% on plants	80 gals.	3		
6. Cyanamid Dust	50 lbs.	3	8	265
7. Granular Cyanamid (pre-emerg) ✓	600 lbs.	1	10	324
KOCN 3.0% on plants	80 gals.	2		
8. IPPC in oil (pre-emerg) ✓	5 lbs.	1	16	362
KOCN 1%	80 gals.	3		
9. KOCN 2%	80 gals.	4	6	413
10. KOCN 2% on plants	80 gals.	4	4	349
L.S.D. 5 percent			6	72
1 percent			8	99

*These were post-emergence treatments except where otherwise noted.

Results and Discussion

The results of the 1947 and 1948 experiments are presented in Tables 1 and 2. While some of the treatments in 1947 were very effective in controlling weeds it is apparent that they were detrimental to the yields since the cultivated plots yielded more than those otherwise treated. All of the differences are significant at the 5 percent level and only the plots treated with Cyanamid and Flame come within the least significant difference range at the 1 percent level. The yields of scraped plots (very shallow cultivation) come within the range at both levels but even here the yield is 10.5 percent less than that produced by deep cultivation. The lower yield in the scraped treatment might be attributed to the pre-emergence Stoddard Solvent spray but this is doubtful since the onions showed no above-ground growth for at least 10 days after spraying and Stoddard Solvent is completely evaporated from the soil in a shorter time than this. No benefit in weed control resulted from this application of Stoddard Solvent in mid-April before weeds had made their appearance. The results here are in line with those of Thompson (16) who found that onions grown on cultivated plots over a period of 6 years yielded 7.69 percent more than those grown on scraped plots.

Flame cultivation was effective in controlling weeds. The onions appeared to be severely injured after the first treatment with flame but recovered in a few days. It was clearly apparent that the flame must be kept moving at a steady rate and not slower than 2.0 miles per hour to prevent excessive injury.

The 0.5 percent solution of sodium pentachlorophenate as a foliar application controlled broad-leafed weeds readily with little or no effect on annual grasses. This material damaged the onion leaves more than any other treatment in the experiment. From tests with onions in the greenhouse and with sweet corn in the field it is evident that the pentachlorophenates are better adapted as pre-emergence herbicides. This is in line with the theory propounded by Crafts (8). Bakke (2) and Fitch (10), however, reported very promising results with this material as a post-emergence spray on onions in Iowa.

Apparently selective di-nitro herbicides do not have the degree of selectivity for onions here that is reported in the Far West. Dow Selective Herbicide and Sinox proved to be quite toxic to the onions and their inability to control grasses to any extent was also a serious drawback. In a cooperative experiment with one grower, however, two acres of onions were saved that otherwise would have grown up in weeds because of a labor shortage. Even so, this block yielded about 70 percent as well as other comparable fields. The sacrifice in yield was probably due to early weed competition as well as later injury from Sinox.

Weeds in the plots treated with Cyanamid dust in post-emergence applications were kept well under control in both years of the tests. It was not possible to predict accurately how much damage would accrue at any particular time of treatment. Best weed control resulted when weeds were wet with rain or dew at the time of application, followed by clear, warm weather for several days. As might be expected most damage to the onions resulted to the onions under the same conditions that promoted best weed control. The grower previously mentioned also treated a two-acre block of onions several times with cyanamid dust in an effort to "save the crop." This block also yielded about 70 percent as well as expected had the field received proper attention but he felt well repaid in view of the fact that little or no crop would have been realized without these treatments. The Cyanamid dust pre-emergence applications were particularly beneficial in controlling the first crop of weeds, especially at the 150 pound per acre rate. This effect was lost, however, in several weeks, and it was then that potassium cyanate applications were especially useful and noteworthy.

Granular Cyanamid as a pre-emergence application at the rate of 600 pounds per acre controlled weeds very effectively for a period of 3 to 4 weeks but after that the weeds came in abundantly. This treatment reduced the stand of plants somewhat and caused a great deal of leaf injury during the early part of the season. Later these plants recovered and appeared to grow in a normal manner but it was apparent that this rate of application was too high for safety on onions.

A 2 percent solution of KOCN was very effective in controlling small weeds but this material should be applied as a side spray and not as a direct foliar spray. It was not possible to predict the amount of injury that might result from spraying with KOCN based on previous sprayings for the attendant injury was quite variable at the various times of treatment. It was very evident that 1 or 2 percent solutions of KOCN were relatively ineffective in controlling large weeds. This was especially true of annual grasses and lamb's quarters. These weeds were not affected by the sprays after they had developed to more than ½ to 3/4 of an inch in height so that it is essential to begin spraying just as soon as the weeds make their first appearance and proceed with later crops of weeds on the same basis.

A number of growers in this area used KOCN successfully for weeding onions in 1948. They were all very pleased with the results and indicated their intention of using it again. One man treated 30 acres of set onions three times with KOCN in addition to his usual cultivation practices and no hand weeding was necessary. Their estimates of the effects of KOCN varied from a slight decrease to a slight increase in yield. The results reported in Table 2 indicate an insignificant reduction in yield

from a side spray of 2 percent KOCN. It should be noted that these plots were not cultivated or hand weeded during the season and while some weeds were present at harvest time they were not of sufficient size or numbers to warrant the expense of their removal. A 4 percent solution of KOCN was very effective in controlling larger weeds with considerably more injury to onion plants.

A pre-emergence application of 2 pounds of 2,4-D reduced the stand of weeds to about 50 percent as compared with untreated plots during the very early season and was classed as poor weed control when compared with the plots treated with KOCN. While the 2,4-D produced no noticeable effect on the onion plants the yields from these plots were the lowest in the experiment. This is in line with other work on set onions (17).

Isopropyl phenyl carbamate did not appear to affect the development of grasses to any extent in these tests but did exert a marked depressing effect on chickweed for a period of about three weeks which was rather surprising on the basis of previous work (13).

A 2 percent solution of sulfuric acid was used in some other tests with onions but the poor control of lamb's quarters, purslane and annual grasses obtained, together with its hazardous nature, do not warrant its further use. It is significant that in greenhouse tests, Crafts (7) and Crafts and Reiber (9) found that they could kill seedling grasses with kerosene or gasoline without harm to onions. In out-of-door experiments at this Station, No. 1 fuel oil (kerosene), No. 2 fuel oil, Sovasol No. 1 (white gasoline), Stoddard Solvent, and Stoddard Solvent at 10 percent, 25 percent, and 40 percent strengths, by volume, with No. 1 fuel oil as the diluent, all proved to be very toxic to onion plants grown from sets, and plants treated with these materials were dead within three days.

A spray of 3 percent Dow Contact Weedkiller applied to the plots just before harvest was effective in controlling weeds and promoted a faster dying back of the tops. This hastened the field-curing process somewhat without any apparent injury to the onion bulbs.

Summary

The results from tests on experimental plots and in commercial fields indicate that a 2 percent solution of potassium cyanate at the rate of 80 gallons per acre is effective in controlling small, annual weeds in fields of set onions. Where three or four timely applications were given during the growing season no hand weeding was necessary. This herbicide should be used as

a side spray and not as a direct foliar spray for the material is not sufficiently selective to permit an over-all application without reducing yields.

A pre-emergence application of 75 to 150 pounds of Cyanamid dust per acre controlled weeds well for several weeks and was a valuable supplement to the spraying program with potassium cyanate.

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CONTROL OF WEEDS IN POTATOES BY PRE-EMERGENCE SPRAYS

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Weeds greatly reduce potato yields annually although much time and expense are involved in cultural practices for their control. Present methods of soil stirring for weed control injure and destroy potato roots. Chemical control of weeds makes it possible to avoid this injury.

Pre-emergence application of chemicals to potatoes for the control of weeds was first made by the senior author in 1946. Potatoes were planted June 6, 1946 and treatments were made June 25 at the time a few sprouts were emerging. Weeds were harvested and weighed September 4. Soil was Lordstown silt loam of pH 4.8 - 5.2. Plots were 1/200 acre in area. Sodium salt of 2,4-D was applied.

Table 1. Effect of pre-emergence application of chemicals on weed growth and yield of potatoes, 1946. Variety, Houma.

Treatment	wt. weeds per plot(gms.)	U. S. 1 Bu./A.
2,4-D, 5 lbs./A	2003	357
2,4-D, 10 lbs./A	465	372
Methyl ester naphthaleneacetic acid, 25 lbs./A	1151	342
Untreated	4336	391

Another experiment was conducted later in the season on Dunkirk silty clay loam soil of pH 5.0-5.2 with the Sebago variety. Potatoes were planted August 24, treatments applied September 6 before any plants had emerged. Plot size was 1/600 acre with three replications. Materials were applied at the rate of 200 gallons to the acre.

Results in 1947

A factorial experiment involved the application of 19 chemicals and combinations of chemicals at two dates before emergence of the potatoes and each chemical at two rates of application or at two concentrations. Six other treatments were made but not a part of the factorial experiment.

Houma potatoes were planted June 10 on Lordstown silt loam soil of pH 4.8-5.2 in plots of .0032 acre, replicated twice. Chemicals were applied 8 days and 14 days after planting. Except where stated otherwise in Table 3 all materials were diluted with water and applied at the rate of 100 gallons to the acre.

*J. H. Ellison and Fred McGoldrick assisted with these experiments in 1946 and 1947.

Twelve of the chemical treatments yielded as high as the cultivated plots and ten of the treatments yielded higher than the untreated plots.

With the broadleaved weeds particularly, the delayed applications of chemicals resulted in better control than early application. This is not so clear-cut with the grasses.

Table 2. Effect of pre-emergence application of chemicals in number of broadleaved plants per plot. October 15, 1946

Treatment	No. of broadleaved weeds
Gulf solvent HS-S5649 undiluted	61
Sovasol #5 "	38
Esso HAN 132 "	6
PDL 43672 "	3
X79TA (Esso) 5 gal.-195 gal. water	1
2,4-D sodium salt 6 lbs. - 200 gal. water	0
2,4-D " " 12 " - 200 " "	0
Dow 652 1 gal. - 199 gal. water	0
Dow 562 3 qts. - 200 " "	4
Dow 532 3 gal. - 197 " "	3
Sinox General, 2 qts.,2 gal. diesel-198 gal.water	0
Methyl ester naphthaleneacetic acid 1-1/3 gal.- 199 gal. water	1
Gulf high flash solvent 7717 undiluted	0
Untreated	73
L.S.D. at 1%	40

Results in 1948

Experiment 1. Sebago potatoes were planted April 30, 1948 on Dunkirk sandy loam soil. Twenty days after planting and before plants emerged, 60 treatments were made to the soil. Plots were 6 x 6 ft. and replicated twice. Materials were applied at various rates and dilutions as indicated in Table 6.

Highly significant reductions in number of broadleaved weeds occurred from the use of most of the chemicals and at most dilutions and rates of application. No significant reductions in number of grasses occurred, however. Sodium pentachlorophenate at 20 pounds to the acre resulted in almost complete control of grasses and broadleaved weeds.

Table 3. Effect of various pre-emergence applied chemicals, concentrations and date of application on yields of potatoes. 1947. Variety, Houma.

Chemical	Rate per acre	Total yield, bushels per acre								
			After planting		Concentration		8 days		14 days	
		Aver.	8 days	14 days	low	high	low	high	low	high
2,4-D Na salt	3 and 6 lbs.	377	384	372	380	376	416	350	343	400
Isopropyl ph. carbamate (IPC)	3 and 6 lbs.	370	405	335	411	330	444	366	377	293
IPC + Sinox General	(3 and 6 lbs.)	398	393	404	401	396	371	414	430	377
(Sinox General)	(3 and 6 pts.)									
Sinox General	3 and 6 pts.	380	385	376	366	394	341	428	391	359
Dow Contact Herb.	2 and 4 gal.	419	380	438	422	416	373	425	471	405
Esso Aromatic NB	60 and 120 gal.	388	406	371	366	411	357	455	375	366
Esso HAN 132	60 and 120 gal.	411	429	393	417	405	425	432	407	377
2,4-D + emuls. SR 758	5 and 10 gal.	435	409	463	397	474	359	457	435	489
emuls. Aromatic NB	10 and 20 gal.	358	373	343	370	347	355	391	384	302
" Tar L	10 and 20 gal.	345	347	343	338	353	322	371	352	334
" HAN 132	10 and 20 gal.	378	378	379	372	385	357	398	387	371
" SR 758	5 and 10 gal.	366	323	410	396	337	357	288	435	384
Esso H28	80 and 160 gal.	365	366	365	353	379	359	373	345	384
2,4-D + IPC		413	401	426	419	408	419	382	439	432
2,4-D + Sinox		385	338	434	379	393	380	295	377	489
2,4-D + Sinox Gen.		383	392	377	367	401	389	393	345	407
2,4-D + emuls. Tar L		380	366	394	404	356	393	339	414	373
Untreated		344	302	387	339	350	274	329	403	371
Normal tractor cultivation		406	418	394	419	393	425	411	413	375
L.S.D. at 5%		34.8	12.4		12.4		35.2			
L.S.D. at 1%		45.8	16.5		16.5		47.1			

Table 4. Effect of various pre-emergence applied chemicals, concentrations and date of application on control of weeds and grass in potatoes. 1947. Variety, Houma.

Chemical	Rate per acre	Average number of weeds and grass in 34 inch square area July 21. Broadleaf weeds: After planting 8 days: Aver.	8 days: low conc.	8 days: high	14 days: low	14 days: high	grasses: After planting 8 days: Aver.	8 days: low	8 days: high	14 days: low	14 days: high
2,4-D Na salt	3 and 6 lbs.	10.1	13.0	19.5	4.0	4.0	6.1	4.0	3.5	7.0	10.0
Isopropyl ph.carbamate (IPC)	3 and 6 lbs.	4.0	9.0	2.5	3.5	1.0	30.9	43.5	23.0	54.0	3.0
IPC + Sinox General	3 and 6 lbs. / 3 and 6 pts.	3.8	3.0	0.5	4.5	7.0	24.4	26.5	22.0	40.0	9.0
Sinox General	3 and 6 pts.	3.4	3.0	9.0	1.5	0.0	20.0	26.0	27.5	24.5	2.0
Dow Contact Herb.	2 and 4 gal.	5.0	15.0	2.0	2.5	0.5	26.5	28.0	17.0	38.5	22.5
Esso Aromatic HB	60 and 120 gal.	5.5	10.0	6.0	1.0	5.0	24.3	32.5	32.0	9.0	23.5
Esso HAN 132	60 and 120 gal.	10.0	15.5	18.5	4.0	2.0	34.4	49.5	33.0	29.0	26.0
2,4-D + emuls. SR 758	5 and 10 gal.	2.8	8.0	0.0	3.0	0.0	8.8	15.5	2.0	7.5	10.0
emuls. Aromatic HB	10 and 20 gal.	6.4	10.0	5.5	2.0	8.0	16.1	4.5	11.0	33.0	16.0
" Tar L	10 and 20 gal.	10.5	14.5	4.5	18.0	5.0	32.6	37.0	62.0	16.0	15.5
" HAN 132	10 and 20 gal.	10.3	7.5	14.0	11.0	8.5	35.3	36.5	13.5	32.5	58.5
" SR 758	5 and 10 gal.	14.3	25.0	19.5	7.0	5.5	21.0	12.5	12.5	40.0	19.0
Esso H 28	80 and 160 gal.	17.6	11.0	22.5	23.0	14.0	31.3	44.0	13.5	15.5	52.0
2,4-D + IPC		3.4	3.0	4.5	1.5	6.5	12.9	10.0	7.5	11.0	23.0
2,4-D + Sinox		0.0	0.5	0.0	0.0	0.0	6.5	7.0	10.5	4.0	4.5
2,4-D + Sinox Gen.		4.8	13.0	6.0	0.0	0.0	5.5	5.5	13.5	1.0	2.0
2,4-D + emuls. Tar L		6.4	8.5	10.5	4.5	2.0	20.5	9.5	46.5	19.0	7.0
Untreated		17.8	9.5	30.0	21.0	10.5	39.0	63.0	39.5	34.0	19.5
Normal tractor cultivation		4.5	6.5	5.5	0.0	6.0	5.8	3.5	8.5	4.5	6.5
L.S.D. at 5%		4.4		8.8			12.9		25.9		
L.S.D. at 1%		5.8		11.7			17.2		34.5		

Table 5. Effect of various pre-emergence applied chemicals, concentrations and date of application on control of weeds and grass in potatoes. 1947. Variety, Houma.

Chemical	rate per acre	Average weight of weeds and grass in 34 in.sq.area(gms) 7/21 broadleaf weeds after planting 8 days	broadleaf weeds after planting 14 days	broadleaf weeds Concentration low	broadleaf weeds Concentration high	grasses after planting 8 days	grasses after planting 14 days	grasses Concentration low	grasses Concentration high
2,4-D Na salt	3 and 6 lbs.	37.2	2.5	25.5	14.2	0.0	1.2	0.0	1.5
Isepropyl ph.carbamate (IPC)	3 and 6 "	21.5	36.5	31.2	26.8	50.5	25.5	33.2	42.8
IPC + Sinox General	(3 and 6 " (3 and 6 pts.	0.0	1.8	0.0	1.8	3.2	4.5	5.5	2.2
Sinox General	3 and 6 pts.	25.5	6.0	27.5	4.0	74.2	2.0	13.5	62.8
Dow Contact Herb.	2 and 4 gal.	13.0	3.2	14.5	1.8	47.8	8.0	13.2	42.5
Esso Aromatic HB	60 and 120 gal.	24.2	3.8	23.5	4.5	12.5	0.0	1.8	10.8
Esso HAN 132	" " " "	25.8	5.2	22.0	9.2	18.0	0.5	12.8	5.8
2,4-D + emuls. SR 758	5 and 10 gal.	8.5	10.2	8.0	10.8	5.5	0.5	5.5	0.5
emuls. Aromatic HB	10 and 20 gal.	32.2	16.5	31.0	17.8	25.0	5.2	15.8	14.5
" Tar L	10 and 20 "	11.8	61.0	32.8	40.0	40.8	17.2	6.0	52.0
" HAN 132	10 and 20 "	75.8	25.5	36.5	64.8	95.2	3.2	89.8	8.8
" SR 758	5 and 10 "	363.0	8.2	319.8	51.5	90.8	38.0	125.5	3.2
Esso H 28	80 and 160 "	71.8	34.8	36.5	7.0	136.5	24.5	116.2	44.8
2,4-D + IPC		0.0	0.0	0.0	0.0	0.8	17.0	17.2	0.5
2,4-D + Sinox		0.0	0.0	0.0	0.0	1.2	0.8	1.8	0.0
2,4-D + Sinox General		19.0	0.0	18.8	0.0	10.0	2.8	3.8	9.0
2,4-D + emuls. Tar L		32.2	0.0	3.5	28.8	25.5	7.2	18.8	14.0
Untreated	--	127.0	143.8	110.0	160.8	66.5	63.2	75.2	54.5
Normal tractor cultivation	--	15.2	26.0	38.8	2.5	0.0	3.8	2.2	1.2
L. S. D. at 5%		46.5		46.5		50.5		50.5	
L. S. D. at 1%		61.9		61.9		67.3		67.3	

Table 6. Effects of various chemicals and concentrations and rates of application on control of weeds, 1948. Variety Sebago.

Treatment	Number of weeds per 8 sq. ft. 7/1/48 broadleaf	grass
2,4-D 2 lbs. in 10 gal. water	6	22
2,4-D 2 lbs. in 100 gal. "	5	7
Dow Contact 3 gal. + 7 gal. water	27	24
" " 3 gal. + 97 gal. "	19	28
Sinox General 3 pints + 6 gal. diesel, 3-5/8 gal. water	3	26
" " 3 pints + 6 gal. diesel, 93-5/8 gal. water	5	9
Na pentachlorophenate 20 lbs. 100 gal. H_2O	1	4
" " 8 lbs. + 8 gal. diesel + 92 gal. H_2O	68	13
Na isopropyl xanthate, 16 lbs. in 100 gal. H_2O	70	23
Allyl mixed chlorophenyl carbonate, 10 lbs. + 5 gal. diesel + 95 gal. water	64	17
Phenylisocyanate, 5 gals. + 95 gal. water	42	61
NH_4 trichloroacetate, 2.4 gal. + 97.6 gal. water	50	2
Na " , 29.32 lbs. in 100 gal. "	33	2
Untreated	183	9
Esso C48-1 15 gal. + 85 gal. water	39	6
" C48-1 30 " + 70 " "	41	15
" C48-1 15 " + 15 " "	57	16
" C48-1 30 " + 30 " "	22	21
" C48-1 15 " undiluted	79	3
" C48-1 30 " "	29	8
" C48-2 15 gal. + 85 gal. water	78	11
" C48-2 30 " + 70 " "	48	10
" C48-2 15 " + 15 " "	55	18
" C48-2 30 " + 30 " "	56	11
" C48-2 15 " undiluted	69	16
" C48-2 30 " "	55	45
" C48-3 15 " + 85 gal. water	78	15
" C48-3 30 " + 70 " "	79	16
" C48-3 15 " + 15 " "	107	5
" C48-3 30 " + 30 " "	40	24
" C48-3 15 " undiluted	57	18
" C48-3 30 " "	51	29
" C48-4 15 " + 85 gal. water	75	9
" C48-4 30 " + 70 " "	68	16
" C48-4 15 " + 15 " "	62	5
" C48-4 30 " + 30 " "	54	9
" C48-4 15 " undiluted	37	7
" C48-4 30 " "	44	7

Table 6. (Continued)

Treatment	Number of weeds per 8 sq. ft. 7/1/48 broadleaf	grass
Esso C48-5 15 gal. + 85 gal. water	75	12
" C48-5 30 " + 70 " "	42	17
" C48-5 15 " + 15 " "	97	10
" C48-5 30 " + 30 " "	72	16
" C48-5 15 " undiluted	89	15
" C48-5 30 " "	56	25
" C48-6 15 gal. + 85 gal. water	46	11
" C48-6 30 gal. + 70 " "	27	20
" C48-6 15 " + 15 " "	92	13
" C48-6 30 " + 30 " "	19	4
" C48-6 15 " undiluted	57	10
" C48-6 30 " "	50	21
" C48-7 15 " + 85 gal. water	43	26
" C48-7 30 " + 70 " "	44	29
" C48-7 15 " + 15 " "	75	6
" C48-7 30 " + 30 " "	52	8
" C48-7 15 " undiluted	52	20
" C48-7 30 " "	88	10
General Weed Exterminator 15 gal. + 85 gal. water	29	32
" " " 15 " + 15 " "	26	11
" " " 15 " undiluted	60	14
Untreated	112	19
L. S. D. at 5%	24.78	—
L. S. D. at 1%	32.96	--
F value	3.49	1.44
F required at 5% (1%)	1.56 (1.87)	1.56

Results of yields obtained from certain treatments and presented in Table 7 show that all treatments except ammonium trichloroacetate increased yields significantly above the untreated plots. 2,4-D treated plots showed some injury and stunting of the potato plants. Yields from these plots were not as high as from several other treatments but statistically these differences were not significant.

Table 7. Effects of pre-emergence application of several chemicals in yields of potatoes. 1948. Variety, Sebago.

Treatment	Total yields, bu. per acre
2,4-D 2 lbs. in 100 gal.	333
Sodium pentachlorophenate, 20 lbs. 100 gal.	413
Ammonium trichloroacetate, 2.4 gal./97.6 gal.	169
Sodium trichloroacetate, 29.32 lbs. in 100 gal.	408
Esso C48-1, 15 gal./85 gal. water	378
Untreated	181
L.S.D. at 5%	140
L.S.D. at 1%	208

Experiment 2. In order to utilize some of the information obtained from early-planted experiment No. 1, Chippewa potatoes were planted in June on Lordstown silt loam soil. Plots were of 4 rows 30 feet long with three replications. The treatments listed in Table 8 were made two weeks after planting before emergence of the potato. Triethanolamine salt of 2,4-D was used. Weed counts on all plots were made on July 15. Since some treatments were not controlling the weeds and since the plots were randomized it was deemed necessary to cultivate the entire area on July 19. No other cultivation was given except on the plots which were hand cultivated throughout the season.

Highly significant differences in the control of both broadleaved weeds and grasses resulted from the application of the chemicals. Thirteen of 17 treatments reduced the weed count significantly below the untreated; eight of 17 significantly reduced the number of grasses below the untreated. Several chemicals were exceptionally good in controlling broadleaved weeds and ammonium trichloroacetate at the reduced concentration controlled both types of weeds to a high degree.

Contrary to the results of 1946 and 1947, 2,4-D did not adequately control grasses. Although 2,4-D concentration was lower than in both preceding years, injury to the potato plants was more marked than previously. Poor grass control by 2,4-D was partially attributed to the constant almost optimum supply of moisture in the soil for most of the season. Although root

systems of nearly mature foxtail grasses often consisted of only one root the ample moisture supply kept it alive until further roots were regenerated and the grass lived to maturity.

Yields of untreated plots and three chemical treatments were significantly lower than the cultivated plots. 2,4-D at 1-1/2 pounds to the acre significantly decreased yields.

Comparison was made of two petroleum products at several rates, diluted and undiluted on the control of weeds and grass. Results of control are presented in tables 9 and 10

Considering number of broadleaved weeds and grasses C48-12 gives much better control with 30 gallons to the acre than with 20 gallons whereas with C48-8 there were no significant differences. With both petroleum products better control of weeds and grass resulted when they were applied undiluted although the differences were not considered significant. No significant differences in weight of weeds and grasses occurred between any of the treatments.

Experiment 3. Soil type, variety, date of planting and date of pre-emergence application of chemicals are the same as in experiment 2. Chemicals were applied June 25. Materials applied and rates and concentrations are given in Table 11.

Highly significant differences in weight of broadleaved weeds occurred between the various treatments and significant differences in weight of grass. Four treatments resulted in complete control of broadleaved weeds and five others had only a trace. Most of the treatments greatly reduced the weight of grasses.

Although total yields of twelve of the treatments are lower than the cultivated only one of these is a statistically significant decrease. Likewise total yields of 14 of the treatments are higher than that of the cultivated treatments although only one of these is a statistically significant increase. Comparison was made of five petroleum products at two rates, diluted and undiluted on the control of weeds and grass. Results of control are presented in Tables 12 and 13.

With C48-9, C48-10, C48-13 and C48-14 numbers of broadleaved weeds were reduced to a significantly greater degree with 30 gallon per acre applications than with 20 gallons per acre. The same trend occurred with C48-11 but the difference was not significant. With grasses the trend was the same as for broadleaved weeds although none of the differences was statistically significant. No significant differences occurred between the diluted and undiluted materials in the control of grasses or broadleaved weeds.

Table 8. Effect of pre-emergence application of chemicals on control of weeds and yields of potatoes. Variety Chippewa. 1948

Chemicals and rates	No. weeds per 6 sq.ft. 7/15 broadleaf	grass	Yield, bu. per acre U. S. 1	Total
2,4-D, 1½ lbs. 10 gal. H_2O	3 *	200	368 #	385 #
2,4-D, 1½ " 100 " "	5 *	238	328 #	349 #
Esso C48-8, 20 gal. + 20 gal. H_2O	52	129	421	444
" C48-8, 30 " + 30 " "	17 *	126 *	434	458
" C48-8, 20 gal. undiluted	18 *	89 *	440	463
" C48-8, 30 " "	20 *	143	360 #	386 #
" C48-12, 20 gal. + 20 gal. H_2O	39	221	428	452
" C48-12, 30 " + 30 " "	34	135	469	492
" C48-12, 20 " undiluted	24 *	140	439	466
" C48-12, 30 " "	30	142	428	450
Dow Contact, 3 gal. + 7 gal. H_2O	15 *	113 *	428	454
" " 3 " + 97 " "	4 *	107 *	453	474
Sinox Gen. 3 pts. + 6 gal. diesel + 3-5/8 gal. H_2O	1 *	116 *	496	523
Sinox Gen. 3 pts. + 6 gal. diesel + 93-5/8 gal. H_2O	3 *	104 *	481	502
Na trichloroacetate, 20 lbs. (70-6%) 100 gal. H_2O	5 *	75 *	407	426
NH_4 trichloroacetate, 1.6 gal. + 98.4 gal. H_2O	9 *	22 *	378	394
Na isopropyl xanthate, 16 lbs. 100 gal. H_2O	3 *	145	400	424
Untreated	55	219	338 #	360 #
Cultivated	--	-	461	482
F value	5.58	2.63	2.37	2.32
F required at 5%	1.75	1.75	1.84	1.84
F required at 1%	2.18	2.18	2.37	2.37
L.S.D. at 5%	-	-	91	91

*significantly lower than untreated #significantly lower than cult.

Table 9. Effect of two oils, concentrations and rates of pre-emergence application on control of weeds in potatoes. 1948

Oil	Number of weeds per 4 sq. ft. grams. 7/15/48 broadleaf 20 gal.	30 gal.	diluted	undil.	grass 20 gal.	30 gal.	dil.	undil.
Esso C48-8	7.17	4.00	6.67	4.50	31.0	31.2	33.7	28.5
Esso C48-12	10.80	4.67	9.83	5.67	58.2	28.3	48.7	37.8
L.S.D. at 5%	3.91		NSD		10.3		NSD	

Rate x dilution interaction for grasses is significant and oil x rate and oil x rate x dilution are highly significant.

Table 10. Effect of two oils, concentrations and rates of pre-emergence application on control of weeds in potatoes, 1948.

	Weight of weeds per 4 sq. ft., grams, 7/15/48.							
	broadleaf				grass			
Oil	20 gal.	30 gal.	diluted	undil.	20 gal.	30 gal.	dil.	undil.
Esso C48-8	2.00	2.17	2.67	1.50	11.3	6.5	12.8	5.0
Esso C48-12	3.17	2.00	3.17	2.00	18.7	4.8	16.3	7.2
L.S.D. at 5%	NSD		NSD		NSD		NSD	

Oil x rate and oil x dilution interactions for broadleaved weeds are significant and rate x dilution and oil x rate x dilution are highly significant.

Table 11. Effect of preemergence application of chemicals on control of weeds and yields of potatoes. Variety Chippewa. 1948.

Chemicals and rates	Wt. weeds, gms. per 3 sq.ft. 7/16 broadleaf	grass	Yield bu. per acre U.S. 1	Total
Esso C48-9, 20 gal. + 20 gal. H_2O	5	35	378	401
" C48-9, 20 gal. undiluted	6	13	445	468
" C48-9, 30 gal. + 30 gal. H_2O	4	12	449	461
" C48-9, 30 gal. undiluted	1	14	506 #	526 #
" C48-10, 20 gal. + 20 gal. H_2O	7	49	367	388
" C48-10, 20 gal. undiluted	1	37	402	437
" C48-10, 30 " + 30 gal. H_2O	1	15	438	455
" C48-10, 30 " undiluted	4	18	414	437
" C48-11, 20 gal. + 20 gal. H_2O	5	90	427	447
" C48-11, 20 gal. undiluted	4	25	380	401
" C48-11, 30 " + 30 gal. H_2O	1	58	389	409
" C48-11, 30 " undiluted	8	16	409	427
" C48-13, 20 gal. + 20 gal. H_2O	5	114	331	345
" C48-13, 20 gal. undiluted	5	14	393	415
" C48-13, 30 gal. + 30 gal. H_2O	3	13	389	402
" C48-13, 30 gal. undiluted	4	13	465	488
" C48-14, 20 gal. + 20 gal. H_2O	4	23	379	402
" C48-14, 20 gal. undiluted	7	43	427	453
" C48-14, 30 gal. + 30 gal. H_2O	1	36	353	370
" C48-14, 30 gal. undiluted	7	16	428	447
Cultivated	-	--	407	426
2,4-D, 1½ lbs. in 20 gal. H_2O	3	122	360	385
Allyl mixed chl. phenyl carbonate 12 lbs. + 6 gal. diesel + 94 gal. H_2O	8	77	309*	327*
2,4,5-T, 2 lbs. in 10 gal. H_2O	6	80	404	426
Penite 6, 1 gal. + 5 lbs. pentachlorphenol 100 gal. H_2O	0	15	449	477
Na pentachlorophenate 20 lbs. + 100 gal. H_2O	0	10	404	425
" " 10 lbs. + 10 gal. diesel + 90 gal. H_2O	0	16	420	441
IPC 10 lbs. + 50 gals. Varsol 2	0	14	457	475
F value	3.39	2.02	-------	--
F required at 5%(1%)	1.73 (2.15)	1.73 (2.15)	--	--
L.S.D. at 5%	--	--	96	96

*significantly lower than cultivated. #significantly higher than cult.

The data for weight of weeds and grass in relation to rate of application of the various petroleum products is similar to that given above for numbers of weeds. Statistically significant differences occurred from the application of diluted and undiluted materials. C48-9 and C48-10 controlled weeds best when undiluted, whereas C48-11 and C48-14 controlled weeds best when diluted with water. Grass control was best with undiluted materials although statistically significant only with C48-11 and C48-13.

Experiment 4. Soil type, variety, date of planting and date of pre-emergence application of chemicals are the same as in experiment 2. Chemicals were applied June 25 before emergence of any potato plants. Plots were 4 rows wide and 30 feet long, replicated four times. Triethanolamine salt of 2,4-D was applied at the rate of 100 gallons to the acre in the concentrations given in Table 14.

Yield data were not obtained as the experiment was abandoned late in the season because of excessive foxtail growth. There were, however, statistically significant differences in control of broadleaved weeds; better control resulting from 1½ and 2 lbs. to the acre than from 3/4 lb. per acre. Potato plants were injured slightly however, from the two higher rates of application. These results are similar to those presented concerning 2,4-D applications in experiments 2 and 3 above. They were on the same farm with the same soil type and with the Chippewa variety. Foxtail millet was extremely bad in this area.

Experiment 5. The Green Mountain variety was planted May 31, 1948, in Chenango gravelly silt loam soil and triethanolamine salt of 2,4-D was applied two weeks later in the concentrations shown in Table 15 before emergence of potatoes.

Since this experiment was primarily to test the effect of various amounts of 2,4-D on yields of potatoes, normal cultivation was given all plots throughout the season. As indicated in Table 15, there were no statistically significant differences in yields of U. S. 1 size or total yields between the various rates of application and the untreated plots. The difference in response to 2,4-D of the Green Mountain on this soil type and the Chippewa on Lordstown silt loam soil (experiments 2, 3 and 4) is very marked and indicates that further fundamental work on 2,4-D toxicity as related to soil type, soil moisture, variety, pH of soil, organic matter content of soil, etc. is badly needed.

Table 12. Effect of various oils, concentrations and rates of pre-emergence application on control of weeds in potatoes. 1948.

	Number of weeds per 4 sq. ft. 7/8/48							
	BROADLEAF				GRASS			
Oil	20 gal.	30 gal.	dil.	undil.	20 gal.	30 gal.	dil.	undil.
Esso C48-9	6.0	2.8	4.3	4.5	33.2	13.8	22.0	25.0
" C48-10	7.7	3.0	4.3	6.3	44.2	34.7	43.5	35.3
" C48-11	7.5	5.3	6.8	6.0	34.7	39.8	47.3	27.2
" C48-13	7.5	3.5	5.7	5.3	30.0	19.5	27.3	22.2
" C48-14	8.8	3.0	8.2	3.7	32.7	24.7	29.2	29.2
L. S. D. at 5%	2.9		NSD		NSD		NSD	

Table 13. Effect of various oils, concentrations and rates of pre-emergence application on control of weeds in potatoes.1948.

	Weight of weeds per 4 sq. ft. gms. 7/15/48							
	broadleaf				grass			
Oil	20 gal.	30 gal.	dil.	undil.	20 gal.	30 gal.	dil.	undil.
Esso C48-9	1.51	1.11	1.40	1.22	8.00	4.33	7.83	4.50
" C48-10	1.28	1.11	1.08	1.11	14.33	5.50	10.67	9.17
" C48-11	1.36	1.29	1.13	1.53	19.17	12.33	24.67	6.83
" C48-13	1.45	1.25	1.30	1.40	21.33	4.33	21.17	4.50
" C48-14	1.51	1.26	1.11	1.66	11.00	8.67	9.83	9.83
L.S.D. at 5%	0.11		0.11		6.18		6.18	

Table 14. Effect of pre-emergence application of various concentrations of 2,4-D on control of weeds and grass 1948. Chippewa

Treatment	Number of weeds in 4 sq.ft.area July 9 broadleaf	grass
2,4-D trieth-salt 3/4 lb.-100 gal.	18.0	9.9
" " " 1½ " - " "	8.5	8.6
" " " 2 " - " "	8.7	10.2
L. S. D. at 5%	6.30	
L. S. D. at 1%	9.63	NSD

Table 15. Effect of pre-emergence rates of application of 2,4-D on yields of potatoes. 1948. Var. Green Mountain.

Treatment	Yield, bushels per acre U. S. 1 size	Total
2,4-D, 3 lbs./A	317	326
2,4-D 1½ lbs./A	382	389
2,4-D 3/4 lb./A	348	355
No 2,4-D	370	381
F value	2.16	2.08
F required at 5%	4.76	4.76

No significant differences

Experiment 6. Sebago potatoes were planted the middle of May on Ontario loam soil and on May 26 applications of the chemicals listed in Table 16 were made before any potatoes had emerged. Plots were six rows in width and 100 feet long with 6 foot alleys at the ends of the plots. Records were obtained from the center two rows. Applications were made with low pressure pump and fan nozzles mounted on a jeep. Dow Contact weed killer was applied at the rate of 50 gallons per acre, all other materials at the rate of 7.5 gallons to the acre. All plots were cultivated once the latter part of June and sprayed with one pound 2,4-D per acre as triethanolamine salt on July 22. This experiment was conducted cooperatively with several members of the Cooperative G.L.F. Exchange, Ithaca, N. Y.

All chemical treatments reduced the numbers of broadleaved weeds to a highly significant degree as compared with one cultivation alone. Isopropyl ester form of 2,4-D at 2 and 3 lbs. to the acre was especially good. Although all treatments reduced the grass counts the differences were not statistically significant. All treatments yielded higher than the one cultivation alone although only triethanolamine salt of 2,4-D at 3 lbs. to the acre and ethyl ester form at one pound per acre were significantly higher. No injury was noted on any of the plants from any of the original pre-emergence applications nor from the one pound per acre post hilling application of 2,4-D as triethanolamine salt.

Twice as much 2,4-D was applied to some of these plots as to those on Lordstown silt loam with the Chippewa variety (experiments 2,3 and 4). Injury was plainly evident under the latter conditions but not the former.

Experiment 7. Effect of pre-emergence application of various chemical weed killers on specific gravity of potato tubers.

Although a large amount of research has been done on the control of weeds in various crops with chemicals little is known of the effect of these materials on the host crop. Obviously some of these chemicals may delay or hasten maturity or otherwise alter growth in such a manner that quality of the crop would be altered.

Chippewa and Green Mountain potatoes were grown with pre-emergence applied materials as listed in Tables 17, 18 and 19. Specific gravity of the mature tubers was determined from each treatment and is herewith presented.

Table 16. Effect of pre- and post-emergence application of chemicals in control of weeds and yields of potatoes. Sebago. 1948.

Chemicals and rates	No. of weeds per 4 sq.ft.6/18 broadleaf	grass	Yield, bu. per acre U.S.1 size
L.F.N.472(97%2,4-D)2 lbs.in 7½gal.H_2O	74.0	34.0	311
462(10%TPC)1 lb. in 7½ " "	33.5	21.2	343
Ethyl ester 2,4-D, 1 lb. in 7½ "	93.0	27.5	362
Triethanolamine 2,4-D, 2 lbs. in 7½ gal.	23.2	19.7	328
" " 3 " " " "	16.2	10.5	429
Isopropyl ester 2,4-D 2 lbs. in 7½ gal.	2.5	6.0	304
" " " 3 lbs. " " "	2.7	9.0	322
Dow Contact weed killer 3 gals.in 47 gals.	8.0	13.5	308
Untreated (one cultivation)	172.5	51.2	283
F value	9.89	1.25	3.09
F required at 5%(1%)	2.36(3.36)	2.36	2.36(3.36)
L.S.D. at 5%	52.5	N.S.	71.0

Table 17. Effect of pre-emergence application of various chemical weed killers on specific gravity of potato tubers.Chippewa.1948

Treatment	Average specific gravity of tubers
2,4-D triethanolamine salt, 1½ lbs.-10 gal.	1.0665
2,4-D " " 1½ lbs.-100 gal.	1.0681
Na trichloroacetate, 20 lbs.-100 gal.	1.0631
NH_4 " , 1.6 gal.-98.4 gal.	1.0616
Normal cultivation	1.0673
L. S. D. at 5%	.0029
L. S. D. at 1%	.0042

Table 18. Effect of pre-emergence application of various chemical weed killers on specific gravity of potato tubers. Chippewa 1948.

Treatment	Average specific gravity of tubers
2,4-D triethanolamine salt,1½ lbs.-20 gal.	1.0644
Na pentachlorophenate, 20 lbs.-100 gal.	1.0636
" " 10 lbs.-10 gal.diesel-90 gal. water	1.0629
Normal cultivation	1.0646
L. S. D. at 5%	NSD

Table 19. Effect of pre-emergence application of various concentrations of 2,4-D on specific gravity of potato tubers. 1948.Green Mt.

Treatment	Average specific gravity of tubers
2,4-D sodium salt 3 lbs.-100 gal.	1.0872
2,4-D " " 1½ " - " "	1.0853
2,4-D " " 3/4" - " "	1.0887
No treatment	1.0878
L. S. D. at 5%	NSD

Results in Table 17 show that sodium trichloroacetate at 20 lbs. to the acre and ammonium trichloroacetate at 1.6 gallons to the acre have reduced the specific gravity of the tubers to a significant degree.

As shown in Tables 18 and 19, however, no statistically significant reduction in specific gravity of tubers of Chippewa or Green Mountain variety resulted from pre-emergence application of any of the chemicals shown.

Chemical Weed Control in Potatoes on Long Island

Walter C. Jacob and Walter T. Scudder
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In continuation of the work on this subject reported at the Northeastern States Weed Control Conference last year, an experiment was conducted in 1948 at the Long Island Vegetable Research Farm, Riverhead, New York involving six materials at three rates each, both as pre and post emergence applications. The chief object of this experiment was to determine the variation in time of application which was possible to have and still maintain adequate weed control with no reduction in crop yield. Three forms of 2,4-D were used to obtain information as to the one most suitable for potatoes and the other materials were: a dinitro, Dow Contact weed killer; an unsaturated hydracarbon, H.A.N. 132; and granular cyanamid. Rates of application were selected to provide a wide range of expected crop injury from the post emergence treatments.

Material and Methods

Six materials at three rates each were used as follows: L.F.N. 472 (97% 2,4-D acid), sodium salt of 2,4-D, and triethanolamine salt of 2,4-D, each at 0.5, 1.0, and 2.0 pounds of 2,4-D per acre, Dow Contact weed killer at 2, 4 and 8 gallons per acre and H.A.N. 132 at 20, 25 and 30 gallons per acre. The above five materials were applied as sprays at the rate of 100 gallons per acre. In addition granular cyanamid was used at 100, 200 and 400 pounds per acre. Three dates of application were selected; (1) one week before emergence of potatoes, (2) emergence time and (3) two weeks after emergence. Plots which received normal cultivation were included for yield comparisons.

The spray treatments were applied with a compressed air hand sprayer and the cyanamid was mixed with sand and broadcast by hand.

Certified Green Mountain seed from Maine was used, and one ton per acre of 5-10-5 analysis fertilizer was applied in bands at planting time. Two weeks after planting the ridges were leveled with a spike toothed harrow.

The potatoes were planted on April 8 and 9 and the weed control treatments were applied on May 11, May 19 and June 1. The normal cultivation plots were weeded 7 times between May 20 and June 30.

Observations as to weed control and potato growth were made on July 2, after which the vines completely filled the rows.

The experiment was in a randomized block design with four replications. Each plot was four rows wide and 24 feet long. The center 20 feet of the middle two rows was used for harvest records. The cultivated plots were 216 feet long and 4 rows wide because of the

shape of the experiment and the need for open ends to permit the use of commercial cultivation equipment.

All data were subjected to analysis of variance procedures to determine significance of differences.

Results and Discussion

Weed Control Observations

A month after the final treatment 3 square foot samples of weeds were removed from each plot. These were weighed and then separated into two classes, crabgrass and broadleaved weeds for counting. The weight of weeds in grams per square foot for the various treatments is given in table 1.

Table 1. Weight of weeds in grams per square foot on plots of potatoes treated with various chemicals. (Observations one month after treatment)

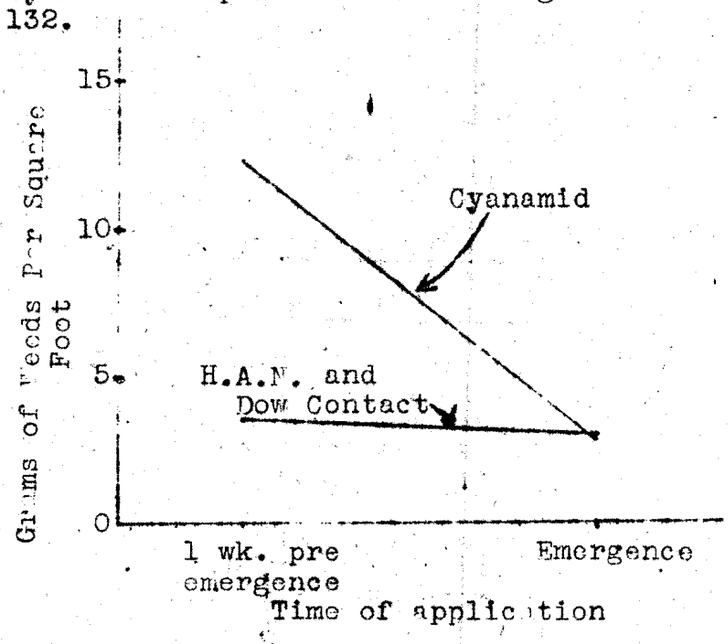
	Date of Application			
Material	1 wk. pre-emergence	Emergence	2 wks. post-emergence	Average
L.F.N. 472 (1)	5.23	4.17	5.44	4.95
Na 2,4-D	3.53	1.69	2.91	2.73
T.E.A. 2,4-D(2)	6.64	1.10	4.99	4.24
Dow Contact	1.90	2.54	2.50	2.31
H.A.N. 132	4.94	3.25	1.26	3.15
Cyanamid (granular)	12.26	2.78	5.01	6.68
Average	5.76	2.59	3.69	4.01

(1) 97% 2,4-D acid
(2) Triethanolamine salt of 2,4-D

Since there was a consistent linear reduction in weed weight caused by increasing the rate of application for all chemicals, the average of the three rates is presented. Analysis of the averages for each material indicates that both Dow Contact and H.A.N. 132 reduced the weed weight significantly below cyanamid. Also the application at emergence time gave smaller weight of weeds than application one week before emergence. This influence of time of application was much more marked with cyanamid than with the H.A.N. 132 and Dow Contact. This can be seen more clearly in figure 1.

The number of crabgrass plants per square fluctuated randomly about a general mean of 4.4. There was no significant effect from any of the treatments on the population of crabgrass so these data will not be presented.

Figure 1. Influence of date of application on the reduction in weight of weeds per square foot on plots treated with cyanamid compared to the average of Dow Contact and H.A.N. 132.



Most of the differences in weed weights could be accounted for by the number of broadleaved weeds present. Lamb's quarters and smartweed constituted the major portion of this classification.

Table 2 is a summary of the effect of materials on number of broadleaved weeds. The important observations here is the very low count for Dow Contact. None of the others differed significantly.

Table 2. Number of broadleaved weeds per square foot on plots of potatoes treated with various chemicals: (Observations one month after treatment)

Material	No. of weeds	Sq. Root*
L.F.N. 472 (1)	4.7	2,28
Na 2,4-D	4.3	2.20
T.E.A. 2,4-D (2)	5.1	2.37
Dow Contact	1.2	1.33
H.A.N. 132	3.7	2.06
Cyanamid (granular)	4.4	2.22

*For purposes of analysis the data were transformed to square root x + 0.5.
(1) 97% 2,4-D acid
(2) Triethanolamine salt of 2,4-D

Table 3. Influence of time of application of weed control materials on number of broadleaved weeds present per square foot.
(Observations one month after treatment)

Date	No. of weeds	Sq.Root*
One wk. pre-emergence	6.3	2.61
Emergence	2.9	1.84
Two wks. post-emergence	2.7	1.78

* For purposes of analysis the data were transformed to square root of x + 0.5.

Table 4. Influence of rate of application of weed control materials on the number of broadleaved weeds present per square foot.
(Observations one month after treatment)

Rate	No. of weeds	Sq.Root*
Low	4.1	2.15
Medium	4.7	2.27
High	2.8	1.81

* For purposes of analysis the data were transformed to square root of x + 0.5.

From table 3 it can be seen that applidation one week before emergencettime was less effective than either emergence or post-emergence applications. On the average of all materials a significant reduction in broadleaved weed population was found at the high rate of application compared to the two lower rates (table 4).

Since there were some few other grasses present in addition to crabgrass, it was considered advisable to analyze the total weed count per square foot. Table 5 gives the total number of weeds per square foot for the various materials applied. Here the only significance is that Dow Contact and H.A.N. 132 are both lower than the others but not different from each other.

Table 5. Total number of weeds per square foot in plots of potatoes treated with various chemicals.
(Observations one month after treatment).

Material	No. of weeds	Sq.Root*
L.F.N. 472 (1)	11.7	3.49
Na 2,4-D	9.4	3.14
T.E.A. 2,4-D (2)	10.1	3.25
Dow Contact	6.1	2.56
H.A.N. 132	8.2	2.95
Cyanamid (granular)	10.1	3.25

* For purposes of analysis the data were transformed to square root of x + 0.5.
(1)97% 2,4-D
(2)Triethanolamine of 2,4-D

Table 6. Influence of time of application of weed control materials on total number of weeds present per square foot.

Date	No. of weeds	Sq.Root*
One wk. pre-emergence	11.3	3.44
Emergence	8.0	2.92
Two wks. post-emergence	8.2	2.95

* For purposes of analysis the data were transformed to square root of x + 0.5.

In table 6 it can be seen that one week pre-emergence was not as satisfactory as the time of emergence or two weeks after emergence. From table 7 it may be concluded that the high rate gave better weed control than the two lower ones.

Table 7. Influence of rate of application of weed control materials on the total number of weeds present per square foot.
(Observations made one month after treatment)

Rate	No. of weeds	Sq. Root*
Low	9.9	3.23
Medium	10.3	3.29
High	7.3	2.80

* For purposes of analysis the data were transformed to square root of x + 0.5.

It should be pointed out here that the weed counts failed to reflect the high weed weight on the early cyanamid plots as shown in table 1. Perhaps some better measure of weed competition may be obtained by a size estimate of weeds in addition to numbers.

Yield of Potatoes

The final estimate of the usefulness of a weed control treatment is its effect on the yield of the crop. The influence on yield of the various materials applied at different times is shown in table 8.

There was a significant decrease in yield by L.F.N. 472 and Dow Contact compared to the other treatments, and all of the chemically treated plots yielded significantly less than the normally cultivated ones. As can be observed from this table there were some differential yield responses to materials applied at different times.

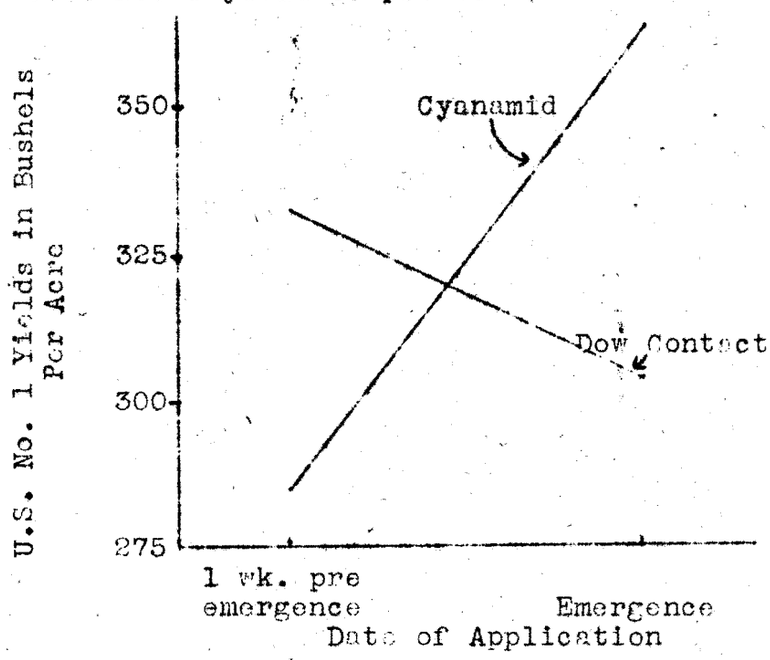
Figure 2 shows the increase in yield by cyanamid applied at emergence time compared to one week earlier as contrasted to the decrease obtained by applying Dow Contact at the same dates respectively.

Table 8. Yield of U.S. No. 1 potatoes in bushels per acre as influenced by various weed control materials applied at different dates.

Material	Date of Application: 1 wk. pre emergence	Emergence	2 wks. post emergence	Ave.
L.F.N. 472 (1)	325	268	288	294
Na 2,4-D	352	350	319	340
T.E.A. 2,4-D (2)	366	377	259	334
Dow Contact	332	304	245	294
H.A.N. 132	334	343	321	333
Cyanamid (granular)	286	364	346	332
Average	332	335	297	321
Untreated				360

(1) 97% 2,4-D acid
(2) Triethanolamine salt of 2,4-D

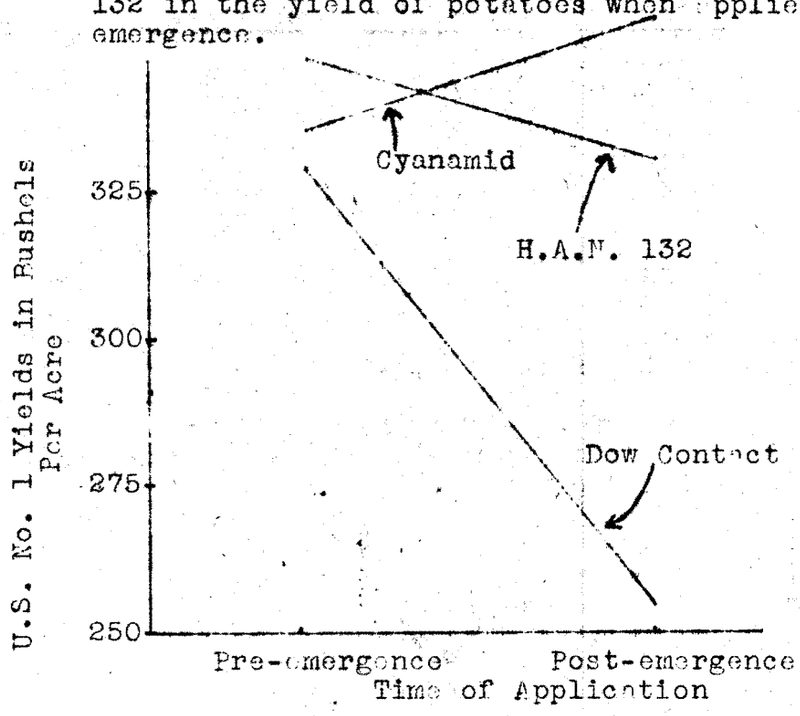
Figure 2. Influence of date of pre-emergence application on the differential effect of Cyanamid and Dow Contact on the U.S. No. 1 yield of potatoes.



The increase from cyanamid is probably caused by the improved weed control at the second time of application. The first application did not kill the weeds and the added nitrogen gave these weeds a much better chance to compete with the potatoes for moisture and nutrients. Averaging the pre-emergence and emergence dates and comparing this average with the post-emergence treatments, it can be seen in figure 3

that cyanamid was not injurious to the crop when applied two weeks after the potatoes were up. However, both Dow Contact and H.A.N. 132 decreased the yields more when applied post-emergence than when applied pre-emergence.

Figure 3. Differential effects of cyanamid, Dow Contact and H.A.N. 132 in the yield of potatoes when applied pre and post-emergence.



Likewise, 2,4-D decreased the yields when applied post-emergence (figure 4) and the triethanolaimne salt was much worse in this respect than was the sodium salt.

The yield figures indicate that there was only very slight tolerance permissable in varying the time of application of the various weed control chemicals. Too early application allowed the weeds to escape injury and too late application caused considerable injury to the potatoes. Application at emergence time seemed to be most promising.

The early part of the 1948 season was very wet and as a result 2,4-D was much more injurious than had been found previously.

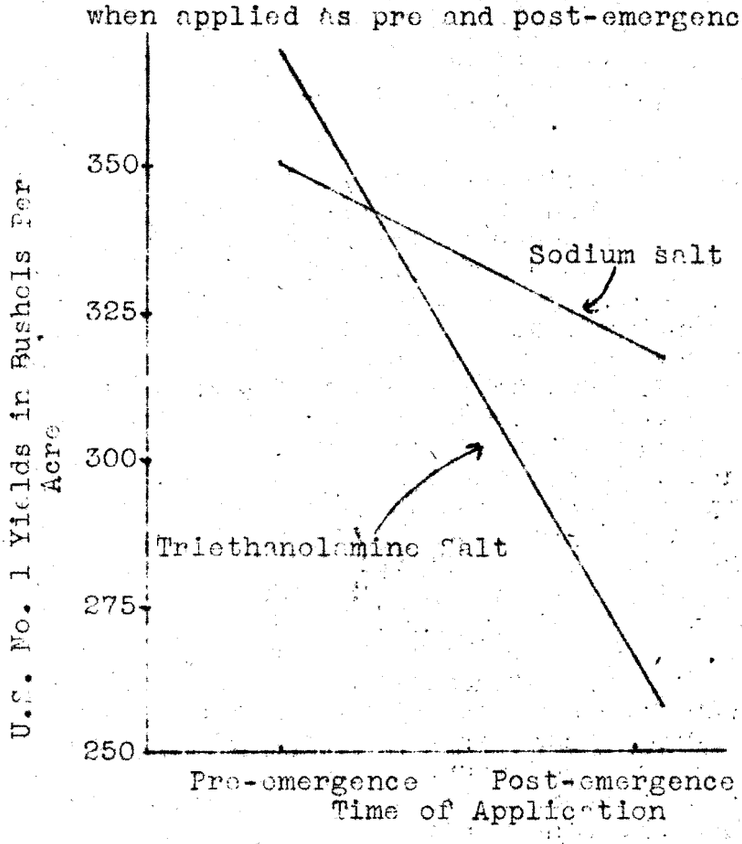
Summary

Six materials at three concentrations each were applied to potatoes at three different times to determine weed control and crop response. Post emergence application of most of the materials injured the crop and reduced the yield even though weed control was

at time emergence

excellent. None of the plots treated with weed control chemicals yielded as well as did the normally cultivated plots. From the standpoint of optimum weed control with minimum crop injury, materials should be applied as near as possible to time of emergence of the potatoes.

Figure 4. Differential effect of two salts of 2,4-D of potatoes when applied as pre and post-emergence treatments.



"1948 Results of Weed Control in Potatoes with Cyanamid and 2,4-D"

J. C. Campbell and D. E. Wolf[1]

The use of chemicals to control weeds in potatoes was investigated at the New Jersey Agricultural Experiment Station during the 1948 season. The two chemicals used were 2,4-D and granular "Aero" cyanamid. Because of the success of pre-emergence treatments with these chemicals in corn, this type of treatment has been suggested for potatoes.

Cyanamid was applied to plots on two different dates after the potatoes had been planted but before they had emerged. Potatoes of the Katahdin variety were planted on May 10th, using 2200 pounds of 4-12-8 fertilizer per acre. Cyanamid was applied broadcast on some plots on May 21st and on others on May 28th. Split applications were made on other plots, the first applied on May 21st and the other May 28th. Rates of treatments were 200, 400, 600 and 800 pounds per acre and the split applications at the rate of 100 and 200 pounds each date. Plots in this experiment were replicated 3 times and randomized. Granular cyanamid was applied with a "Cyanamid Spreader" to 4 row plots. Because of the exceedingly wet spring, it was impossible to cultivate the plots as was intended and it was necessary to pull the weeds out of the check plots by hand. Because of this weed competition which became a factor in the plots later in the season, yields were variable and not as high as might be expected. Comparisons are valid however on relative yields, and on weed counts made 4 weeks after the last treatments were applied. This data is summarized in the following table:

Rate	Days After Planting	Mean Weed Count	% of Check
100	11 - 18	57	71
200	11 - 18	37	46
200	11 - --	55	69
400	11 - --	47	59
600	11 - --	26	32
800	11 - --	21	26
200	-- - 18	69	86
400	-- - 18	36	45
600	-- - 18	36	45
800	-- - 18	19	24
Check		80	100

[1]Assistant Research Specialist in Plant Pathology and Agent, U.S.D.A., respectively, N. J. Agricultural Experiment Station.

No injurious effects were noted on the potatoes from the cyanamid treatments. Plants in the plots receiving the cyanamid were darker green in color beginning about June 15. Good weed control was obtained by treatments at the rate of 400 pounds and above. There was a trend toward increased yields as rates of Cyanamid were increased. This control of weeds eliminated the need for the first two cultivations and the plots remained rather free of weeds until about the middle of July. This method of treatment shows promise as a weed control practice and should be further investigated.

Use of 2,4-D

Since the use of 2,4-D as a method of controlling weeds in corn has been shown to be practical, it was also tried on potatoes.

In a pre-emergence experiment, treatments were made sixteen days after the potatoes were planted. Rates of 1/2, 1 and 2 pounds of 2,4-D in the amine form were used in this experiment. All plots were cultivated once late in the season, no cultivation being made during the growing season. The ridges made over the seed pieces at planting time were not harrowed down as is the usual practice and this low ridge aided greatly in reducing tuber damage from sunburn.

Good weed control was obtained by all rates of treatment but 2 pounds per acre kept the plots free from weeds for a much longer period of time than did the smaller quantities. Weed counts were low even in the check plots and the only weed that ever really became a problem in the test plots was crabgrass.

Potato plants in the plots receiving 1/2 and 1 pound 2,4-D per acre were normal and unaffected by the treatment while plants in the plots receiving 2 pounds per acre showed some distortion and stunting. Weed counts and yields are summarized in the following table.

Treatment	No. weeds per sq. ft.	% of Check	Yield in bus./A	% of Check
0	23	100	329	100
½	11	48	345	106
1	10	44	315	96
2	7	30	259*	79

*Significantly lower than the control plot at the 5% level.

Preliminary data from this experiment would indicate that pre-emergence treatment with 2,4-D does have some promise as a method of controlling weeds in potatoes. It is apparent also that under these conditions, rates of ½ to 1 pound per acre would be most satisfactory. Much more research under various soil and weather conditions are necessary before any recommendations can be made in New Jersey. Cultivation is often desirable on some soils even in plots where weeds are not a problem.

Post-emergence treatment of potatoes with 1/8, 1/4 and 1/2 pound of the amine salt of 2,4-D was tried in several preliminary experiments in New Jersey in 1948. In all cases excellent control of broad-leaved weeds was obtained, but the effect on the potatoes was variable. These affects ranged from no injury to severe injury to both plants and yields. No logical explanation of these differences can be given at this time. The results were so inconsistent that no data from these experiments is given.

Taste tests were made on potatoes taken from the plots receiving cyanamid and the pre- and post-emergence plots of 2,4-D. No difference in quality, flavor or odor was detected by this test.

Both cyanamid and 2,4-D show promise as weed control chemicals for use in potatoes. However, much more data is needed before recommendations can be made.

Treatments for Weed Control in Potatoes

Katahdin variety used. Localities, Center and Lehigh Co.

Per Acre Treatment	Total weeds Dicots	Total weeds Monocots	Bu. per A Ave.	Bu. per A Center Co.	Bu. per A Lehigh	Bu per A Av.both
1. 2 lbs. 2,4-D acid	30	183	391.0	485.0		422
2. 4	9	71	395.0	462.0		417
3. 6	6	160	378.0	370.0		375
4. 2 lbs. 2,4-D B. Es.	6	122	393.0	341.0		376
5. 4	12	201	318.0	346.0		327
6. 6	3	92	386.0	408.0		393
7. 50 lbs. ammate	39	260	338.0	423.0		366
8. 100 lbs. ammate	31	191	421.0	427.0		423
9. 500 lbs. cyanamid	34	205	418.0	441.0		426
10. 900	17	156	442.0	489.0		453
11. 1200	17	131	484.0	532.0		498
12. 100 gal. oil sol.(Post)			313.0	378.0		335
13. 150			289.0	371.0		316
14. Check	81	315	349.0	431.0		372
15. 1/2 lb. 2,4-D B. Ester (Post)			347.0	325.0		340
16. 3/4 lb.			297.0	396.0		330
			L.S.D.	L.S.D.		L.S.D.
			1% 140	1% 84		1% 96

Preemergence here means one week before plants broke thru the ground. All treatments were thus except those marked (Post).

Treatments were applied in a 1 ft. wide band across the row, so that only 1/3 the material required per acre was actually used.

Weed counts were made 5 weeks after treatment and represent the same relative area over each plot.

Plots consisted of 4 rows, each 40 ft. long.

Post emergence treatments were made 4 weeks after the plants emerged. The plants and weeds were a foot or more in heighth. Poor weed control was obtained and considerable top damage was in evidence.

A dry spell of weather followed the treatments for about 10 days. Some top damage was seen on the 2 and 4 lb. 2,4-D plots and considerable on the 6 lb. 2,4-D plots. This damage seemed to be gone after 4 weeks of growth.

However, the difference in yield does not seem to be consistent. The reduction in weed population as compared with the check is fairly consistent for the heavier treatments. The only seemingly significant increase in yield is from the 1200 lbs. cyanamid which may be chiefly fertility benefits.

Altho the weeds were reduced by some 2,4-D treatments, the yields were not raised significantly above the check.

REVOLUTIONARY CHANGES IN POTATO PRODUCTION AS A RESULT OF WEED CONTROL

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Department of Vegetable Crops, Cornell University

The control of weeds in potatoes with chemicals is perhaps the livest topic in potato production today. The potentialities of this phase of potato growing is tremendous and has promise of being the biggest labor saver since mechanized potato growing arrived. Weeds take a heavy toll annually in reducing yields of potatoes although much time and expense is involved in cultural practices devoted to the purpose of controlling weeds. Conventional methods of soil stirring for weed control injure and destroy some potato roots. Control of weeds with chemicals will make it possible to avoid this root injury. The idea of weed control in potatoes with chemicals is extremely new and this work is still in the experimental stage.

Chemicals adapted to this purpose are classified as dinitro compounds, such as Dow Contact Herbicide and Sinox General, certain petroleum products and growth regulators. Weeds may be killed by application of contact herbicides which are non-selective, killing the portions of the weeds with which they come in contact. Selective herbicides kill some types of plants, leaving others uninjured. Soil application of chemicals appears to have the greatest potentialities in the control of weeds in potatoes, although this may be supplemented with subsequent application of selective weed killers. In New York State we found in 1946 that potatoes could be grown successfully without any cultivation whatever. No tool except the sprayer for insect and disease control touched the land between the planting and harvesting operations. 2,4-dichlorophenoxyacetic acid (2,4-D) was applied at rather high rates two weeks after planting but before potato emergence. This method of treatment for control of weeds we have designated "pre-emergence application."

In 1947 further experiments on a more extensive scale were made. Applications of about 20 chemicals singly and in combination at several concentrations were made at various intervals after planting. When applied at this time and with no further stirring of the soil good control of grasses and broadleaved weeds was obtained. Yields of these plots were equivalent to those receiving the accepted cultivation procedures. Some of these chemicals were 2,4-D, Sinox General, Dow Contact Herbicide and several petroleum products such as Aromatics HB and Heavy Aromatic Naphtha No. 132. During the current growing season there are many areas in which experiments on chemical weed control are being conducted. In New York State we have found several additional chemicals which, when applied at "pre-emergence" have given excellent weed control with no injury to potatoes. Some

of these are sodium pentachlorphenate, ammonium trichloroacetate, sodium trichloroacetate, and several petroleum products applied either as thirty per cent emulsions at the rate of 100 gallons to the acre or undiluted at the rate of 30 gallons to the acre.

Assuming that chemical control of weeds will be as widely practiced in the near future as application of fertilizers are at present, it is necessary that we look into the future to determine what this may do to other potato cultural practices. The main reason for spacing rows of potatoes 32 to 36 inches apart is to furnish space for the cultivator in weed control. Assuming that weeds will be controlled by chemical sprays it no longer will be necessary to waste this space. We now have experiments in progress where potatoes are planted 11 x 10 inches over the entire area except for passage of sprayer wheels at each 30 to 35 foot width. With plane or helicopter application of insecticides and fungicides this area also could be planted. Of course, by this close spacing we are multiplying the number of plants per acre by three, hence more nutrients will be needed to grow this crop. Consequently we have applied fertilizers at rates as high as 5000 pounds 5-10-15 per acre. Since moisture supply may be the limiting factor we also are equipped with irrigation. The use of blight-resistant varieties also will aid in the control of late blight in the close-planted fields.

1948 Experiments

METHODS

The Sebago variety was grown and planted June 3 and 4, 1948 in Lordstown silt loam soil of pH 4.8-5.2. The crop was harvested for records October 6, border rows not being included.

The following treatments were made:

A. Method of weed control

(1) 2,4-D, 2 lbs. in 100 gals. water per acre
(2) Wheel hoe
(3) Normal tractor cultivation

B. Spacing of rows and seed pieces

(1) 34" x 10" (normal spacing)
(2) 11-1/3" x 10" (close spacing)

C. Soil moisture level

(1) Unirrigated
(2) Irrigated (rainfall plus irrigation 1" per week)

D. Soil fertility level

(1) 2500 lbs. 5-10-15 per acre
(2) 5000 lbs. 5-10-15 per acre

The experiment was of factorial design. Plants were sprayed with Bordeaux mixture and DDT at weekly intervals with no wheel injury to any of the plants. Plots of 11-1/3 ft. x 30 ft. were in triplicate. All fertilizer was broadcast before plowing. Triethanolamine salt of 2,4-D was applied with knapsack sprayers on June 17, which was 13 and 14 days after planting, before emergence of any potato plants. Rainfall was adequate and well distributed throughout the season, hence no irrigation was necessary. Specific gravity determinations of each treatment were made by weighing samples in air and in water.

RESULTS

The results represented in table 1 show that yields of U. S. No. 1 size tubers (above 1-7/8") were not influenced by any of the treatments to a significant amount.

Table 1. Effect of fertilization, spacing and methods of weed control on yield of potatoes. 1948. Variety, Sebago.

Treatment	Yield, bu. per acre		
	U.S.No. 1	Size 2	Total
2,4-D;34"x10"; 2500 lbs. 5-10-15	586	71	657
2,4-D;34"x10"; 5000 lbs. "	618	75	693
2,4-D;11-1/3"x10"; 2500 lbs. 5-10-15	617	237	854
2,4-D;11-1/3"x10"; 5000 lbs. "	672	226	898
Wheel hoed;34"x10"; 2500 lbs. "	695	60	755
Wheel hoed;34"x10"; 5000 lbs. "	700	63	763
Wheel hoed;11-1/3"x10"; 2500 lbs."	628	223	851
Wheel hoed;11-1/3"x10"; 5000 lbs."	709	227	936
Tractor cultivated;34"x10"; 2500 lbs. 5-10-15	665	73	738
Tractor cultivated;34"x10"; 5000 lbs. 5-10-15	686	71	757
F value	1.87	70.96	7.13
F required at 5% (1%)	2.46	2.46(3.60)	2.46(3.60)
L.S.D. at 5%	N.S.	9.7	33
L.S.D. at 1%		13.3	46

Number 2 size potato yields were affected to a highly significant degree primarily by spacing. Significant differences in yield of No. 2 tubers also exist between 2,4-D treated potatoes and wheel hoed plots when both were planted normal distances. 2,4-D treated plots with close spacing at low fertilizer rate had more No. 2's than any

other closely spaced plots regardless of weed control method or rate of fertilizer application. Lowest yields of No. 2's were in plots wheel hoed and spaced normally.

Highly significant differences in total yield were obtained between several of the combinations of treatments. Lowest yields resulted from normal spacing, low rate of fertilizer application and 2,4-D application. Highest yields occurred in closely-spaced, wheel hoed plots with high rate of application of fertilizer. The results in table 2 are grouped to indicate differences from one or two of the three varied factors. There are indications that 2,4-D applications have reduced total yields and perhaps yields of U. S. No. 1 size as compared with wheel hoeing and tractor cultivation.

Table 2. Effect of fertilization, spacing and methods of weed control on yields of potatoes. 1948. Variety, Sebago.

Treatment	Yield, bu. per acre		
	U.S. No. 1	No. 2 Size	Total
2,4-D, 2 lbs. per acre	623	152	775
Wheel hoed	683	143	826
2,4-D, 2 lbs. per acre	602	73	675
tractor cultivated	675	72	747
2,4-D; close spacing	644	221	865
2,4-D; normal spacing	602	73	675
Wheel hoed; close spacing	668	225	893
Wheel hoed; normal spacing	697	61	758
Tractor cultivated; normal spacing	675	72	747
2,4-D; 2500 lbs. 5-10-15	601	154	755
2,4-D; 5000 lbs. 5-10-15	645	150	795
Wheel hoed; 2500 lbs. 5-10-15	661	141	802
Wheel hoed; 5000 lbs. 5-10-15	704	145	849
Close spacing	656	223	879
Normal spacing	650	67	717
2500 lbs. 5-10-15	631	147	778
5000 lbs. 5-10-15	675	147	822

Yields of U. S. 1 size are practically the same at the two spacing distances but total yields and yields of No. 2 size are much higher on closely spaced plots.

Slight but consistent increases of U. S. 1 size and total yield occur at the higher rate of application of fertilizer.

Growers of table stock potatoes are interested in methods of growing potatoes which might result in changes in mealiness of cooked potatoes as measured by the specific gravity method. Seed stock growers desire some method of growing potatoes which will reduce the average size of tubers since these can be more economically prepared for planting and are in greater demand than the larger tubers. Results of both of these measurements are shown in table 3.

Table 3. Effect of fertilization, spacing and methods of weed control on size and specific gravity of U. S. 1 size potatoes. 1948. Sebago.

Treatment	Specific gravity	No. U.S.1 size tubers per bushel	Wt. per U.S.1 size tubers, ozs.
2,4-D; 34"x10"; 2500 lbs. per A.	1.0732	195	4.93
2,4-D; 34"x10"; 5000 " " "	1.0706	202	4.82
2,4-D; 11-1/3"x10";2500 lbs.per A.	1.0690	271	3.55
2,4-D; 11-1/3"x10";5000 " " "	1.0686	259	3.71
Wheel hoed; 34"x10";2500 " " "	1.0714	187	5.15
Wheel hoed; 34"x10";5000 " " "	1.0698	188	5.12
Wheel hoed;11-1/3"x10";2500 lbs.per A.	1.0702	265	3.63
Wheel hoed;11-1/3"x10";5000 " " "	1.0683	246	3.91
Tractor cult; 34"x10"; 2500 " " "	1.0740	207	4.65
Tractor cult; 34"x10"; 5000 " " "	1.0684	195	4.99
L. S. D. at 5%	.0034	24.5	0.51
L. S. D. at 1%	.0047	33.6	0.71

Application of 2,4-D has not influenced the specific gravity of tubers. In every comparison, high rate of fertilizer application has resulted in lowered specific gravity, although significant in only one case.

There are highly significant differences in the sizes of U. S. 1 tubers as indicated by weight per tuber and number per bushel. Neither application of 2,4-D nor rate of fertilizer application has influenced the weight or size of tubers. Spacing has greatly affected tuber size, the smaller tubers occurring at the close spacing.

EFFECTS OBSERVED FROM THE USE OF 2,4-D IN VARIED FIELD TRIALS

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One of the most outstanding herbicides for specific field crops is 2,4-dichlorophenoxyacetic acid. Unfortunately this chemical cannot be used at all stages of growth or on all types of soil because of the injury that may occur to the crops. Field and sweet corn, small grains (not seeded), asparagus and potatoes have been sprayed with 2,4-D with a high degree of success. Warren and Hernandez (5) used rates of 2, 3 and 4 pounds of acid equivalent per acre of 2,4-D as a pre-emergence, observing good weed control on corn and injury occurring only at the higher rates. Ellis and Bullard's (3) work showed the varietal response of sweet corn to 2,4-D spray and Ennis, Svanson, Allard and Boyd (4) used 2,4-D with some success on potatoes. Alban and Keirns (1) sprayed asparagus beds immediately after discing controlling all broad leaf weeds throughout the cutting season with a minimum of injury to the asparagus plant.

Materials and Methods

The 2,4-D used was triethanolamine salt, sodium salt and various ester formulations. The work was accomplished on farms in New York and Long Island, New Jersey and Pennsylvania. The soil varied from a very sandy loam in south Jersey to the heavy loams of New York; muck soils were also sprayed.

For pre-emergence spray 1 to 3 pounds acid equivalent per acre of both the amine salt and ester was used. For post-emergence sprays $\frac{1}{4}$ to 1 pound of the amine salt was applied. Applications were made with a jeep mounted with a low gallonage, low pressure spray equipment. Plots usually consisted of a minimum of 6 rows sprayed the length of the field. A minimum of four replicated and randomized plots were used in some of the tests. Rate of application was 7.5 gallons of spray per acre.

The following weed species were present in most cases: Curled Dock (Rumex crispis), Pigweed (Amaranthus retroflexus), Purslane (Portulaca oleracea), Lambs quarters (Chenopodium albun), Chickweed (Stellaria media), Wild mustard (Brassica arvensis), Field Bindweed (Convolvulus arvensis), Common Ragweed (Ambrosia artemisiifolia) and Canada thistle (Cersium arvense), was also present in the small grain plots.

Results

2,4-D Pre-emergence with corn, potatoes and asparagus:-- Concentrations of 1 and 2 pounds of the triethanolamine salt and isopropyl ester were used as a pre-emergence herbicidal treatment with field plantings of sweet corn. Applications

were made after the corn had been seeded several days but just before the corn seedling broke through the ground.

Concentrations of 1 and 2 pounds of the triethanolamine salt and the isopropyl ester gave excellent initial weed control, while the concentration of one pound per acre of the amine salt and ester lost their residual effect after 3 weeks. The 2 pound per acre concentration of both materials gave good weed control for 4 to 6 weeks.

Four weeks after application, weeds were counted in 20 one square foot sections chosen at random, and the results are presented in Table I.

Table I

Formulation of 2,4-D	Rate per Acre	Total weeds in 20 sq. ft., 4 weeks after application	Average total weeds per square foot
Triethanolamine salt	1-lb.	210	10.5
Triethanolamine salt	2-lb.	140	7.0
Check	--	736	36.8
Isopropyl ester	1-lb.	236	11.8
Isopropyl ester	2-lb.	110	5.5

The relatively good control of grasses, compared with broad leaf weeds is supported by results of other workers (2). Observations of grass control as high as 90% in the higher concentrations were noted in some of the trials.

Although weeds were materially reduced in sweet corn plantings using 2,4-D spray, varietal response to 2,4-D was an important factor. Ellis and Bullard's work (3) showed a large range of susceptibility with sweet corn varieties. Results of our field trials showed North Star and Seneca Dawn to be very susceptible to 2,4-D injury. Span Cross and Golden Cross was less tolerant while Lincoln was the most tolerant to 2,4-D injury.

Weed control in field corn plots was similar to that in sweet corn field trials, but field corn did not show as much susceptibility within varieties as did sweet corn.

In general, observations from these plots have shown that soil moisture and soil type are important factors in the effectiveness of 2,4-D as well as injury from 2,4-D.

Rain immediately following application greatly reduced the effect of weed control with 2,4-D. Applications followed by rain in many cases increased initial injury to the crop. Rain within 48 hours following application decreased residual effect of 2,4-D. These injuries consisted of curling and whipping of leaves, bracer root injury and yellowing of leaves.

The type of soil had an important effect on the crop injury where 2,4-D was used as a pre-emergence in field trials. When 2,4-D was used at 1 and 2 pounds acid equivalent per acre on very light, sandy and gravelly soils, as found in some locations in New Jersey and northern New York, injury to sweet and field corn was observed; whereas when 2,4-D was applied to these crops grown on soils of heavier structure, such as the loams and even sandy loams, no visible injury was observed using the same rates of application.

Concentrations of 1 and 2 pounds of triethanolamine salt and isopropyl ester of 2,4-D per acre was used as a pre-emergence spray on Katahdin potatoes. Weeds were materially reduced in plots using both forms of 2,4-D. Four weeks after application of the 2,4-D the weeds were counted in 20 one square foot sections selected at random and the results are presented in Table II.

Table II

Formulation of 2,4-D	Rate per Acre	Total weeds in 20 sq. ft., 4 weeks after application	Average total weeds per square foot
Triethanolamine salt	1-lb.	147	7.3
Triethanolamine salt	2-lb.	23	1.01
Check	--	357	17.85
Isopropyl ester	1-lb.	23	1.0
Isopropyl ester	2-lb.	21	1.0
Check	--	454	22.7

Annual grasses were satisfactorily controlled and plots containing the higher concentrations of 2,4-D were 80 to 90% free of these grasses when weed counts were taken. This observation is supported by results of other workers (2) showing

that pre-emergence sprays give relatively good control of grasses.

Soil moisture and the type of soil plays an important part in the effectiveness of 2,4-D when applied as pre-emergence spray to potatoes.

Severe injury was observed when potatoes received a pre-emergence spray on very light, sandy soil such as found in parts of southern New Jersey. When 2,4-D was used on the sandy loams as found on Long Island and central New Jersey, no injury was observed.

When established asparagus beds were treated with 2,4-D at 1 and 2 pounds acid equivalent per acre immediately after discing, weeds were satisfactorily controlled and grasses were controlled 60-65%. There was no injury to the asparagus spears when used at this rate and time of application. 2,4-D sprayed at 1 pound per acre after cutting, weed control again was satisfactory. However, drop pipes were used to avoid hitting the tops of the ferns with the spray to avoid injury.

2,4-D Post-emergence with corn and small grains (not seeded):--Concentrations of 1/4 to 1 pound of 2,4-D per acre were applied to sweet and field corn. Both the isopropyl ester and the triethanolamine salt were used. Corn sprayed varied in height from 3" up to 5' tall but before tasseling. Some of the plots received a pre-emergence spray without cultivation while other field trials were cultivated at least once before applying a post-emergence spray. It was interesting to note that in all post-emergence sprays applied to field corn under 14" - 16" tall, no bracer root or leaf curling injury was noticed while sweet corn showed definite varietal differences at equal rates of application. When sprays were applied to field corn over 1-1/2' tall these injuries were observed. The amount of bracer root injury was proportional to the height of the corn and also the concentration used. Brittle stalks and leaf curling were also proportional to the height of the plant and the concentration used when 2,4-D was applied after the corn was over 1-1/2' tall.

In a field trial on Long Island a post-emergence spray was applied to 613 Marcross variety three days after cultivation; corn was 6" - 8" tall. The spray was applied directly over the corn plants. Twenty, one square foot sections were chosen at random throughout the plant and check three weeks after application; results are presented in Table III.

Table III

Material	Rate	Weed count in 20 sq. ft. at random	Average number of weeds per sq. ft.
Triethanolamine salt	1/2-lb. per acre	101	5.0
Check	--	548	27.4

Concentrations of 1/4 and 1/2 pound per acre of amine salt of 2,4-D were applied to many fields of oats and wheat (not seeded). Applications were made when the grain was from 3" to 6" tall or fully tillered up to jointing time. Concentrations not exceeding 1/2 pound of 2,4-D per acre gave no injury to the grain. When the rate of 1-1/2 pounds 2,4-D per acre was used to kill the more resistant weeds, the grain had smaller leaves with yellow color and heading was delayed.

Small grains (seeded to Red clover and Ladino):--Oats sprayed after heading was completed to avoid mustard seed formation, at the rate of 1/4 pound acid equivalent per acre of the amine salt, was very effective without any visible injury to the crop. In general little injury occurred to red clover seeded with the oats when sprayed at this stage of development and the clover plants recovered from the slight injury that did occur with little reduction in stand.

2,4-D spray on strawberries the year planted:-- Concentrations of .4 to 1-1/2 pounds sodium salt and amine salt of 2,4-D gave varied results when applied to established beds of strawberries. In most areas of New York State and New Jersey 1 pound of 2,4-D acid equivalent per acre gave good control of broad leaf weeds when application was made in early spring. When 2,4-D was applied to strawberries on light, sandy soils in northern New York, injury was observed with concentrations as low as .4 pound per acre of both sodium salt and amine salt formulations. Weed control was satisfactory with both types of 2,4-D but the sodium salt of 2,4-D gave varied weed control when different formulations of this material was used.

Formulation differences:--In general, when equal concentrations of acid equivalent of esters and amine salt formulations were used at rates to produce injury, initial injury was greater to crops sprayed with the ester formulations. No difference in ultimate weed kill resulted

between formulations. Some of the ester formulations showed longer residual effect in pre-emergence applications.

Summary

Pre-emergence and post-emergence herbicidal application of 2,4-D in various forms were applied to sweet and field corn, potatoes and asparagus. Post-emergence sprays were applied to small grains (not seeded).

In general, pre-emergence sprays at 1 pound of 2,4-D per acre controlled weeds for two to three weeks while 2 pounds of 2,4-D per acre controlled broad leaf weeds as long as 6 weeks under widely varied field conditions.

Concentrations of 2 pounds of 2,4-D per acre gave relatively good control of annual grasses in corn, potatoes and asparagus plantings.

Soil moisture and soil types were an important factor in the effectiveness of 2,4-D and injury to the crops from the use of this herbicide.

Weather condition following 2,4-D application had a marked effect on weed control and initial crop injury.

Sweet corn had a definite varietal response to 2,4-D injury whereas field corn varieties showed less differences in resistance to 2,4-D.

Weed control was good in plots of Katahdin potatoes, except severe injury was observed when spray was applied to potatoes planted on very light sandy soils.

Good weed control can be obtained in established asparagus beds with application of 2,4-D after discing and again after cutting time.

Post-emergence sprays on corn plantings over 1-1/2' tall showed more tendency for brace root, leaf curling and brittle stalk injury. Injury was proportional to the height of the corn plant and concentration used.

Small grains (not seeded) sprayed with 2,4-D after they were fully tillered up to jointing time gave good results when concentrations not exceeding 1/2 pound 2,4-D per acre was used.

Applications of 2,4-D on strawberries gave good weed control when sprayed in early spring. Injury occurred to strawberries on light, sandy soils with concentrations as low as .4 pound per acre. Sodium salt formulations of 2,4-D

varied in effectiveness of weed control.

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"Two Years Results of Pre-Emergence Weed Control with Cyanamid"[1]

Rodney A. Briggs and Dale E. Wolf[2]

The possibility of controlling weeds in corn with the use of cyanamid was investigated at the New Jersey Agricultural Experiment Station in 1947 and again in 1948.

The following data is pertinent to the experiment conducted in 1948:

Corn Hybrid Used - Ohio K24
Date of Planting - June 10
Ground Prepared - June 5 and June 10
Cyanamid Applied - June 10
Spacing of Check rowed hills - 42" x 42"
Soil - A loamy sand
Soil Analysis - Sand 82%
Silt 9%
Clay 9%

Granular cyanamid was used and was applied by a cyanamid spreader.

Fertilizer - 800 lbs./A - 5-10-5 broadcast
Soil temperature at planting - 50°
Rainfall Record:

June 7 - .32 in.
June 8 - .20
June 13 - .90
June 15 - .31
June 16 - .10
June 19 - .75
June 20 -1.95

The plots were cross cultivated on July 14 clearning the field of most weeds.

[1]Acknowledgment is made to the American Cyanamid Company for their support of this project.

[2]Research Fellow, Farm Crops Department and Agent, U.S.D.A., New Jersey Agricultural Experiment Station.

Plot	Rate of Cyanamid	Time of Soil Preparation
1	200 lbs./Acre	Just prior to planting and treating
2	400 lbs./Acre	
3	600 lbs./Acre	
4	800 lbs./Acre	
5	Check	
6	200 lbs./Acre	5 days before planting and treating
7	400 lbs./Acre	
8	600 lbs./Acre	
9	800 lbs./Acre	
10	Check	

This experiment was started May 27 but crows reduced the corn population to such an extent that the experiment was started on a new piece of ground with a short season hybrid, Ohio K24. Valid weed counts were made before the experiment was reestablished.

Weed counts were made on June 21 on the initial experiment. The following table gives the weeds per square foot in the plots:

Plot	Mean Weed Count	Per Cent of Check
1	16	36
2	7	15
3	7	15
4	6	13
5	44	--
6	18	35
7	7	13
8	9	17
9	8	15
10	51	--

Weed counts on final experiment were made July 8, 1948 with the following results:

Plot	Mean Weed Count	Per Cent of Check
1	37	74
2	26	52
3	27	54
4	22	44
5	50	--
6	57	118
7	39	81
8	36	75
9	29	60
10	48	--

There appeared to be no difference in type of weeds present. The weeds present were:

Ragweed	Lambs' quarters
Pigweed	Annual grasses
Pennsylvania smartweed	Yellow nutgrass

Yield Data

The plots were harvested on October 22, 1948. The computed yields are in terms of No. 2 shelled corn at 15.5% moisture. Yields are as follows:

Plot	Mean Yield in Bu./Acre
1	40.7
2	59.9
3	59.5
4	63.9
5	25.4
6	38.4
7	47.8
8	59.4
9	55.0
10	24.6

This data was analyzed using R. A. Fisher's analysis of variance. The difference between means required for statistical significance is 6.3 bushels at 5% and 8.6 bushels at the 1% level.

Observations

The treatments had no apparent effects on the corn plants until the second week in July when a definite nitrogen stimulation was noted on the plots that received cyanamid. This was noted throughout the growing season. The plants in the check plots were smaller in size and yellow in color compared to the dark green and healthy appearance of the plants receiving the cyanamid.

Summary

The first and possibly the second cultivations were eliminated by the cyanamid treatments in this test as well as those conducted last year. The number of weeds present decreased from the check to the 800 lb. rate. Rates of 400 lbs. and above significantly reduced weeds and increased yields, but treatments of 600 lbs. and 800 lbs. showed no significant difference over the 400 lb. rate.

In light of other experiments carried out this year, the native fertility and the type of soil determine the use of cyanamid as a weed killer in pre-emergence form. In light soils, as a result of our two years work, it consistently appears as a sound treatment, at the 400 lb. rate. In heavy fertile soils this last summer silage yields were reduced at high rates when the cyanamid was applied 5 days after the corn was planted; however, this reduction was not significant.

Conclusions

It appears to us that the results would justify trying this method of treatment when corn is grown on light soils. Comparable results were found by workers in Sweden in 1948. More complete data is needed, however, before any recommendations can be made at this time.

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2,4-D FOR WEEDS IN CORN

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This is a brief account of the work done during the three summer months of 1948 on the problem of weed control in corn.

The work was not planned as an experiment, but rather to try out on a field scale some of the treatments a farmer or a custom operator might make, and to discover, if possible, the difficulties that might be encountered, the damage that might be done to crops and the success in weed control that could be expected.

Corn was treated with 2,4-D on 30 farms in 10 New York Counties. There were, in all, 42 tests. The size of treated areas varied from a few rows across a field to an entire forty-acre field. Untreated check areas were left in every case.

The equipment used was an 18-foot boom to which were fitted 12 spray nozzles of the Spraying System No. 650067 type and mounted on the front of a Jeep. The pump was an Oberdorfer gear pump operated by the power-take-off of the Jeep. It was not difficult to maintain the desired pressure of 30 pounds. A ceramics filter removed solid material from the 2,4-D solution so successfully that there was no trouble from clogging of nozzles, and the fine mesh wire screens in the nozzle fittings seldom needed cleaning.

Milk cans were used for the 2,4-D solutions, which were drawn out through a small metal tube passing through a stoppered hole in the cover. The close-fitting cover prevented spilling any of the solutions no matter how rough the road or field. Use of a measuring stick graduated to show quarts made measurement of solution and accurate dilution easy.

Success of the work exceeded expectations at the beginning and both field operation and road travel was much easier than had been anticipated. Several problems that interfered with proper operation of the equipment had to be solved, but this was not a serious matter.

Although results were very good, there were more problems at the end of the season for which I wanted answers than I knew about when I began work.

With but two exceptions, all applications were made at five gallons of solution to the acre.

Some of the conclusions arrived at from the summer's work are:

1. Some of the most troublesome New York corn field weeds can be controlled by much less 2,4-D than is suggested for pre-emergence treatment.

2. A properly timed application of as little as 0.05 of a pound of 2,4-D acid equivalent applied as the ester will check such sensitive weeds as wild radish sufficiently to eliminate serious competition with the corn, and will kill most of the plants that have recently germinated from seed.

3. Two applications of one-tenth of a pound of acid equivalent per acre made at properly spaced intervals will eradicate such weeds as field mustard and wild radish as completely as any greater amount will when applied in a single treatment, and results are more uniformly good.

4. Results are best when applications are made at light rates soon after weed seeds have germinated and plants have reached the surface, repeating the treatment as often as necessary to catch weeds at this stage of growth.

5. It is better to consider separately those weeds or groups of weeds whose seeds germinate in the corn field at about the same time and treat when control of this group of weeds is most likely to succeed. By following this procedure, results will be better and more uniform than they are likely to be if a heavy rate of treatment is made early in the season, with the expectation that effects will last through the season and control those weeds which start from seed in midsummer.

6. Some of our most serious corn field weeds can be successfully controlled at rates of application so low that treatment made, by mistake or otherwise, at 2, 3, or 4 times the intended rate will not injure the corn.

7. Danger of serious injury to sensitive dairy field crops from drift or volatilization of the ester is not a serious problem when applications are at light rates in a volume of five gallons per acre and the spray is directed downward from a height of two feet or less under a pressure of 30 pounds per square inch. I made no study of vegetable crops, but I was unable to detect 2,4-D effect on any of the most sensitive weeds at a distance of one foot from where the spray hit the ground, regardless of the amount of wind or its direction.

Some of the weeds with which I had good success were:

Field mustard, (Brassica arvensis)
Wild radish (Raphanus Raphanistrum)
Hedge bindweed (Convolvius sepium)

Red root (Amaranthus retroflexus)
Lambs quarters (Chenopodium album)
Rag weed (Ambrosia artemisiifolia)

Some other weeds, like the Polygonaceae, not easily killed, are sufficiently checked to allow the corn to gain an advantage and produce a good crop. I had no success at all with horse nettle (Solanum carolinense) or husk tomato (Physalis subglabrata) both of which are bad corn field weeds.

After a season's work using the sodium salt, an amine and an ester, I should not hesitate to recommend the use of any one of the materials.

For a given result under uniformly favorable conditions, I believe that no one product needs to be used at any heavier a rate of acid equivalent than another. For unpredictable field conditions it is quite a different matter.

In order to get good results under excessive moisture conditions with water soluble materials, it is necessary to make heavier applications than are necessary with oil soluble forms. Such applications, made at rates heavy enough to control weeds under unfavorable conditions, are likely to cause crop damage if weather and moisture conditions turn out to be favorable to 2,4-D action. The danger of crop damage resulting in this way from the use of water soluble salts is greater than the danger from use of oil soluble esters used in amounts which will control weeds under least favorable conditions. With the esters there is little or no need to vary the rate of application to meet conditions that are expected to exist during the period of 2,4-D activity. Results from the use of esters on a given crop are more uniform and more predictable than they are from water soluble materials. In this respect they gave me more satisfactory results than I got from the water soluble compounds.

It may be worth while to mention some of the questions about which we need more information.

1. In view of the results obtained from a single treatment of 0.05 of a pound of 2,4-D acid equivalent per acre for the control of wild radish, it would be worth while to know what would be the result from two, three or more applications at the same very light rate.

2. If treatments are properly timed, will two or more treatments at less than 0.05 of a pound of 2,4-D acid equivalent per acre successfully control those weeds that are as sensitive as is field mustard?

Answer to this question leads to the question as to whether very light rates of treatment may be made in such a way as to con-

sistently control mustard in spring grains without serious damage to legume seedings made with the grain.

3. It has frequently been reported that pre emergence treatment of corn successfully controlled summer grasses. Failure or poor success has also frequently been reported. I have seen some miserable failures this past summer. Is there a satisfactorily light rate of application and proper times for repeated treatment throughout the summer that will successfully and consistently control summer grasses?

4. What is the maximum rate of 2,4-D application that can be applied at two- to three-week intervals throughout the summer without reducing corn yields?

5. How successfully can hard-to-kill weeds, such as Canada thistle, smart weed, etc., be kept under control by repeated treatment at rates that will not decrease corn yields?

It may be that someone already has the answer to these questions and to several others that have occurred to me. Unless I can get them from some one else, I hope to find answers to them myself this next summer.

A few of the Kodachrome pictures that I took this past summer and a description of a few of the tests may clarify some of the points I have tried to make.

Mr. Fritz Campbell's corn, Wisconsin 412 A, was about 10 inches tall when four 18-foot strips across the field were sprayed on June 25. Treatments were at 0.1, 0.2, 0.4, and 0.8 of a pound of 2,4-D acid equivalent per acre in butyl ester.

On July 5 a repeat treatment of 0.1 of a pound per acre was applied to one half the area where that amount had been applied before and a second application at 0.2 of a pound per acre was made also to half the area treated at that rate on the first date. At the same time, additional strips across the field were sprayed at 0.1, 0.2 and 0.4 of a pound per acre.

The weeds that were a most serious problem in this field were hedge bindweed and field mustard.

When the corn was harvested in late October, yields from four adjacent rows 25 feet long were taken at 26 places in treated corn and at 30 adjacent places in the untreated corn. The average increase for treatment for all the plots was 32 per cent. In only one case did the weight of sample from a treated area weigh less than that from the corresponding untreated area and that by an insignificant amount of 3 per cent. Although the 0.4-pound and the 0.8-pound per acre treatment caused considerable corn leaf rolling, every sample from these areas showed an increase in yield. All

yields were calculated to a uniform moisture content of ear corn.

It should be remembered that failure to produce an increase in crop yield may signify simply that weeds at the place where the sample of untreated corn was taken were not reducing the yield.

Another field of corn near Syracuse, badly infested with hedge bindweed, was treated with 2,4-D in both the sodium salt and the butyl ester. Eight strips 18 feet wide across the field were sprayed on June 25 when the corn was about 10 inches tall.

Twenty-four harvested plots from treated areas, 3 from each of the treated strips, and 24 from adjacent places in the untreated corn, showed an average overall increase of 12 per cent. This field was rolling and both the growth and the stand of corn were quite uneven. As a result, eight of the 24 plots harvested from treated corn gave yield weights less than the corresponding weights from untreated corn. The fact that there was rather a serious infestation of both horse nettle and husk tomato unevenly distributed over the field and neither much affected by the 2,4-D undoubtedly contributed to irregularity of the results.

Treatment was begun on June 19 on another field near Groton, New York when the corn was very small, about 4 to 6 inches tall. 2,4-D was applied at 0.2, 0.4, and 0.8 of a pound of acid equivalent per acre. Four 18-foot strips across the field were treated at each rate, two with sodium salt and two with butyl ester.

Nineteen days later, on July 8, 0.2 of a pound of acid equivalent in butyl ester was applied as a repeat treatment to one strip each of those which had been previously treated with sodium salt and with butyl ester at rates of 0.2 and 0.4 of a pound of acid equivalent per acre.

On the second of July, 13 days after making the first treatment, seven additional strips across the field were treated with butyl ester at rates of 0.05, 0.1, 0.2, 0.4 and 0.8 of a pound of acid equivalent per acre.

Cultivation is discontinued on this field after 2,4-D treatment was begun. This was true also of the two fields from which I have just reported results. Wild radish in this field was so bad that it just about took over where no 2,4-D was applied. Every rate of treatment kept this weed well under control, but it was not completely eradicated by single applications at the lighter rates. The sodium salt was somewhat less effective here than the ester but 0.2 of a pound per acre of acid equivalent in the sodium salt followed by 0.2 of a pound in the ester killed the wild radish as completely as did the 0.8 of a pound of acid equivalent in either form applied all at one time and there was very little rolling of corn leaves.

I didn't regret that the crop from this field was harvested for silage before yields could be determined because yield figures would have indicated only how serious the weed problem could be. Weeds were so well controlled where the corn was treated and they checked corn growth so seriously where the corn was not treated that differences in yield were close to the difference of a good crop and no crop at all. I was interested principally in how successfully the weeds could be controlled or killed and the effects on corn yields. There were no apparent differences in corn yield as a result of different rates of 2,4-D treatment.

The Morphological Response of Several Corn Hybrids to Post-Emergence Applications of 2,4-D.

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Since the advent of 2,4-dichlorophenoxyacetic acid in the field of weed killing, conflicting reports of its effect on growing corn plants have been received. It seemed that the observations must have been made on different genetic stocks, on different rates of 2,4-D application or on combinations of both. Accordingly, an experiment was set up to study the effects of various rates of application of 2,4-D on several hybrids.

On May 22 5 hybrids, HyxL317, B42xJ47, U.S. 13, N.J. 7, and K24, were planted in five treatment blocks. The blocks were treated with 0, $\frac{1}{4}$, $\frac{1}{2}$, 1 and 2 lbs. per acre of 2,4-D acid equivalent from 2,4-Dow Weed Killer, Formula 40 when the corn was from six to ten inches high. Application was made on June 7, 16 days after planting. The test was replicated 3 times on good corn land, a Sassafras gravelly loam.

In making this study 13 characteristics were evaluated and studied. Data on bending of the plants taken 7 days after treatment showed definite differences between hybrids and between rates but not interaction. The percent of bending was a straight line function of rate of application up to 1 pound. The two pound application had very little more effect than 1 pound. HyxL317 had much less bending than any of the other hybrids.

Brittleness or icicle condition tested 12 days after treatment showed an average breaking of 9% for the check, 35% for $\frac{1}{4}$- and $\frac{1}{2}$-pound and 60% for 1- and 2-pound applications. Hybrid differences were not significant.

Leaf rolling or "onion top" varied widely in rate, hybrid and in interaction. U.S. 13, K24 and N.J. 7 were affected by $\frac{1}{2}$ lb. whereas the others required a pound or more to bring on this condition. HyxL317 was the least affected.

Days to median anthesis was entirely independent of rate of application. Days to median silking was increased significantly by the higher rates. The average for the 2 pound rate was 2 days later than the other treatments.

Measurements of the ear leaf showed that its greatest width varied depending on the hybrid but independent of rate of application of 2,4-D. Lengths of the same leaves varied highly significantly with both hybrid and rate but without interaction of these two factors. HyxL317 had shorter leaves than the other hybrids and each hybrid was significantly different from all the others. Applications of ½, 1 and 2 pounds of 2,4-D per acre caused the leaf lengths to be significantly shorter than those with none or ¼ pound per acre.

Area of ear leaf was calculated as the length times the greatest width times a factor for each hybrid. Rate and hybrid differences and their interaction all were highly significant for leaf area. The average differences between hybrids ranged up to 20%. The 1 and 2 pound applications showed a significant decrease in leaf area as compared to the check and the lower rates. The initial ¼ pound stimulated leaf growth significantly for B42xJ47 but had the opposite effect on HyxL317. Leaf area on N.J. 7 was decreased definitely by ½ pound per acre but in common with the other four hybrids additional increments had no further effect.

The average height of the plants was significantly decreased by the 1 and 2 pound applications as compared to the check. The smaller amounts produced very little effect.

Grain yields were not significantly affected by the various rates of application. The hybrids comprised a rather wide range of maturity and yields varied accordingly.

The moisture content in the grain at harvest showed that the 1 and 2 pound applications definitely interfere with the normal growth of the corn plant thereby delaying maturity. The check and the two lower rates showed little difference in moisture content.

Five plants from each treatment in one replication were dug up in a block of soil 1 foot square and 8 inches deep. The soil was washed off and the volume of the below-ground portions of the plants determined. A summary of these root volumes indicated an average increase of 15 to 20% over the check where ½ pound or more 2,4-D was applied per acre.

The above-ground parts of the 5 plants mentioned above were oven-dried and weighed. A summary of their weights shows $\frac{1}{2}$ pound of 2,4-D per acre produced the heaviest stalks. Two pounds and the check produced stalks of the identical weights with $\frac{1}{4}$ and 1 pound intermediate.

The persistence with which significant F values showed up for replication seemed to be an indication that the condition of the plant was highly important in studying effects of 2,4-D applications. If final grain yield indicated general vigor of the plant during the growing season then this condition was associated with high amount of seedling leaf bronzing, low incidences of icicle condition and leaf rolling. The converse was true where plant vigor was not so great.

Summary

The response of 5 corn hybrids to 5 different rates of application of post-emergence 2,4-D was studied in thirteen characteristics.

The hybrids differed significantly with respect to bending, leaf rolling, days to anthesis, days to silking, leaf width, leaf length, leaf area, plant height, yield of grain and moisture content of grain.

The variation due to the various rates of 2,4-D applications were significant for bending, brittleness, leaf rolling, days to silking, leaf length, leaf area, plant height, and moisture in the grain at harvest.

The interaction of hybrid and rate was significant only for leaf rolling and leaf area.

Root volume and dry weight per plant were greatest at $\frac{1}{2}$ pound of 2,4-D per acre.

"Three Years Results on Pre-emergence in Corn with 2,4-D"

D. E. Wolf, J. C. Anderson and C. S. Garrison[1]

The pre-emergence control of weeds in corn with 2,4-D was first reported in 1946 by the New Jersey Agricultural Experiment Station. It was indicated from this work that corn could be grown, under certain conditions, to maturity without cultivation. This necessity for cultivation was eliminated because almost complete control of weeds was obtained by using 2,4-D as a pre-emergence treatment. The rates of this first experiment ranged from 2.7 to 9.3 pounds per acre. It was apparent that 2.7 pounds per acre gave as good weed control as higher rates and that less injury to corn was obtained. This work was continued in 1947 and results indicated that rates of 1½ pounds per acre applied 5 to 8 days after planting gave good weed control with little injury to the corn. Again in 1947, the corn was grown to maturity without cultivation. Yields of the treated plots were equal to those obtained on the plots which were cultivated normally. On the basis of these tests and several trials made by farmers, pre-emergence control of weeds in corn with 2,4-D was recommended for trial on a small scale during the 1948 season. Precautions were stated, however, that this treatment be used only on heavier soils, since severe injury and little weed control had been obtained when this type of treatment was tried on sandy soils.

During the 1948 growing season, extensive research on this type of weed control was tried at the New Jersey Agricultural Experiment Station and throughout the state. Aside from these plots, nearly 1,000 acres were treated with 2,4-D as a pre-emergence spray by the farmers.

Plots at the Experiment Station were replicated 4 times and 3 rates of treatment were applied at 4 different dates after the corn was planted. It was the purpose of this experiment to determine the proper

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rate of 2,4-D to be used and the most desirable time of application. Treated plots were cultivated only when weeds became a severe problem and this was true only on those plots treated one day after planting. In these plots, fair weed control was obtained for the first few weeks, but there was little weed control after a period of 5 weeks. Control plots were cultivated normally and hoed at the time of the last cultivation to completely eliminate weed competition. Table 1 summarizes the results obtained in the 1948 trial.

Table 1
2,4-D Pre-emergence on Corn (U.S. 13)

Rate in lbs./A	Days After Planting	Weed Count per sq. ft.	Length of Weed Control in Weeks	Yield in bus./A
0	1	59	0	87.9
½	1	30	4	87.8
1	1	30	5	84.1
2	1	17	7	82.4
½	5	24	5	67.3
1	5	11	7	66.8
2	5	8	9	78.4
½	11	17	6	66.6
1	11	13	8	77.4
2	11	8	9	83.1
½	18	16	8	94.5
1	18	20	9	95.8
2	18	14	9	76.6

The corn was planted on May 21 and weed counts were made 4 weeks after the 2,4-D was applied. The best weed control was obtained at the 2 pound per acre rate. Rates of ½ and 1 pound per acre gave particularly good weed control when applied 11 days after the corn was planted. One of the most important points brought out by these results is the fact that treatments applied on the 5th, 11th and 18th day after planting gave much more permanent weed control than did treatments applied 1 day after planting. The corn emerged on the 10th day after planting and yields indicate that the corn is very resistant at early stages of growth. It would seem to us that the most important principle to follow in treating corn with 2,4-D on a pre-emergence basis is that application should be made at the time the weeds are beginning to germinate rather than on a certain day after

planting. Since the young corn plants are tolerant to 2,4-D treatment, this would allow the farmer to treat at a time when the chances of injuring the corn are the smallest and the possibility of controlling weeds the largest.

Emphasis was placed on the value of cultivation by several tests which included 2,4-D treated plots cultivated once during the growing season and those which were uncultivated as compared to normally cultivated plots. Results obtained in this test appear in Table 2.

Table 2.
2,4-D Pre-emergence Applied to Corn 7 Days After Planting (Ohio C88)

Rate	No. of Times Cultivated	Av. Weed Count per sq. ft.	Yield in Bus./Acre
0	3	55	81.8
$\frac{1}{2}$	0	21	68.0
$\frac{1}{2}$	1		83.9
1	0	16	66.1
1	1		87.0
$1\frac{1}{2}$	0	8	68.1
$1\frac{1}{2}$	1		88.4
2	0	9	62.8
2	1		74.3

The corn was planted May 20 and weed counts made on July 2. At the time the counts were made weeds in the control plots were 6-10 inches tall while those in the treated plots were 1 inch tall.

Yields in this test which was on a Hoosic gravelly sandy loam soil were reduced where there was no cultivation. It is apparent, however, that under these conditions, one cultivation was sufficient to bring the yields of the treated plots to equal those of the control.

An extensive experiment was also conducted on the Walker Gordon Farms near Princeton, New Jersey in which the corn was harvested for silage. All plots were cultivated immediately after weed counts

were made, and therefore, this test measures only the affect of 2,4-D treatment on the corn. Results obtained from this test appear in Table 3.

Table 3
2,4-D Pre-emergence on Silage Corn (Funk G-145)

Rate in lbs./A	Material	Weed Counts	Green Weight in lbs./A
Check		36	32,616
1	Sodium Salt (J. T. Baker)	8	28,993
1	LFN472 (American Chemical Paint)	4	31,027
1	Butyl Ester of 2,4,5-T (Sherwin Williams)	17	31,726
1	Triethanolamine (Dow)	4	29,882
2	Sodium Salt	4	26,094
2	2,4,5-T	2	29,254
2	Amine	3	30,938

This corn was planted June 21 and the 2,4-D was applied on June 26. Approximately 5% of the corn had emerged at this time. Weed counts were made July 7.

SUMMARY

The pre-emergence treatment of corn with 2,4-D for the control of weeds has proved, in general, successful in New Jersey for the past 3 years. On the basis of these results the New Jersey Agricultural Experiment Station will recommend in 1949 that pre-emergence treatment with 2,4-D be used on the heavier soils in the state. We will suggest that 1 to 1½ pounds acid equivalent of any formulation of 2,4-D be applied 5 to 12 days after the corn is planted or at the time the weeds are beginning to germinate.

Weed Control in Corn With 2,4-D and Cyanamid

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The control of weeds in corn was studied in four different tests with the primary interest in the possibility of injury and reduction of stand of corn by 2,4-D and cyanamid in relation to depth of planting. In four tests three rates each of 2,4-D and cyanamid were used with corn planted one, two and three inches deep by changing the depth of the corn planter. The 2,4-D was applied by having three 650067 nozzles behind each wheel controlled by three valves in front of the planter seat, each nozzle applying one pound per acre. Pressure was supplied from a 2900 cubic inch oxygen tank, with an air pressure regulator set at 35 lbs. The cyanamid was applied by spreading the quantity of cyanamid required for each 40 foot row on a belt distributor which spread the material over an area one foot wide and 40 feet long. The rates were 40, 80 and 120 pounds of nitrogen per acre over the row (1/3 of the area) or an actual application of 13/1/3, 26 2/3 and 40 pounds of nitrogen from cyanamid per acre.

Two treatments in each test were rolled with a small roller behind the planter wheel. The 2,4-D nozzle and the cyanamid distributor were behind the roller. 2,4-D and nitrogen were combined and used as a treatment. 2,4-D was applied to the three depths of planting at three rates when the corn was between one and three inches high. All plots were cultivated except an extra set of zero, one, two and three pounds of 2,4-D per acre which was treated over the entire area. Weed and stand counts were taken at first cultivation. The results are given in table form. There were 160 plots in each of these four tests.

Ohio M 15 corn was planted May 31 and June 1 on a silt loam soil which was very lumpy and rather dry. The stand of corn was very poor especially on the one inch planting depth. There were no apparent reductions in stand from the 2,4-D or the cyanamid treatments. The 2,4-D applied when the corn was one to three inches tall did not injure the corn. The dicots were controlled very well by the 2,4-D and not very well by the rates of cyanamid used. The control of grasses was poor primarily because of quack grass. Yields were not taken because of the poor stand.

The same variety of corn was planted June 11 on a rolling chirty sandy loam of very low fertility with the aim of observing injury to the corn, as the soil was too variable for yield. There was no apparent injury in stand or plant growth.

Funks G 7 corn was planted near Williamsport on sandy loam river bottom land on May 27. The stand on the shallow planted corn was somewhat poor and more spotty than on the deeper planted corn. There was fair control of both monocots and dicots. When the corn was cultivated the first time, there was no apparent rolling of the leaves or reduction in height of the corn but later in the season the plots which were not cultivated and those receiving the applications where the corn was one to two inches tall were somewhat stunted and the leaves showed typical 2,4-D rolling. The effects were greatest on the heavier rates. Those plots receiving 2,4-D at planting time and cultivation were not stunted and did not show the 2,4-D rolled leaves. There was little rainfall during the early season. The cultivated 2,4-D treated plots yielded statistically significantly more corn than the treated non-cultivated plots. The treated cultivated plots yielded statistically significantly more corn than the cultivated non-treated plots. There was no significant difference between 2,4-D and cyanamid treated plots.

A third test was planted at State College on June 23 and 24 using the same corn variety and similar soil to that planted May 31. An excellent seed bed was prepared by disking a field of corn which was about 18 inches tall. The corn emerged very quickly and was one to two inches high by July 1 when one, two and three pounds of 2,4-D was applied to the shallow, medium and deep planted corn. All applications severely burned the corn, killing many plants. The three pound rate on the shallow planting being the most severely injured. Apparently neither the cyanamid nor the 2,4-D applied at planting time affected the germination.

The test plot was injured by the southern corn root worm (Diabrotica duodecimpunctata). The plots treated with 2,4-D were injured much more than the other plots. The shallow planted plots were injured more than the deeper planted plots.

The control of the dicots was excellent and fair control of the monocots, which were in this case all yellow foxtail. A heavy application of redroot pigweed, lamb's quarters, smartweed and yellow foxtail seed was applied the day before the corn was planted. It would have been better to have applied the weed seeds earlier, especially the yellow foxtail.

The lamb's quarter which came up after the last cultivation of August 10 in the 2,4-D treated plots grew normally and were 12 to 14 inches tall by September 25 when we had some fall rain and cool weather. The growing ends of the lamb's quarter plants then took on the characteristic 2,4-D growth appearance.

The 1/4, 1/2 and 3/4 pounds of 2,4-D ester applied when the corn was 12 to 14 inches high stunted and rolled the leaves all the rest of the season. This injury we believe was associated with the heavy infestation of southern corn root worm.

In an adjoining test cyanamid was applied at the rate of 160 and 200 pounds of nitrogen per acre over the row or 53 1/3 and 66 2/3 pounds of nitrogen per acre without cultivation. These treatments gave as good control of weeds as the heavy applications of 2,4-D without injuring the stand of plants. One, two and three pounds of 2,4-D applied in 15 gallons of water per acre gave as good control as the same amount of 2,4-D applied in 75 gallons of water.

Pre-emergence application of 1 1/2 pounds of 2,4-D was applied to 36 inbred lines without apparent injury. When the inbred lines were 10 to 18 inches high 1/4 and 1/2 pounds of 2,4-D ester was applied as a post-emergence application. Only four lines failed to show root or stalk abnormalities.

One, two and three pounds of 2,4-D acid, sodium salt, diethanolamine, triethanolamine, iso-propylanolamine morpholine, methyl ester, two ethyl esters, iso-propyl ester, two butyl esters, amyl ester and two 2,4,5-T all applied as pre-emergence treatments and 2,4-D acid, sodium salt, triethanolamine and butyl ester applied when the corn was one to two inches high. They were applied to 10 hybrids using two replications, making 20 plots for each rate of material. There was no apparent injury from any material used.

One iso-propyl ester formulation was statistically significantly poorer than all other 2,4-D formulations. The best control was with one formulation of butyl ester. It was statistically significantly better than the other butyl ester formulation. It was not significantly better than the sodium salt or amines. The 2,4,5-T as pre-emergence applications were poorer than most 2,4-D formulations.

In this experiment where there were 380 paired comparisons the 1 pound rate was significantly poorer than the two pound rate. There was no significant difference between the two and three pound rates.

The applications made when the corn was one to two inches high did not control the dicots better than the same material applied at planting time. The control of monocots in this experiment was somewhat poorer than the pre-emergence applications.

Number of weeds in 16 square feet of non-treated area and the percentage reduction of weeds

Treatment	Rate per acre	Rate per acre over the row	Percentage reduction State College Hagerstown loam	State College Sandy loam	Williamsport Sandy loam	
Planted			June 23	May 31	June 11	May 27
		Dicots				
No treatment (No. of weeds)			(159.7)	(292.3)	(54.3)	(39.4)
2,4-D at planting time	1/3#	1#	88.3	89.3	53.0	42.4
	2/3#	2#	93.3	94.3	73.8	57.1
	1#	3#	94.7	97.4	75.6	42.8
	Rolled +	2#	93.7	92.5	72.4	67.0
	Nitrogen +	2#	95.0	52.8	66.8	61.9
Cyanamid at planting time	13 1/3# N	40# N	50.8	6.4	14.0	21.0
	26 2/3# N	80# N	72.0	21.8	26.9	35.8
	40# N	120# N	87.0	45.3	50.2	45.4
	Rolled +	80# N	67.4	43.9	46.6	59.0
2,4-D corn 1 to 3 inches	1/3#	1#	98.1	90.0	65.0	81.0
	2/3#	2#	98.5	91.7	91.4	70.2
	1#	3#	99.0	98.8	96.3	67.0
		Monocots				
No treatment (No. of weeds)			(67.4)	(268.9)	(50.7)	(82.4)
2,4-D at planting time	1/3#	1#	42.1	-9.6	-0.1	59.1
	2/3#	2#	42.9	24.7	31.0	69.4
	1#	3#	60.0	40.2	27.0	63.2
	Rolled +	2#	58.5	-3.8	50.7	72.7
	Nitrogen +	2#	51.1	14.2	17.2	79.1
Cyanamid at planting time	13 1/3# N	40# N	18.9	.1	-39.3	31.6
	26 2/3# N	80# N	-5.8	12.1	-29.5	52.0
	40# N	120# N	35.2	-10.5	14.6	63.0
	Rolled +	80# N	33.3	9.5	-81.4	57.4
2,4-D corn 1 to 3 inches	1/3#	1#	26.8	4.7	40.8	68.4
	2/3#	2#	21.9	15.9	37.6	65.7
	1#	3#	23.9	27.6	59.9	38.1

"Chemicals for Crabgrass Control"

Ralph E. Engel and Dale E. Wolf[1]

Without doubt crabgrass is the most troublesome weed in turf areas. In addition, it is frequently a serious pest with many cultivated crops. More efficient chemicals for the control of crabgrass would prove valuable additions to the herbicide field. Sodium arsenite was generally considered the best material from the era of the 1930's until 1946. At that time, Rhode Island Agricultural Experiment Station workers observed that several phenyl mercuries showed considerable promise for controlling crabgrass. A program of comparing sodium arsenite, several organic mercuries, and some additional chemicals was developed at the New Jersey Agricultural Experiment Station during 1948. The Gallowhur Chemical Company and the Sowa Chemical Company aided in this work by supplying chemicals for testing and adding active support.

Four tests were made; the first started on June 19, the second on July 15, the third on August 6, and the fourth on August 27, 1948. A total of 22 materials were used with variations in rate of application and in combination. Treatments were made on crabgrass infested plots of mixed turf which were 3' x 10' in size. Each treatment was replicated or repeated three times.

Application was made by a single nozzle, hand sprayer with a pressure ranging from 15 to 30 pounds. Where multiple applications were made on certain plots, five day intervals were allowed between each application.

Two days after the last application, the degree of discoloration ratings were made on the basis of the following scale:

1. Trace
2. Definite discoloration
3. Intermediate to 2 and 4
4. Serious discoloration
5. Intermediate to 4 and 6
6. Intermediate to 5 and 7
7. Browning of grass leaves
8. Intermediate to 7 and 9
9. Definite loss of turf grasses
10. Serious loss of turf grasses

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[1]Research and Extension Associate in Farm Crops and Agent, Division of Cereal Crops & Diseases, Bureau of Plant Industry, Soils & Agricultural Engineering, Agricultural Research Administration, U. S. Dept. of Agriculture, New Jersey Agricultural Experiment Station, respectively.

Estimations of the percent control of crabgrass were made by four individuals on September 23. The average number of seedheads per square foot were also recorded for tests I and III on September 23 and 24. Some results of the four tests are given in Table 1, Sections A, B, C, and D. The percentage control of crabgrass resulting from the mercury treatments included range from 79.9 to 90.0 per cent, 68.8 to 87.0 per cent, 86.8 to 97.9 per cent, and 80.4 to 91.4 per cent for the respective sections. Sodium arsenite gave 45.5, 58.2, 87.5, and 42.0 per cent control in the corresponding tests. In all but one individual comparison, the mercury-treated plots had lower discoloration ratings than the sodium arsenite-treated plots. It is of considerable interest to note that the degree of control obtained from the mercury treatments is quite similar for all treatments.

In 1947, Grigsby of the Michigan State Agricultural College, reported favorably on certain petroleum products namely, L-2687 and L-2988. These materials were applied at New Bruhswick, New Jersey on July 15, 1948 at the rate of 40 gallons per acre. Very poor control of crabgrass resulted. Similar results were obtained from the August 6 application of 80 gallons per acre. The rate was than increased to 150 gallons per acre for the August 27th test. L-2687 gave 51.5% control and L-2988 gave 54.2% control with the increased rate. This indicates that these products do not perform as efficiently for controlling the crabgrass of this area as they apparently do under Michigan conditions.

An effort was made to find some single-treatment materials that were non-poisonous or less toxic than sodium arsenite and the mercury compounds. Several chemicals showed promise in one or more of these respects. Some of the better performances for six of the chemicals are given in Table II. It seems very likely that one or more of these compounds may prove valuable for crabgrass control. Changes in the rates and methods of application could greatly increase the efficiency of several of these chemicals. These materials justify more study.

Conclusions

(1) The mercury compounds studied gave better control of crabgrass than sodium arsenite.

(2) It appears that the phenyl mercury compounds are quite similar in their ability to control crabgrass.

(3) Several experimental chemicals (Fs33, potassium cyanate, S1840, S1861, S-1980, and S-1998) are very worthy of further study because of their ability to control crabgrass, and because of additional considerations such as being non-poisonous, lower cost, and requiring fewer treatments.

Table I. A comparison of mercury treatments for crabgrass control in 1948.

	No. of Applications	Gals. of H_2O per sq.ft.	Concentration %	Discoloration	Control of crabgrass %	No. Seedheads per ~~1000~~ sq.ft.
Section A. Treatments from test started June 19, 1948						
Check	-	-	-	-	-	220
Sodium Arsenite	1	10	3oz/1000	8.3	45.5	146
Puratized 641	3	10	.011	4.0	90.0	19
" 806	2	10	.025	3.6	85.9	28
Puraturf Crabgrass Killer (1)	3	10	.020	2.6	79.9	29
C-Lect (2)	3	13	.014	6.6	85.3	18
Phenyl mercuric Acetate Sol. (3)	3	13	.017	6.6	87.2	17
Section B. Treatments from test started July 15, 1948						
Sodium Arsenite	1	10	3oz/1000	8.6	58.2	-
Puratized 641	2	10	.020	7.0	82.2	-
" 806	3	10	.020	7.3	87.0	-
Puraturf Crabgrass Killer	3	10	.020	7.0	72.2	-
C-Lect	3	13	.014	6.6	79.8	-
Phenyl mercuric Acetate (sol.)	3	13	.017	6.3	79.7	-
S-2000	3	13	.016	6.6	68.8	-
Section C. Treatments from test started August 6, 1948						
Check	-	-	-	-	-	290
Sodium Arsenite	1	10	2oz/1000	7.2	87.5	24
Sel-Tox (4)	3	10	.018	2.6	89.9	22
Puratized 641	2	10	.020	4.8	93.4	8
" 806	2	10	.025	5.8	97.9	7
Puraturf Crabgrass Killer	3	10	.020	5.0	93.4	10
C-Lect	3	13	.014	5.3	86.8	0
Phenyl mercuric Acetate Sol.	3	13	.017	5.5	97.5	0
S-2000	3	13	.016	4.8	95.9	10
Section D. Treatments from test started August 27, 1948						
Sodium Arsenite	1	10	2oz/1000	8.3	42.0	-
Sel-Tox	3	10	.035	4.6	80.4	-
Puratized 641	2	10	.025	6.3	86.3	-
" 806	3	10	.033	6.0	91.4	-
Puraturf Crabgrass Killer	3	10	.029	6.3	84.9	-
C-Lect	3	13	.014	6.3	81.0	-
Phenyl mercuric Acetate Sol.	3	13	.017	7.3	83.2	-

-4- (continued)

Table I continued.

(1) Puraturf Crabgrass Killer contains 3% phenyl mercuric tri-ethanol ammonium lactate.
(2) C-Lect contains 1.75% phenyl mercuric acetate.
(3) The phenyl mercuric acetate solubilized used was a 11.2% active solution prepared by the Gallowhur Chemical Company.
(4) Sel-Tox contains 2.3% Phenyl mercury monoethanol ammonium acetate.

Table II. A comparison of the mercury compounds, sodium arsenite, and some additional materials for crabgrass control.

	Material	Discoloration	Control of Crabgrass %
Test II	* Average of 3 mercury treatments	7.0	83.0
	Sodium arsenite	8.3	58.2
	FS-33	4.3	53.8
	S-~~1990~~ 1980	5.6	77.7
	S-~~1988~~ 1998	6.3	64.9
Test III	* Average of 3 mercury treatments	5.4	94.2
	Sodium arsenite	7.2	87.5
	**FS-33	6.0	89.2
	S-1980	2.1	70.5
	S-~~1988~~ 1998	3.4	78.3
	Potassium Cyanate	3.8	96.4 ←
Test IV	* Average of 3 mercury treatments	6.2	87.5
	Sodium arsenite	8.3	42.0
	FS-33	8.0	65.6
	S- 1840	8.6	94.9
	S- 1861	8.6	94.9
	S- 1980	8.0	62.9
	S- 1998	8.0	81.4
	Potassium Cyanate	7.3	74.9
	" "	8.6	87.4

* The three most desirable mercury treatments were selected from Table I.

** Two applications of FS-33 were made. All other treatments in this table except those of the mercury compounds are single application treatments.

x The fourth test made on August 27 was put on when the temperature was over 100 degrees. This probably accounts for the severe discoloration.

"Low Pressure, Low Volume Spray Equipment for Applying 2,4-D and Other Herbacides to Turf"

A. M. S. Pridham, P. B. Kaufman, E. B. Wahlgren

Cornell University

Many significant changes have occurred in the types of equipment used for turf chemical weed control. Today, diversity of such equipment still exists. It is the purpose of this paper to indicate these differences, as well as recent developments in new types of equipment built at Cornell University.

A brief survey of the literature best indicates the diversity and types of turf chemical weed control equipment. Low volume, low pressure apparatus has been described by Terry (1948), Pridham (1948), and French (1948). Terry shows schematic diagrams of liquid pump and compressed air or gas systems, and Pridham shows photographs of the low volume, low pressure system mounted on single mower and gang mower systems. Anon (1947) and Davis (1947) show photographs of, and report on, high volume, high pressure turf spraying apparatus. Davis (1947) and Pridham (1948) show photographs of truck-mounted spray apparatus used to spray turf; Davis (1947) shows spray apparatus mounted on a wheelbarrow. Spot sprayers, used for spot application of herbacide to turf weeds, are described by Davis (1947) and Anon (1945).

Three basic considerations govern the construction of the turf equipment which is described in this paper. These are (1) mounting the spraying system on the mower, (2) disseminating the herbacide while cutting grass, and (3) using low volume, low pressure spray equipment. These considerations were applied to single and gang power mowers at Cornell University in 1948. Laboratory tests to determine rate of spray discharge from nozzles, time to empty one tank, etc. were made for both types; field tests to determine area covered by one tankful, speed of apparatus, and effectiveness of weed control have not been completed.

Single Mower System:

The single power mower spraying system is relatively simple in construction. It represents a modification of equipment designed by Pridham and apparatus built by the James Cunningham Son and Company (Rochester, New York). Pressure is derived from a hand-pumped sprayer or a carbon dioxide cylinder. Spray boom position was tested by placing booms in front of the mower blades and to the rear of the blades; it was found that the placement of the boom behind the mower blades was more advantageous because (1) it was not likely to be bent or broken

in this position, and (2) better contact of the herbacide with weeds was obtained. In one experiment conducted during the summer of 1948, a boom mounted in front of the mower blades was snapped off when it hit a woody plant hedge. The boom placed behind the blades could be elevated or lowered by bolting it at different heights on a vertical metal bar having holes placed in it at one-half inch intervals; the bar was attached to the framework of the power mower. Three nozzles, each having an orifice size adapted to low volume, low pressure spraying, a built-in strainer, and a fan-shaped spray, can be placed six inches apart in a twelve inch boom and tilted at such an angle that spray is disseminated between the roller of the mower and the wheels of the garden tractor or the operator, depending upon the type of equipment. The angle of these nozzles can be adjusted so that two unbroken fans of spray pass down to an eighteen inch strip of grass beneath the curved mass of grass clippings, which are thrown back by the mower blades. The diagrams following illustrate this principle.

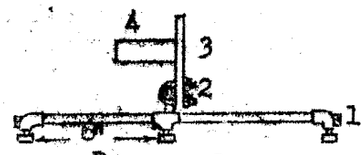

Diagram 1

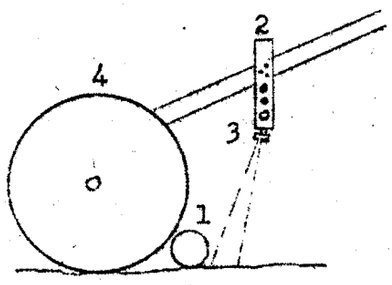

Diagram 2

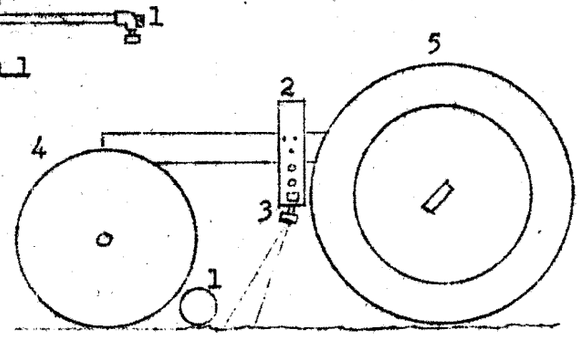

Diagram 3

Diagram 1, applicable to both pieces of equipment diagrammed, shows (1) boom with 3 tees and 3 nozzles, (2) U-bolt attachment of boom line to adjustable height bar, (3) bar having holes drilled in lower half, and (4) mower handle or frame yoke; Diagram 2 shows (1) wood roller or mower, (2) bar to which boom is attached, (3) position of boom attachment, and (4) power driven mower; Diagram 3 shows (1) wood roller of mower, (2) bar to which boom is attached, (3) place of boom attachment, (4) mower, and (5) garden tractor.

A three and one-half gallon capacity tank may be mounted on the mower handle or on the handle of the garden tractor. In the line between the tank and the boom, nearest to the tank, a glass bowl strainer should be inserted to accomplish two purposes: (1) to strain the solution as it leaves the tank and (2) to let the operator observe when the herbacide solution is no longer passing from the tank to the boom. One-fourth inch copper or galvanized pipe may be used in the line, substituting rubber tubing when necessary.

It was found that under field conditions suitable speeds for power-driven single mowers was from two to five m.p.h. A specific test indicated that at 2.5 m.p.h., using 20 p.s.i. pressure, three gallons of solution could be disseminated from three 0.022 inch Monarch nozzles in an average of 28 minutes. This represents an area of 0.21 acres sprayed every 28 min. at 2.5 m.p.h.

Three important operating precautions or devices were observed or developed for this equipment. First, triple straining, involving (a) the use of four thicknesses of cheesecloth to strain herbacide solution through a funnel into the tank, (b) a glass bowl strainer in the spray line, and (c) a strainer in each of the nozzles. The second device is a quarter-turn shut-off valve, used by the operator to stop the movement of herbacide solution from nozzles quickly. This prevents excessive quantities of herbacide from dripping from the nozzles when the spray equipment is not in motion. And a final device is a piece of copper wire which is used to clean a nozzle orifice quickly when it does not produce a perfect spray fan.

Gang Mower System

The construction and placement of spraying apparatus on gang mowers is more complex than the case just described. Thus, for the sake of clarity, diagrams of the spraying apparatus alone and in relation to the gang mower are presented below. They are based on equipment built at Cornell University in 1948.

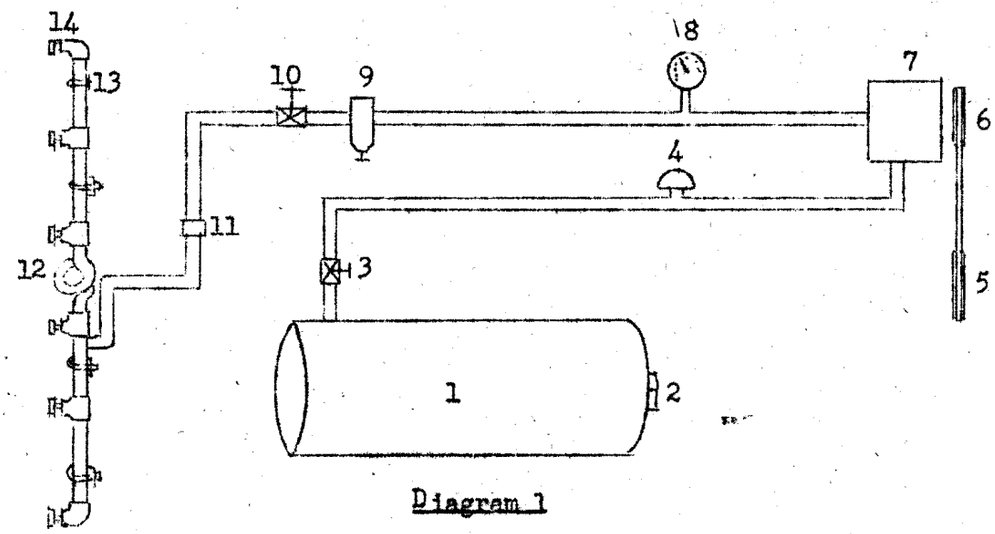

Diagram 1

1 - tank
2 - opening at top of tank
3 - 1/4-turn valve
4 - inverted glass bowl strainer
5 - drive pulley of tractor engine
6 - driven pulley of liquid pump
7 - liquid pump or air compressor
8 - pressure gauge
9 - line strainer and drain
10 - 1/4-turn shut-off valve
11 - detachable hose coupling
12 - looped hose section connecting each boom
13 - adjustable height metal bar attachment for boom
14 - boom with 3 tees and 3 nozzles

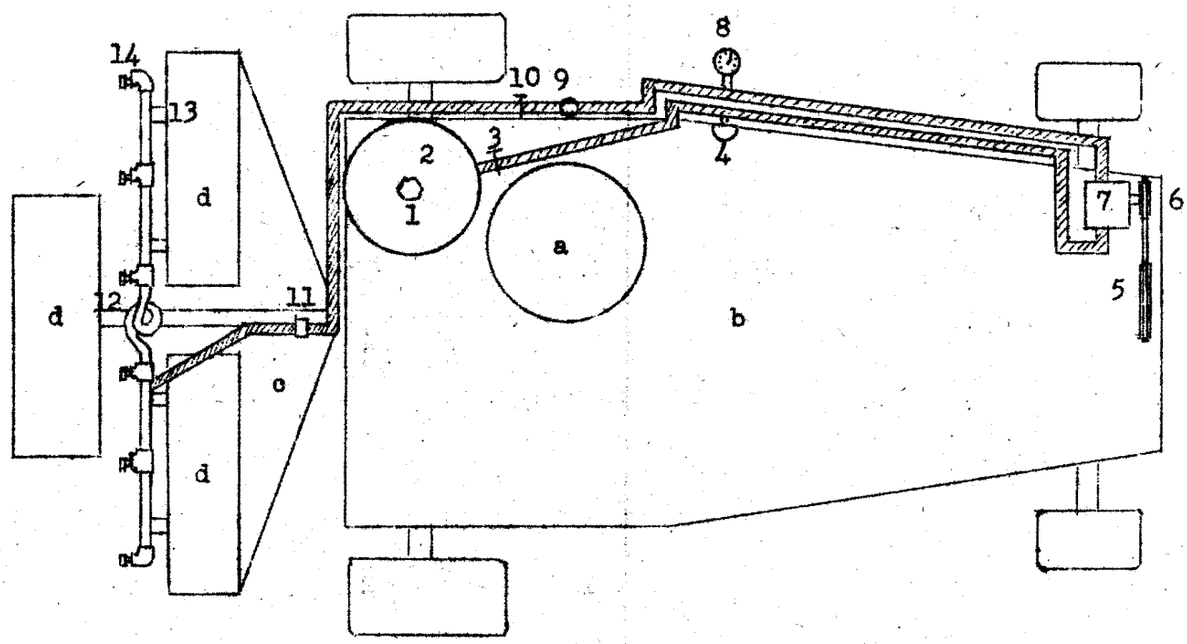

Diagram 5

a. driver's seat
b. tractor
c. trailer to which mowers are attached
d. mowers (36")

1 - tank secured behind driver's seat
2 - opening at top of tank
3 - 1/4-turn valve
4 - inverted glass bowl strainer
5 - drive pulley of tractor engine
6 - driven pulley of liquid pump
7 - liquid pump or air compressor
8 - pressure gauge
9 - line strainer and drain
10 - 1/4-turn shut-off valve
11 - detachable hose coupling
12 - looped hose section connecting each boom
13 - adjustable height metal bar attachment for booms
14 - boom with 3 tees and 3 nozzles

Further explanation of some of the parts indicated in the foregoing diagrams is indicated as follows: (1) quick-mounting and de-mounting brackets, used to attach the pressure gauge and inverted glass-bowl strainer, respectively, to the tractor, are not shown in the diagrams; (2) the glass bowl in the intake line, used so that the operator can see when no more solution is passing through the lines, and the pressure gauge on the return line are mounted in such a position as to afford the tractor operator simultaneous views of both, such views being carried in direct line of sight to the left front wheel, and the cut of grass; (3) a quick-acting quarter-turn valve (diagram 5 - item 10) is situated in the pressure line to the spray booms, directly handy to the operator's left hand, allowing instantaneous use when necessary; (4) a shut-off valve is installed at the outlet of the tank so that the lines may be drained, without draining herbacide solutions from the tank; this is invaluable when a break or leak occurs in the line, especially since the leakage of 2,4-D type herbacides is so detrimental to turf; (5) the two spray booms are assembled to the rear of the two leading mowers and forward of the third or trailing mower; (6) boom height may be adjusted by attaching the boom at different positions on vertical metal bars with holes drilled in them at one-half inch intervals; the bars are mounted to the framework to which the mowers are attached; (7) a cross-over loop, attached to each boom, allows for swiveling action of the leading gangs; (8) nozzles were placed 13 inches apart in each boom to give 30 percent overlap and complete coverage where grass was cut; and (9) the spray boom could be adjusted so that spray could be disseminated below a curved mass of grass clippings thrown back by the mower blades.

Calculations: In order that low volume, low pressure turf spraying equipment may effectively disseminate the proper pounds of herbacide per acre of turf, one must determine a number of factors and make a few simple calculations. A method followed by the authors is presented below.

First, one should ask: what factors must I determine or calculate in order to effectively disseminate the proper pounds of herbacide per acre of turf? Table 1 presents a summary of these factors as well as where one might search to determine the factors and how the answers are derived.

Table 1

Factors, their Sources and Determination, Used for Effective Operation of Low Volume, Low Pressure Turf Spraying Equipment.

Factors Which Must Be Obtained	Source	Answer
1 - low volume	literature	5-10 gal. per acre
2 - low pressure	do.	20-30 p.s.i. at nozzle
3 - pounds herbacide per acre	do.	see literature
4 - speed of equipment	field test	5-10 m.p.h. for turf equipment
5 - coverage by spray fans	literature: Terry (1948)	30% or double usually
6 - distance between nozzles	literature: Terry (1948)	see literature: Terry (1948)
7 - ht. of nozzles from ground	do.	see literature: Terry (1948)
8 - number of nozzles	calculation	determined by 5 & 10
9 - type of nozzle	manufacturers: Terry (1948)	fan-shaped best: Terry (1948)
10 - length of boom	calculation	determined by specific equipment
11 - spray swath		determined by 5, 6, & 10
12 - gal. per hour per nozzle	calculation from an equation	calculation
13 - exact nozzle size	manufacturer's tables (Terry: 1948)	see mfg. tables
14 - exact pressure	do.	do.
15 - dilution rate	calculate from manufacturer's data given on the label on herbacide container	calculate from manufacturer's data given on the label on herbacide container

Second, one would ask: what approximate order should I follow in determining these factors: Such an arrangement, based on the experience of the authors, is presented as follows:

1 - determine coverage by spray fans: 30% overlap or double coverage.

2 - determine (a) distance between nozzles, (b) height of nozzles above ground, and (c) number of nozzles needed.

3 - determine length of boom and width of spray swath.

4 - make a speed test.

5 - determine from literature or manufacturer's date (a) type of nozzle (b) pounds herbacide to be applied per acre, and (c) volume of diluted herbacide solution to be disseminated per acre.

6 - calculate the gallons of herbacide disseminated by one nozzle in one hour (gal./hr./nozzle).

7 - from 6 - see manufacturer's data or tables presented by Terry (1948) to derive (a) exact nozzle size and (b) exact pressure in the low volume range.

8 - determine rate of dilution of herbacide.

Third, one would ask: what about calculations? An example, based upon the gang mower system built by two of the authors, is presented to illustrate steps 1 - 8 above.

1 - coverage = 30% overlap.

2 - (a) distance between nozzles = 13 inches; (b) height of nozzles from ground = 14 inches; and (c) number of nozzles needed = 6. These were derived from a table in the work of Terry (1948).

3 - (a) length of boom = 65 inches; (b) width of spray swath = 78 inches.

4 - speed = 5 m.p.h.

5 - (a) type of nozzle = Monarch fan-type; (b) to disseminate 1.6 pounds of 2,4-D acid equivalent per acre of turf; and (c) to apply 5 gallons of diluted 2,4-D per acre.

6 - calculation of gal./hr./nozzle: This is based on a modification of an equation presented by Terry (1948), which is stated as follows:

$$\text{gal./hr./nozzle} = \frac{\left[\dfrac{(\text{gal. herbacide solution per acre}) \times (\text{m.p.h.}) \times (\text{width spray swath in inches})}{(99)}\right]}{[\text{number of nozzles}]}$$

$$x = \frac{\left[\dfrac{(5)\ (5)\ (78)}{99}\right]}{[6]} = 3.28$$

7 - Using Monarch Nozzles, and staying in a low pressure range of 20-30 p.s.i., one could use Monarch 0.022 nozzles at slightly less than 30 p.s.i. pressure. This data was derived from tables referring to Monarch Nozzles.

8 - 40% 2,4-D acid equivalent solution is to be applied at the rate of 1.6 pounds of 2,4-D acid equivalent per acre. Dilution would be as follows:

(a) 1.6 pounds equals approximately 1.6 pints
(b) 2.5 x 1.6 pints = 4.0 pints
(c) Thus, for every 5 gallons spray mixture to be disseminated over one acre, 4.0 pints of 40% 2,4-D acid equivalent solution would be used.

Care of Equipment: The following points are presented with reference to this topic:

(1) herbacide mixtures should be prepared immediately before use and not left standing for long periods in the spray tank, because residues tend to form which later interfere with effective spray discharge from nozzles.

(2) all spraying apparatus should be rinsed thoroughly, in an area away from where economic or ornamental plants are grown, after each spraying operation. Note that this apparatus should not be used for the dissemination of other non-herbacidal chemicals (insecticides and fungicides).

(3) all mower and spray apparatus parts should be tightened or lubricated as necessary before any spray operation is conducted.

(4) nozzle strainers should be replaced if they are not working effectively.

(5) spray apparatus should be dismantled, cleaned, and stored in a box when the spraying program is over. This allows for further use of the mower without excessive wear on the spraying apparatus. It also keeps dust, etc. from entering any part of the spraying system when it is not in use.

Conclusions:

The following points concerning low volume, low pressure turf spray equipment should be emphasized:

(1) A quick turn shut-off valve should be quickly accessible to the operator on both single mower and gang mower systems to prevent

nozzle drip on turf when such equipment is not in motion.

(2) A device, such as a bowl-type strainer, should be introduced into the spraying system so that the operator can observe when the herbacide solution is no longer passing through the lines.

(3) Three types of straining devices may be conveniently and successfully used in a single mower system and four in a gang mower system; both systems may utilize (a) cheesecloth in the funnel at the tank when pouring in solutions, (b) a bowl-type strainer in the lines, and (c) strainers attached to each nozzle. The latter system has one additional device - a strainer placed in the line between the boom and the source of pressure.

(4) The spray boom should be placed behind mower blades so that it will not be snapped off. Moreover, nozzles should be oriented in such a direction that spray fans are directed beneath the arch of grass blades being thrown back by the mower blades so that these fans remain unbroken.

(5) Nozzles should be cleaned after each operation with kerosene, then soap and water with the aid of a small brush.

(6) A hand-pumped 3.5 gallon spray can has been found most economical for single mower spraying systems, and has been operated successfully without excessive effort by the operator. An air compressor appears to be a very satisfactory device for a source of pressure on a gang mower system; until liquid pumps can be greased in such a way that emulsified grease doesn't appear on nozzle screens, they are not as satisfactory as air compressors.

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Weed Control in Turf by Use of Adapted Species and Good Management Practices

by
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Weed control in turf should be considered in two phases. These are weed eradication and weed prevention. Weed eradication naturally must be the first step if the turf is already infested. When a weed-free turf is obtained the task of weed prevention begins.

Herbicides which have come into use during the last several years have done a remarkable job in eradicating weeds from turf. In fact, these herbicides have done such a good job that much more attention has been given to weed eradication than has been given to weed prevention.

This paper deals entirely with the preventive phase of weed control through the use of good management practices and the use of turf grass species, which compete successfully with weeds. The greater part of our attention is focused on crabgrass because of the relative difficulty of crabgrass eradication by the use of herbicides.

It is known from observation that weeds are not a serious problem in a dense healthy turf. Weedy turf then must be the result of poor conditions for the growth of the turf at a season favorable for the germination of weed seeds. The soil is apparently almost universally infested with large numbers of weed seeds. Whenever the vegetation is sparse enough, these seeds germinate and the weeds begin to fill in. Very close mowing of such grasses as Kentucky bluegrass and the fescues may encourage weed invasion. Scars resulting from maintenance operations should be avoided insofar as is possible. Typical injuries are burns from improper distribution or spillage of fertilizer, fungicides, and herbicides. Mechanical injuries resulting from scalping or wheel tracks are just as serious.

The control of diseases and insects is sometimes an excellent weed-prevention measure. It has been noted many times that clover comes into putting greens whenever disease has thinned the turf. Japanese beetle grubs often damage turf to such an extent that crabgrass may become established very easily.

It is advisable to plan maintenance or renovation practices in such a way that the turf is not predisposed to the invasion of weeds. Here again it is crabgrass that is the most important consideration. 2,4-D sprays are very effective in knocking out broadleaf weeds in early summer. However, if the turf is infested heavily with broadleaf weeds, the destruction of these weeds will leave an open turf which will be an easy mark for crabgrass invasion. In areas where crabgrass is a serious problem, treatment of the turf with 2,4-D should be made in the fall. Fertilizing should be done in early spring and early fall. Where a thin or weedy turf exists, late spring or summer fertilizing helps the weeds much more than it helps the grass. Where the turf is composed of bluegrass and fescue, and where the service requirements of the turf permit, mowers should be set to cut about two inches during the summer months.

There is much evidence to indicate that the various grass species or combinations of species differ greatly in their resistance to weed invasion. There is further evidence that those species which make their best growth during the months when crabgrass is a problem are the ones which are most resistant to this pest.

Bermudagrass and the Zoysia grasses are among those which show the most promise. The range of adaptability of these grasses is almost identical with that of crabgrass. These grasses begin growth in the spring before conditions are favorable for the germination of crabgrass, and they provide a very dense, durable turf throughout the crabgrass season.

The main objection to Bermudagrass and to the Zoysiagrasses is that they are dormant and straw-colored during the winter. This undesirable feature may be overcome by overseeding with cool-season grasses such as bent and bluegrass.

In October, 1947, strips of several cool-season species were overseeded on a rather thin turf of Zoysia japonica. The cool-season species were seeded alone and in combination. These plots were laid out for exploratory purposes in an effort to determine which species would lend themselves best to growth in combination with Zoysia japonica. The plots were established in duplicate, but no effort was made toward randomization. Therefore, no attempt has been made to apply statistical treatment to the data reported herewith. However, there was such a striking difference in the amount of crabgrass present in the various plots that it was considered worthwhile to take crabgrass counts. The line-transect method was used in making the counts. Each figure reported in Table I is the average of 20 counts:

Table I. Crabgrass in turf composed of Zoysia japonica and cool-season grasses. Each figure is the average of 20 counts.

Zoysia japonica turf overseeded with:	Average number of Crabgrass Plants
Alta Fescue	32.25
Kentucky Bluegrass	23.6
Kentucky Bluegrass (B-27)	17.15
Chewing Fescue (Penn State Blend)	36.45
Alta Fescue & Chewing Fescue (PSB)	29.85
Bluegrass, Bentgrass & Chewing Fescue	9.3
Bentgrass mixture (Astoria, Highland)	2.75
Not overseeded	79.4

A turf which has Zoysia or Bermudagrass as its basic component remains dense and closely knit throughout the entire year if it is properly managed. The overseeding of cool-season grasses provides a desirable winter color. Zoysias and Bermudas heal over scars rapidly during the summer months when there is the greatest likelihood of weeds coming into the turf because of injuries. Both of these grasses thrive under the close mowing necessary for

some turf uses. The addition of cool-season grass species through overseeding extends the length of the season during which the turf is growing actively and therefore able to heal rapidly.

To summarize, it is believed that through the use of species which are naturally able to compete successfully with weeds and through proper management, much may be accomplished toward keeping turf weed-free. Until more is learned about weed-prevention we will be faced with the ever-recurring problem of weed eradication.

THE CONTROL OF WEEDS IN FOREST TREE NURSERIES WITH OIL SPRAYS.

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More than one half of the cost of growing forest tree planting stock has been the eradication of weeds in the seedbed and transplant areas. Experience to date has shown that the use of oil sprays will materially reduce this cost and will in turn increase the annual production of planting stock so that more idle lands of this country can be reforested.

There are in this country but slightly over 100 forest tree nurseries, which produce an estimated one half billion trees annually. Yet the areas for weed control are small compared with the weed control on the agricultural lands. However, it may be of interest to note that the value of a crop of trees per acre of seedbeds may range from 3 to 8 thousand dollars. What agricultural crop can beat this? The foresters and the forest nurserymen are vitally interested in the subject of weed control.

In the coniferous evergreen nurseries only the petroleum oil products have met with much success. In the deciduous or broadleaf nurseries the oils have been successfully used only in pre-germination applications. The use of oil sprays to control weeds in coniferous seedbeds dates back to June 1946, when Cossitt (1) working in Louisiana, Robbins et al (2) in Michigan and the writer in New York (3) made the first tests with oil products. All these trials were the result of independent curiosity, following the knowledge that such products had been used successfully in the carrot fields of California and elsewhere. However, Gilgut in Mass. in 1945 used an oil spray to control weeds in a lined-out nursery and found many conifers highly resistant.

Subsequent tests in 1946 in the New York State forest tree nurseries were convincing evidence that oil sprays could be of great value, so that in 1947, 7,000 gallons of oil were used and this past season more than 10,000 gallons were used in areas containing 60 million trees. The success of oil spraying can be stated briefly. Instead of fields of weeds and grass at the end of the season, these areas were practically free of any weeds this fall by using spray oil plus some supplemental hand weeding. Actually the weeding cost was reduced to less than 50% of what it would have been without the oil. The writer has distributed material (3, 4) and has been in contact with many forestry nurserymen through out the country and finds that in at least 30 nurseries success has been obtained in the use of one or more oil products in 1948, with an expected increased use in 1949. The most success has come when large scale operations have been put into effect.

The material used include several trade named products such as: Sovasol, Stanisol, Vasol and Sioho weed killer. Also some common names such as Stoddard solvent and Mineral Spirits. The rate per acre per application varies from 30 to 100 gallons with the majority of nurserymen using from 40 to 75 gallons per acre. Applications are made, for best success, up to 3 and 4 times per season.

The methods of applying has grown, as in New York State, from the "flit gun" stage in 1946 to the power rig with an 18 foot boom capable of spraying several acres per day in 1948.

A few operations may be of interest here, as a result of the experience so far.

(1). Coniferous species generally are highly resistant to the oil sprays. There is some difference of species, but a greater difference in resistance or damaging effects comes with trees of different forms of foliage and periods of growth. For example, in the pine species the cotyledons and primary needles are more resistant when young, than are the mature needles. Since the mature or fascicled needles do not appear until the second year, the success of the use of oil is greater during the first growing season than the second. There are periods during the second and subsequent years, when the needles are very young that spraying should not be done or if so, very lightly.

The needles of the spruces are highly resistant at all ages, while the deciduous needles of the larch species are quite susceptible to damage.

(2). The most troublesome groups of weeds in the New York State nurseries are the so-called "summer grasses". The oil sprays readily kill these when applied at the time they are small. A large number of other weed species are also killed. It is of interest to note that many of the weed species which are resistant to killing frosts are also resistant to the effects of oil sprays. This operation may be of interest when the true nature of the resistance of oil sprays is determined. The appearance of oil killed plants is similar to that of frost killed ones. Could it be possible that more than a similarity of appearance is involved?

In conclusion it can be seen that foresters are highly interested in weed control, and successes in other fields are rapidly keeping up with modern methods.

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Dec. 13, 1948.

"Low Pressure, Low Volume Spray Equipment for Applying 2,4-D and Other Herbacides to Roadsides"

A.M.S. Pridham, P. B. Kaufman, and C. W. Terry
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There are many diverse types of spraying apparatus used for chemical weed control along roadsides. Two general types of equipment exist: (1) that adapted to low volume, low pressure spraying and (2) that adapted to high volume, high pressure spraying. The purpose of this paper is to discuss the construction and use of the former type.

Review of Literature: The following has been reported by various workers concerning equipment which may be or has been adapted to roadside chemical weed control: (1) Terry (1948) indicates schematic diagrams, parts, and operation of (a) liquid pump and (b) compressed air or gas low volume, low pressure spraying systems; (2) Bruhn and Berge (1948) have presented a very extensive report on building low pressure chemical weed control equipment, including much detail on pumps, screens and filters, booms, nozzles, and diagrams of the equipment; (3) French (1948), Pridham (1948), and Willard (1948) report on low volume spray equipment in a more general way than the above workers; (4) Willard (1948) and Pridham (1948) show photographs and give brief descriptions of low volume, roadside, spray equipment; (5) Anon (1947) has reported on high volume spray equipment mounted on a truck and its use for controlling roadside weeds; several photographs of the equipment are shown; (6) Barrons and Goulter (1948) report the use of knapsack sprayers to disseminate herbacide solutions on cut stumps; (7) Price (1943) gives a good description of booms. The most extensive survey of highway chemical weed control is reported by Willard (1948). The most complete and extensive work on low volume, low pressure spray equipment in the cited literature is presented by Terry (1948) and Bruhn and Berge (1948).

Basic Principles of the Equipment: Low volume, low pressure spray equipment, used for chemical weed control along roadsides, has four basic principles: (1) the mounting of the spraying system (a) on a truck, (b) on a tractor, or (c) on wheels, towed behind a truck; (2) the placing of the boom in front of the operator; (3) the operation of the spray apparatus itself by a single operator; and (4) the use of a low volume, low pressure spraying system.

The Equipment: These principles were applied to a tractor-mounted spraying system in the summer of 1948 in New York State. This type, mentioned in principle (1b), will be described in this paper.

The basic parts used in the construction of the tractor-mounted spraying system are shown in the schematic diagram below:

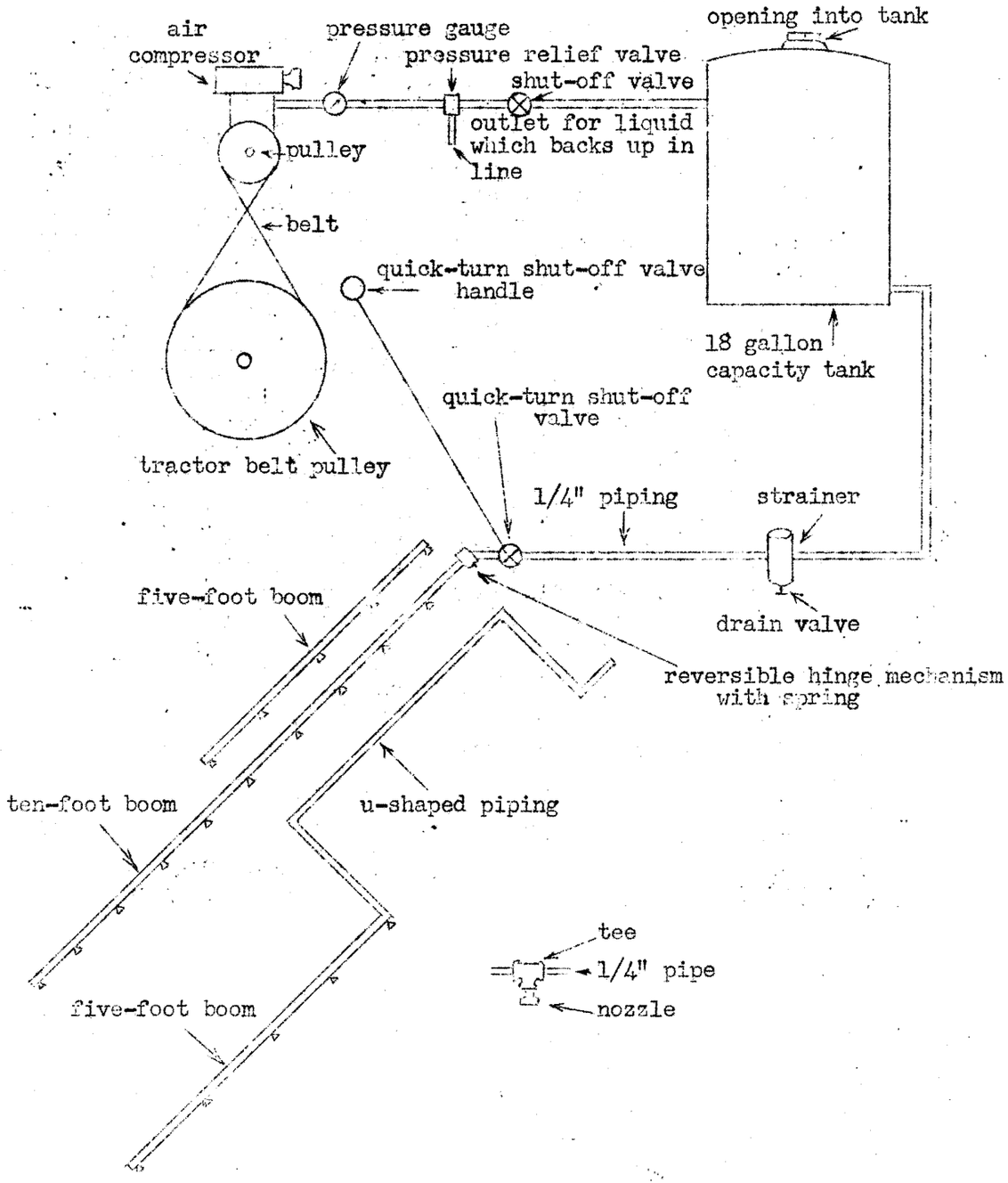
air compressor
pressure gauge
pressure relief valve
shut-off valve
opening into tank
outlet for liquid which backs up in line
pulley
belt
quick-turn shut-off valve handle
18 gallon capacity tank
quick-turn shut-off valve
tractor belt pulley
1/4" piping
strainer
five-foot boom
drain valve
reversible hinge mechanism with spring
ten-foot boom
u-shaped piping
tee
1/4" pipe
nozzle
five-foot boom

Diagram 1

Further explanation of some of the parts shown in the diagram is presented as follows: (1) booms: (a) ten-foot boom was used primarily for areas above or below the highway ditch (to the right of the ditch), (b) the five-foot boom was used to spray the first five feet of roadside, i.e. from the margin of the highway to the ditch in most cases, and (c) a u-shaped piece of piping was placed in the line ahead of the ten-foot boom when posts or mail boxes obstructed spraying beyond the ditch; (2) booms were always attached to a reversible hinge mechanism with a spring, allowing a boom to swing ahead or back when objects were hit by the boom, then swinging it back into its original position due to the action of the spring; (3) a shut-off valve was inserted as close to the boom as possible, and its handle was placed in reach of the operator by means of an extension rod so that flow of herbacide solution could be stopped as quickly as possible; (4) a strainer with drain valve at bottom was placed near the boom so that (a) herbacide solution could be strained between the tank and boom and (b) the solution could be removed from the tank and lines easily; (5) the pressure relief valve maintained the desired pressure and could be adjusted to change the pressure if so desired; (6) the fitting over the pressure relief valve acted as an outlet for herbacide solution which sometimes backed-up in the line when the solution flowing to the nozzles was stopped; (7) the air compressor was driven by a belt from the tractor pulley below the driver's seat. A similar drive was used for an emery wheel which was used to sharpen the mowing machine knives; (8) the tractor, on which the above spraying apparatus is mounted, is also used for sickle bar mowing; (9) the sickle bar does not have to be removed when spraying.

Use of the Equipment: A discussion of the actual use of the equipment is presented below:

(1) roadsides and weed populations: The following diagrams will help to illustrate how this equipment may be adapted to roadside spraying:

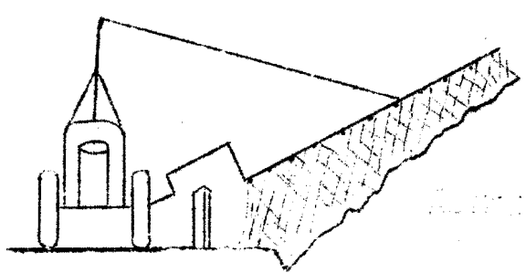

Diagram 2

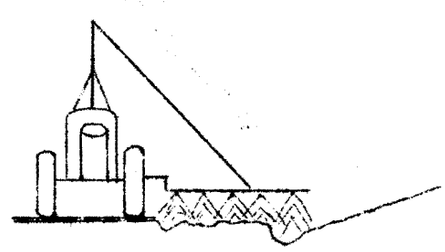

Diagram 3

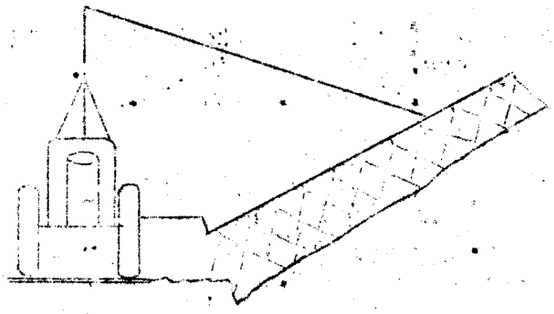

Diagram 4

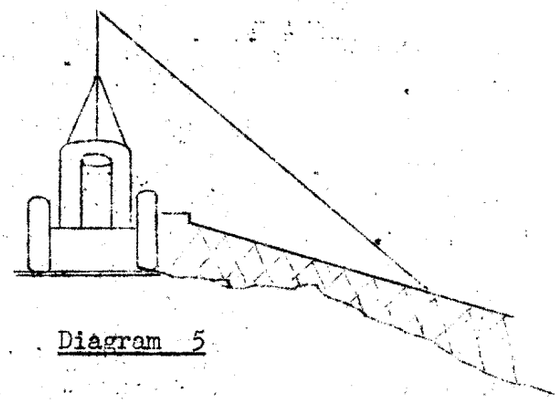

Diagram 5

Diagram 2 shows the use of a u-pipe section attached to a ten-foot boom; the ten-foot boom is spraying the vegetation from the post to the top of the bank. Diagram 3 shows a five-foot boom spraying the usual strip of vegetation between the margin of the highway and the roadside ditch. Diagram 4 shows the ten-foot boom spraying the same section without the u-pipe section; under normal conditions, the system in diagram (2) is usually necessary in hilly country where fences or posts are frequent. Diagram 5 shows the ten-foot boom spraying a bank which slopes downward from the highway.

(2) loading herbacide solutions: Loading herbacide solutions may be accomplished by three general methods: loading and reloading (a) at one centralized location near the highway, (b) from drums on gravel piles at convenient locations along the highway, and (c) from a truck which may follow the spraying apparatus. In general, it has been found in recent spraying operations in New York State that the third method (c) is most practical.

(3) straining herbacide solutions through spray apparatus: In the loading process, it was found necessary to strain prepared solutions to avoid foreign material in tank, lines, and nozzles. Four thicknesses of cheesecloth make a suitable strainer when placed in the funnel which is used to fill the tank; herbacide solution passed through a milk strainer too slowly. Although nozzles had strainers, and the line between the boom and tank had one, the above technique was found necessary to keep nozzles clean during spraying operations.

(4) results pertaining to the amount of herbacide disseminated per unit area per unit of time: The case cited below is taken from the actual operation of the equipment during the summer of 1948.

given: A five-foot, five nozzle (0.022 Monarch nozzles) boom; 4.5 m.p.h. speed; 30 p.s.i. pressure; and 18.0 gallons of herbacide solution.

calculations: It was found that 18 gallons of herbacide could be disseminated over a strip 2.88 miles long, five feet wide, in 37.4 minutes. This represents an area of about 1.75 acres. Thus 10.3 gallons of solution per acre were disseminated.

(5) maintenance of equipment: Nozzles should be cleaned with soapy water and kerosene, respectively, using a small brush to remove dirt, etc. after each spraying operation. Lines, tank, and supplementary equipment, such as funnels, pails, drums, etc., should be thoroughly rinsed with water at the completion of each day's spraying operations. The place chosen for cleaning this equipment should be away from any area where susceptible crops are being grown. It should be emphasized that 2,4-D cannot be removed from spray equipment completely. Thus, equipment should be used only for 2,4-D; when it is worn out, it should be discarded completely. It is a good practice to keep unused supplementary equipment clean and in storage.

(6) a suggested highway spraying program: The following program, outlined in chronological order, is based on the experience of workers at Cornell University: (a) cut brush on banks and in ditches along the roadside with sickle bar mower or with the scythe in the early fall. This process (I) facilitates spraying operations and (II) reduces the amount of foliage which must be covered by the herbacide. (b) Herbaceous weeds are best sprayed between May 15 and June 15; it is at this time that most of the seeds of herbaceous weeds have germinated. Woody weeds may also be treated effectively between these dates. The primary reason for spraying at this time is that the tissues of woody and herbaceous weeds are most susceptible to 2,4-D injury. It is recommended that 5.0 pounds per acre for woody weeds and 3.2 pounds of 2,4-D acid equivalent for herbaceous weeds be applied in the form of one of the non-volatile salts of 2,4-D (amine or metallic) at this time in order to avoid 2,4-D vaporization injury to farmers' crops growing near the roadside. The sprayed vegetation should not be cut until about a month after spraying; this will allow the 2,4-D to have its effect upon the tissues being sprayed. (c) The above spray program should be done every year. Initially, the job is to eradicate the existing weeds; later, it is a process of protecting roadsides from weed infiltration. (d) Where weed eradication by chemical methods leaves bare areas, grass or desirable legumes should be planted in such locations to prevent soil erosion.

Conclusions:

(1) Low volume, low pressure spray equipment mounted on any tractor can be used for chemical weed control along roadsides by a single operator satisfactorily.

(2) The spraying is done in early spring, depending on the type of vegetation. The spray equipment is then removed and the tractor used for sickle bar mowing in late spring and throughout the summer.

(3) Special types of spray booms may be adapted to different types of situations along roadsides so that spray may be disseminated effectively.

(4) In order for the spraying system to operate with maximum efficiency, it should (a) be cleaned after each day's spraying schedule has been completed, (b) be loaded quickly with herbacide solution, (c) have at least three types of straining systems, i.e., at the nozzles, in the line, and at the point where herbacide solution is placed in the tank, and (d) have an operator who can use it effectively under the different situations met along highways.

(5) Quick shut-off valves, the placement of the boom in front of the driver, a more or less constant speed range, correctly diluted solutions, and clean nozzles are other prerequisites for effective roadside chemical weed control.

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CONTROLLING BRUSH ON UTILITY RIGHT OF WAYS

by R. H. Beatty

The control of woody plants on utility right of ways has remained a problem since the first right of way was constructed. The woody plants must be controlled on thousands of acres of land so they will not come in contact with the wires, and so the right of ways are accessible for inspection or necessary repairs. In the past, this has been accomplished by hand cutting and the use of heavy machinery.

However, the use of machinery for right of way work is limited by the ground to be treated. The soil may be too wet, extremely rocky, or the terrain too rough or dangerously steep for its efficient operation, and so the utility companies look forward to the many possibilities offered by chemical spraying. It is this phase of control that I would like to discuss with you today.

I have asked some of the men most active in the field of chemical brush control to help me in presenting to you the latest information and data concerning the control of woody plants with the three outstanding chemicals being used today -- Ammate (Ammonium sulphamate), 2,4-D (2,4-Dichlorophenoxyacetic acid) and 2,4,5-T (2,4,5-Trichlorophenoxyacetic acid). I thoroughly appreciate their whole-hearted cooperation because only by pooling the thoughts and experience of workers from all parts of the country can we clarify the basic principles involved in brush control.

Chemical control of brush is not a new development. However, many of the early chemicals used were not adaptable to right of way work because they constituted a fire hazard, were poisonous to livestock, and seriously interferred with the growth of grasses. Ammate, 2,4-D and 2,4,5-T do not have these disadvantage, and should certainly be considered in preparing any chemical control program.

Ammate

Ammate is effective in killing woody plants and may be applied as a liquid or in the dry form. The dosage usually recommended is 1 lb. per gallon of water applied to the foliage of the entire tree or sprouts, arising as regrowth; the concentration required will vary with different plant species (5).

With regard to volume, Elwell (6) has found it necessary to use 250 gallons of spray containing 1 lb. of Ammate per gallon on brush having a density of 18,000 to 20,000 plants per acre and an average height of four feet or under. As

density and height increase, a maximum of 600 gallons per acre may be required.

Many trees and resprouts are killed by Ammate. Peevy (12) reported that a 32.5% solution (4 lb. per gallon) of Ammate was effective on sprouts 1 inch or less in diameter. Trees killed include black-jack oak, sweet gum, black gum, elm, ash, cypress, bay, ironwood, willow, pine, and the red, post, pin and water oaks. The effect was slower on hickory, beech, persimmon and white oak, and he suggests a heavier dosage on these species.

Elwell (6), using 1 lb. of Ammate per gallon of water, reports kill on crabapple, elm, hickory, locust, oak, osage orange, redbud, sassafras, sumac, wild grape and willow. Tops have been killed on mesquite and persimmon, but re-sprouts occurred.

Ammate is efficient in destroying stump sprouts (5). If the freshly cut stubs or crown of many woody plants are treated with 3 to 5 lbs. of the dry material per square rod (480 to 800 lbs. per acre) death of the stump and roots will occur.

Experimental progress is being made in reducing the amount of Ammate and water required. Elwell and Cox (6) in preliminary tests (July, 1948) with an Orchardaire air blast sprayer report good control of scrubby oak with 50 gallons of liquid and 100 lbs. of Ammate per acre. This air mist machine required only 1/3 as much Ammate and 1/6 as much water as the hydraulic type machine under comparable conditions. If this machine proves effective upon further test, it will probably be widely used to control low brush on the right of ways over which machinery can operate.

2,4-D and 2,4,5-T

2,4-D and 2,4,5-T are not new chemicals to this conference; a large percentage of the recognized facts concerning their action on woody plants has been published in the Proceedings. Since 1946, 2,4-D has been known to be effective on several woody species (8). Extensive research has continued in an effort to develop chemicals or combinations of chemicals that will control varieties of woody plants common to right of ways which have been resistant to treatments used so far. The specific effect of 2,4,5-T on members of the genus Rubus and other varieties resistant to 2,4-D, and the successful use of a combination of 2,4-D and 2,4,5-T on mixed woody vegetation were reported (3) to this conference last year.

Many workers now agree that a combination of these two chemicals (varying the amount of 2,4,5-T from 25% to 50% of the total acid used) is more effective on a greater variety

of woody plants than is either chemical used alone.

From the data collected, there appears to be two general methods used for applying these chemicals to right of ways.

Ashbaugh (2), cooperating with the Dow Chemical Company, has been using ester formulations in high volume water sprays. Best results have been obtained with a mixture of 50% 2,4-D ester and 50% 2,4,5-T ester at a concentration of 3000 p.p.m., applying a minimum of 100 gallons per acre. In the spraying operation, he uses a Pecan type nozzle at 250 lbs. pressure.

The other method, used by Kauffman (10) cooperating with the American Chemical Paint Company, involves the application of 2,4-D acid plus 2,4,5-T acid in Diesel oil (at a concentration of 4% total acid) at a rate of 9 to 15 gallons per acre on low brush not over 48" high. This applies 3 to 5 lbs. of total acid per acre. The special knapsack sprayer used to apply these oil sprays is operated at a spraying pressure of 12 to 15 lbs., with low volume nozzles on a four-foot wand carried at the side of the operator. This method is particularly useful in terrain where the mechanical sprayers cannot operate. An experimental low volume unit mounted on a tractor or truck and applying 25 to 40 gallons of solution per acre with varying amounts of oil in a combination of 2,4-D acid plus 2,4,5-T acid shows promise.

Susceptibility of woody plants

In planning the intelligent use of these chemicals for right of way spraying, it is highly important to consider the susceptibility or resistance of the plants to be treated.

Ashbaugh (2), using the treatment described, has reported kills on aspen, birch, Rubus spp., box elder, catalpa, dogwood, elm, hickory, horse chestnut, locust, some maples, tuliptree, crabapple, tree of heaven, oak, osage orange, pine, poison ivy, poplar, sassafras, spice bush, sumac, sycamore, wild cherry, wild grape, willow, virginia creeper, honeysuckle, elderberry, walnut and butternut. He reports ash and basswood as being resistant.

Kauffman (10), Zahnley (14) and Garmhausen (7), working with the 2,4-D and 2,4,5-T in oil spray, report approximately the same species as being susceptible. Kauffman (10) also reports chestnut and sweet gum as susceptibile, and finds ash, red maple, persimmon and scrub oak as the most resistant plants. Zahnley (14) identifies the species of susceptible oak as pin, white and scarlet, and lists Osage orange as resistant to the 2,4-D oil spray.

It is evident from the above reports that several of the plants formerly considered resistant to 2,4-D are now being controlled by the combination sprays in water and Diesel oil.

The question of spray drift or volatility should be considered in working with esters on any right of way.

Ashbaugh (2) and other workers using the esters in water at high pressures report some injury to nearby crops, but on the whole have experienced a relatively small amount of damage as compared with the large areas covered.

Kauffman (10) and Zahnley (14), working with the low volume Diesel oil and ester combination, report damage to nearby crops and ornamentals. Epinastic effects have been noted on cotton plants a mile from the point of application of esters in oil in Georgia.

I will not try to determine whether such damage was caused by volatility or spray drift. However, Allen (1) in working with these oil sprays has developed a formulation containing 2,4-D acid plus 2,4,5-T acid and co-solvents that has proven relatively non-volatile in tests and in applications made to 3,000 acres of right of way. Extensive volatility studies are now in progress with these compounds and the cellosolve esters which emulsify in water.

Stump treatment

Another method of chemical control which is of practical importance in controlling right of way brush is the stump treatment. Barrons and Coulter (3) report that a solution of 1% to 2% of 2,4-D ester applied as a stump treatment to species susceptible to 2,4-D has given excellent results. The use of 1% 2,4,5-T ester and 1% 2,4-D ester is suggested for use on species known to be resistant to 2,4-D, such as Osage orange and the genus Rubus. Although there are factors responsible for erratic results, they feel that total regrowth on treated areas may be reduced as much as 75% when such a solution is applied thoroughly to the sides and cut surface of low cut stumps at any time thruout the year. Melander (11) reports that the application of salts and esters of 2,4-D to cut surfaces of large barberry bushes is highly promising.

Kauffman (10) working with a 4% 2,4-D acid and 2,4,5-T acid combination in Diesel oil, reports excellent kill from this treatment applied during December of 1947 to large stumps of most species, including red maple, which is highly resistant to foliage sprays.

Zahnley (14) observed excellent results using the 2,4-D and

2,4,5-T combination in oil if the trees were cut before the leaves fell.

Thimann and Torrey (13), investigating the application of herbicides to the cut stumps of Aroma or Marabu (Dichrostachys nutans) report that a 20% aqueous emulsion of 2,4-D ester applied twice was the most effective in repressing new shoot growth. Higher or lower concentrations of 2,4-D, the ester of 2,4,5-T and concentrated sodium arsenite solutions were all less effective.

Any discussions of stump treatment would not be complete without mentioning the basal treatment applied to uncut woody plants now being used experimentally by many workers.

Kauffman (10) applied a 4% solution of 2,4-D acid plus 2,4,5-T acid in Diesel oil to resprouted scrub oak about 36" high during the dormant period (December, 1947). It was applied to one group as an overtop spray covering most of the plant, and to the other group as a basal spray covering the sprouts from the ground line to a height of 2 or 3 feet. Resprouting occurred on 25% of the plants given the overtop spray, but by the following summer no sprouting was evident on the basal treated plants.

As a follow-up spray on right of ways this year, basal treatments using Diesel oil, 2,4-D and 2,4,5-T combination have been applied by the single nozzle knapsack to sprouts arising from regrowth and small trees 3 to 4 inches in diameter. Excellent top kill has been noted on ash, red maple and other resistant varieties, showing a longitudinal splitting of the trunk at the point of application, vigorous callus growth and enlarging of the lenticels. Whether or not we are getting penetration into the root system will be determined by spring observations.

Future investigations

All these chemicals are promising but there are many unsolved problems. It is true that there have been conflicting reports on the resprouting of susceptible varieties. This may be due to the concentration of material used, local climatic conditions, etc., but one factor which should be carefully considered in evaluating these chemicals on small plots is the inter-connected root systems with plants arising some distance away.

More basic information is needed on whether 2,4-D or 2,4,5-T are inactivated by certain resistant woody plants, or whether there are other factors which explain why these chemicals do not translocate into the root system.

So that we can time our sprays more effectively, experimental data should be obtained on the time in their life cycle when the resistant species show the lowest amount of starch content in their root systems, as it has been clearly determined (12) that 2,4-D sprays reduce the starch content of certain plants.

New chemicals, combinations of chemicals, and better penetrants should be tested on the resistant species. The information contained in the recently published work of Hitchcock and Zimmerman (9) on the activation of 2,4-D by various adjuvants should be evaluated experimentally on woody plants.

Summary

In summarizing the data presented, a right of way having tall brush should be prepared for chemical treatment by cutting or mechanically treating the brush and then spraying the cut stubble with Ammate or the 2,4-D plus 2,4,5-T combination in oil. After new growth starts in the spring, regrowth should be sprayed by either the high volume or low volume method as the terrain will determine. Follow-up sprays should be used to control the growth as local conditions indicate.

It has been estimated that at least 25,000 acres of right of ways were chemically treated this past summer. When the results of this work are properly evaluated and combined with results of the experimental work now in process, we will have a more definite plan to offer for the control of woody plants.

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COMBINATIONS OF CHEMICALS FOR WEED CONTROL

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Early during the 1948 growing season it was observed that several chemicals used as pre-emergence applications to potatoes controlled weeds and grass very satisfactorily. In some instances slight injury to the potatoes was noticed. The present experiment was initiated in an attempt to determine the minimum concentrations of these chemicals singly and in combination for adequate control of weeds.

Six materials were applied alone in three concentrations, also combinations of each material with each of the others at the medium concentration and each with combinations of two other materials at the lower concentration. The materials were applied August 20 at the rate of 100 gallons to the acre to soil which had been prepared and fitted ten days previously. Plots were of 36 square feet, randomized and replicated three times. Counts of broadleaved weeds and grasses were made on October 5. The predominant weeds were lambs quarter, pigweed, foxtail grass and some nut grass. (Table 1)

Highly significant differences in control of broadleaved weeds resulted from the use of several of the chemicals and combinations of chemicals. Of 52 treatments with chemicals 19 resulted in complete control of broadleaved weeds. Grasses occurred rather sparsely and variable between plots so that no significant differences occur between any of the treatments.

When the results from 18 plots receiving each chemical are averaged it is shown that excellent control of broadleaved weeds resulted from applications of ammonium thiocyanate, sodium pentachlorophenate and 2,4-D. All treatments reduced the weed count to a highly significant amount. (Table 2)

Table 1. Effects of several chemicals and combinations of chemicals on control of weeds. 1948.

Treatment	No. of weeds per 108 sq.ft. 10/5/48 broadleaf	grass	
NH_4 thiocyanate(ATC) 60 gal./A.	0	0	
" " 30 gal./A.	0	2	
" " 20 gal./A.	1	9	
Esso HAN 132 30 gal./A.	20	15	
" " " 15 gal./A.	31	43	NO
" " " 10 gal./A.	70	86	
*ATA 1.6 gal./A.	14	18	
" 0.8 gal./A.	130	41	NO
" 0.53 gal./A.	228	42	
*STA 20 lbs./A.	34	30	
" 10 lbs./A.	29	24	NO
" 6-2/3 lbs./A.	64	4	
*SPCP 20 lbs.	1	17	
" 10 lbs.	0	17	?
" 6-2/3 lbs.	5	17	
2,4-D 1½ lbs.	5	18	
" 3/4 lb.	6	20	?
" 1/2 lb.	30	14	
ATC 30 gal. + Esso HAN 132, 15 gal.	0	2	
" " " + ATA 0.8 gal.	0	4	NO
" " " + STA 10 lbs.	0	2	gain
" " " + 2,4-D 3/4 lb.	0	4	
Esso HAN 132 15 gal. + ATA 0.8 gal.	5	31	
" " " " " + STA 10 lbs.	4	2	gain
" " " " " + SPCP 10 lbs.	0	3	
" " " " " + 2,4-D 3/4 lb.	6	9	
ATA 0.8 gal. + STA 10 lbs.	22	20	
" " " + SPCP 10 lbs.	1	10	NO gain
" " " + 2,4-D 3/4 lb.	6	10	
STA 10 lbs. + SPCP 10 lbs.	3	1	
" " " + 2,4-D 3/4 lb.	7	8	gain
SPCP 10 lbs. + 2,4-D 3/4 lb.	0	3	
ATC 20 gal. + HAN 132 10 gal. + ATA 0.53 gal.	0	10	
" " " + " " " " + STA 6-2/3 lbs.	3	10	NO
" " " + " " " " + SPCP 6-2/3 lbs.	4	9	
" " " + " " " " + 2,4-D 1/2 lb.	0	7	
" " " + ATA 0.53 gal. + STA 6-2/3 lbs.	0	1	
" " " + " " " + SPCP 6-2/3 lbs.	0	0	NO
" " " + " " " + 2,4-D 1/2 lb.	0	7	
" " " + STA 6-2/3 lbs. + SPCP 6-2/3 lbs.	0	1	
" " " + " " " + 2,4-D 1/2 lb.	0	37	
" " " + SPCP 6-2/3 lbs. + 2,4-D 1/2 lb.	0	12	

Continued

Table 1. (Continued)

Treatment	broadleaf	grass
Esso HAN 132,10 gal.+ ATA 0.53 gal.+STA 6-2/3 lbs.	21	23
" " " " " + " " " +SPCP 6-2/3 "	0	23
" " " " " + " " " +2,4-D ½ lb.	6	6
" " " " " + STA 6-2/3 lbs.+SPCP 6-2/3"	0	11
" " " " " + " " " +2,4-D ½ lb.	1	12
" " " " " + SPCP 6-2/3 lb.+2,4-D ½ "	3	0
ATA 0.53 gal.+ STA 6-2/3 lb.+ SPCP 6-2/3 lb.	1	45
" " " + " " " + 2,4-D ½ lb.	5	33
" " " + SPCP 6-2/3 lb.+ 2,4-D ½ lb.	2	13
STA 6-2/3 lbs. + SPCP 6-2/3 lb.+ 2,4-D ½ lb.	2	4
No treatment	219	23
F value	13.04	1.41
F required at 5%	1.48	1.48
F required at 1%	1.73	---

* ATA = ammonium trichloroacetate
STA = sodium trichloroacetate
SPCP = sodium pentachlorophenate

Table 2. Effects of several chemicals on the control of weeds. Each figure is an average of 54 plots representing several concentrations and combinations.

Treatment	Number of weeds per 108 sq.ft. 10/5/48 broadleaf	grass
Ammonium thiocyanate	0.5	6.9
Esso HAN No. 132	9.7	16.8
Ammonium trichloroacetate	24.5	18.7
Sodium trichloroacetate	10.9	14.9
Sodium pentachlorophenate	1.3	10.9
2,4-D, triethanolamine salt	4.4	12.1
No treatment	* 219.0	* 23.0

*Average of 3 plots.

PROGRESS IN THE HERBICIDAL APPLICATIONS OF PENTACHLOROPHENOL

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For those of you who may not be familiar with pentachlorophenol, I would like to begin my talk with a few comments on its history as a herbicide, and its properties.

Monsanto Chemical Company in 1940 obtained the patent covering the use of pentachlorophenol and its alkali-metal salts as herbicides.[1] In 1945, Dr Hance of the Hawaiian Sugar Planters Association was issued a patent covering a water-soluble pentachlorophenate in conjunction with water soluble inorganic arsenites or chlorates.[2] Today, oil fortified with these materials is widely used as a herbicide in Hawaii.[3] In this country it is receiving mounting interest in certain crops, as well as for general weed control along highways and railroad rights-of-way.

This material is essentially a contact killer and does not translocate. It will not sterilize the soil; it has a repellent taste to livestock; is non-volatile, and is economical to use.

Just as 2,4-D is used in several forms, so pentachlorophenol is applied as such or as the sodium salt (sodium pentachlorophenate). With a few exceptions, results seem to be the same regardless of which form is used. The choice depends on whether the material is to be dissolved in oil or in water. If water is to be the solvent, the sodium salt is used. If formulations involving oil are needed, pentachlorophenol itself is easier to use if the oils available are aromatic enough to be suitable solvents for this material. However, if the available oils are not good solvents, we can get around this by preparing an oil in water emulsion in which the water phase acts as the solvent for the sodium salt.

We have then, four possible types of sprays:

The sodium salt in water.
The sodium salt with an oil-in-water emulsion.
Pentachlorophenol with an oil-in-water emulsion.
Pentachlorophenol in oil.

Pentachlorophenol or its sodium salt may be used as a pre-emergence herbicide (before weeds emerge), as a selective spray in certain crops, or for contact killing of emerged vegetation at all stages of growth.

The simplest means of preparing a pre-emergence spray is by dissolving the sodium salt in water. At times 4 lbs. of the sodium salt per acre have given good weed control, but somewhat higher rates may be necessary. In some instances this type of spray shows a greater effectiveness than those which also contain oil. However, reports on such comparisons are conflicting, probably because of different soil conditions, and at the present we feel experiments are still necessary in each locality to establish this point.

A 0.5 to 2.0 percent water solution of the sodium salt is used by some commercial growers as a selective spray in certain crops such as onions, grains, and flax, which seem to have a significant resistance to the chemical's action. When used in such crops the spray kills the top growth of most broadleaved weeds and some of the grasses. The concentration and rate of application must be adjusted within the limits I mentioned to provide the proper degree of selectivity in the crop under the particular conditions of spraying.

The type of spray in which pentachlorophenol is most universally applied at present involves the use of oil. When oil is included in a pre-emergence spray, it frequently seems to increase the margin of safety between killing the weeds and damaging the crop plants. Since the oil also is herbicidal, less pentachlorophenol is required per acre.

Oil is essential in any formulation designed for killing the top growth of emerged grasses as well as broadleaves. In such a spray the herbicidal action of the oil is increased considerably, and the amount of oil needed may be reduced to a tenth or less. Such a spray, with or without water, is an excellent contact killer of all types of non-woody vegetation with which it comes in contact, which means it will kill any annuals and all top growth of herbaceous perennials to which it is correctly applied.

In these oil or oil emulsion sprays, pentachlorophenol or its sodium salt should be used at 7 to 10 percent by weight of the oil, regardless of the amount of water present,

since the water frequently is used only to give better coverage. If the oil available for weed killing can dissolve 7 to 10 percent of pentachlorophenol, this chemical is the easier to use. However, if the supply or economic considerations require the use of oils like crankcase or diesel, which usually cannot dissolve enough pentachlorophenol, then the sodium salt can be used. In such cases the oil must be emulsified in water, and the water serves here as the solvent for the sodium salt.

Whenever oil is to be emulsified in water, the question of emulsifiers arises. Oils differ in their ease of emulsification, and the more agitation available in the spray tank, the less emulsifier is needed. In some types of sprays no emulsifier at all is used. In general, when pentachlorophenol is added to oil, more emulsifier is needed for a given degree of stability. If the concentrate which may be prepared for diluting in the field is made without water, an oil soluble emulsifier must be used. If a concentrated emulsion of oil and water is to be used with pentachlorophenol or its sodium salt, either an oil-soluble or water-soluble emulsifier may be used. A number of suitable emulsifiers of either type are available. In special cases, combinations of emulsifiers have definite advantages.

In spraying of any sort, results depend upon the equipment used. Since this chemical does not translocate, it is necessary to get good coverage on the vegetation we wish to kill, or uniform application to the soil surface if we are applying a pre-emergence spray. This is usually achieved by adding the proper amount of water to the spray so that the equipment available will produce a uniform application. As with 2,4-D, the trend seems to be toward those formulations and equipment which will give uniformity with as little as 5 gallons per acre. At such a rate a spray need consist only of oil in which pentachlorophenol is dissolved. Several tests of this nature have given good weed control in crops when used as pre-emergence sprays.

Rates of application still vary considerably among investigators and commercial users. Most commercial applications of spray containing oil usually consist of 4 to 6 gallons of oil and from 2 to 5 pounds of pentachlorophenol per acre. Information has not yet been developed to the point where we can prescribe specific rates for all given sets of conditions, but extensive tests in all sections of the country should serve to clear up the situation. The

cost of materials as used in most commercial work usually stays in the range of $1 to $3 per acre. Weeds are controlled from a minimum of 30 days to the entire growing season, depending on climatic conditions.

As I mentioned before, these chemicals have been widely used for some time in both sugar cane and pineapple. Interest in them has only comparatively recently spread to the States, but already results indicating success on pre-emergence tests have been made for crops such as sugar beets, potatoes, corn, soybeans, asparagus, green and lima beans, curcubits, peas, and other legumes. Probably the earliest commercial use in this country involved the application of the sodium salt as a selective spray in growing onions.

In addition to its use in crops this chemical in combination with oil is being used increasingly for the control of weedy growth along highways, around tank farms, lumber yards, substations, along railroad rights-of-way, and for clean culture in orchards, which is particularly important in irrigated areas. The cost of such sprays, which in the past have frequently consisted only of oil, can be appreciably reduced by using pentachlorophenol to decrease the quantity of oil needed.

Pentachlorophenol or its salts can also profitably be combined with other herbicides to either reduce the cost or decrease the hazards involved. Successful combinations of this type include those in which either chlorates, arsenicals or borax constitute the other active ingredient. Combinations with 2,4 D have given good results in killing perennial grasses in certain areas.

In addition to its use in weed control, pentachlorophenol is attracting interest as a defoliant for certain crops. Successful tests have been conducted on soybeans and potatoes and its use for this purpose will undoubtedly be adapted to other crops in which defoliation may be an advantage.

Favorable reports on pentachlorophenol are becoming more and more numerous. With the help of investigators throughout the States, it is finding its place in this country as an economical, effective herbicide to be used in situations in which 2,4 D or other chemicals are not suited.

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[2]U. S. Patent, No. 2,370,349: issued to F E. Hance, February 27, 1945.

[3]Hance, F. A., Paper presented before Western Weed Control Conference, Proceedings of Tenth Annual Western Weed Control Conference, 1948, p.52.

Preliminary Report on Quack Grass (*Agropyron repens*) Eradication with Ammonium Trichloroacetate and Sodium Trichloroacetate under Field Conditions

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Early in 1947 the E. I. DuPont DeNemours & Co. supplied us with a limited amount of a new herbicide, Ammonium trichloroacetate, which, at the time, was recommended as being particularly effective against grasses. Limited applications by us in the summer of 1947 gave rather remarkable results in the control of Quack grass and showed other possibilities as well. In early 1948 the DuPont Co. kindly provided us with a considerable quantity of the Ammonium trichloroacetate in a much more concentrated liquid form as well as a comparable amount of the newly synthesized dry sodium trichloroacetate. For purposes of convenience the name Ammonium trichloroacetate will henceforth, in this paper, be abbreviated to ATA and the Sodium trichloroacetate to STA. The ATA was a concentrated liquid containing 69% of active Ammonium trichloroacetate; the STA was a dry material containing 70.6% of active sodium salt. Since there was approximately the same amount of active material in the STA as in the ATA, the two substances were used on a pound-for-pound basis throughout the experiment.

Previous Work

In addition to the preliminary tests carried on by the DuPont Co., considerable experimental work was done during 1947 using ATA on a variety of weed-grasses. Willard & Neville (1) and Zahnley (2) reported it as effective in treating Quack grass at the meeting of the North Central Weed Control Conference in December 1947. In May 1948 Carlson & Moulton (3) reported results of using ATA and STA on flats of Quack grass and Kentucky bluegrass in the greenhouse. Applications to foliage of 200 lbs. per acre or at the rate of about ½ lb. per hundred sq. ft. resulted in a complete kill of rhizomes with both the ammonium and sodium salts. At considerably lower concentration, their published results showed the STA to be somewhat consistently the more effective of the two materials, although their published conclusion was to the effect that the ammonium salt and the sodium salt were "equally effective".

Experimental Work

The experiments were designed (1) to compare the two chemicals as to herbicidal value, (2) to determine the conditions during late spring and summer for most effective application, (3) to discover the results of varying the concentrations and total amounts of the two chemicals at each time of application.

It was decided to experiment on several relatively small infestations, because more might be learned by trying out the materials under several different conditions than by using the rather limited quantities of herbicide in a series of replications. In all cases, except where otherwise noted, applications were in aqueous solution and were sprayed uniformly as a fine spray over each plot at the rate of one gallon per one hundred square feet.

Four areas were treated from June 15-July 21 inclusive. Two of these were in Dover, one in Durham, and one in Bedford—all in New Hampshire. The Dover and Bedford areas were dense and almost pure stands of Quack grass. The Durham plot was an area of Quack grass abundance but with an admixture of many other weeds.

July 15 treatments. The first series of treatments was in Dover and consisted of a rank and apparently uniform growth of Quack grass between cold frames. The three narrow strips of grass treated were slightly more than 3 feet wide and 120 feet long. Each strip was divided into two halves, each 60 feet long and estimated to contain about 200 sq. ft. of surface. Each of the six uniform plots thus marked off was given a different treatment, as indicated in the accompanying chart.

JUNE 15 FIELD TREATMENTS OF QUACK GRASS WITH ATA AND STA

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Plot	Herbicide	Amount per 100 sq. ft.	Effect on Quack Grass July 1	July 22	Oct. 4	Effect on other weeds July 1	July 15	Oct. 4
A (300 lb/A)	ATA	3/4 lb.	all dead	no grass	a few plants near edges of plot	no weeds	annual weed seedlings	numerous annual weeds
B	STA	3/4 lb.	all dead	no grass	several small clumps	no weeds	weed seed-lings	scattered annual weeds
C (200 lb/A)	ATA	½ lb.	all dead	no grass	several small clumps	no weeds	weed seed-lings	abundant annual weeds
D	STA	½ lb.	all dead	no grass	3 clumps near edges of plot	no weeds	weed seed-lings	scattered annual weeds
E (100 lb/A)	ATA	¼ lb.	mostly dead	few plants persist-ing	scattered plants and clumps	no weeds	weed seed-lings	abundant weeds
F	STA	¼ lb.	mostly dead	few plants persist-ing	scattered plants and clumps	no weeds	weed seed-lings	abundant weeds

The weather up to June 15 in Dover had been cool and wet. The soil was a moderately heavy loam and at the time of treatment was wet. The afternoon of treatment was sunny and the temperature ranged between 70 and 75°F.

About one month after treatment, five species of annual weeds were germinating or had recently germinated and were present on all plots in some abundance. By far the most numerous of these was Purslane but also present were Chickweed Stellaria media, Lambs-quarters, Red-root and Galinsoga. No grasses, annual or otherwise, were noted except for a few scattered persisting clumps of Quack grass in the 1/4 lb. treatments. Some injury to the annual weeds, particularly to Galinsoga, was observed.

On October 4 some differential effects of ATA and STA were evident. The 3/4 lb. and 1/2 lb. treatments of STA had slightly more effectively destroyed Quack grass than had the comparable ATA treatments, but the depressing effect of STA on the germination and growth of annual weeds, particularly with the 3/4 and 1/2 lb. applications, was much greater than that of ATA. The effects were rather more pronounced in the 3/4 lb. than in the 1/2 lb. applications. With the ¼ lb. treatment any differences in the effects of STA and ATA were not evident.

On October 4, Purslane, Lambs-quarters and Red-root were generally common, except as above noted with STA, and scattered plants of the following species

occurred also on all plots: Crab-grass, Galinsoga, Carpet-weed, Charlock, Yellow wood-sorrel, Plantain and Dandelion. The presence of vigorous plants of Petunia and Tulip-poplar on one plot indicated the suitability of treated areas for a variety of cultivated plants as well as weeds within a period of a month or six weeks following treatment.

July 2 treatments. This area was in Durham and consisted of a weedy garden 25 feet square formerly planted to strawberries. The area was divided into two halves nearly alike in weed content and physical characteristics to which ATA and STA respectively were applied. The concentration used in each case was ½ lb. per gallon of water. The principal weeds in this old garden plot were grasses but with a considerable admixture of a great variety of perennial and annual weeds. Some twenty species of broad-leaved weeds were noted on July 2 at the time of treatment. The grasses in the order of their abundance were: (1) Quack grass, (2) Kentucky blue grass, (3) Timothy, and (4) Redtop. On July 14, twelve days after treatment, most of the grass plants were dead or obviously very sick. Timothy and Bluegrass appeared to be more resistant than Quackgrass and Redtop. The majority of the annual weeds seem to have been destroyed by the treatment but many of the biennials and perennials seemed to be persisting.

By late summer many of the perennial weeds had completely recovered and were thriving. Also, numerous annual species were filling in the empty places where the grasses had died out.

By October 4, when the last observation was made, a total of 36 species was listed as growing on the treated plots. Fifteen of these were perennials or biennials and of these the majority were species that had survived the treatments. Of the remaining 21 annuals all except five were species that had not been observed at the time of treatment. Three annual species of grasses were present but only Timothy of the perennial grasses survived to any considerable degree. A careful search among the numerous other weeds revealed two small clumps of Quack grass near the margin of the plot. No apparent differences between the ATA and STA treatments could be found. The soil in these two plots was a heavy clay soil and was wet at the time of treatment.

July 12 treatments. This area in Bedford in the Merrimack Valley consisted of a nearly pure stand of uniform Quack grass growing in an old Peony bed. Scattered plants of Redtop, Common Vetch, Sulfur Cinquefoil and Daisy fleabane were noted.

An area 60 x 30 feet was marked off into a linear series of six plots each 10 x 30 feet. The treatments and results may be summarized in the following chart.

JULY 12 FIELD TREATMENT OF QUACKGRASS WITH ATA & STA

Plot	Herbicide used	Am't per 100 sq.ft.	Condition of Quack Grass July 26	Condition of Quack Grass October 20	Condition of other weeds July 26	Condition of other weeds October 20
A	ATA	3/4 lb.	all dead	all dead	more evident	more evident
B	ATA	½ lb.	all dead	all dead	more evident	more evident
C	ATA	1/4 lb.	all dead	all dead	more evident	more evident
D	STA	3/4 lb.	all dead	all dead	more evident	more evident
E	STA	½ lb.	all dead	all dead	few plants of daisy fleabane and cinquefoil	as on July 26
F	STA	¼ lb.	all dead	all dead	" "	as on July 26

The day of treatment was very hot, with a maximum of 90°F., and dry. The soil was a light sandy loam and very dry at the time the treatments were applied. Within two weeks the Quack grass was brown and dessicated and apparently dead in the plots receiving 3/4 lb. and 1/2 lb. applications. Later the ¼ lb. application seems also to have been effective, for in none of the plots has any reappearance of Quack grass been noted this year. No seed-germination occurred on any of the six treatments during the remainder of the summer and fall.

The failure of seed germination on these plots as compared with the Durham and Dover treatments discussed previously may perhaps be explained by the fact that the surface layers of soil were well dried out by July 12 and that there were no heavy soaking rains during late July and August. The inhibiting effect of herbicide on seed germination would have ceased by late July but from that time on conditions for seed germination were undoubtedly unsatisfactory. A further unique feature of the Bedford experiment was the nature of soil--a light sandy loam which may have rendered the ammonium and sodium trichloroacetate more potent, particularly at the lower concentrations.

July 21 treatments. The fourth and final series of plots was set up in Dover. The following chart will indicate the treatments and results:

Plot	Herbicide	Am't per 100 sq.ft.	Effect on Quack Grass July 22	July 29	October 4
A	ATA	3/4 lb.	foliage browned somewhat	crisped	all dead
B	ATA	½ lb.	foliage browned somewhat	mostly crisped	some living plants scattered
C	ATA	1/4 lb.	browned slightly	some living	scattered living grass
D	STA	3/4 lb.	foliage browned somewhat	crisped	all dead
E	STA	1/2 lb.	foliage browned somewhat	crisped	all dead
F	STA	1/4 lb.	browned slightly	some living	sparse living grass
G	ATA	3/4, in ½ gallon	foliage browned	crisped	all dead

To one of the seven plots a total aqueous solution of ½ gallon was applied instead of 1 gallon per 100 sq. feet. This was intended to demonstrate the possibility of reducing the materials used as well as the time necessary to apply the herbicide--a step in the direction of low-gallonage operation.

The principal weed in all of these plots was Quack grass. Scattered Timothy plants were present in all plots. Occasional plants of Ragweed, Lambsquarters, Yellow Foxtail, White daisy, and Daisy fleabane occurred throughout the area and in parts of plots F and G in particular. As in the Bedford experiments, the grass was left unmowed for the treatments. Eventually most of the annual weeds were killed by the various treatments; some perennials persisted; Timothy was more resistant than Quack grass.

The soil in these treatments was a heavy clay loam and at the time of application was thoroughly dry on the surface and to a considerable depth. The day of application was hot--about 85° at 2:00 P.M.

Summary and Conclusions

1. Applications of 3/4 lb. per gallon of ATA and STA were entirely effective in controlling Quack grass in all types of soils studied and at all times of application.

2. In light dry soils ½ lb. and ¼ lb. applications of both ATA and STA were entirely effective in midsummer and in dry weather when soils were quite dry.

3. Both ATA and STA behave as temporary soil sterilants inhibiting germination and growth of broad-leaved annuals and perennials as well as grasses for a period of from several weeks to several months, depending on the conditions.

4. STA seems to have a more potent residual effect than does ATA.

5. STA seems also to produce a slightly better control of Quack grass at medium and low concentrations.

6. On the basis of a single application, it is suggested that the total amount of solution may be reduced somewhat as long as the total amount of active herbicide is used per unit area.

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Chemical Control of Quack Grass

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An area with a good sod of quack grass (Agropyron repens) was plowed and harrowed, then treated with 20 and 40 pounds of 2,4-D acid, sodium salt, and butyl ester, 5,10,20, and 40 pounds of IPC, land 2 tons of cyanamid 1,000 pounds ammate and one ton of borax on August 8 and 9, 1947. Half of each plot was harrowed after the treatments were applied. The harrowed portion gave poorer control in nearly all cases.

The control with IPC was poorer than with 2,4-D. Cyanamid reduced the stand in the fall, but stimulated the remaining plants in the spring. The borax killed all the quack grass, no growth appeared on the plots in 1948. The ammate plots without harrowing killed the quack grass 100%, where harrowed the kill was about 70%. Annual weeds were growing on the ammate plots in 1948.

A second series of plots were treated on September 23, 1947, using 5,10, and 20 pounds of IPC from 3 different sources and ammate at 500 and 100 pounds per acre with three replications. The fall was very dry. No treatment gave more than 20% control in 1947. In 1948 there was no sign of any control even from 1,000 pounds of ammate.

On August 7, 8, and 9, 1948, a sod which had been plowed and harrowed was treated with 10 and 20 pounds per acre of 2,4-D acid, sodium salt, amine and ester of 2,4-D, 2,4,5-T ester, and PIC applied wet and dry, 500 and 1,000 pounds of borax, ammate, and sodium thiocyanate, 100 and 200 pounds of ammonium and sodium TCA and a sodium mixture of mono,di, and tri chloroacetate at the same rate. This mixture contained about 80% trichloroacetate.

The quack grass plots treated with 200 pounds of TCA have nearly 100% kill, while those treated with 100# have about 98 to 99% kill. The few remaining plants are very weak. The plots with 80 pounds of TCA are about 95% killed. The 1,000 pounds of sodium thiocyanate was about the same as 100 pounds TCA. The other kills were 500 pounds sodium thiocyanate 90%, 500 and 1,000 pounds ammate 80 and 90%, 500 and 1,000 pounds borax 15 and 35%. The 20 pounds of the different 2,4-D formulations, killed about 15 to 20% and 40 pounds about 25 to 30%. The IPC at the same rates were somewhat poorer than the 2,4-D when applied on the quack grass sod which had been plowed.

2 4 D	20 - 40 lb/A	N.G
IPC	to 40 lb/A	N.G
Cyanamid	2 ton	Fall only
Amate	½ ton	Good
Borax	1 ton	Good
2 4 5 T	20 lb/A	
Sod Thiocy	1000 lb	Good
5 TCA		
TCA +	200	Good

"METHODS AND MATERIALS FOR OUT-STATE WEED CONTROL DEMONSTRATIONS"

C. S. Garrison

During the spring, summer and fall of 1948 a series of 65 demonstrations using different herbicides as weed killers were conducted in asparagus, pasture, alfalfa, sweet corn, field corn, oats and barley fields and strawberry beds. The purpose of these demonstrations was to fully acquaint farmers in all areas of New Jersey with the proper use of herbicides. While the majority of the demonstrations included different kinds of 2,4-D, other herbicides such as Cyanamid and 2,4-5T (trichlorophenoxyacetic acid) were used.

In planning for these demonstrations it seemed best to use large plots since farmer groups would be visiting the fields. Farmers are more impressed with results which can be demonstrated on field scale operations than from small plots. Adequate replications had to be used where yield results were to be obtained.

The same kind of spraying equipment as used by farmers was employed to put on the over-state demonstrations in all but a few of the cases. The equipment consisted of a station wagon, equipped with a low gallonage sprayer. The sprayer power unit was a Briggs Straton one-horse gasoline engine belted to a No. 2 Oberdorfer pump, both mounted on a wooden frame and set in the rear of the station wagon. From this wooden mounting a metal frame, approximately 42 inches wide, consisting of two pieces of strap iron and a connecting cross bar, was made to extend over the tailboard of the station wagon. At the end of each piece of strap iron a vertical arm was attached and drilled with holes approximately one inch apart. These vertical arms made it possible to adjust the height of the sprayer boom from 14 inches to 48 inches above the surface of the ground.

An 18 foot boom (three 6-foot sections) with Tee-Jet nozzles spaced 18 inches apart was used for all large scale spraying demonstrations. Two different nozzle sizes were used which put on five and ten gallons of solution when the sprayer was moving at four miles per hour. This three section boom made it possible to use plots 6 feet, 12 feet, and 18 feet in width.

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The different solutions of herbicides were carried in five gallon milk cans or metal drums. Thus the feeder hose connected to the pump was easily changed from one solution to another. Between each plot it took approximately forty seconds for the pump to clear the system of the solution used on the previous plot.

In most of the work with 2,4-D on corn, oats, pasture, asparagus, etc., three to five rates and two different materials (amine salts and esters) were used.

The pump was normally operated to deliver 30 pounds pressure. A by-pass valve made it possible to vary the pressure from a very low figure up to about 70 pounds. The ground speed of the vehicle when spraying was four miles per hour in practically all the demonstrations. In a few instances other speeds were used. The speed was read from an electrical tachometer with the dial located in full view of the driver. This instrument was calculated in RPMs and can be read more accurately than a speedometer. The number of RPMs needed to maintain a given speed in low gear was known. The electrical tachometer worked so satisfactorily that it was not necessary to use a governor.

Plots of at least 100 feet or more in length were best although ones as short as 50 feet were used. A fifty foot plot doesn't allow enough distance to get the vehicle to the desired speed, and still have an adequate footage left for yield determination. The best demonstrations were those where the plots ran the full length of the field. Not only did this give a better view of the results obtained but in cases where mechanical harvesting equipment was used it simplified the problem of obtaining yields from the plots. Forage choppers and corn huskers were used to harvest corn silage and grain demonstrations.

To demonstrate the use of aero granular Cyanamid as a pre-emergence treatment of corn for the control of weeds a regular granular Cyanamid spreader was mounted on the back of the station wagon. By varying the ground speed and the size of openings on the bottom of the spreader it was a simple matter to put on two to eight hundred pounds of granular Cyanamid per acre and get a uniform coverage of the soil.

Two 2 x 4's were bolted to the gasoline engine-pump mounting and extended approximately 18 inches beyond the tailboard. The Cyanamid spreader was fastened to the 2 x 4's with two angle irons. The splash board was fastened underneath the 2 x 4's.

All the spray equipment and the Cyanamid spreader could be carried to any part of the state at the same time in the station wagon. The spreader being just short of seven feet in width did not have to be dismantled when traveling over the highways. Also, having the sprayer boom in sections eliminated entirely dismounting it. The two outside sections of six feet each were removed. The center section mounted in the steel frame stayed in place when traveling from one farm to another. Thus, little time was spent in mounting and dismounting of the sprayer.

Where it was best to use small plots, a knapsack sprayer with a six foot-four nozzle boom was employed. It was also possible to put on demonstrations with this hand boom by attaching it to the power pump with a good grade of garden hose. Several demonstrations of spraying poison ivy and honeysuckle around trees were tried. Fifty feet of garden hose was used so the operator could cover a large area. The station wagon was driven in or near the thinned wooded area and the operator of the boom was able to work on each side of the vehicle for a distance of fifty feet. A longer hose could be used if desired.

Insofar as possible the over-state demonstrations were laid out with the thought of using them as a means of obtaining additional research information. In all cases the same material and rates were used in the over-state demonstrations as in the tests at the Experiment Station. This gave an opportunity to correlate results from different soil types found in the various areas of the state.

THE EFFECT OF NOZZLE PATTERNS AND DISTRIBUTION ON SPRAYING EQUIPMENT DESIGN AND OPERATION

by

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This is a brief version of a paper to be presented in more detail with figures and illustrations at the Northeastern Weed Control Conference. In it some of the problems in the design of sprayers for chemical weed control in corn growing areas will be discussed. The data to be presented apply also to areas growing other crops in rows. Corn may be sprayed for weed control without damaging the crop provided the spraying is done at the proper time. Certain problems are encountered in spraying weeds in row crops that do not enter into flat spray work such as in small grasses, pastures, and meadows.

Basic Requirements for Sprayers

There are at least two basic requirements that weed spray equipment for corn growing areas should meet. It should be possible to adjust the equipment to do a satisfactory job of spraying for the control of European corn borer. Then without major change it should be possible to adapt the machine to spraying for control of weeds. Experiments have been conducted to determine some of the design requirements of spraying equipment. Major emphasis has been placed on nozzle location and spray distribution.

For the control of the European corn borer, the nozzle arrangement should be such that one nozzle sprays directly down into the top of the corn plant and two nozzles spray from side positions onto each plant. It is important to place DDT in the whorl of the corn plant and into the leaf shields at the side of the plant. While specific nozzle locations cannot be made, research work under way will probably answer this point in the near future. It is not the main purpose of this paper to discuss equipment for corn borer control, but it must be assumed that any weed control equipment designed for this area should be able to handle corn borer spraying as well. Twenty inch nozzle spacings along the boom of our experimental sprayer fit the requirements of the forty inch rows that are commonly used in the Corn Belt.

In order to adapt the same experimental sprayer to cover four rows of corn for weed control, the spray nozzles are off-set ten inches from the position they occupy when used for corn borer work. This permits operation with two nozzles between each pair of rows. To obtain this nozzle arrangement, provision was made

for shifting the boom ten inches horizontally on the tractor or trailer on which it may be mounted. This is a desirable feature. A similar effect may be obtained by placing a plug in the nozzle directly over the row and using drop pipes on forty inch spacings with double nozzle heads working midway between the rows as will be discussed later. Basic requirements considered essential in the design of this experimental equipment were that when spraying weeds, the chemical or spray material should be controlled and directed onto the weeds, not onto the crop plant, and that when spraying for corn borer, the chemical should be placed on the crop plant.

Spray Nozzle Tests

Uniformity of application of material should be one of the aims in the design of spray equipment. In studying this problem tests of distribution patterns of individual nozzles was first to receive attention. The test apparatus used consisted of a sheet of corrugated aluminum with 2.7 inch corrugations. A section 4 feet by 6 feet makes up the test tray. The 6 foot dimension is across the series of corrugations. The sheeting is so mounted that the corrugations are inclined in their longitudinal direction (the 4 foot dimension) and drained to the front. At the bottom of the incline there is a rack holding graduated cylinders. Above the test tray, and mounted on standards providing height adjustments, is a pipe which carries the nozzles to be tested. A pump, adjustable for pressure, pumps a standard mixture of butyl ester and water through the nozzles for testing. The standard mixture used in these tests was one quart of 40% 2,4-D liquid to 10 gallons of water.

In testing individual nozzles three different nozzles of each kind, selected at random from commercial stocks, were used. A series of tests was made on four kinds of fan-type nozzles at 30 pounds per square inch pressure. Nozzle No. 1 is rated to give a 65° spread of spray material. It was found that when this nozzle was run at a height of 18 inches it gave about twice as much material in the center 2.7 inches as it did at the outer edge of the 20 inch fan. If spraying is being done at a rate of application close to an amount that would cause crop damage, it can be imagined what the effects on the crop plant might be if such a nozzle were placed directly over the crop row. On the other hand little damage would result if the nozzle was placed so the crop plant was at the edge of the fan.

In similar tests, nozzle number 2, an 80° nozzle, showed that the rate of application at the edge of the fan was only 66% of that at the center 2.7 inch section. It was found that considerable variation exists between individual nozzles of some makes and frequently an odd pattern is formed. Nozzle number 3, a 70° nozzle, gave a high point not in the center but at a point about 5 inches away from center. Discharge was about twice as great at the peak as at the 20 inch borders. Nozzle number 4 with an

80° fan pattern showed 36% variation between the high points and the 20 inch points. When the same nozzles were tested at a 40 pound per square inch pressure, the uniformity of application was essentially the same as with the 30 pound pressure. In general the fan angle or width of coverage was increased.

In the next series of tests two fan-type nozzles were arranged at 20 inch centers, as they would be on a multiple-nozzle boom. In the first test in this series 65° nozzles were located 12 inches above the test tray. The rate of application was not uniform. The center portion received only about 1/4 of the average; the boom being too low to give uniform coverage. This may happen under field conditions if the boom is improperly placed or on irregular ground when the boom passes over a ridge or high point. On the other hand, this might be a desirable condition if the operator was trying to put a minimum amount of spray material on the crop plant. Of course, the rows would have to be located midway between the nozzles to attain the desired effect.

In the second test in this series the boom was raised to 18 inches above the test tray but no other changes in arrangement were made. Here the sum of the discharges from the two nozzles gave a rather uniform rate of application. A slight peak occurred at the center which would be desirable if weeds were numerous in the row between the corn or crop plants.

In a pair of similar tests but with 80° nozzles at 12 and 18 inch heights respectively, a more uniform rate was obtained at the 12 inch height due to the wider angle. At the 18 inch height a pattern similar to that with the 65° nozzles was obtained.

Next, several individual nozzles were tested with their axes inclined 30° to 35° from the vertical. The total width of spray pattern was about 40 inches, but the distribution varied greatly over the 40 inch width. In the 20 inch space adjacent to the nozzle the delivery pattern was fairly uniform. The gradually decreasing rate in the remaining 20 inches indicated possibilities for combining nozzle patterns to obtain uniform rates of application throughout the length of the boom.

Out of several combinations with inclined nozzles, where the inclination was adjustable, two were selected that showed very good uniformity of distribution. In one of these, 65° nozzles, inclined 30° from vertical, were tested at 18 inches above the test plane. In the other, 80° nozzles at 35° from vertical were operated at the same 18 inch height. Drop pipes were spaced 40 inches on centers along the boom in both cases. It is likely that other satisfactory combinations could be found through more exhaustive tests.

Commercial twin nozzle attachments for drop pipes are on the market. The included angle is fixed at 65°. Using 65° nozzles in these attachments, fairly good distribution was attained

at a height of 16 inches except there was a deficiency of spray material directly below the drop pipe where the fans failed to meet. This difficulty was overcome by using 80° nozzles in the attachment. The distribution was excellent when these nozzles were placed 14 inches above the test tray.

Desirable Features of Field Sprayers

The experimental sprayer mentioned earlier in this paper was not intended for commercial development but rather to satisfy the needs of experimental work, specifically as regards nozzle location and adjustment. However, a sample model has shown satisfactory field performance, and it includes several desirable features.

The main frame is of hardwood and no provision is made for folding the ends of the boom. This wooden frame mounting, without hinges or fold-back features, provides shock absorbing qualities together with a degree of rigidity not always found in commercial units. Only two bolts hold the spray boom assembly to the front framework. Two pairs of holes allow placement of the boom in position for weed spraying or for corn borer spraying as desired by the operator. To transport or store the unit, the two bolts are removed and the boom assembly is carried on supports at the side of the tractor. The boom is made from 1/2 inch pipe and regular pipe fittings are used. The pipe is so mounted on the lower edge of the wooden support member that it will fold back if a nozzle or drop pipe strikes an obstruction.

The unit has three strainers; a relatively coarse one in the supply tank, a finer one at the discharge side of the pump, and the finest screen at the nozzle. A power-take-off type of pump is used, capable of developing about 100 pounds per square inch. Pressure control is through a pressure gage and two hand-adjusted by-pass valves mounted on the tractor steering column.

Field Tests of Nozzle Location

Results of one years tests on the effect of nozzle location and spray distribution on corn yields are available. Randomized plots of corn with ten replications were given four treatments. All of these were treated with one-half pound 2,4-D acid (butyl ester) per acre. All treatments were at 20 to 24 inch height of corn. The treatments were (1) spray nozzle directly over row, 20" spacing, (2) drop pipes 20 inch spacing with nozzles 10 inches from corn row, (3) 40 inch spacing, double head nozzle, (4) check or no treatment. All corn was cultivated twice. These data were taken: weed count, net yield of corn, down ears, leaning stalks, corn picker losses.

Table 1 gives the results of the tests. Statistical analysis has not been completed. Preliminary examination, however, shows significant weed count differences between spraying and no treatment. This was not reflected in yields, however. It should be

explained that the weeds, mostly pig weeds, were small at spraying time, and the corn was growing rapidly. Even in the check plots the weeds never developed enough to seriously compete with the corn. The leaning stalks show significant differences between sprayed plots and check plots but not between distribution patterns.

Table 1

Effect of Nozzle Location on Yields of Corn

Performance Measurements, Averages, 10 Replications	1 Nozzle Over Row 1 Between 20" Spacing (1)	10" Each Side Row 20" Spacing (2)	2 Nozzles Between Row 40" Spacing (3)	Check Number Treatment (4)
Weeds per acre, 5 weeks after spraying	13,200	12,800	7,500	44,900
Corn plants per acre	12,754	12,640	13,326	13,210
Down ears per acre	1,158	1,272	1,330	1,454
Leaning stalks per acre	1,580	1,738	1,562	1,142
Picker ear losses, bushels per acre	4.27	4.99	5.03	4.22
Net yield, bushels per acre	85.79	81.08	84.34	86.51
Gross yield, bushels per acre	91.17	87.22	90.50	91.85

CYANAMID AND ITS DERIVATIVES FOR WEED CONTROL

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It appears necessary that biologists working with chemicals for weed control should have a rather complete knowledge of the chemical and physical characteristics as well as the physiological effects of the compounds with which they are experimenting, if the compounds are to be most efficiently adapted and applied for weed control. This information is of value in several aspects. First, in the selection of experimental compounds which have the best chance of accomplishing the desired weed control under the environmental conditions and cultural practices in the area in which it is to be employed; Second, in developing the optimum methods and time of applying the chemicals; and third, in interpreting and understanding the results obtained from a given test, particularly in relation to data obtained with the same or similar compounds in other sections of the country.

I would like to take this opportunity to present certain information regarding the chemical and physical characteristics of crude calcium cyanamide and some closely related compounds for the purpose of illustrating how such factors can influence the utility of herbicides. The compounds to be considered are:

crude calcium cyanamide	-	CaNCN
monosodium cyanamide	-	NaHNCN
sodium cyanide	-	NaCN
ammonium thiocyanate	-	NH_4SCN
potassium cyanate	-	KOCN

Calcium cyanamide is and has been produced principally as a source of nitrogen for crop fertilization. However, because of the unique chemical nature of this compound it is also finding additional uses as a contact and selective herbicide, as a defoliant and as a soil treating compound for the killing of weed seeds. Brief consideration of the method of manufacturing this material appears in order since it has bearing on the uses and limitations of the compound as a herbicide. Calcium cyanamide, $CaCN_2$, is made by passing pure nitrogen through ground calcium carbide which is heated to about 2,000 degrees Fahrenheit. The white hot carbide combines with the nitrogen to form calcium cyanamide and free carbon. After this reaction takes place, the crude product is a hard solid mass. It is then processed for commercial purposes by crushing and grinding to a fine powder for dusting or by granulating to facilitate handling for soil treatment. The primary toxic principle is

formed when this crude cyanamide comes in contact with water on plants or in the soil where it decomposes, as shown by the following equations, to form free cyanamide (H_2CN_2).

$$2\ CaCN_2 + 2H_2O \rightarrow Ca(HCN_2)_2 + Ca(OH)_2$$

$$Ca(HCN_2)_2 + 2H_2O \rightarrow 2H_2CN_2 + Ca(OH)_2$$

Since water is required for the formation of free cyanamide from calcium cyanamide, it is necessary that for herbicidal or defoliation action the material be applied either when the plants are wet with dew or when dew is expected within a few hours after application. Further, because the Cyanamid particles are hard fused masses the rate of solution of calcium acid cyanamide is fairly slow, requiring 30 minutes or more to obtain maximum solution or extraction, the dew period following application should persist for at least this length of time to obtain maximum lethal action. Failure to appreciate this moisture requirement for contact herbicidal or defoliation action by Cyanamid has resulted in improperly timed application and variable results by many experimenters.

In the soil Cyanamid further hydrolyzes to produce urea, according to the following equation:

$$H_2CN_2 + 2H_2O \rightarrow 2H_2NCONH_2$$

Because urea is also used as a soil treating compound for the control of weed seeds, many investigators have concluded that the toxicity from Cyanamid is due to this urea formation with the subsequent production of free ammonia. Such does not appear to be the case because free cyanamide has been found to have a much higher level of toxicity than urea, and at the rates at which Cyanamid is normally used for soil treatment the urea produced would not be sufficient to form enough free ammonia for sterilization. The knowledge of the fact that the free cyanamide is the principal toxic compound produced from crude calcium cyanamid will explain why optimum soil conditions for toxic action from Cyanamid will not necessarily be the same as for urea, and that conditions favorable for the rapid conversion of Cyanamid to urea may not necessarily result in the best weed control.

Monosodium cyanamide is now being experimented with in an attempt to overcome the moisture requirements of the crude calcium cyanamide when used as a contact herbicide or a defoliant. The sodium salt has been employed as a crude dust and as a soluble spray. Monosodium cyanamide is hygroscopic in nature and

when employed as a dust it takes up sufficient moisture from the air, under most environmental conditions, to be activated. Because of this factor monosodium cyanamide dust has proven more effective than the crude calcium cyanamide dust in many of the arid sections of the country. This soluble grade monosodium cyanamide applied as a spray has an advantage over the crude calcium cyanamide which because of the large proportion of insoluble material present cannot practically be applied in most spray equipment. Sodium cyanamide does not appear to have any appreciable advantage over crude calcium cyanamide for soil treatment probably because there is usually sufficient moisture in the soil to activate the calcium cyanamide.

Sodium cyanide is included in this list because of its apparent similar chemical structure to the cyanamides rather than because of any use or possible use of the cyanides as herbicides. It is of interest to note the marked difference in toxicity to animals between the cyanide (CN) group and the cyanamide (CN_2) group, the cyanide group having an extremely high order of toxicity to members of the animal kingdom, permitting widespread use of its compounds as insecticides, and the cyanamide group having an extremely low order of toxicity to both insects and higher animals. Cyanides do have a fair degree of toxicity to plants but not sufficient, particularly considering the level of toxicity to higher animals, to warrant any consideration of their use as herbicides. It might be pointed out that in spite of the close apparent relationship between cyanamides and cyanides there is no evidence that calcium or sodium cyanamide does or can convert to cyanide when employed for agricultural purposes.

Thiocyanates, particularly the ammonium salt, have been experimented with as herbicides for many years. The principal source of thiocyanates has been as a byproduct in the process of manufacturing gas free coal. Ammonium thiocyanate has a fairly high order of toxicity to plants. It has been tested rather extensively as a herbicide and has been found of value for the contact killing of annual plants. Also, since it is quite readily translocated in plants, it has been proven to be effective for the control of certain perennial plants including poison ivy. However, apparently because of the competition from other cheaper or more efficient compounds the herbicidal use of thiocyanates has never developed to any appreciable extent. Its corrosiveness to metals and its extremely hygroscopic nature have also served to deter widespread commercial use. At the present time ammonium thiocyanate is being used to a limited extent as a cotton defoliant in the arid regions. Its exact value for this purpose remains to be established.

Potassium cyanate is one of the newer compounds to be developed as a herbicide. This compound has about the same general

order of toxicity to plants as monosodium cyanamide and ammonium thiocyanate. However, its virtues and commercial application lie primarily in its selective killing. Most plants having narrow leaves, as onions, most grasses, certain ornamentals etc, and those plants having a bloom on their leaves as peas, flax, cabbage and closely related plants, etc. are quite resistant to potassium cyanate, while most annual weeds are readily killed. Because of the ability of potassium cyanate to kill purslane, one of the most important weed pests in onions and a weed considered resistant to most herbicides, this compound has been extensively employed on a commercial scale for the control of weeds in onions. Experimental or semi-commercial applications have also indicated its value for the selective killing of crab grass in lawns, selective weeding of gladioli, peas, asparagus, small grains, etc. The ease of handling this compound both from the standpoint of lack of any disagreeable effect on the operator and non-corrosive nature to machinery, encourages the prospect that this material will find other specialized herbicidal uses. Cyanates do not appear to be readily translocated in plants and consequently have not proven effective for the control of perennial weeds. Cyanates are stable in alkaline solutions, and since spray solutions of the potassium and sodium salts are moderately alkaline, they will remain fairly stable. However, on contact with acid soils break down occurs quite rapidly, with the potassium cyanate decomposing to form potassium bicarbonate and ammonia, both of which are relatively non-toxic. This break down occurs rapidly enough so that cyanates are not effective for the treatment of most soils to kill weed seeds before or during germination. However, this decomposition is advantageous in connection with its use as a selective herbicide since the danger of toxic action through the roots of crop plants is lessened, and there is no danger of harmful concentrations of potassium cyanate accumulating in the soil. This rapid breakdown is also a favorable factor in connection with the use of potassium cyanate as a contact pre-emergence herbicide.

It is hoped that sufficient illustrations have been given to indicate the way in which chemical and physical characteristics of compounds other than the strictly physiological effects can influence the merits and limitations of the materials as herbicides. These factors make it even more desirable that an increase in cooperation between the Federal and State Experiment Station workers and the commercial people be continued to provide free interchange of information in order to develop the most efficient uses and means of application for the many new herbicides which are being developed, and so that the unfruitful experimental work and commercial failures can be kept to a minimum.

THE PHENOLIC HERBICIDES

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The phenolic herbicides, particularly those of the so-called dinitro group, have been used on a limited scale in the Northeast for post-emergence selective and general contact spraying. Recent developments in pre-emergence and pre-planting weed control give these chemicals an increasingly important place on our list of useful weed killers. This paper is intended as a review of our knowledge of the herbicidal properties of the phenolic derivatives and of their present and possible future use for weed control purposes.

Herbicidal Properties

Many phenolic compounds have herbicidal properties but only the most phytotoxic are of interest. Among the first phenolics to be extensively used was dinitro-o-cresol (DNOC) available for many years as the sodium salt under the proprietary name, Sinox. Recently a more phytotoxic compound, dinitro-o-sec-butyl phenol (DNOSBP) has largely replaced DNOC. It is available under various proprietary names as the ammonium salt for selective spraying, and in emulsifiable formulations as a contact herbicide. The closely related dinitro-o-amylphenol and dinitro-o-cyclohexylphenol have been used in contact sprays to a more limited extent.

Many chlorophenols also have marked phytotoxicity. Pentachlorophenol (PCP) has been used for a number of years particularly in Hawaii for contact spraying and residual soil treatment and is becoming increasingly important elsewhere. Both the parent compound in emulsifiable oil formulations and its water soluble sodium salt have been utilized.

When applied in aqueous solution the salts of the phenolic compounds exhibit considerable selective action on many waxy-leaved species. Selectivity is believed to be largely physical in nature. Differential wetting and differential absorption through the cuticle are, no doubt, the important factors.

The parent phenols have limited water solubility but are soluble in oil to varying degrees. They are commonly sold in emulsifiable oil formulations for contact spraying but are also used to fortify straight oil sprays. Oil solutions and emulsions containing the phenolic compounds may be classified as general contact herbicides because of their general rather than selective effect.

Toxicity is localized and acute; there is little if any translocation of these materials whether applied as selective or general contact formulations. Action is limited to plant parts actually wet with the spray. The various phenolics have a similar but not identical type of effect on plant tissue. The chief difference appears to be in their degree of phytotoxicity. For general contact spraying DNOSBP is approximately four times as active pound for pound, as PCP however, their relative toxicity varies to some degree with the plant species. Similar differences exists in toxicity between the salts of these compounds when used as selective sprays, however specificity of action is even more pronounced as will be subsequently noted.

Selective Spraying with Phenolic Compounds

The ammonium salt of DNOSBP is the chemical of the phenolic group being most widely used at present for selective spraying. This compound is less likely to injure peas and probably other legumes than the sodium salt of DNOC which was more widely used until recently. Legumes are currently the most important group of plants being treated with phenolic selectives. Considerable acreage of canning and seed peas are now treated for the control of various annual weed species. New seedings of alfalfa and other forage legumes have been improved by selective sprays of the ammonium salt of DNOSBP particularly in the West. As companion grain crops commonly used in the Northeast are adequately resistant to this spray it appears that selective treatment of new seedings offers great possibilities for the general farmer. Recent work indicates that new seedings of red, alsike, and ladino clover may be treated with 2,4-D if certain precautions are taken but only the ammonium salt of DNOSBP is suggested for alfalfa and sweet clover.

Onions have been treated successfully with this selective chemical in the more arid sections but results in the humid areas have been erratic particularly on muck. Presumably the cuticle tends to be too thin to provide ample protection when growth proceeding application has been particularly succulent. The sodium salt of PCP and the sodium salt of trichlorophenol have been reported to be less risky on onions than the dinitro selectives. These instances in which certain phenolic derivatives appear to have a wider margin of safety on certain crops than those now used, should stimulate further research with various phenolic compounds.

Among the specialized crops on which the ammonium salt of DNOSBP has been successfully used as selective sprays are gladiolus, Dutch iris, narcissus, and chives and onions grown for seed. Aiming the spray at the base of these dicots reduces the risk of "burning" the older tissue at the tips of the leaves. It is of interest to note that it is usually the older tissue that shows injury first, the bottom leaves of dicots and the tops of the leaves of monocots.

Phenolic selective herbicides should be applied as coarse sprays to give minimum wetting of waxy leaf surfaces. As there is always some wetting of the crop leaves a low volume, highly concentrated spray will be put more toward in contact with the crop plants and is therefore likely to cause injury. High volume dilute sprays are generally recommended.

The Phenolic as General Contact Herbicides

General toxicity and costs are the important factors in the choice of a contact spray for general vegetation control. The phenolic compounds applied in oil emulsion offer considerable savings over the use of straight oil. In the event that a straight oil spray is preferred it may often be used in lower volume if fortified with a phenolic weed killer. The amount of oil that should be in an emulsion varies with the type of vegetation. For example, relatively little is needed when preparing a spray to be used as a potato vine killer but as much as 20% may be desirable for ditch bank where tough grasses are involved. Oil serves to improve spreading and penetrating properties of the spray.

Contact sprays have been most widely used in the West particularly for such jobs as keeping down all vegetation in non-cultivated orchards, preparing roadside vegetation for controlled burning as a fire preventative measure, and controlling ditch-bank vegetation. Preharvest contact spraying of flax to kill green weeds that hinder combining operations has been practiced in California and Arizona with considerable success. In central California winter annual weeds and grasses in alfalfa have been controlled by dormant season contact spraying. No doubt many specialized uses for contact herbicides will develop in the Northeast.

Contact Preemergence and Preplanting Treatments

The phenolic general contact sprays have been used successfully in a number of instances for killing very tiny weeds that emerge before the crop. This technique has been called contact pre-emergence weed control in a recent review of terminology.(2) Timing is very critical as the crop will be injured if it is beginning to break the surface at the time of application. Very small amounts of the phenolic toxicants with a minimum amount of oil in the emulsion will kill the tiny weeds that one encounters when this method is used. Specific recommendations regarding concentrations, rates and methods for this technique have recently been made.(2)

Tiny weeds are frequently killed by shallow tillage after the seed bed is prepared. The phenolic contact herbicides have been found very useful for doing this job. The term, pre-planting treatment has been applied to the killing of tiny weeds on previously fitted land with contact sprays. This technique is

most successful when planting equipment is used that disturbs the soil as little as possible so viable weed seeds will not be brought near the surface where they may germinate.

Residual Pre-emergence Treatment with Phenolic Compounds

A recent development is the use of relatively large residual dosages of salts of PCP and DNOSBP, to prevent the emergence of weed seeds from the upper layer of soil and thus reduce the need for cultivation and hand work. This technique called residual pre-emergence weed control was first used with sugar cane but recent experiments indicate that it may be valuable with a number of large-seeded crops including cotton, corn, beans, peas, soy beans, peanuts, sunflower, and the cucurbits. No doubt other large seeded crops and those propagated by tubers, corms, and bulbs may be safely given this kind of treatment. Asparagus may be treated prior to the cutting season and again after the post-cutting discing to prevent weeds developing in the fern growth. Residual pre-emergence methods should be extensively tried under a variety of conditions before general recommendations are made. Rates of application for further trials have been suggested.(2)

Selectivity is believed to be largely a matter of depth protection although some physiological differences in reaction do occur. Small seeds germinating near the surface will not tolerate the toxic concentrations which exist near the surface. Under most soil conditions toxicity does not extend to the depths at which large seeds are ordinarily planted. Top growth pushing through a toxic surface layer of soil seldom absorbs enough to cause damage because waxy stem and leaf surfaces will not permit the efficient entry of ionic materials. Roots which lack a waxy covering do absorb such materials and death occurs at the time or soon after germination. In a few instances the parent phenolic compounds have proved more satisfactory than their salts for residual pre-emergence treatment. Possibly where porous soil and heavy rainfall make for excessive leaching and dilution of the salts the parent compounds will remain at toxic concentrations near the surface over a longer period. Under these same conditions the salts may be more likely to cause crop injury. It is likely that the salts of these parent phenols are gradually formed through reaction with constituents of the soil solution.

Limited residual pre-emergence comparisons on corn indicate that the phenolic compounds may give annual weed control equal or superior to that provided with 2,4-D. With many crops there would be less risk from the phenolics than from 2,4-D and even on corn they are definitely worth further trial. Preliminary tests on corn with mixtures of some phenolics with 2,4-D have given promising results.

With the quick-emerging crops such as beans, corn and cotton, application at the time of planting appears to be as

satisfactory on the average as at a later date. Thus a spray nozzle may be mounted behind each planter box to give a band treatment over the row with a minimum of chemical at low application cost. With slow-emerging crops such as potatoes and gladioli where delayed application is desired to prolong the period of effective weed control, there may be some weeds up before treatment. If a salt of a phenol is used in such instances the addition of about 5% fuel oil plus an emulsifier will give the spray better wetting and penetrating properties for the control of waxy leaved seedings including grasses.

Specificity of action between weed and crop species with the different phenols appears to be even more marked when used for residual soil treatment than for selective post-emergence spraying. On the average, DNOSBP is considerably more effective than PCP but further research is required before the relative value of these or other phenolics for different crops and different kinds of weeds will be known.

These compounds owe their toxicity to their molecular configuration and not the presence of a toxic element. Accumulative soil toxicity could occur only if they remain relatively stable. The fact that certain phenolic compounds have been repeatedly used on pineapple and sugar cane soils without evidence of accumulative toxicity indicates that they are lost in some manner. Soil micro-organisms are known to decompose certain phenolic compounds[4] and it is likely that such action may account for the disappearance of these herbicides from the soil. Further investigation is needed relative to the liklihood of toxic amounts remaining in various soils under different conditions of moisture and temperature.

Other New Developments

Still further new uses for the phenolic herbicides have been suggested. Crafts[3] has pointed out the value of phenolic contact sprays when applied to short weeds at the base of tall growing crops, the stems of which will not be injured. This technique has been extensively used on sugar cane and has possibilities with corn.

Residual pre-emergence chemicals have also been used as ground sprays in growing crops to prevent late emergence of weed seedlings. Notable success has been obtained with this method in pineapple and sugar cane. Such post-emergence residual soil treatments may have a place with a number of long season plants including perennial crops and nursery stock.

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[3]Crafts, A. S. Results of soil treatment vs contact sprays in corn and cane weed control, Agricultural Chemicals, 3 (5):25-27, 81, 83, 85. May 1948.

[4]Geultoneau, G. and R. Chevalier. Utilization of phenol compounds as sources of energy by the azotobacter of the soil, Soil Science Society of America Proceedings 4:237. 1939.

Presentation of papers:

1. Factors Affecting Aerial Distribution of Pollen - Professor Velz, Chairman of the Department of Civil Engineering, Manhattan College, N.Y.

2. Development of Ragweed Control Program in Westchester County - Dr. Holla.

3. Ragweed Control Program in Teaneck, N. J. - Morris Bourne

4. Observations of 2,4-D Application on Ragweed Ecology - Mr. Gorlin

Upon the return of the Temporary Committee, Mr. Agar, the Chairman, read the following recommendations:

1. It is suggested that the organization be named the Public Health Section of the Northeastern Weed Control Conference.

2. Mr. A. Fletcher was nominated as Chairman of the section for a period of one year.

3. A list of names was suggested as a Promotional Committee to foster interest in weed control:

   Matthew Bassity, Brooklyn Botanic Gardnes, N.Y.
   Dr. Wodehouse, Lederle Laboratories
   Morris Bourne, Shade Tree Warden, Teaneck, N. J.
   W. Green, Freedom Garden Club, Bronx, New York
   Dale E. Wolf, Rutgers University, New Brunswick, N.J.
   Mr. McLaughlin, Director, Sanitary Engineering, Westchester County, N. Y.
   Mr. Agar, N.Y. State Health Department
   Mr. Robert Beatty, American Chemical Paint Co., Ambler, Pa.
   Mr. Windblum
   Mr. A. Gorlin, N.Y. City Health Department
   Mr. S. Lang, CDCA, U.S. Public Health Service
   Dr. Rafael

4. An active Program Committee was also nominated:

   Mr. A. Fletcher, N.Y. City Health Department
   Morris Bourne, Shade Tree Warden, Teaneck, N.J.
   Dr. Wodehouse, Lederle Laboratories
   Mr. McLaughlin, Director, Sanitary Engineering, Westchester County, N.Y.

Mr. Dale E. Wolf was named to act as advisor to the Program Committee.

These proposals were put to vote and were carried unanimously.

The session was adjourned.

William A. Holla, M.D., Commissioner of Health
Westchester County Department of Health

Introductory

The announced title of my subject was "Developing a Program of Ragweed Control in a County". It would be presumptuous to claim that any one individual or organization has been responsible for the very excellent programs which are being undertaken in parts of the county, or for the lack of similar programs for the entire area. We have 46 municipalities, including six cities, each of which is autonomous as far as existing laws relating to the control of noxious weeds and growths. Accordingly, I would like briefly to report on the progress that has been made in this suburban county towards the eradication of ragweed. The information on which this report is made is based upon a recent survey which may not have reached the proper officials in every municipality. If there are omissions or if credit is not given to the officials or agency most responsible for the work accomplished, I trust they will promptly speak up so that the record will be made clear.

The Problem

Although there were some programs under way in previous years, credit must go to the efforts of the City of New York Department of Health in (1) undertaking an excellent program within their own limits, (2) for stimulating activity in adjacent communities, and (3) for making available an excellent course of instruction in ragweed control during 1947 at New York University.

Under present state laws local ordinances must be adopted by each municipality that wishes to engage in ragweed control. Of the above 46 municipalities, two are contiguous villages and towns. Four of the cities containing approximately half the county population are served by their own health departments. The remainder of the county, including two cities, are under the jurisdiction of the Westchester County Department of Health.

It is obvious from a review of the ordinances enacted that most of them are based upon the control of local nuisances which may be caused by accumulations of rubbish and obnoxious growths and fire hazards on vacant lands. In a number of communities the amount of work done is directly proportional to the number and persistence of complaints received that are directed at particular properties. In a few cases the work is based upon a fairly careful survey of all public and private properties.

There are few pollen counting stations maintained within the county area. Accordingly the success of programs must be based upon the general response of the benefitted public. Since

we must recognize that praise is the last thing that we get for such work, the effectiveness of the work done has been difficult to calculate.

1948 Programs

In the cities of Mount Vernon, New Rochelle, White Plains, Yonkers and Rye, active programs were undertaken. The following estimates of results have been given me by the agencies in each of these cities.

City	Public Lands Cleared	Private Lands Cleared
Mount Vernon	75	50
New Rochelle	100	80
Yonkers	60	60
Rye	90	80
White Plains	70	1*

* A large amount done by private owners as a result of enforcement of local ordinances.

In the villages, of which there are 22, all in the health district, the results were:

7 have ordinances.
10 undertook some control of growths on public lands.
9 undertook some control of growths on private lands.
16 some action stimulated by local garden clubs by voluntary appeal to private owners.

In the towns, of which there are 18, two with no unincorporated area, all in the health district, the results were:

1 has an ordinance.
1 undertook control of growths on public lands.
1 undertook control of growths on private lands.
9 some action by private agencies, including garden clubs

In addition to the above, the county-owned lands, such as parks and highways, were fairly well taken care of by cutting or spraying. Large areas of "vacant" lands owned by the county, not in parks or highways, did not get such care.

Large holdings of the City of New York did not get the attention that was planned, largely because of manpower shortages in the agencies in direct charge of these lands.

Areas along state highways were cut but not sprayed. The State Department of Public Works did some work with respect to control of poison ivy but not with respect to the control of ragweed. In other words, this state agency has recognized that the public should not be made to scratch if they picnic along the highways.

It is hoped that they will recognize the "sneezability" of many 4 other patrons who travel by automobile.

Our roll of honor for 1948 includes the cities mentioned above, the villages of Bronxville, Irvington, Briarcliff Manor, Ossining, Pelham Manor, Port Chester, and the town of Eastchester.

Cooperating Agencies

A number of local garden clubs and other organizations have zealously campaigned in support of the achievements here recorded. Much remains to be done. The County Agricultural Agent, Mr. M. E. Buckley, has sent out a great deal of information.

In the communities where official activities are undertaken, the work is directed by a large variety of agencies, but the actual work is done in most instances by the highway, public works, forestry, or parks department or bureau. As far as is known there has been no substantial work accomplished without such work by publicly financed agencies. It is obvious that the results obtained will be directly proportional to the recognition of the amount of work to be done and the provision of adequate funds.

The county health department has been required to limit its contribution to providing speakers and educational material to groups and agencies that can be interested in stimulating action by local municipal boards who can enact suitable ordinances and thereafter activate such ordinances by providing personnel and funds to achieve the desired results.

Conclusion

The work done under organized programs in 1948 directly benefitted over 400,000 persons, or nearly 70 per cent. of the county's population. These persons are living in about 17 per cent. of the total area of the county. The greater part of this area is adjacent to New York City.

In most of the areas where such work was undertaken it also was extended to cover clearing of vacant lands of obnoxious accumulations of rubbish and also to the elimination of poison ivy growths, a far more difficult problem than the control of ragweed.

The programs now being undertaken have indicated that substantial relief to hay-fever sufferers will result by the elimination of local sources of ragweed pollen, particularly in our areas of high population density.

A RAGWEED CONTROL PROGRAM FOR THE SUBURBAN COMMUNITY

M. S. Bowen
Shade Tree Superintendent
Teaneck, New Jersey

Among the many non-fatal ills afflicting the human race there is probably none more widely spread and more uncomfortable to its victims than hay-fever. Hundreds of thousands of people suffer acutely from this trouble every summer and modern medical science does not seem able to develop any reliable cure or form of immunity. Medical research, however, has determined that pollen from the two forms of ragweed - giant and common - is the most active agent in causing hay-fever. To prevent ragweed plants from producing pollen is, therefore, the most effective and practical method of preventing the disease.

Of all weeds, ragweed, unfortunately, is one of the most widely distributed and rank growing in the centers of population. Its elimination and ultimate extermination has long been the dream of medical men and municipal officials but the old-time slow mechanical and hand methods of eradication have been utterly useless in accomplishing such results. During and since World War II chemical research has produced certain materials, primarily 2, 4-D, which, when used as sprays will quickly and cheaply kill large areas of ragweed. The complete elimination of the pest from a community is now entirely possible and is dependent only upon the degree of enthusiasm shown by municipal officials in providing money for the necessary mechanical equipment, spray material, and manpower to do the job.

The purpose of this paper is to tell what one typical suburban community has done to control ragweed during the past two years. The Township of Teaneck, located in Bergen County, N. J. covers an area of 6.5 square miles, has approximately 100 miles of streets, and a population of about 33,000. There is within the Township a great amount of new home construction with its consequent disturbance of ground surface providing ideal conditions for ragweed growth. Make no mistake about it, there is an abundance of ragweed in Teaneck.

Teaneck is under the municipal manager form of government. Under this system the manager is empowered to make appropriations, subject to confirmation by the Council, for whatever municipal activities he deems necessary. Teaneck's manager has always been convinced of the value of ragweed control. In the early spring of 1947 when the New York City Health Department began to ask for the cooperation of neighboring suburban communities in ragweed control, the Manager put $500.00 in Teaneck's budget for ragweed spraying. Having had no experience in such work it was not known how far that amount of money would go in covering the Township but it was a start in the right direction. Teaneck maintains an active Shade Tree Division in its Department of Public

Works whose duty it is to take care of the trees, shrubs, and lawns on all public property. It seemed logical to put the ragweed control work under the supervision of the Shade Tree Department. This was done and in early July, 1947 ragweed spraying began.

The Department of Public Works supplied a truck on which was mounted a tar distributor with a 75 gallon tank which had been in use in the department for several years. This tank was thoroughly cleaned out and fitted with 125 feet of 1/2 inch hose to which was attached a 3 foot boom holding 4 nozzles which emitted a fan shaped spray under pressure varying from 35 to 60 lbs. Such was the only spraying equipment available without purchasing something new and so it was used. Time proved it to be very satisfactory.

A supply of highly concentrated 2, 4-D acid in dry powder form was purchased and used at the rate of 1 pound to 75 gallons of water. Two men were assigned to the spray truck - one to drive and operate the motor on the spray machine, and the other to do the actual spraying. The $500.00 put into the budget had to take care of purchasing the hose, 2, 4-D, and the salaries of the two men who operated the equipment. It was, therefore, decided to limit spraying operations to the public property area along the main streets of the Township and if additional time permitted to spray as many empty lots as possible where there was heavy growth of ragweed. On this basis spraying progressed until, when the money was exhausted in the first week of August, it was found that both sides of all main streets within ten feet of the curb had been sprayed. This covered a distance of twelve miles one way or twenty-four miles both ways. In addition several empty lots were thoroughly sprayed.

In 1948 another appropriation of $500.00 was available. Ragweed spraying began on June 25th, and ended on August 2nd. Within this period the actual spraying time was twenty days for the two men and truck. So effective were the results of the 1947 spraying that very little of the area sprayed then had to be gone over in 1948. Since this was true it was possible to cover all the remaining streets of the Township this year within ten feet of the curb and many additional empty lots.

After two years of ragweed spraying what conclusions can be drawn? The most encouraging result is the actual disappearance of ragweed and the assurance this gives that if a spraying program is conducted over a continuing period of years it will be possible to eliminate ragweed from the community. It is also surprising how reasonable the cost of ultimate elimination can be.

For the benefit of other communities that may be contemplating a ragweed control program, it is only fair to point out certain features that have contributed to the success of the Teaneck program. The Township manager and Council were from the very beginning in favor of the project thereby making the necessary money and equipment available without the delay that is oftentimes encountered due to the time it takes to convert the "powers that be".

The people of Teaneck were acquainted with the ragweed program 7 through poster advertising and a moderate amount of newspaper publicity in the form of news articles. As a result there has been almost no criticism when privately owned vacant lots have been sprayed. The owners welcomed this service rendered by the Township as a public benefaction. Teaneck has been fortunate in having men on the spraying program who have conscientiously carried out the details of the work. Spraying has been done carefully with the fact in mind that valuable shrubs and plants can be seriously injured if hit with 2, 4-D spray. It should be borne in mind that the more thorough the ragweed eradication becomes the more danger there is for possible injury to valuable plants.

There are different concentrations of 2, 4-D and it is well to remember that the lighter ones are entirely satisfactory for killing ragweed. When too heavy concentrations are used not only ragweed but practically all vegetation that is hit with the spray is killed. The result is a most unsightly appearance of browned areas all over a community in the middle of the summer. When spraying with the lighter concentrations only the ragweed is killed and as it dies other vegetation takes its place with a minimum of unsightliness.

Such, in more or less detail, are the highlights of Teaneck's two year ragweed control program. As the program for 1949 is anticipated it is encouraging to know that the manager has appropriated funds for purchasing a modern engine equipped trailer model spraying unit which will make possible coverage of larger areas of ragweed more efficiently and in less time than with the old equipment. Since all township streets have been covered during the past two years much more attention can be given in 1949 to killing ragweed that is growing in empty lots and more or less out-of-the-way places. With this new equipment and a slight increase in the 1949 budget it will also be possible to spray lawn areas in the parks and around public buildings for the control of such weeds as dandelions and plantain. If there are members of this conference who came here with the idea that any ragweed control is expensive and impractical it is hoped that the information given in this paper will help to rectify their opinions. Ragweed can be eliminated and the greater the cooperation among neighboring towns in such work the greater will be the generally improved health of the citizens.

FACTORS AFFECTING AERIAL DISTRIBUTION OF RAGWEED POLLEN

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The disease of hayfever consists in hypersensitivity of the individual to pollens of weeds, grasses, shrubs and trees. Transmission is essentially through the air contact. Atmospheric pollution is limited to the pollenization season, April to June principally trees, June and July principally grasses, August to October principally ragweed. The degree of pollution depends upon the density of growth, plant population, and proximity to the sourc of pollution.

Until recently any thought of action against hayfever through engineering control of the environment by elimination of the sources of atmospheric pollution appeared hopeless. The discovery of 2, 4-D and the demonstration of its effectiveness as an herbicide in the control of growth of ragweed are likely to change the emphasis from curative treatment of the individual to preventive effort as a mass public health measure. 2, 4-D offers the first hope and prospect of bringing relief to large aggregations of population. The tool is available; what is now needed is the application of engineering intelligence to the problem. In accepting this challenge and responsibility, the public health engineer must know more about the nature of pollen pollution and the factors that influence its production and distribution. A whole procedure is yet to be developed and tested if practical control programs are to be devised and their effectiveness evaluated.

METHODS OF MEASUREMENT OF POLLEN CONCENTRATION IN ATMOSPHERE

Two methods of measuring pollen concentration in the atmosphere are in use, volumetric and so-called gravimetric. Volumetric devices remove pollen from a measured flow of air passing through the apparatus and concentration is expressed as pollen grains per cubic yard of air. These devices in their present stage of development provide consistent reliable data but are expensive and are not readily adapted to routine operation without careful supervision.

The so-called gravity method consists essentially in exposing a one inch by three inch petrolatum jelly coated slide placed horizontally in a standard shelter for 24 hours. Pollen grains are identified and counted under a microscope and concentration is reported as pollen grains per sq. cm. of slide area. Results are subject to considerable variation and are sensitive to type of shelter employed and its orientation. It is assumed that pollen grains are deposited one the slide by gravity, subsiding in quiescent air in accordance with Stokes' Law. On this assumption several equations have been proposed for converting concentrations per sq. cm. to concentrations per cu. yd. In actual practice,

however, comparative counts by gravity and volumetric methods do not substantiate the gravity theory. This is not altogether surprising, as normal air movements at prevailing velocities are far from quiescent or stream line flow. Probably because of high degree of turbulence, pollen grains actually land on an exposed slide more in accordance with the laws of chance than with the laws of gravity.

A rational conversion factor based upon simultaneous counts by the standard gravity method and volumetric methods has been proposed by Durham* and approved by the Committee on National Pollen Survey of the American Academy of Allergy. The average catch of ragweed pollen on one sq. cm. of slide exposed in a standard shelter for 24 hours multiplied by 3.6 is taken as the equivalent concentration per cu. yd. While this rational conversion is preferable to the previous theoretical factors, the data on which the conversion factor is based show considerable scatter. (Figure 1) The ratio determined from the line of best fit is 2.8 as compared with 3.6. Durham points out gravity slide counts show wide degree of variation as compared to volumetric counts. Hence, caution should be exercised in converting gravity slide data to a volumetric basis. This particularly applies to old data where type of exposure shelter is not known or where a theoretical conversion factor based on Stokes' Law may have been employed.

In addition to its high degree of variability, the 24-hour gravity slide method does not measure instantaneous concentration, which with the type of exposure employed, makes it a poor method to reflect local sources of pollution.

Notwithstanding the shortcomings of the 24-hour gravity slide method, it has been adopted by the allergists as their standard procedure and it is most widely used, principally because of its simplicity and inexpensiveness. While standardization of exposure shelter and technique is an important advance, the 24-hour gravity method is far from satisfactory from the standpoint of reliability and flexibility. Probably not until an inexpensive volumetric device is perfected, capable of reflecting continuous as well as instantaneous counts, will measurement of pollen concentration be adequate for the needs of engineering control measures.

DATA AVAILABLE

Data available on pollen pollution of the atmosphere have been collected principally for allergists with a view to serving as a guide in treatment and in attempting to indicate to

* Jrl. Allergy, Vol. 17, No. 2, March 1946.

hayfever sufferers regions relatively free of pollen pollution.* [10] An attempt is made for national coverage and therefore stations are widely spaced. A great amount of work has been done by Durham of Abbott Laboratories and he is very generous in sharing his information. In the New York Metropolitan Area, the Jewish Memorial Hospital, under the direction of Dr. Walzer, has made an effort to obtain a more concentrated coverage. Data for 17 stations have been published for 1947, and for 11 stations for 1946. The results are reported as daily counts per sq. cm., 24-hour exposure in standard shelter. Unfortunately, data for other years have not been published and are not available.

General aerial incidence based on a few scattered sampling stations may be adequate for the work of allergists in considering such elements as approaching seasonal peaks of pollution, but such data are not adequate for engineering purposes. For environmental control it is essential to have data from a large number of stations covering the area to be protected, including peripheral radius of influence. In addition to the 24-hour gravity slide, it is essential also to have instantaneous count data, adequately to evaluate local sources. Unfortunately, but few public agencies have established sampling stations for local survey purposes. A few state departments of health such as New Hampshire are conducting state-wide surveys. Essentially it is a responsibility of bureaus of environmental sanitation in public health agencies to establish and continue pollen sampling and to publish the detailed data.

PROBABLE FACTORS INVOLVED

In order more fully to appreciate the need for more and better pollen pollution sampling data, it might be well to point out some of the factors which probably affect pollen distribution. Ragweed pollen inherently in nature's design is intended for air borne distribution; hence, it is radically influenced by meteorological conditions.

Wind direction and intensity in relation to a source are very important factors in interpreting sampling data. Prevailing wind direction may change from day to day and from hour to hour within the day. In addition, due to unequal heating of the face of the earth, there may be upward drafts or downward drafts. Longitudinal direction as well as lateral and vertical distribution take on radically different patterns, depending upon the combination air movements at play.

* The present procedure is to report pollen grains per sq. cm. as determined by the standarized 24-hour gravity slide method. Earlier work is frequently reported as pollen grains per 1.8 sq. cm. of 24-hour gravity slide but not in standard shelter. No satisfactory conversion of old records to standard procedure results is available. At times gravity slide data are reported as though volumetric, in pollen grains per cu. yd. of air. Volumetric measurements are reported directly as pollen grains per cu. yd. of air.

Precipitation, relative humidity and sunshine influence not only day to day distribution, but also affect plant pollen production. Precipitation acts as an air wash and removes pollen pollution from the atmosphere. It also interferes with the discharge of pollen by the plants.

Orographic effects of local topography can radically alter the distribution of pollen pollution. A deep sharp valley may be almost free of effects of pollution beyond its own local sources. Sharp rises of hills or mountains may act as guide vanes or shelter walls. Unobstructed open water or level land areas may serve as pathways in distribution. These orographic effects are important factors in the selection of sampling stations and interpretation of sampling data.

In addition to meteorological and topographic conditions, vegetative cover and the characteristics of plant pollen production are factors influencing concentration and distribution of pollen pollution. Where natural vegetation prevails undisturbed by man's activities ragweed is generally absent. Ragweed, contrary to the usual concept, is generally found in urban areas where the soil is frequently disturbed and natural vegetative cover eliminated. Abandoned lots, garden plots, highway and railway rights of way are usually areas of high production of ragweed.

Variation in ragweed growth and crop of pollen produced per season is primarily a problem for botanists. Undoubtedly, many natural phenomena are at play, including meteorologic and hydrologic conditions. It is well known that these natural phenomena vary from year to year in accordance with the laws of probability. Hence, variation in pollen production under natural conditions, likewise, should follow the laws of chance distribution. An analysis of total seasonal counts for several stations indicates such a normal probability trend.

Trends of pollen production during a season are best reflected by weekly averages of daily counts. (See Figure 2). For this climatological region (New York) the ragweed season extends through August and September, with the peak production occuring the last week of August or the first week of September. Again this interpretation is based on sampling station counts rather than direct plant production data, and hence is affected by meteorological factors, principally wind direction.

A major factor which influences distribution of pollen pollution and which is not adequately reflected by the 24-hour gravity slide count is the fact that ragweed does not continuously shed its pollen during the 24 hours of the day, but releases its daily production as a batch or slug. The daily batch is shed usually in early morning between 6:00 a.m. and 10:00 a.m. With a sudden gust of wind, the entire day's batch can be discharged in a few moments, with practically no further release for the rest of the day. Durham reports an instantaneous count in the midst of a 30-acre stand of ragweed of almost 10 million pollen grains per cu. yd. of air. Obviously, this batch or slug method of release of pollen complicates the study of the nature of its distribution

from a source. Certainly some type of continuous recorder of momentary concentrations of pollution is needed to provide adequate quantitative data for determining concentration of slugs and their subsequent horizontal, vertical and lateral aerial distribution.

The location of sampling stations in relation to sources of ragweed, while not inherently affecting distribution of pollen, does affect the pollen catch. It is axiomatic that a physical survey, mapping areas of important sources of ragweed, should precede the location of stations and is fundamental to interpretation of sampling data and the design and control of any pollen pollution abatement program.

NEW YORK METROPOLITAN DATA

It is of interest to interpret New York Metropolitan sampling data in light of these probable factors influencing distribution of pollen pollution. Figure 3 is a map showing the 17 sampling stations for 24-hour gravity slide counts, as reported by Walzer* for 1947 season. Major sources of ragweed in New York City as determined by the Health Department survey at the beginning of the 1946 season are also shown. Three suspected areas in New Jersey of heavy pollen pollution having a marked effect on New York City counts are indicated by cross-hatch.

Orographic influence of topography in New Jersey are illustrated in the cross-sections along latitude 40°-44' cutting through Maplewood, N. J., sampling station and latitude 40°-50' cutting through Verona, N. J., station. Referring to latitude 40°-44' (Figure 4), at the left the sharp rise is South Mountain range, elevation 550, followed by a sharp drop to the East Branch of Rahway River and again a sharp rise. Maplewood sampling station lies in this rather deep protected valley. The extent of this protection is markedly apparent in the Maplewood record. Toward the east there is a gradual slope to the Passaic River to sea level, the Jersey Meadows, and then a sharp rise to the Jersey Palisades to elevation 100, and again a precipitous drop to Hoboken flats, the Hudson River and lower Manhattan Island. Similar sections exist all along to the north. At latitude 40°-50' (Figure 5), it is noted that Verona is in a similar deep protected valley.

A general picture of the formation may be obtained from a topographic map. To the southwest will be observed the sharp flank of the Watchung and South Mountains, ranging from 450 to 700 feet elevation. Below this are plains sloping to the sea, forming an open approach toward Staten Island and Brooklyn. Toward the north this open approach is sharply obstructed by the tall thin vane of the Palisades, sheltering to an extent, Manhattan and the upper Bronx. The Palisades vane has an orographic effect particularly with respect to pollen scooped out of Secaucus-Monachie area and under certain wind conditions and combinations of up draft, deflects over Manhattan and the Bronx. For example, September 2, 1947, a high pollen production day with high southwest wind, de-

* New York State Journal of Medicine, Vol. 48, No. 18, September 15, 1948.

flection of the Palisades hopped the Bronx station with a count of only 8 per sq. cm., but showed up farther to the east with a count of 30 per sq. cm. at White Plains. Production at the major pollen source in the Monachie area for this day is estimated at about 60 per sq. cm.

A remarkable illustration of the influence of precipitation and the batch or slug pollen release characteristics of ragweed plant is afforded in a comparison of Staten Island counts September 2 and September 5, 1947. Both days are in the normal peak production period of the pollenization season. On both days the prevailing wind was from southwest from Staten Island in direct line of travel from the high production area near New Brunswick. On September 2, there was 0.68" of rain, but it occurred during the night, starting at 3:16 a.m. and ending at 5:10 a.m.; during the day sun shone for 430 minutes, or 55 percent of the total possible. The night storm followed by sunshine did not prevent release of a large slug of pollen, as the count at Staten Island was high, 60 per sq. cm. However, on September 5, rain of 0.53" occurred during the hours of normal pollen release, 6:17 a.m. to 9:00 a.m., and the sun shone only 60 minutes during the day, 8 percent of the total possible. In this instance, count at Staten Island was unusually low at 3 per sq. cm.

The effect of wind direction and location of sampling stations in relation to sources of pollen pollution are illustrated by the maps of distribution for September 2 and September 3, 1947. (Figure 3. On September 2 prevailing wind was south and west 17.1 miles per hour with a maximum of 26 miles per hour, west. Wind direction was not clearly defined and therefore the major axis of distribution is not clear, but there can be little doubt that heavy pollen counts were transported from the suspected New Jersey areas. Figure 3 shows probable outlines of three major belts of distribution. The lower belt with major pollution source southwest of New Brunswick shows count at New Brunswick of 113 per sq. cm., Staten Island on the north edge 60 per sq. cm., Rockaway and Fire Island near the central axis at 70 and 35 per sq. cm., respectively. The middle belt with major source of pollution from Secaucus-Newark, N. J. meadows shows counts for Manhattan 50 sq. cm. and Flushing and Jamaica of 30 and 35 per sq. cm., respectively. The upper belt with major pollution source Monachie, N. J. area, shows counts at Teaneck, N. J., north of axis of 40 per sq. cm. and White Plains also to north of axis of 30 per sq. cm. The low count of 8 per sq. cm. for Bronx, as previously mentioned, is probably due to orographic effect of the Palisades.

The Brooklyn station appears to be on the fringe of the lower and middle belts with a count of 18 per sq. cm. This is lower than might be expected, but there are only two counts (20 and 25 per sq. cm.) higher for the entire season at this station.

On September 3 the prevailing wind was more distinct, west, but the velocity was less, 9.8 miles per hour, with maximum of 23 miles per hour, also west. Similar patterns of distribution are shown for this day. With less variation in wind direction

narrower distribution belts are evidenced, particularly for the lower belt emanating from the pollution source southwest of New Brunswick.

A a further verification of distribution from New Jersey sources of pollution, daily counts (excluding days affected by rain) for 1946 and 1947 peak pollution period (August 24 to September 14), a comparison was made of counts on days when wind was from only the New Jersey sources with counts on days when wind was not from New Jersey sources.

Manhattan Station relative to Secaucus-Monachie, N. J., source of pollution:
Wind from only N. J. source - mean of 17 counts - 24 per sq. cm.
Wind excluding N. J. source - mean of 23 counts - 9 per sq. cm.

Staten Island relative to Newark meadows and Secaucus, N. J. source of pollution.
Wind from only N. J. source - mean of 4 counts - 35 per sq. cm.
Wind excluding N. J. source - mean of 16 counts - 8 per sq. cm.

Staten Island relative to New Brunswick, N. J., source of pollution:
Wind from only N. J. source - mean of 6 counts - 42 per sq. cm.
Wind excluding N. J. source - mean of 16 counts - 8 per sq. cm.

Brooklyn relative to Newark meadows, Secaucus and New Brunswick, N. J., sources of pollution:
Wind from only N. J. sources - mean of 16 counts - 16 per sq. cm.
Wind excluding N. J. sources - mean of 23 counts - 7 per sq. cm.

Rockaway relative to New Brunswick, N. J., source of pollution:
Wind from only N. J. source - mean of 3 counts - 49 per sq. cm.
Wind excluding N. J. source - mean of 11 counts - 12 per sq. cm.

Bronx relative to Secaucus-Monachie, N. J., sources of pollution:
Wind from only N. J. source - mean of 15 counts - 22 per sq. cm.
Wind excluding N. J. source - mean of 24 counts - 13 per sq. cm.

The Flushing and Jamaica stations have such high local incidence, 20 per sq. cm., that effect of outside sources of pollution is not so markedly apparent.

The variation of pollen production from season to season, as mentioned previously, very likely follows the laws of probability. While records are too short to determine the degree of variation with accuracy studies of several station records show normal distributions with a coefficient of variation of the order of 0.4. This coefficient is in line with what we know of hydrologic and meteorologic data.

Walzer* reports a 11-year mean 1936-1946 for Brooklyn station of 1823 per sq. cm. on basis of old shelter. Reported data

* Reference N. Y. S. Journal of Medicine, Vol. 47, No. 18, September 15, 1947.

for the last three years 1946, '47 and '48 indicate seasonal counts between 950 and 800/sq./cm. Using Walzer's mean of 1823 and a coefficient of variation of 0.4, it could be expected that 50% of the seasonal totals, over a long period, would fall between 1330 and 2320. The probability of any one year's total being as low as 950 or less would be 0.115, and the probability of seasonal counts of 950 or less occurring consecutively in 3 years is very small, of the order of 0.0015. Therefore, this indicates that the 2, 4-D ragweed spraying program of the last three years has reduced the total annual counts below that expected from natural variations. Similar results may not be reflected at all of the New York City stations however, as some are dominated by sources of pollution outside of the areas sprayed. Actually, instantaneous counts at ground level in the vicinity of local sources before and after spraying will demonstrate the real efficacy of the elimination program.

THEORIES OF DISTRIBUTION OF POLLEN FROM A SOURCE OF POLLUTION

Few quantitative data are available from which to test theories of distribution of pollen pollution. The 24-hour gravity slide count is not entirely adequate because of its time lag in relation to batch or slug releases by ragweed plants. Instantaneous concentration data along the axis of air movement as well as lateral and vertical cross-sections at short intervals following the release of daily pollen batches are needed, both for the study of general aerial pollution and more important, for evaluation of local ground level sources.

Some indication of the character of general aerial distribution of pollen from a source is reflected in the 24-hour gravity slide counts. Selecting days with strong prevailing southwest wind. Figure 6 shows such data, considering New Brunswick, N. J., vicinity as the major source of pollution. Making allowances for stations one side or the other of the major axis of direction, there appears to be with distance from source a constant percentage decrease of the remaining concentration. Such a relationship expressed in terms of percent of initial pollution concentration would be of the form.

$$P_L = 2. - kD \quad \ldots\ldots\ldots\ldots\ldots (1)$$

where P_L is log of the percent of pollen concentration remaining at any distance D from the source and k is the logarithmic rate of decline.

From the meager data available, expressing D in miles from the source of pollution, k varies between .01 and .02 with mean of .017. Using this mean, decline in general aerial pollen concentration from a source may be expected as follows for standard 24-hour gravity slide data:

Percent Reduction in Pollen Concentration	Remaining Pollen Concentration Percent of Initial Concentration	Distance from Sources of Pollution in Miles
0	100	0
25	75	7.3
50	50	17.5
75	25	35.5
90	10	58.8

As more data become available for refinement of the constants in the distribution equation, it will be possible to define within practical limits the radius of circle of influence of general aerial pollen pollution. This will be an invaluable guide in environmental control programs.

Various theories of distribution of pollen from a source may be considered. One commonly accepted attributes the decline in concentration of pollen with distance from a source of pollution to subsidence of pollen grains. I find it hard to accept this as a major basis in light of the observed declines during high turbulent wind velocity. A more logical theory would appear to be dispersion; and in view of the intermittent discharges of pollen, both longitudinal and transverse dispersion are likely to be involved. In light of our knowledge of dispersion through continuous flow devices and the statistical nature of turbulence, concentration at any position could be determined from probability distribution curves. Any single day's slug, due to shortcircuiting, would tend longitudinally toward a probability distribution. Also laterally on either side of the longitudinal axis, due to turbulence it would tend toward a probability distribution. Similarly, there would tend to be a probability distribution upward from the ground, subject perhaps to some distortion due to subsidence as turbulence diminishes and stream line flow is approached. The 24-hour slide count may be taken as an integration of these distributions, the mean of which would be approached by the simplified equation (1) as demonstrated by the observed data.

While this may be a plausible explanation of the decline in concentration of general aerial pollution along a course of prevailing wind, it does not adequately account for the initial momentary distribution in the immediate vicinity of the ragweed plant following release of its daily slug. The transition from momentary concentrations of nearly 10 million per cu. yd. of air at the plant to general aerial concentrations of the order of 500 to 1,000 per cu. yd. is of more significance. Unfortunately, there are no sampling data, to my knowledge, defining this high concentration transition. Obviously, if such high concentrations can exist locally in the immediate vicinity of plants, the periodic slug which sufferers may encounter in the vicinity of plants must greatly overshadow any dose which may come from general aerial pollution. And it follows, certainly, that the elimination of local sources of ragweed is of far more importance than that reflected

by general aerial concentration determined from 24-hour gravity[17] slide data. It is conceivable that local momentary high concentration phase of distribution may be the real guide to hayfever sufferers; certainly it is destined to be a major guide for rational evaluation of ragweed elimination programs.

Fig. 1

OBSERVED RELATION BETWEEN VOLUMETRIC AND GRAVIMETRIC RAGWEED POLLEN COUNTS

(after Durham)

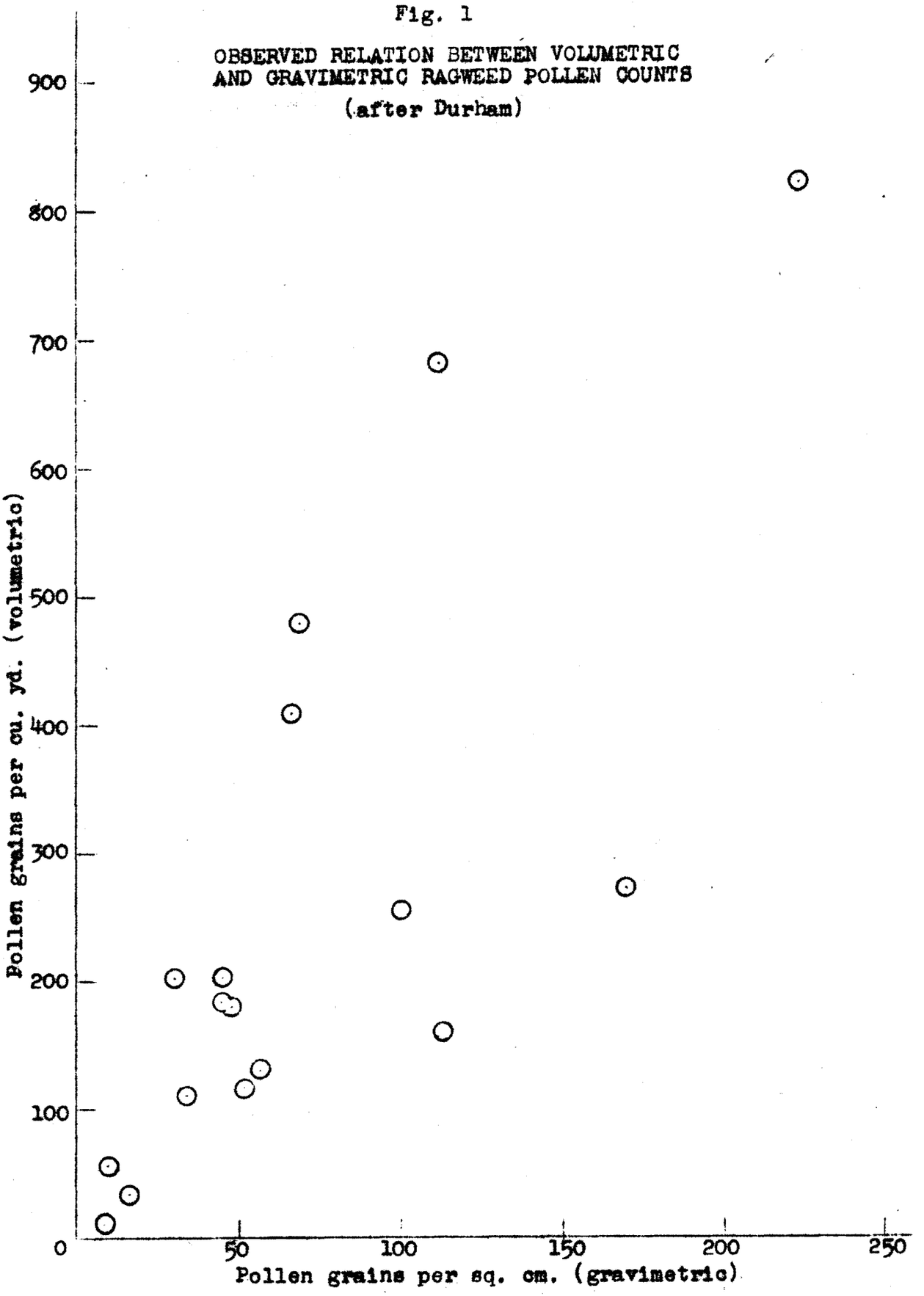


Fig. 2

SEASONAL PEAK, JAMAICA AND FLUSHING

Daily Counts as Weekly Average

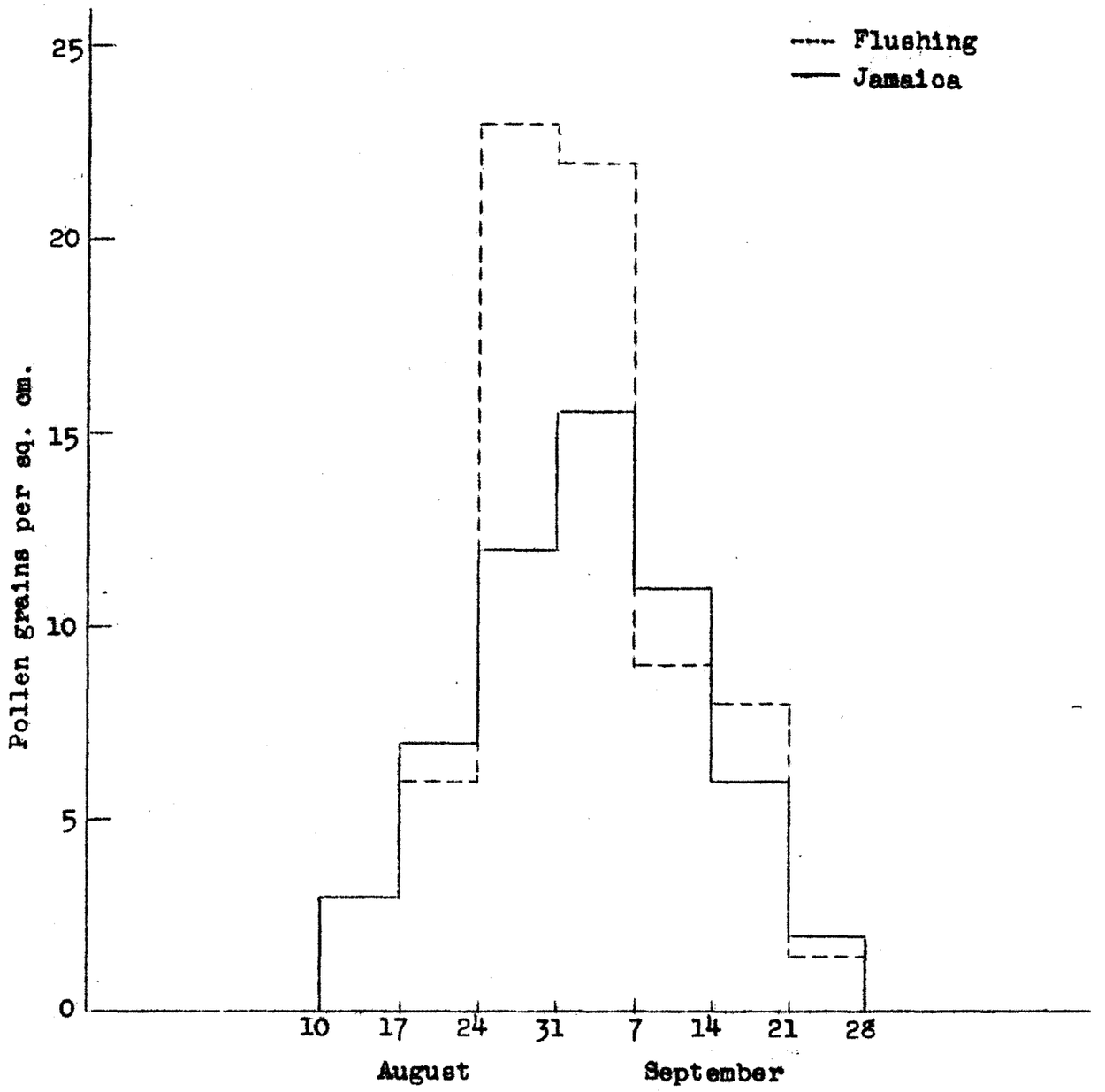


Fig. 3

NEW YORK-NEW JERSEY METROPOLITAN DISTRICT
RAGWEED POLLEN SAMPLING STATIONS

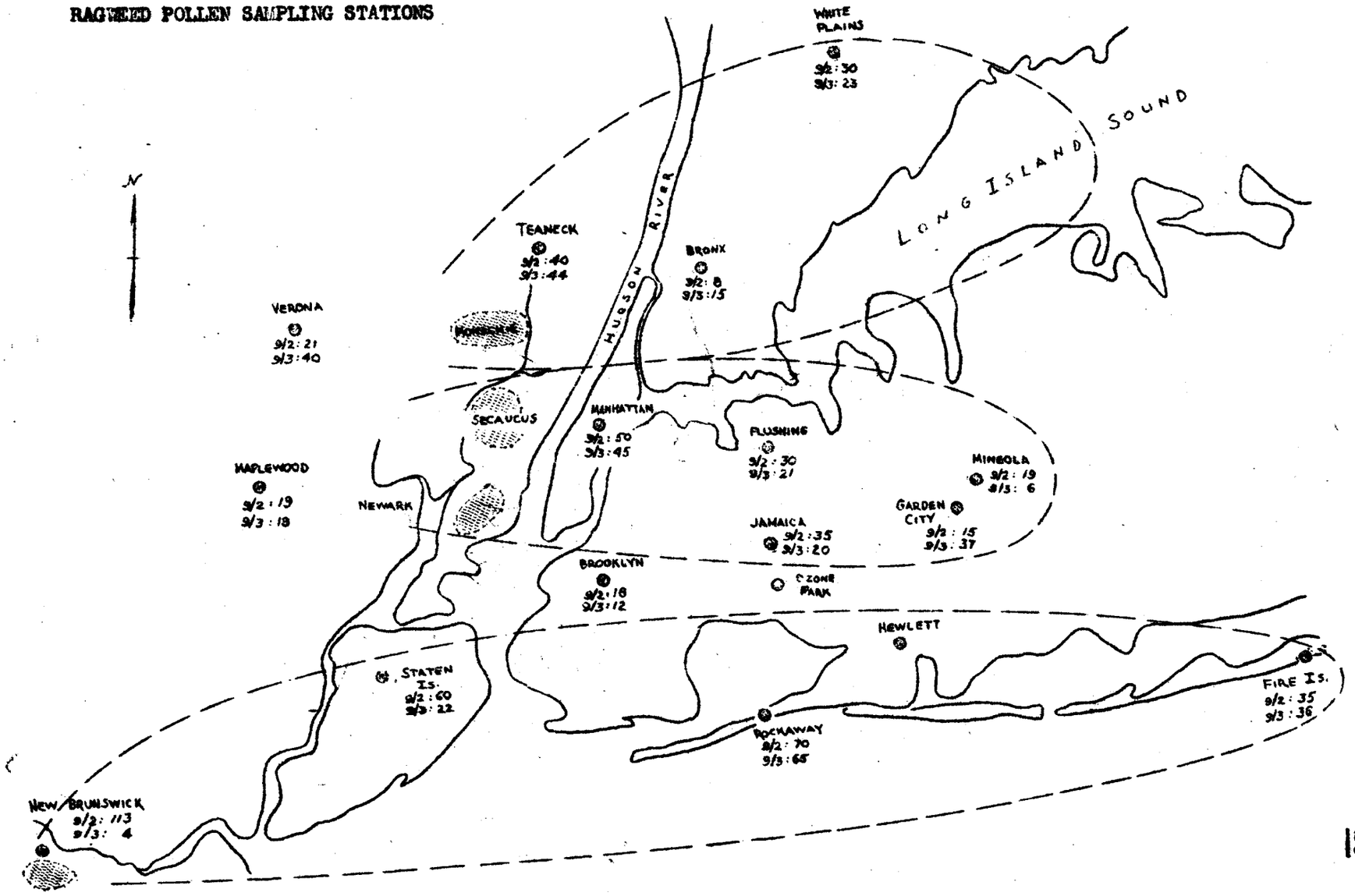


Fig. 4

CROSS SECTION ALONG LATITUDE 40°-44'

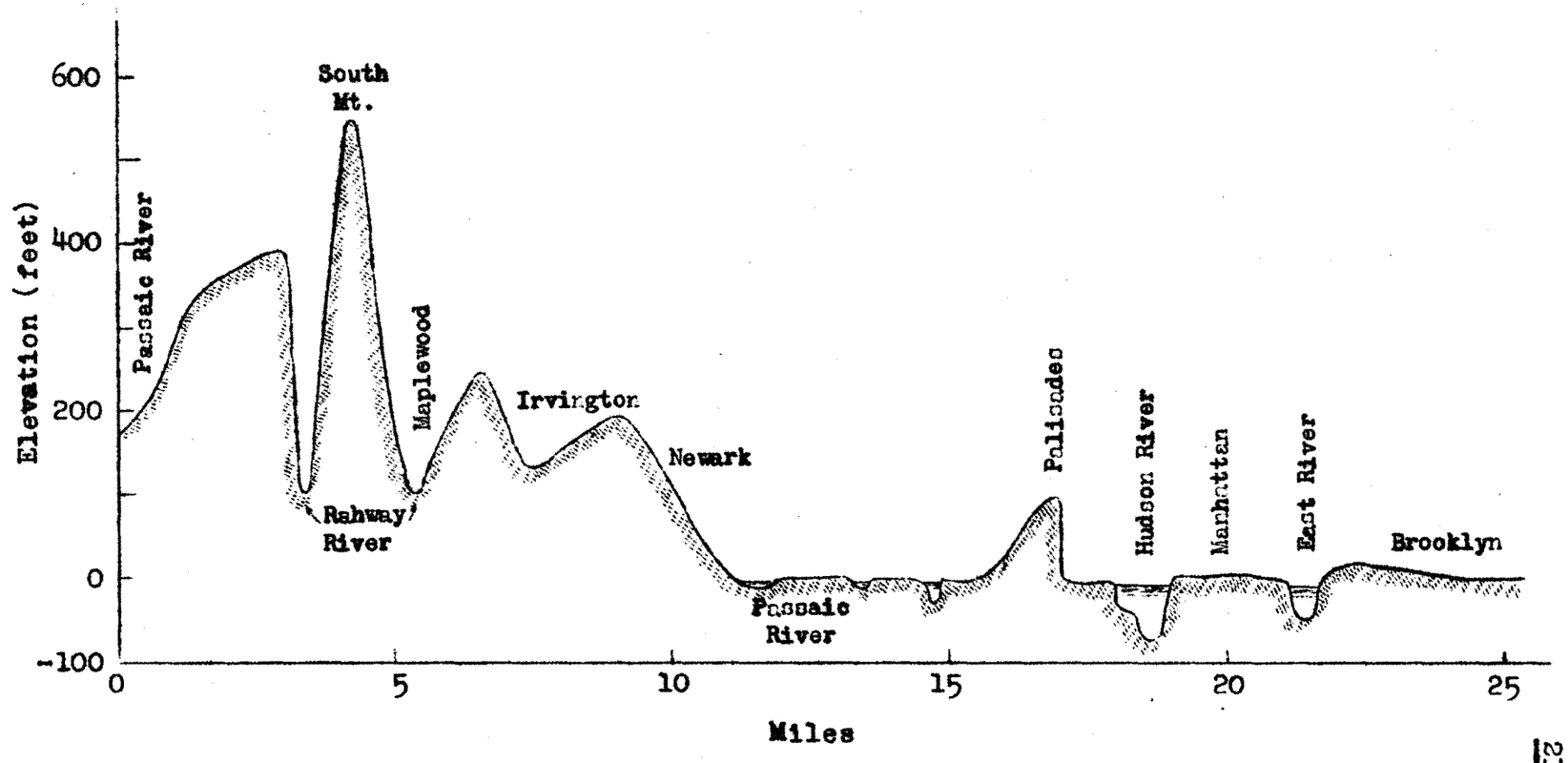


Fig. 5

CROSS SECTION ALONG LATITUDE 40°-50'

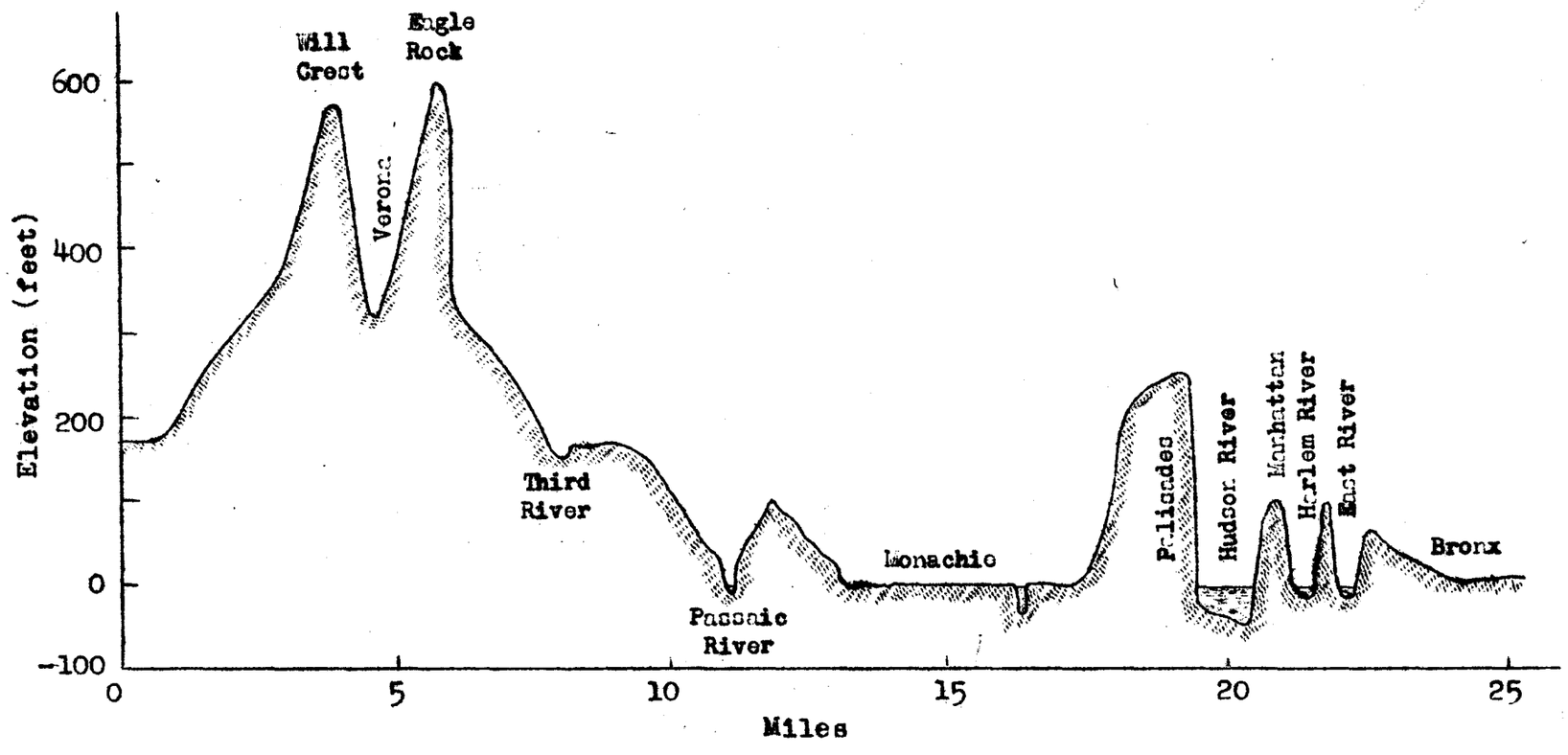
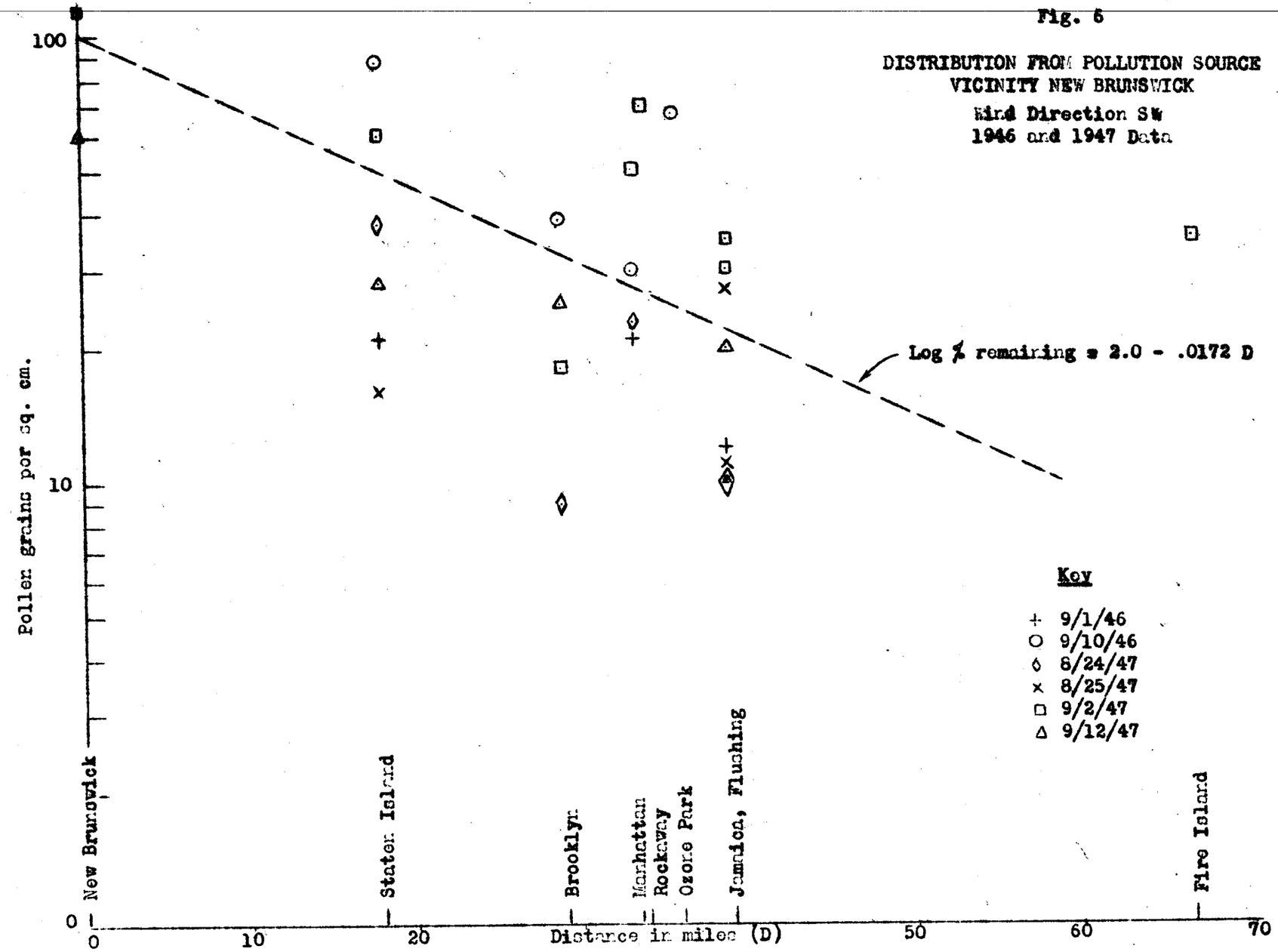


Fig. 6

DISTRIBUTION FROM POLLUTION SOURCE
VICINITY NEW BRUNSWICK
Wind Direction SW
1946 and 1947 Data



CONTROL OF GRASSES IN RASPBERRIES BY FALL, SPRING AND SUMMER APPLICATIONS OF SODIUM TRICHLOROACETATE [1]

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Quack grass (Agropyron repens L.) and Kentucky blue grass (Poa pratensis L.) often become established in the rows of older raspberry plantings. These grasses compete with raspberry plants for nutrients and moisture, and in addition, they interfere with spraying and picking operations. The control of these grass weeds by mechanical means is almost impossible, especially where the hedge-row system is used. Therefore, if control could be obtained by a chemical spray, labor and cost of production would be reduced. Preliminary studies made in 1947 under greenhouse conditions, indicated that TCA (Trichloroacetate)2 could be used to control grasses if applied when the raspberry plants were dormant. On the basis of this work, actual field applications were made in November 1947, and in April and July 1948.

MATERIALS AND METHODS

These studies were made in Alpena county [3], in a thirteen-year old planting of Latham raspberries badly infected with quack grass and Kentucky blue grass. Sodium trichloroacetate readily dissolves in water and it was applied with a knapsack sprayer in aqueous solution at different rates per acre. The amounts of the material used in the different treatments were calculated on the basis of actual acetate, and the area covered was based on the actual area sprayed with the chemical. The spray was directed toward the base of the canes so that the lower portion of the canes as well as the grass was thoroughly covered.

EXPERIMENTAL RESULTS

Fall applications: - TCA was applied November 10 at the rates of 10, 30 and 60 pounds per acre. At this time the old canes had been removed and only the fruiting canes remained. These canes had shed their leaves and were in a dormant stage. The quack grass was green, appeared active, and 10 to 12 inches tall. The soil was moist and a light snow followed the application.

When observations were made April 28, the following spring, there was no new growth of quack grass in the treated rows, while there was abundant growth of grass in the check rows. Later, July 6, some weak growth of Kentucky blue grass and quack grass was present in the rows that received 10 pounds per acre but only Kentucky blue grass was found in the rows that received the 30 pound rate. At the 60 pound rate there was complete control of both grasses. There were no apparent

1. Journal Article No. 1000 (n.s) of the Michigan Agricultural Experiment Station.

2. The material for this work was supplied by the Dow Chemical Company, Midland, Michigan and E. I. duPont de Nemours and Company, Inc., Wilmington 98, Delaware.

3. The authors acknowledge the cooperation of Ralph Trafelet, County Agricultural Agent, who chose the grower where the work was done and who also gave assistance in the work.

symptoms of injury on the canes in April, but in July the leaves on the fruiting canes and on "suckers" showed slight chlorosis between the veins. This was most noticeable on plants that received the highest rate per acre and very slight on the plants that received the lowest rate.

Spring application: - On April 28, 1948 an application similar to the one in the fall was made. At this time the buds of the fruiting canes had started to break, that is, the buds were about one quarter inch long. The quack grass and Kentucky blue grass had produced new growth above the winter-killed grass as shown in the check rows. The results were similar to those obtained from the fall application, although the chlorosis on the leaves was more severe. Some marginal burning of the newly opened leaves was also observed in July.

Summer applications: - TCA at the same rates (10, 30 and 60 pounds per acre) was applied July 6 when the raspberry plants were in full leaf and the fruit was beginning to mature. The "sucker" plants were numerous, and varied in height from emerging to two feet tall. Some of the grasses in the rows were headed out, but still green, and about two-thirds the height of the raspberry plants. In order to secure coverage of the grasses it was necessary to spray a large portion of the raspberry foliage. As a result, much more of the material came into direct contact with the raspberry plants than it did in the dormant applications.

Two months later (September 6) the foliage of the raspberry plants showed considerable yellowing and curling. The younger shoots were definitely stunted due to the fact that they were completely covered with the spray material. The control of the grasses appeared comparable to that of the previous treatments.

Effect of spray on new cane growth: - Measurements of length of new canes in all treatments were made September 6. The averages of these measurements are shown in Table I together with the effects on foliage and grasses. The fall application did not seem to interfere with the growth of new canes as they compared favorably with

TABLE I - - Comparative lengths of raspberry canes from plots treated with TCA at different times and at different rates per acre, the effect of treatments on leaves of the raspberry plants, and effect on the grasses. Observations made: September 6, 1948.

Date of Application	Pounds Per Acre	Cane Length in inches	Leaf Chlorosis	Effect on Grasses	
				Quack grass	June grass
November 10, 1947	10	45.9	None	X	X
	30	44.5	Slight	0	X
	60	46.4	Slight	0	0
	Check	44.3	None	XX	XX
April 28, 1948	10	43.2	Slight	X	X
	30	40.4	Medium	0	X
	60	33.0	Medium	0	0
	Check	42.8	None	XX	XX
July 6, 1948	10	39.0	Slight	X	X
	30	43.6	Medium	0	X
	60	38.8	Serious	0	0
	Check	41.6	None	XX	XX

XX = Matted with grass
X = Reduction in stand of the grass
0 = Complete control of the grass

the check rows, whereas, the highest rate (60 pounds per acre) of the spring application caused some reduction in cane length which was probably due to the fact that some shoots had emerged or were emerging at the time of the application. The summer application did not produce a significant difference in cane length in any treatments.

DISCUSSION OF RESULTS

From observations and data collected, it appears that the fall application gave the best control of the grasses without injury to the raspberry plants. Because of the fact that the raspberry plants were dormant and the grasses more or less active (tops were not yet killed by frost and were green) most of the material was absorbed by the grasses and very little by the raspberry plants. Since there was no foliage on the raspberry plants more complete coverage of the grasses was possible than with the summer application where a considerable amount of the material was sprayed on the foliage of raspberries.

The spring application gave satisfactory control of grasses, it is believed that if the application had been made before the buds of the raspberry plants had begun to break the results would have been similar to those obtained by the fall application. From these observations, it is believed that either fall or early spring applications at 30 pounds per acre would give satisfactory control of quack grass and Kentucky blue grass, but that summer applications are not advisable because of possible injury to the raspberry plants.

From these field observations it is not possible to tell whether the material was absorbed by the grasses through the roots or stem or both. Since some of the material got into the soil it is possible that some of the killing action came through the absorption of the material by the roots.

The fall and spring applications did not interfere with the production of fruit. This is based on the observations of the grower cooperating in these tests. It was noticed that the summer application interfered with the normal production of fruit because the berries from treated areas were smaller than those from canes of the unsprayed rows.

Quack grass rhizomes were dug from all treatments for examination. The rhizomes from the rows that had been treated with 10 pounds of TCA per acre were not dead as was indicated by the presence of new shoots and normal buds, while the rhizomes from the 30 pound application had very few active shoots and buds. The rhizomes from the 60 pound application had no active shoots or bud and were apparently dead. This was true for all treatments, that is, fall, spring and summer applications.

The data presented in this paper is preliminary in nature, and, therefore, is not intended for general recommendations. A follow-up study of the treated plants is needed in order to determine the possibility of delayed injury.

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EXPERIMENTS ON THE CONTROL OF WEEDS IN ONIONS

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This is a report on the use of Aero Cyanate to control weeds in onions on the Holland-Bradford marsh in 1948. The Holland-Bradford marsh, an area of organic soil, is located approximately 35 miles north of Toronto and lies between Yonge Street (No. 11 Highway) at Bradford and No. 27 Highway at Schomberg. There are approximately 6,000 acres on the marsh under cultivation, of which 1,600 acres are onions. The production of onions from the area is close to one million 50 pound bags.

The material and experimental plans were supplied by the North American Cyanamid Limited. This firm also statistically analysed the data.

The most common weeds present at the various farms were as follows: Nettle-leaved goosefoot (Chenopodium murale), barnyard grass (Echinochloa crusgalli), horsetail (Equisetum arvense), lamb's-quarters (Chenopodium album), groundsel (Senecio vulgaris), oak-leaved goosefoot (Chenopodium glaucum), various species of annual grasses, pigweed (Amaranthus retroflexus), and purslane (Portulaca oleracea).

Miscellaneous Experiments

Miscellaneous experiments were conducted: (1) to determine the rates of Aero Cyanate weedkiller required per acre to control various weeds; (2) to compare the effectiveness of different rates when applied in different volumes of water; (3) to determine the maximum rates and concentrations of spray solutions that may be applied to onions in various stages of growth without causing serious injury to the crop.

Three rates, namely, 4, 8, and 12 pounds, were used in three different volumes of water, 25, 50, and 100 U. S. gallons per acre. Each treatment was replicated three times, and was repeated on different farms at various stages of growth of weeds and onions. Three random square foot weed counts were made in each plot.

Horsetail appeared to be completely tolerant of Aero Cyanate and was not killed. Lamb's-quarters was susceptible in the cotyledon stage but its resistance to killing increased as the plant grew. In fact lamb's-quarters was very difficult to kill completely after true leaves had formed. This was true to a lesser extent for the control of all above-mentioned weeds with the exception of groundsel. This weed was fairly easy to kill in larger stages. Purslane was readily killed from the cotyledon stage up to the size of a fifty cent piece. Larger purslane were more difficult to kill.

According to the statistical findings on weed counts, 12 pounds of Aero Cyanate per acre were significantly better than 8 pounds, and 8 pounds were significantly better than 4 pounds. There was no significant difference in the effectiveness of different rates when applied in different volumes of water. At the various stages of onion growth from $\frac{1}{8}$ inch to 12-14 inches no injury was noticeable when any one of the three rates was used.

Main Experiment

The purpose of the main experiment was to determine the best weed control programme using Aero Cyanate spray with regard to dosage, time of application and effect on yield. Dates of application, dosage and numbers of treatments were determined as the experiment proceeded.

The initial applications were made when the onions were 1" - 1½" in height and the weeds were ¼" to ½" in height. Three rates were used, namely, 5, 10, and 20 pounds in 62.5 U.S. gallons of water per acre. A block of plots included four plots treated at 5 pounds, three plots treated at 10 pounds, and 2 plots treated at 20 pounds per acre. There were four replicated blocks, and with checks made a total of 40 plots. A second application was made when onions were 12" - 14" in height and the weeds were ½" to 1½" in height. The rates and numbers of treatments used were based on results obtained from the initial application and were as follows: 1 plot treated at 5 pounds, 3 plots treated at 10 pounds, 2 plots treated at 15 pounds and 3 plots treated at 20 pounds.

The cotyledon stage to the three to four true-leaf stage of oak-leaved goosefoot and red-root pigweed were killed easily using the 10-pound or higher applications per acre. Larger plants were more difficult to kill. Purslane was killed readily from the cotyledon stage to the size of a fifty cent piece. Lamb's-quarters was killed easily in the cotyledon stage but when true leaves appeared resistance to Aero Cyanate increased and 20 pounds per acre often only stunted its growth. Various species of annual grasses were killed readily using the higher rates, when in the cotyledon stage. But larger plants were often only tip-burned. Horsetail seemed to be completely tolerant at any stage of growth.

On May 25th, four days after the first treatment was applied, it was apparent that 20 pounds per acre of Aero Cyanate caused severe onion injury. No onion injury was produced by the 5 pounds per acre application. However, it did not give visual evidence of efficient kill of weeds and in most cases only stunted their growth. The 10 pounds per acre application for the most part seemed to give satisfactory control of weeds with no injury to the onions.

Statistical analyses of weed count data indicated that the 20 pounds per acre treatment was significantly better than the 10 pounds, and the 10 pounds was significantly better than the 5 pounds.

At the time of the second treatment (July 13) many onion tops had broken over and shielded some weeds completely or in part from the spray. Injured weeds generally recovered but remained smaller in comparison to those in the check plots.

The 20 pounds per acre treatment at this stage of onion growth did no harm to the onions. The 5 pounds per acre treatment gave fair to poor weed control. The 10 pounds and 15 pounds per acre applications gave good visual control with no onion injury.

Statistical analyses of weed count data indicated that 20 pounds per acre was significantly better than 15 pounds per acre. There was no significant difference between 15 and 10 pounds per acre and 15 and 10 pounds per acre were significantly better than 5 pounds per acre.

Yield data show that the 20 pound treatment not only caused severe injury to the young onion plants, but it also depressed the yield by an average of 59, fifty pound bags per acre. The 10 and 5 pounds per acre treatments gave an increase in yield of 10 and 28, fifty pound bags, respectively, per acre over the check plots.

Tentative Conclusions and Recommendations.

(1) Approximately 10 - 12 pounds of Aero Cyanate in 60 U.S. gallons of water would seem to be an efficient rate of application per acre of onions on the Holland-Bradford marsh.

(2) Under climatic conditions existing in 1948, 20 pounds per acre may be applied without causing serious injury to onions 12 - 14 inches in height. Onions 1 - 4 inches in height will be severely damaged using the same rates.

(3) Weeds should be small or as close to the cotyledon stage in size as possible when treated with Aero Cyanate. Larger weeds are more difficult to kill and they shield the smaller ones.

(4) The foliage of every plant should be thoroughly wet with spray in order to ensure a complete kill.

(5) A heavy rainfall before or after application of Aero Cyanate will reduce the effectiveness of the spray. Light rainfall does not seem to cause any harm.

(6) Land should be level so that depressions will not shield the small weeds.

(7) For fast results spray should be applied on a warm dry day. Cool temperatures delay the killing action.

(8) Grasses and lamb's-quarters are very difficult to kill when beyond the cotyledon stage.

SODIUM ISOPROPYLXANTHATE AS A NEW SELECTIVE HERBICIDE

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The B. F. Goodrich Company, Biochemical Laboratory

and

Benjamin Wolf

Seabrook Farms Company

Chemical weeding of vegetable or grain crops after a weed problem presents itself is generally more economical than mechanical weeding if satisfactory selectivity is obtainable. Several materials, i.e., dinitro derivatives, 2,4-D, and cyanamide compounds, have demonstrated different types of selectivity for certain crops. Sodium isopropyl xanthate (Good-rite n.i.x.) is a new herbicide that gives promise of enlarging the number of crops which can be selectively weeded.

N.i.x. is a water soluble compound that can be applied as a concentrate spray, dilute spray, or dust. Its high water solubility enhances its activity as a dust and reduces the possibility of toxic residues being left in the soil. To date, no residual toxicity has been noted.

The application of n.i.x. is particularly effective in periods of low rainfall. Satisfactory results were generally obtained when a rain-free period of ten to fifteen hours, preferably twenty-four, followed application. Extremely high rainfall immediately after applications causes loss of material applied since, as might be expected, much will leach from the surface soil before its effect for good weed control can be realized. By way of illustration, thirty pounds of n.i.x. per acre was only partially effective when applied eight hours previous to a four-inch rainfall.

Although n.i.x. can be applied more uniformly as a spray, it appears to be just as effective when applied as a dust. While 10 to 12 lbs. per acre in spray form may be ample, an increase to 12 to 14 lbs. per acre of a dust formulation may be required to insure coverage.

As a concentrate, as much as 60 lbs. per acre can be applied with 25 gals. of water. Better coverage was secured when 25 to 50 gals. of water per acre were used but lethal dosages of n.i.x. can be applied with considerably less water if appropriate nozzles are used.

N.i.x. has shown little evidence of initiating hormone activity. Its selective activity appears to be largely a matter of differential wetting. Evidence of physiological resistance and differential age-tolerance by certain plants has been observed but has not been clearly

demonstrated. For example, many plants sensitive to it when less than 2 inches tall are resistant, or only slightly injured by it, when mature even though the concentration is greatly increased.

The addition of sufficient wetting agent to obtain uniform wetting of the plants increases its activity. Whether this difference in activity is due to more uniform coverage or superior penetration resulting from a solubilizing activity of the wetting agent is not known, but mature annuals that are unaffected by n.i.x. alone are killed when the wetting agent is added. For example, potato vines were not killed when sprayed with n.i.x. at concentrations of 0.5%, 1.0% and 1.5%, but 1.0% and 1.5% applications gave complete kill when 0.125% sodium lauryl sulfate was added.

Variations in rainfall and temperature and humidity may affect the activity of n.i.x. It has been noted that weeds were killed more rapidly, even at low concentrations, when applied on days of extremely high temperatures (approaching 100° F.) and humidity. Also, more injury to peas and beans was observed under these conditions. Hot weather following applications does not, however, appear to influence its activity.

To date, cabbage, lettuce, onions, lima beans and peas have been successfully weeded with post-emergence applications of n.i.x. Some injury to these crops may result if the temperature is high at the time of application, but it is generally negligible. Varietal differences in resistance have been indicated in snap beans.

Discussion of Data

The following data were secured from 100-square-foot-plots replicated 2 to 4 times, unless otherwise indicated.

To control annual garden weeds such as portulaca, lamb's quarters, chickweed and galinsoga in a cabbage planting, the surface of the soil was dusted with n.i.x. at the indicated rates (Table I). A minimum amount of dust was directed on the plants, but later tests indicated that this precaution would not have been necessary. The plot sizes varied from 92 to 138 square feet. Applications were made August 19, 1947, and final observations made October 6, 1947.

TABLE I

Weed Control in Cabbage with n.i.x.

(Conducted at Boyce Thompson Institute for Plant Research)

Plot	Rate of Application	Wt. of all weeds in plot/sq. ft.	Observations on Weeds Remaining, Based on Estimated Number
1.	Untreated	477 gms./sq. ft.	50% galinsoga 40% portulaca 10% misc. weeds
2.	17.3 lbs./A.	27 gms./sq. ft.	40% emerging portulaca 30% crabgrass 30% lamb's quarters chickweed and Bidens sp.
3.	34.6 lbs./A	35 gms./sq. ft.	95% crabgrass 5% misc. weeds
4.	83.1 lbs./A	18 gms./sq. ft.	95% crabgrass 5% misc. weeds
5.	155.7 lbs./A	4.5 gms./sq. ft.	100% crabgrass

No injury to the cabbage resulted from these applications, even though it had been planted just two days before dusting. Repetition of this experiment during 1948, using 17 lbs. of n.i.x. per acre in a water spray, caused no serious injury to cabbage when the herbicide was sprayed over it at the same rate as applied between the rows.

In another experiment (Table II), it was apparent that n.i.x. is well suited for weeding a fast growing crop such as peas. The following data demonstrates the relative effectiveness of dust versus water spray formulations in addition to degree of weed control. Applications were made at the time when weeds were from 1 to 2 inches high and the peas from 6 to 8 inches tall. The plots were subject to unusually high rainfall and were inundated at least twice between time of application and the collection of data. These plots contained 100 sq. ft. and were replicated twice.

The water spray applications were made on April 29, 1948, and the dust applications in adjacent plots on May 4, 1948. Final observations were made at harvest, June 9, 1948. These plots received a total of 10.41 inches of rain during this period.

TABLE II

Weed Control in Peas with n.i.x.

Variety: Glacier

(Conducted at Seabrook Farms, Bridgeton, N. J.)

(A) N.i.x. applied as water spray (100 gals./A)

Plot	Rate of Application	Wt. of weeds per sq. ft. in plot	Observations on Weeds Remaining, Based on on Estimated Number
1.	Untreated	67.6 gms.	40% lamb's quarters 45% chickweed 3% pigweed 10% henbit 1% crabgrass 1% ryegrass
2.	30 lbs./A	5.6 gms.	90% crabgrass 5% ryegrass 4% pigweed 1% chickweed
3.	25 lbs./A	5.6 gms.	60% crabgrass 35% henbit 5% misc. weeds
4.	20 lbs./A	4.6 gms.	70% crabgrass 20% henbit 5% lamb's quarters 5% misc. weeds
5.	15 lbs./A	6.2 gms.	85% crabgrass 5% lamb's quarters 5% henbit 5% misc. weeds
6.	10 lbs./A	4.6 gms.	50% crabgrass 50% henbit

(B) N.i.x. applied as Dust (diluent added to make application at rate of 75 lbs./A)

Plot	Rate of Application	Wt. of weeds per sq. ft. in plot	Observations on Weeds Remaining, Based on on Estimated Number
	Untreated	81.2 gms.	35% lamb's quarters 40% chickweed 15% crabgrass 5% pigweed 5% misc. weeds
7.	30 lbs./A	3.6 gms.	85% crabgrass 15% misc. grass
8.	25 lbs./A	2.2 gms.	95% crabgrass 5% misc. grass
9.	20 lbs./A	1.8 gms.	90% crabgrass 10% misc. weeds
10.	15 lbs./A	5.8 gms.	85% crabgrass 10% ryegrass 5% misc. annuals
11.	10 lbs./A	5.4 gms.	55% crabgrass 30% ryegrass 10% misc. annuals 5% henbit

Although weed control was satisfactory with all applications, rates greater than 15 lbs. per acre caused injury to the basal leaves of the peas.

The results of a replication of the foregoing experiment are indicated in Table III. In this instance, the variety was Shasta and the peas were 2 to 3 inches high at time of application. Although many weeds had germinated, only a few were showing above the ground at this time. The herbicide was applied May 11, 1948, and final observations were made June 30, 1948. During this period these plots received 11.61 inches of rain.

TABLE III

Weed Control in Peas With n.i.x.

Variety: Shasta

(Conducted at Seabrook Farms, Bridgeton, N. J.)

(A) N.i.x. applied as Water Spray (100 gals./A)

Plot	Rate of application	Wt. of weeds/sq. ft. in plot
1.	Untreated	162.2 gms.
2.	15 lbs./A.	43.6 gms.
3.	10 lbs./A	36.8 gms.
4.	7 lbs./A	25.8 gms.

(B) N.i.x. applied as Dust (Diluent added to make application at rate of 75 lbs./A)

5.	Untreated	164.2 gms.
6.	15 lbs./A	31.6 gms.
7.	10 lbs./A	27.2 gms.

Weeds Surviving on Treated Area (Estimated number)	Weeds on Control Plots (Estimated number)
70% crabgrass	40% hedge bindweed *
10% yellow foxtail	25% lamb's quarters
5% ragweed	20% ragweed
5% lamb's quarters	5% chickweed
2% chickweed	5% misc.
5% hedge bindweed *	5% yellow foxtail, crabgrass

* Doubtlessly n.i.x. gave some control of bindweed but the percentage control here indicated is disproportionate because this weed was not uniformly distributed over the study area as were the other weeds.

Effectiveness of n.i.x. when applied as a Concentrate Spray

In a series of prepared plots known to contain an abundance of grass weed seeds, n.i.x. was applied at various rates and with various amounts of water (Table IV). Rates of as much as 60 lbs. per acre were included in this test in order to measure the effect of n.i.x. on control of crabgrass germination.

The applications were made on June 17, 1948, at which time the crabgrass and pigweed plants were just beginning to break through the soil. Due to heavy rains only qualitative data could be secured June 30, 1948. Final quantitative data were obtained July 20th. During this period these plots received 3.91 inches of rain.

It was of considerable interest to observe that on plots where relatively good control was obtained, the few remaining crabgrass plants were five to ten times larger than on adjacent untreated plots. Thus, the qualitative data listed below is probably too conservative. The quantitative data were taken from five scattered 1-sq. ft. plots in the 100-sq. ft. plots.

TABLE IV

Weed Control With n.i.x. when applied as a Concentrated Spray

Plot size: 100 sq. ft.

(Conducted at Seabrook Farms, Bridgeton, N. J.)

(A) 75 Gallons of Water Per Acre

Plot	Rate of Application	Amt. of weed Control June 30	Wt. of weeds per sq. ft. July 20	No. of each weed in 5 sq. ft. of plot 7/20
1.	60 lbs./A	80% weed free Only crabgrass remaining	9.0 gms.	38 crabgrass 2 pigweed 2 portulaca 3 bedstraw 1 lamb's quarters
2.	30 lbs./A	90% weed free only crabgrass remaining	44.0 gms.	60 crabgrass 3 portulaca 1 lamb's quarters 1 pigweed 1 bedstraw
3.	15 lbs./A	75% weed free only crabgrass remaining	104.6 gms.	107 crabgrass 9 bedstraw 2 pigweed

(B) 50 Gallons of Water Per Acre

Plot	Rate of Application	Amt. of weed Control June 30	Wt. of weeds per sq. ft. July 20	No. of each weed in 5 sq.ft. of plot 7/20
4.	60 lbs./A	97% weed free only crabgrass remaining	12.0 gms.	28 crabgrass 2 bedstraw
5.	30 lbs./A	97% weed free only crabgrass remaining	20.0 gms.	51 crabgrass 3 portulaca 6 galium 1 pigweed 1 lamb's quarters
6.	15 lbs./A	85% weed free only crabgrass remaining	50.8 gms.	39 crabgrass 20 yellow foxtail 4 portulaca 5 bedstraw 1 lamb's quarters 1 pigweed

(C) 25 Gallons of Water

7.	60 lbs./A	100% weed free	17.8 gms.	23 crabgrass 2 bedstraw 1 pigweed
8.	30 lbs./A	100% weed free	10.6 gms.	24 crabgrass 11 yellow foxtail 10 bedstraw 1 portulaca
9.	15 lbs./A	95% weed free only crabgrass remaining	69.0 gms.	35 crabgrass 30 yellow foxtail 10 bedstraw 1 pigweed
Untreated (average of 15 1-sq.ft. plots scattered thru adjacent untreated areas		30% crabgrass 30% pigweed 10% lamb's quarters 10% portulaca 10% yellow foxtail 5% bedstraw 1% ragweed	186.2 gms.	80 crabgrass 36 yellow foxtail 20 portulaca 20 lamb's quarters 78 bedstraw 2 pigweed 3 ragweed

Except for some crabgrass, the size of all the annuals as of July 20 was small, indicating that the weeds existing on the treated areas were of recent germination. The usual pattern of herbicidal activity of n.i.x. is

again demonstrated, e.g., it provides good control for annual broadleef weeds, but only partial control of grasses. Cursory examinations of germinating weeds suggested that crabgrass seeds and possibly other grass seeds germinate at a greater depth than broadleef weeds. This may explain why n.i.x. consistently killed a portion of grass seedlings, probably those occurring near the surface. The deeper lying seeds may never have come in contact with lethal concentrations of the herbicide.

Weed control that might be obtained under ideal conditions was represented in an experiment designed to weed selectively small lima beans, variety Ben Fish Thorogreen (Table V). An acre plot of beans was sprayed with 12 lbs. of n.i.x., using the equivalent of 50 gals. of water per acre. The trifoliate leaves had not yet expanded and the weeds were beginning to appear above the ground. No unusual rain immediately followed this application, and a dry period occurred near harvest when a second germination of weeds would normally occur. Application of the herbicide was made June 22, 1948, and final observations were made on July 20, 1948. 3.22 inches of rainfall occurred during this period.

For water conservation and maintenance of desired soil texture, it was desirable to have at least one cultivation in this plot, regardless of weed conditions. However, the treated area had but one cultivation, while the untreated portion of the field required three cultivations. Furthermore, hand weeding was necessary everywhere except on the treated plot.

The following data illustrates the degree of weed control obtained in the drill rows; that portion normally requiring hand weeding. A drill row was considered as a strip 3 inches on each side of the plant stalk, and the sample consisted of 10 strips each 10 feet long. Final observations were made approximately one week before harvest.

TABLE V

Weed Control in Lima Beans With n.i.x.

Variety: Ben Fish Thorogreen

(Conducted at Seabrook Farms, Bridgeton, N. J.)

Treatment	Wt. of Weeds	Variety of remaining weeds
12 lbs./A and 50 gals. water/A	30 gms./100 linear ft.	100% foxtail & crabgrass
Untreated	2230 gms./100 linear ft.	80% pigweed 10% lamb's quarters 5% portulaca 5% misc. grass

Recommendations for Use of n.i.x.

Available information suggests that n.i.x. is especially applicable for controlling annual weeds in crops but is, of course, not limited to this use. It can be applied either as a pre-emergence or post-emergence spray or dust.

For pre-emergence work, it should be applied at rates ranging from 15 to 30 pounds per acre. There appears to be no difference in activity between dust or water sprays.

Best weed kill and least damage to crops from post-emergence applications were secured with rates ranging from 7 to 15 pounds per acre, but 10 to 12 pounds were adequate for most purposes. It should be applied to weeds at some time between their appearance above the ground and until they are about 2 inches high.

N.i.x. should be used without a wetting agent where selective activity is desired, but where selectivity is not an end, the addition of a wetting agent will enhance its phytotoxicity considerably.

Weeds known to be killed in seedling state by n.i.x. are:

Clear weed -- *Pilea pumila*

Smartweed -- *Polygonum* spp.

Lamb's quarters -- *Chenopodium album*

Pigweed -- *Amaranthus* spp.

Mouse ear chickweed -- *Cerastium vulgatum*

Common chickweed -- *Stellaria media*

Portulaca -- *Portulaca* spp.

Spotted spurge -- *Euphorbia supina*

Evening primrose -- *Oenothera biennis*

Milkweed -- *Asclepias* spp.

Bindweed (seedings) -- *Convolvulus* spp.

Henbit -- *Lamium amplexicaule*

Purslane speedwell -- *Veronica peregrina*

Bed straw -- *Galium spp.*

Ragweed -- *Ambrosia* spp.

Spanish needles -- *Bidens* spp.

Fleabane -- *Erigeron* spp.

Galinsoga -- *Galinsoga ciliata*

MINUTES OF BUSINESS MEETING
January 7, 1949

Treasurer's Report

The treasurer's report was presented and accepted. It was proposed that the Finance Committee study ways and means of supporting the activities of the Conference. The Conference is in favor of continuing the trade show for those who prefer to exhibit as a means of participating, and is also in favor of accepting contributions from those who prefer a direct way of helping support the Conference.

Report of the Research Committee

It was proposed that the present membership of the committee be retained and the number at least doubled to include the members and activities of the Policy Committee and the members of the Executive Committee. This enlarged group could be identified as the Coordinating Committee. Its function would be to survey weed control activities up to the present, determine what future action should be taken, and the best ways of attaining the objectives set up. It was moved that the report be accepted for discussion.

Mr. Patterson moved that the Coordinating Committee function to acquaint those working on a specific project with what other workers are doing in the region. Motion accepted for further study.

The most appropriate name for the committee and its functions were discussed. Dr. Yowell favored "Committee for Coordinating Research" and thought the new committee intended to take over the work of the retiring Policy Committee. The report of the Research Committee was accepted and was referred to the new executive committee for any action that is necessary.

Report of the Policy Committee

Dr. Prince presented the report of the Policy Committee, which seriously doubts the possibility of discharging its duty to draw up and present a definite policy concerning the position and use of various herbicides under Northeastern conditions, and therefore, requested its dissolution. Discussion from the floor produced differing comments concerning the value of developing and presenting such a report. The question is how to get the policy report instead of whether to develop one. The matter was referred to the new executive committee for further study and appropriate action at the time that seems best.

Committee for Regional Support

As a result of work done by the Committee for Regional Support, which was appointed at the 1948 meeting, there is now a technical weed committee to handle regional support problems. This Committee was made up of Dr. H. Albrecht, Dr. G. H. Ahlgren and Dr. R. D. Sweet and since they have accomplished their mission this Committee was dismissed with an expression of appreciation from the Conference for a job well done.

Report of the Publications Committee

Dr. Beatty reported that the Publications Committee considered organization of a national herbicide publication and contacted the other Conferences with regard to it. All are in favor of starting it, but no one wants to initiate action. Discussion from the floor indicates that such a step is probably premature, and should be postponed until the weed conferences develop a national organization. However, the opinion of the Northeastern Conference was expressed as being willing to cooperate with the other Conferences in what they may initiate. In the meantime, the committee has issued an informal newsletter containing reports and a current bibliography of pertinent information. The Conference voted in favor of continuing the NEWCC Newsletter on the present basis of current news.

The following resolution from the 10 Annual Meeting of the Western Weed Control Conference was read:

RESOLUTION NO. 1

WHEREAS, the weed control field is fast achieving its rightfult position of importance in agriculture, and

WHEREAS, most sections of the United States and Canada now have organized regional weed control conferences, and

WHEREAS, the need for closer coordination of the activities of those interested in weed control is self evident,

NOW, THEREFORE BE IT RESOLVED that the Western Weed Control Conference, assembled at Sacramento, California, February 2, 3, and 4, 1948, favors and will encourage the establishment of an over all executive council to coordinate the activities of the various weed control conferences.

It was moved that the resolution be accepted as read, and the proper communication be forwarded to the proper officials of that organization. Moved and accepted.

The Conference gave a rising vote of thanks to Wheeler McMillen, the banquet speaker. The Conference's appreciation of the fine type of cooperation and good services provided by the Hotel New Yorker was also expressed.

The question of how experiment stations want to handle new compounds being developed was discussed. Dr. Prince suggested that the per cent of active ingredients and the possibility of the material's getting into production should be known. Such materials should be past the screening stage. Dr. DeFrance felt that the policy should be determined by the officials at each experiment station.

Dr. Raleigh proposed that in the future the Conference meet at luncheons, rather than dinners, leaving the evenings completely free.

Report of the Nominating Committee

The Nominating Committee presented the following slate of officers for the consideration of the Conference:

President - Robert D. Sweet, Cornell University
Vice President - Howard L. Yowell, Standard Oil Development Company
Secretary-Treasurer- Dale E. Wolf - Rutgers University

There were no other nominations or discussion. It was moved and seconded that the nominations for the Northeastern Weed Control Conference for the next year be accepted, that the nominations be closed, and that one ballot be cast for the slate of officers. Unanimously carried.

The retiring president, Dr. G. H. Ahlgren, expressed appreciation for the help that so many have given and for the interest commercial people have shown and the support they have given.

The new president, Dr. R. D. Sweet, made the following committee chairman appointments:

Coordinating Committee - Walter C. Jacob - Cornell University
Program Committee - Alton E. Prince - University of Maine
Publications Committee - Robert H. Beatty, American Chemical Paint Company
Trade Show - Gilbert H. Ahlgren - Rutgers University

The meeting was then adjourned.

REGISTRATION LIST
NORTHEASTERN WEED CONTROL CONFERENCE

HOTEL NEW YORKER - NEW YORK CITY
January 5, 6, and 7, 1949

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