PRESENT AND FUTURE OF AQUATIC WEED CONTROL

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The importance of aquatic and marginal weeds and their control is closely related to the importance and value of water. Water is now or is rapidly becoming the most precious and limiting resource in most parts of our country. Deficiencies in quantity or quality of available water limit agriculture, industrial and urban development, navigation, or recreation in many areas. Therefore, it is not surprising that aquatic and marginal weeds that waste water, reduce water quality, interfere with economic uses of water, and prevent its free and timely flow through waterways should cause general public concern.

Aquatic weeds may be grouped into the following types: filamentous algae, nonfilamentous algae, floating, rooted submersed, rooted emersed, and marginal weeds. These types of weeds cause losses or create public nuisances in aquatic areas in many ways. They may reduce the flow in canals and streams, and interfere with navigation, delivery of irrigation water or drainage of excess water and may cause flooding, breakage of canal banks, or damage to bridges and other structures and may result in salt-water intrusion in low-lying coastal areas during drought periods. Algae and other aquatic weeds may affect the health and comfort of people and livestock by causing undesirable odors or tastes in potable water, harboring insect pests and vectors of human diseases, and interfering with proper sewage disposal and stream sanitation. Many forms of aquatic vegetation are nuisances in fishing and bathing areas and in wildlife habitats. Emersed aquatic weeds such as cattails (Typha spp.), tules (Scirpus spp.), and common reed (Phragmites communis Trin.) transpire large quantities of water from reservoirs, canals, and marshes, and thus cause serious losses in areas of water shortage.

I do not wish, however, to imply that all aquatic plants are harmful. Many forms of aquatic vegetation, properly managed, are beneficial and necessary, especially in fish and wildlife habitats.

Extent and Importance of Aquatic Weed Problems

Reliable statistics on the total area of different aquatic environments in the United States that have important weed problems are not available. Also, no overall figures are available on the total monetary losses caused by aquatic and marginal weeds or on the cost of controlling them. However, a few examples of such losses and costs and of the extent of certain aquatic weed problems may give some indication of their economic importance.

A survey of the extent of aquatic- and bank-weed infestations, losses caused by weeds, costs and benefits of weed control on irrigation and drainage systems in 17 Western States provided some interesting and apparently reliable data for 1957 (8). Approximately 65 percent of the canals, laterals, and drains and 74 percent of the ditchbanks were infested with weeds. Totals for the 17 Western States showed that 90,768 miles of channels

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were infested with aquatic weeds and 395,020 acres were infested with bank weeds. Total estimated losses of water caused by weeds in 1957 was 1,966,068 acre-feet. This water was valued at $3,626,742 at the farmer's headgate and had an estimated net productive value of $39,321,360. The cost of other damages by the weeds was $2,112,422. The total cost of weed control on irrigation systems in the 17 Western States in 1957 was $8,113,297. This cost added to the losses from weeds brought the total annual cost of weeds on western irrigation and drainage systems to nearly $50 million. Incidentally, the estimated losses prevented by the expenditure of $8,113,297 for aquatic and bank weed control in 1957 was $15,860,026, a net saving of $7,746,729. This was a sizeable annual return on the Nation's investment in research, extension, and other efforts directed toward the development and use of improved methods of controlling weeds in the irrigation and drainage systems of the West.

No equally comprehensive and reliable data are available on the extent of aquatic and marginal weed problems, the losses caused by them, and the extent and costs of control in other parts of the United States. However, fragmentary information indicates that aquatic weed problems are just as critical in other parts of the country as in the West. It was estimated in 1947 (5) that there were 500,000 acres of Louisiana waterways and wetlands infested with waterhyacinth and alligatorweed. Figures supplied by the U. S. Army Corps of Engineers (3) show that over $5 million was spent controlling waterhyacinth in Louisiana, Florida, and Alabama between 1905 and 1955. The infestation in Louisiana has been reduced about 50 percent to 250,000 acres according to recent estimates.

The Central and Southern Florida Flood Control District has a network of 500 miles of drainage canals for which the annual costs of aquatic weed control exceeds $50,000. In addition, about $30,000 is spent annually for aquatic weed control in the smaller irrigation and drainage ditches serving 15,570 square miles of agricultural land in southeastern Florida.

One way to estimate the potential aquatic weed problem in the United States is to determine the extent of different aquatic areas in which weed problems could occur. Pertinent data on that question from the 1949 or 1954 Agricultural Census and the 1961 Statistical Abstract of the United States are summarized in table 1.

In an attempt to obtain information on the extent of weed problems in these aquatic areas and on the extent of control programs, methods used, and costs of control a questionnaire-type survey was initiated in September 1961. Questionnaires on the problem in farm ponds, drainage ditches, and irrigation canals were sent to all 50 State Agricultural Experiment Stations and questionnaires on inland natural lakes and waterways and artificial impoundments stocked with fish were sent to Fish and Game Commissions or Conservation Departments in all 50 states.

Replies received from 38 State Experiment Stations and 31 Fish and Game Commissions indicate that very little definite information is available on aquatic areas in central and eastern regions of a type that was obtained for irrigation and drainage systems in the West. However, the 13 complete and 22 incomplete reports from Experiment Stations and the 13 complete and

13 incomplete reports from Fish and Game Commissions provide valuable information. Most of the information on percentages of aquatic areas occupied by problem weeds were based on estimates by aquatic weed specialists and can be considered the most reliable information now available. Only a very few of the specialists attempted to estimate the monetary losses caused by aquatic and marginal weeds.

Table 1.--Aquatic areas in which weed infestations could occur.

Region of the United States	Kind of aquatic situation			
	Ponds and reservoirs[1]	Drainage ditches[2]	Irrigation canals[2]	Inland water surface[3]
	Number	Miles	Miles	Sq.mi.
Northeastern	107,790	2,336	None	7,621
Northcentral	624,624	100,636	6,312	11,045
Southern	878,792	39,956	15,601	20,927
Western	153,184	12,525	117,954	26,616
Total	1,765,020	155,423	139,867	66,209

[1] From 1954 Agricultural Census.

[2] From 1949 Agricultural Census.

[3] From 1961 Statistical Abstract of the United States. Data include permanent inland freshwater surface such as lakes, reservoirs, and ponds having 40 acres or more area, and streams, sloughs, estuaries, and canals one-eighth mile or more in width. The Great Lakes were not included.

Complete reports from 13 Northcentral, Southern, and Western State Agricultural Experiment Stations indicate that filamentous algae, rooted submersed, rooted emersed, and marginal weeds all constitute serious problems in farm ponds and drainage ditches in each of the three regions and in irrigation canals in the West. The weed problem is especially serious in farm ponds in the northcentral and southern regions where each type of weed is a problem in 15 to 84 percent of the ponds. The average percent infestation of each of these weeds in drainage ditches and irrigation canals ranges from 11 to 70 percent in the three regions. Floating weeds are a problem in 10 to 19 percent of the farm ponds and 5 to 7 percent of the drainage ditches in Southern and Northcentral States. No complete reports were received from the 13 Northeastern States on aquatic weed problems in farm ponds and drainage ditches.

Complete reports from 12 Northeastern, Northcentral, and Southern State Fish and Game Commissions indicate that the different types of aquatic weeds constitute problems much more frequently in marshes and artificial impoundments than in natural lakes and streams. This is especially true of rooted types of weeds average 10.4, 8.7, 3.4, and 3.3, respectively, in marshes, artificial impoundments, natural lakes, and natural streams for all three regions. The highest percentages of infestation by each type of aquatic weed in any region are as follows: filamentous algae - 16, nonfilamentous algae - 24, rooted submersed - 44, rooted emersed - 41, floating - 11, and woody plants - 16. Algae and rooted submersed weeds were reported as problems much more frequently in natural lakes and streams in the northcentral region than in other regions.

The single complete report from the western region was not considered representative of that region. You, no doubt, will be interested in the report from Alaska which states there are no weed problems in any aquatic situations there. Apparently Alaska, with its primeval lakes and streams, abundant fish and game, and few people, is comparable with your own Northeast about 200 years ago. Probably, when all information from the questionnaire survey in 1961 has been summarized, checked, and interpreted, a final report will be published similar to the joint report published on the survey of weed losses, costs, and benefits of weed control in western irrigation and drainage systems in 1957.

More than 130 aquatic weeds are common enough in the United States to justify being included in a list of common and scientific names now being considered by the Weed Society of America Terminology Committee for official action. That suggested list was prepared by ten aquatic weed specialists in different parts of the country. The genera or species that most frequently cause problems include pondweed (*Potamogeton* spp.), watermilfoil (*Myriophyllum* spp.), elodea (*Elodea canadensis* Michx.), coontail (*Ceratophyllum demersum* L.), naiad (*Najas* spp.), stonewort (*Chara* spp.), cattail, smartweed (*Polygonum* spp.), waterhyacinth (*Eichhornia crassipes* (Mart.) Solms.), alligatorweed (*Alternanthera philoxeroides* (Mart.) Griseb.), spatterdock (*Nuphar advena* (Ait.) Ait. f.), common reed, buttonbush (*Cephalanthus occidentalis* L.), willow (*Salix* spp.) and the groups of duckweed and filamentous algae.

History of Aquatic Weed Control and Research

Progress in research and improvement of methods of controlling aquatic weeds has lagged considerably behind that for control of land weeds and is just beginning to catch up. At this point let us review briefly the recent history of aquatic weed control and research to give us a better understanding and appreciation of their present status and future prospects. Hand-cleaning and mechanical methods of control probably were used on aquatic weeds about as early as on land weeds. The U. S. Army Corps of Engineers has made extensive use of various mechanical methods of controlling waterhyacinth since 1900. Underwater mowers for submersed weeds were in use by 1930. Many types of chains, drags, and disks were being used for removing aquatic weeds from irrigation ditches by 1940 (1). We are still relying on mechanical methods for aquatic weed control to a much greater extent than we are for control of land weeds.

Copper sulfate was first used for control of algae as early as 1904 (7) and it is still the most widely used method. Sodium arsenite was used rather extensively for control of waterhyacinth in Louisiana from 1902 to as early as 1926 in Wisconsin (6). It is still the most extensively used herbicide for control of submersed weeds in lakes and ponds in many parts of the country despite its toxicity to warm blooded animals.

During the early 1940's chlorinated benzenes were used to some extent for control of submersed weeds in eastern ponds and lakes and in western irrigation canals. Research by Agricultural Research Service and Bureau of Reclamation scientists beginning in 1947 developed an effective method of using xylol-type benzenes, commonly called aromatic solvents, for control of submersed weeds in irrigation canals (2). More than 500,000 gallons of xylol is now used annually for this purpose.

The renaissance in general weed control, which was sparked by the discovery of the herbicidal properties of 2,4-D in 1944 and really got underway about 1947, did not have much effect on aquatic weed control or research until nearly 10 years later. A few exceptions were the research on control of waterhyacinth with 2,4-D by several Federal and State agencies beginning in 1946, the research on methods of controlling weeds in western irrigation systems by the Agricultural Research Service and Bureau of Reclamation beginning in 1947, and the research on control of marsh weeds with 2,4-D by the U. S. Fish and Wildlife Service and Tennessee Valley Authority beginning about 1947.

The general lack of interest in aquatic weed control research prior to 1955 is indicated by the fact that less than 2 percent of the papers presented at Northeastern, Northcentral, and Southern Weed Control Conferences each year were on aquatic weeds. Research subcommittees on aquatic weeds were not established until 4 to 8 years after general research committees were created. It was only in the Western Weed Control Conference that an early interest was shown in aquatic weed control research. Beginning in 1950, 5 to 10 percent of the papers and research reports in that conference were on aquatic weeds and the Research Section included an aquatic weed subcommittee from its establishment in 1952.

The reawakening in aquatic weed control really began about 1957. In that year the Agricultural Research Service increased its research effort on aquatic weeds from about 3 man-years to 9 full-time scientists. A contract was arranged with Auburn University to conduct primary evaluation of 750 chemical compounds as aquatic herbicides on representative submersed aquatic weeds and to check 100 of the most promising of these for toxicity to representative species of fish. Previously, very few of the many thousands of chemicals tested for herbicidal activity on land weeds had been tested for effectiveness on aquatic weeds by the chemical industry.

In July 1958, Congress authorized, under Section 104 of Public Law 85-500, the annual expenditure of $1,350,000 by the U. S. Army Corps of Engineers and eight Atlantic and Gulf Coast States for the control of alligatorweed and other obnoxious aquatic plant growths in the combined interest of navigation, flood control, drainage, agriculture, fish and wildlife conservation, public health, and related purposes including continued research for development of the most effective and economic control measures. The cooperative research program, "Expanded Project - Aquatic Plant Control," which was developed as part of this total program, involves six Federal and

Present Status of Aquatic Weed Control and Research

That brief history brings us to the present when public interest in aquatic weed control and research seems to be at flow tide and to be surging higher. One indication is the fact that 25 papers on aquatic weeds were presented at the Weed Society of America program in December 1961 as compared with 11 papers in 1960, 13 in 1958, and 7 in 1956. Another indication is the fact that 16 State Agricultural Experiment Stations submitted proposals in September 1961 for participation in a regional research project on aquatic weed research financed by Federal funds designated as the "Central Research Fund." Four of these proposals by the Alabama, California, New York, and North Carolina State Experiment Stations were approved and funded. Previously, only the Alabama, Michigan, and Oregon State Experiment Stations had been active in research on aquatic weed control.

The 38 State Experiment Stations which replied to my questionnaire sent out in September 1961 reported a total research effort on aquatic weed control of 10.5 man-years annually. The 31 State Fish and Game Commissions reported a total research effort on aquatic weed control of 24 man-years annually.

The total acreage of aquatic areas treated for control of different types of aquatic weeds in 1961 as reported by 10 to 16 State Fish and Game Commissions in Northeastern, Northcentral, and Southern States were 10,552 (14) of filamentous algae, 33,808 (10) of other forms of algae, 15,373 (16) of rooted submersed weeds, 10,576 (16) of rooted emersed weeds, and 39,611 (10) of floating weeds. With the possible exception of floating weeds these treated areas represent only small fractions of the areas in which these weeds were reported to be serious problems.

Reports on the extent of treatment of farm ponds and drainage ditches for aquatic weed control in northeastern, northcentral, and southern regions were not sufficient in number for a reliable general indication. However, there appeared to be considerable chemical treatment for weed control in farm ponds in New Jersey, Ohio, South Carolina, Missouri, and Texas. Apparently, the use of weed-control practices in aquatic areas is not nearly as extensive in Central, Southern, and Eastern States as it is in irrigation and drainage canals of the West. The survey mentioned earlier (8) showed that 63,448 miles of canals were treated for aquatic weeds and 328,232 acres of ditchbank were treated for weed control in 1957. These were 54 and 80 percent, respectively, of the total weed-infested areas.

A summary of reports in the questionnaire survey indicates the order of preference for chemical and mechanical methods of controlling the different types of aquatic weeds as follows with the number of specific mentions shown in parentheses after each method:

<u>Algae</u> - copper sulfate (32), sodium arsenite (8), carp (2), dichlone (1).
<u>Rooted submersed (ponds and lakes)</u> - sodium arsenite (27), 2,4-D (24), silvex (12), endothal (9), mechanical methods (2). <u>Canals and ditches</u>) - mechanical methods (7), xylol (4), urea (2), acrolein (2).
<u>Rooted emersed</u> - 2,4-D (38), dalapon (22), amitrole (16), mechanical methods (15), silvex (7), 2,4,5-T (5).

Floating - 2,4-D (19), 2,4,5-T (4), silvex (4).
Marginal - 2,4-D (34), dalapon (26), amitrole (13), 2,4,5-T (12), silvex (11), mechanical methods (10), oil (8), burning (6).

The Hawaiian Agricultural Experiment Station reported that a herbivorous fish, Tilapia mossambica, has given excellent control of submersed aquatic weeds in canals, ditches, ponds, and reservoirs with permanent water supply. This fish is used for food in Hawaii and the Philippines but is not highly regarded as a food or game fish in Southern United States where preliminary tests have shown it to be not well adapted.

Lack of time prevents my saying more about control methods. I recommend for your reading a recent publication by T. F. Hall (4) which contains an excellent discussion of the nature of aquatic weed problems and of control and management methods with an extensive review of literature.

Future Prospects for Aquatic Weed Control and Research

All signs point toward continued and probably much increased interest and activity in aquatic weed control. We have a larger backlog of unsolved problems than in most other phases of weed control. As water supplies become more limiting and critical those aquatic weed problems will increase and become more acute. The 38 replies to my questionnaire to State Agricultural Experiment Stations reported a need for increasing research on aquatic weeds from 10.5 to 88.5 man-years, eight times as many. The Federal agencies that have shown an early interest in aquatic weed problems probably will continue and perhaps increase their present efforts.

The replies to the survey questionnaire were almost unanimous in pointing out the need for a more effective, less expensive, longer lasting, more easily applied aquatic herbicide that is safe for fish, humans, livestock, and wild game. I do not predict that many miracle herbicides that meet all those specifications will be found but the prospects seem promising for much better herbicides than we now have in commercial use. A total of 131 chemicals of the 854 compounds evaluated by Auburn University in the initial contract with the Agricultural Research Service gave 90 percent or better control of representative aquatic weeds at 5 ppm. Sixteen of these chemicals proved safe for fish. Many of these promising chemicals are now undergoing secondary evaluation, and a few look extremely promising in field tests. Probably additional promising aquatic herbicides will be discovered in two primary evaluation programs still underway at Auburn University. Several chemical companies have recently established screening programs for aquatic herbicides. That development should greatly increase our supply of promising aquatic herbicides for further testing and development.

Biological agents probably will play an important role in future control of aquatic weeds. The Entomology Research Division of the Agricultural Research Service is now investigating in South America the feasibility of introducing promising insect pests of alligatorweed into the United States. A large fresh water snail, Marisa cornuarietis L., has shown considerable promise for control of certain submersed and floating weeds in Puerto Rico and Florida in investigations conducted by the Agricultural Research Service, control of filamentous algae are underway at Auburn University. Observations by Bureau of Reclamation personnel in Washington indicate that a low-growing species of water plantain (Alisma gramineum K. C. Gmel.) is an effective competitor with rank growing pondweeds in large irrigation canals.

Future research on aquatic weeds undoubtedly will place more emphasis on the anatomy, morphology, physiology, and life cycles of aquatic weeds in relation to their control. The fate of herbicides in water and aquatic soils and the factors that affect adsorption, retention, and decomposition in soils will also be thoroughly investigated. Participants in the new cooperative Regional Research Project on Aquatic Weeds involving the Alabama, California, New York, and North Carolina Agricultural Experiment Stations will investigate fundamental aspects of the problem and should contribute greatly to the understanding and improvement of aquatic weed control.

Control efforts probably will continue to be directed toward final eradication of certain problem species. However, I agree with Dr. T. F. Hall (4) that "For most aquatic species control will be more realistic and economical than attempts at eradication." For the most economical and long-lasting results we will need to take full advantage of the natural forces of plant competition and biotic balance aided by judicious use of herbicides and management.

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The Role of the State in Residue Determinations and Clearances with Particular Reference to Agricultural Chemicals.

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The rapid expansion in the use of chemicals in all phases of modern agriculture is one of the great developments of recent decades. The primary concern of your conference is with an important part of the field of agricultural chemicals -- the development and use of herbicides. Closely related chemicals used as insecticides, fungicides, nematicides, plant growth regulators, defoliants and related compounds, have much in common in the research programs of many of the State Colleges of Agriculture and their Agricultural Experiment Stations. The topic I have been asked to review deals with the broad field of policy, as well as opportunity for service in the state experiment stations, regarding residues that may result from the use of these chemicals in modern agriculture, and the state's role in obtaining tolerances and registration for use of materials needed in its programs. My own professional experience has come from association with insect-control programs in which insecticides have been of primary concern; yet in a broader sense, cooperative research projects within our own experiments stations at Ithaca and Geneva, as well as participation on the Northeastern Regional Residue Research Program from its inception, have provided an awareness of the total problem.

It is essential at the outset to remind ourselves that the State workers are partners in a cooperative venture with representatives of the agricultural chemical industry, at home and abroad, and the several agencies of the federal government engaged in research, extension, and regulatory programs in this field. In short, we have responsibilities, but they must integrate with those of others. I should like to review a few developments to illustrate this point.

RESIDENT INSTRUCTION IN OUR STATE COLLEGES AND UNIVERSITIES.

Since the establishment of the Land Grant Colleges through the Morrill Act by the Congress and the President in 1862, the importance of teaching agriculture has been recognized in each of the several states. This is the Centennial Year for the Land Grant Colleges, and recognition of their many contributions to our nation continues to be highlighted. Further, one of the great developments of the past century has been the rise of research in our land grant institutions, designed to be of service to the citizens of the states. The Hatch Act of 1888 recognized the need for federal support for establishing the agricultural experiment stations at the land grant universities and continues with increasing support today. Then, as new knowledge became available, the Cooperative Extension programs at these same land grant units was made possible by federal support through the Smith-Lever Act in 1914. The pattern of teaching at the undergraduate and graduate levels, the conduct of research in basic as well as applied fields, and its application through extension channels throughout the several states, has become a well-known pattern

In most of the states, regulatory activities pertaining to agriculture in the broad sense of the term, have remained separate from the educational programs referred to above. But I would hasten to add that these programs have needed close cooperation from the educational institutions, and, for the most part, have received it.

It is worth noting that government and industry are consumers of trained personnel that are a product of the teaching and research programs of our colleges and universities. Thus, an important part of the state's contribution to the problems we have under consideration is its ability to provide trained men and women to conduct the work. We have been assisted in recent years, in support of the graduate training programs particularly by industrial grants and foundation support. The launching of the Russian sputnik a few years ago brought into sharp focus the need for support of basic research and development in the sciences in the United States. For example, the great growth of dollar support for the plant sciences by federal and private foundations during the past five years is giving the universities, both state and privately supported, unparalleled opportunities for expansion of fundamental research in all areas at a level never before known. It has brought into greater prominence postdoctoral training in specialized areas of science in all parts of the world, which should reflect in increased productivity among scientists in the days ahead. The teamwork of modern scientists in attacking problems with equipment and instrumentation that promote progress continue to amaze the uninformed. In spite of the long history of science in the world, it is estimated that of all scientists who ever lived, 90 per cent are alive today! With our current rate of development, knowledge is doubling every 10 years. It has been amply demonstrated that ideas know no political boundaries. Our phenomenal developments in communication and travel have made us a functional part of the world community, wherever we may be. We must keep abreast of the work of scientists in all lands.

RESEARCH IN OUR STATE COLLEGES, UNIVERSITIES AND EXPERIMENT STATIONS.

One of the important phases of any research program that seeks to develop a herbicide, insecticide, fungicide or other agricultural chemical or food additive is determining whether a residue of the chemical remains in or on the raw agricultural commodity or the processed product, and if it does, evaluating its toxicity to man and other warm-blooded animals. Broader concerns with residues exist; for instance, the accumulation of these products in the soil, the metabolism of the compounds by plants or animals in the case of systemic pesticides, and the like.

From the viewpoint of research in the development of new compounds, the major contributions in the field of agricultural chemicals have come from industry and the federal laboratories. Much of the work in this fundamental area of chemical research will of necessity continue to come from industry, with occasional contributions from federal and state stations. The production and sale of agricultural chemicals is industry's business, and likely will so remain. Once selected chemical compounds are through primary screening and are available for secondary screening and developmental research, the states traditionally have provided much help. For several years following the unveiling of 2,4-D in 1945 a considerable amount of field testing was necessary to catch up with grower demands for usage. The recent trend of this research keep developmental work in progress to guide their extension recommendations. Obviously the benefits have not been one-sided, because the scientists in the experiment stations kept abreast of new developments and acquired experiences on performance prior to grower use; industry was able to spread its range of environmental conditions into different ecological situations in many parts of the country and speed its decisions about the value of candidate compounds as well. Thus, cooperation helped speed progress.

The great array of synthetic organic compounds that have appeared in the past two decades have been sorted and finally put into significant use as agricultural chemicals because the state scientists, cooperating with those of industry and the federal government, have provided much needed data on biological performance and levels of residues on specific crops under a variety of conditions. In the aggregate, these data have meant much to industry in preparing the petitions for registrations with the U. S. Department of Agriculture of agricultural chemicals moving in inter-state commerce, as well as supporting the request for tolerances or exemption tolerances by the Food and Drug Administration where they are required. State residue research, supplied directly to government or industry for these purposes, has made a vital contribution.

It became obvious in the years immediately following the Second World War that the pesticide chemist was an essential member of the team of scientists working in scientific agriculture. A number of the state experiment stations undertook residue research as a basis for guiding their extension programs for pesticide recommendations and use. The public hearing in Washington in 1950 held by the Food and Drug Administration to determine the necessity for use of pesticides in the production of fresh fruits and vegetables brought forth much data from state sources as well as the federal and industrial laboratories. The obvious inadequacy of the Food, Drug and Cosmetic Act at that time in establishing residue tolerances or exemptions, was remedied with the passage of the Pesticide Chemicals amendment in 1954. The earlier legislation involving the Insecticide, Fungicide and Rodenticide Act in 1947 established the pattern for registration of chemicals going into interstate commerce. It became mandatory upon the firm's application for registration of an agricultural chemical for a specific use to provide the essential information by which the USDA and the FDA, in most instances, could arrive at a decision on these requests. Thus, residue data assumed a new role of importance in the agricultural chemical field. The pattern was set and residue reserach became an integral part of practically all pesticide research programs. The state experiment station chemist, working with other companions in the investigations, based the residue determinations on analytical methods provided by the manufacturer of the chemical, or those developed through his own research. In some states without the services of a full-time pesticide chemist, the treated samples were sent to the industrial laboratories for analysis. This procedure still is being followed, but with increasing effort supported in part by federal regional research funds, to equip and staff the state experiment stations laboratories for their own residue research programs. The federal foundations have given generously in support of research dealing with residues and providing matching funds for building health related facilities.

With the expanding interest and capability for residue research on the part of the states, industry has been able to extend its developmental program to cover the major fields of use for a given compound, and to cooperate with in limited areas. This further emphasizes the cooperation that exists between industry and state and federal government.

There are times when public service patents may cover a good and useful agricultural chemical, but because of the non-exclusive nature of the patent, no company is willing to carry out the developmental program on residues, toxicity studies and the like necessary for FDA and USDA tolerances and registration. In important instances, it is up to the state stations, alone or in cooperation with the federal government and/or industry, to do the work and seek the approval and registration of the product. Such recently was the case with some of the blossom thinning chemicals for use in fruit set, diphenyl amine for reducing fruit scald on apples stored in controlled atmosphere storage, certain of the chemicals for prevention of post-harvest rots in citrus, chloro IPC for use as a sprout inhibitor on Irish potatoes in storage, and the like. Current programs are underway to seek clearance of 2,4,5-TP for use in established legume stands and with 4(2,4-DB) for legume seedling establishment. These are important areas for growers and industries within the states, but may well be of minor economic concern to the chemical manufacturer in his total volume of business. The costs involved in research of this type often deter industry unless there is reasonable assurance of covering their investment.

Still another area of responsibility for residues of agricultural chemicals is the need for state workers to determine their effect on beneficial insects, for example, the honey bee and other pollinating insects. Many fruit and vegetable crops are increasingly dependent on the honey bee as the one reliable pollinating species. Constant concern is felt by beekeepers for the safety of their bees and, in some instances, that sufficient nectar producing crops of indirect value, as well as cultivated plants, be grown to insure a nectar flow. The parasite complex with many injurious insects is also affected adversely by residues of pesticides in the environment.

Public concern and even furor has resulted from alleged harmful effects of some agricultural chemicals that have been used widely. These problems include drift of the chemical beyond the treated areas, destruction of fish and wildlife, and difficulties for owners who did not want their crops to undergo accidental treatment. Some of the large scale control programs have become beset by these problems. It is increasingly important that State workers participate in public relations to avoid misunderstandings and to inform the public in advance about the nature of some of the programs. Inevitably, State workers are called upon in damage disputes.

Rapid strides in residue research have been made possible because basic research is providing new information on plant physiology, insect physiology, biochemistry, ecology, microbiology and related fields. As we understand more about the mechanism of the processes that go on in living cells, there will be opportunities to utilize knowledge in selective regulation of species populations. Many of us were delighted to see the importance of weed research recognized by the last Congress which provided substantial sums for additional research on almost all aspects of weed control. These new funds will provide the states with support for work in depth in specific areas, as for example with aquatic weeds, weed life cycles, range weeds, fate of residues, ecology, perhaps biological control and the like. Through an exchange of information, cooperative effort will benefit all states interested in the problems.

A broad area of responsibility considered in many of the States and elsewhere, is the effect of pesticide residues on flavor and other quality determining attributes of foods. With an increasing growth in processed foods, the necessity for maintaining uniform high quality in the products is mandatory in a competitive industry. Much work continues to be done in this important area by research scientists in food technology at the state experiment stations. Similarly, the problems reach animal products like meats, eggs, milk, poultry, and the like, both in terms of possible harmful residues as well as effects on flavor and quality. The use of antibiotics for mastitis control in dairy cattle, for example, has had far reaching effects in terms of residues, because they affect marketability of the milk. Fortunately bio-assays have been most helpful in residue determinations for several products that are used in mastitis control programs.

A word of recognition should be given to several of the states in which work has been done on the development of accurate, streamlined analytical methods for pesticides. One of the great break-throughs of recent months has been the use of gas chromotography for certain residue determinations. The speed of the method, plus its extreme precision, will provide research workers in the residue field with a much better understanding of residue levels of certain types of chemicals in or on commodities than was ever possible by other methods. A number of the systemic pesticides have yielded to the use of radioactive tracer research techniques in determining the metabolic products as well as the mode of action. Still other fields of residue research have benefited from bio-assay techniques, using both plants and animals as indicator mechanisms.

EXTENSION IN OUR STATE COLLEGES AND UNIVERSITIES.

The Cooperative Extension Service of the Land Grant institutions has been a great force in quickly dispensing available information on the use of agricultural chemicals for specific problems and conditions to farmers and homeowners. The magnificent benefits received from their use, as well as the safety record with their use, attest to this point. The extension worker, whether a herbicide specialist, entomologist, plant pathologist or plant physiologist, selects from the information that research has available and recommends the products that have met with the regulatory procedures for safe use. Based upon his own judgement from field trials as well as grower use, industry experience, and the like, he makes his recommendations to suit his particular geographical areas and problems. This is a great responsibility, but is one that is being met by capable workers throughout the country.

In addition to a review of field and laboratory research in progress with cooperators of industry, government, and adjoining states, the extension man must set the stage for product recommendation and use within his areas of responsibility, and coordinate the information to minimize confusion. In addition, he calls attention to failures in field performance, new problems, and similar voids in our information that offer a basis for future research. He works closely with the county agricultural agents on programs that meet safety standards and residues tolerances. The extension specialist from the State colleges and universities has a great responsibility, and his recommendations must be based on reliable research that is correctly interpreted, and is supported by industry in terms of available products. He is the man on the

SUMMARY.

Because the topic of this paper is the role of the State in residue determinations and clearances, it calls for emphasis on the work of the state scientists, but recognition must be given to the fact that they are but one important part of a cooperative team including industry and government working for development and safe use of agricultural chemicals.

The Land Grant College movement in the United States has provided this nation with an educational resource in support of modern agriculture that is second to none in the world. The three major functions of these institutions in their service to the people of this country are teaching, research and extension. One major contribution of the teaching programs to the important field of agricultural chemicals is the output of trained men and women who go to other agencies for their productive careers. As knowledge and support expand, our universities are expanding their graduate programs rapidly. Great emphasis is now being placed on many areas of basic research.

Regulatory activities with agricultural chemicals and food additives are usually a separate function in state government, and not a part of the teaching, research and educational program of the Land Grant institutions. However, close liaison is essential between them for effective programs. Further, state regulatory programs are obviously essential in coordinating the intra-state activities with uniform inter-state regulations of the FDA and USDA.

Research conducted by the state experiment station is traditional and essential in the agricultural chemical field. It is recognized that cooperation with industry and the federal laboratories is an integral part of the program. The states, almost without exception, depend upon industry for the development and selection of new chemicals as well as producing and marketing them. The States work with their performance, mode of action, safety when used as directed, determination of residues that may be present, schedules of application, and in many other important areas basic to their ultimate use.

Concerning residues specifically, many states have developed their own research laboratories for residue research as an important part of their agricultural chemical program. Much of the research is made available directly to the industry that supplies chemical formulation to the State for research and appraisal. In turn, residue data as well as performance data are given to industry for support of their registration and tolerance petitions.

In instances of minor crops where the volume of use may be small, and with chemicals not covered by patents of an individual company, the state experiment stations have assumed responsibility for the development of performance and residue data, and even helped arrange for toxicity studies before applying for tolerances, registrations for specific uses, or both. State scientists also are focusing attention on schedules or uses that must be considered where products are to meet export requirements.

State research workers are expanding fundamental research in biochemistry, physiology and fields allied to growth and development of living organisms. These data help materially in understanding the metabolims of chemicals in living systems, or their accumulation in soils and the like. Methodology of

State workers have to consider residues in relation to natural populations where increased public concern is voiced about widespread use of chemicals in the environment.

The extension specialist coordinates information for recommendations that will assure safe use of agricultural chemicals and avoid excessive residues. His contribution is a most important link in the chain of cooperation; his program extends to the county agricultural agents, and often directly to individual users of the pesticide. He plays a major part in the public relations aspects of the use of pesticides.

The role of the state university and its experiment station, in work concerned with agricultural chemical residues, will increase in importance, because more and more, modern agriculture, suburban living and community development projects utilize the broad array of modern agricultural chemicals to secure their many benefits. The Land Grant institutions must remain in the forefront of teaching, research and extension to provide better educational programs in the development and safe use of modern agricultural chemicals.

SOME CHARACTERISTICS OF QUACKGRASS AND THEIR RELATION TO CONTROL 1/

K. P. Buchholtz 2/

Quackgrass is a widely distributed and persistent weed in the northern states and Canada. It has proved to be adapted to cool, temperate regions and is favored by humid or sub-humid climates. The weed is most troublesome in areas that are subjected to periodic, but not continuous tillage. It competes strongly with forage crops, grains, corn and other row crops, fruits, and vegetables. It is objectionable in forestry plantations, lawns, and industrial sites.

In order to develop effective control programs for quackgrass it is necessary to consider the factors that account for its adaptation in the northern states and the reasons for its persistence. Quackgrass spreads by both rhizomes and seeds. It is probable that spread by seeds is more widespread than is generally realized. Because of similarity in shape the seed is more common in oats than in seed of other cereals. In 1957 a study in Wisconsin showed that 35% of 799 oat samples handled by the State Seed Testing Laboratory in that year contained quackgrass seeds. Seeder box surveys of oats being seeded have consistently shown that from 50% to 60% of the grain being used as seed in Wisconsin is infested with quackgrass seed. Viability of quackgrass seed in seed grain was frequently as high as that of the oats. In addition to the spread in seed grain the mature seeds of quackgrass are frequently harvested with hay and ultimately find their way back to the field in manure or bedding. Seeds also mature in pastures where they shatter readily and infest the soil. The prevalence and viability of quackgrass seeds often allows reinfestation after all established plants have been eradicated.

The ability of quackgrass to spread by rhizomes is widely recognized. These spreading underground stems may extend as much as 3 or 4 feet in a single year. Tillage often extends the area of infestation much farther than this by dragging fragments of the rhizomes beyond the area of initial infestation. Rhizome production is prolific in a productive soil. Meyer (9), Schirman and Buchholtz (14) and Johnson (4) all found as much as 6000 lb/A of dry rhizomes in heavily infested areas. This mass of rhizomes was contained in the plow slice and in an undisturbed sod was concentrated in the upper 4 inches of soil.

The life of a particular rhizome is not as long as would be expected. Sagar (13) mentioned that the rhizomes may live for 3 years in England, but seldom longer. Johnson and Buchholtz (6) found no evidence that the rhizomes lived more than 2 years under more rigorous conditions in Wisconsin and a large proportion of them lived no longer than 1 year. The fact that the rhizomes are relatively short-lived is a vulnerable point in the life cycle of the weed. If new rhizome growth could be limited or eliminated for 1 year, the persistence of the weed would be sharply reduced.

1/ Published with the approval of the Director of the Wisconsin Agricultural Experiment Station as a collaborator under North Central Regional Coop-

The vigorous regrowth of quackgrass is related to the large number of dormant buds that are present on the rhizomes in an infested area. Weight of dry quackgrass rhizomes averages about 0.4 gm per foot. If an area contains 5000 lb of the dry rhizomes per acre, this is equal to about 130 feet of rhizome per sq ft. The nodes on rhizomes average no more than 1 inch apart. Therefore, it is safe to assume that in excess of 1500 buds exist on the rhizomes in each sq ft of infested soil. Quackgrass stands seldom exceed 150 shoots per sq ft. From this it is apparent that 90 percent or more of the buds on the rhizomes remain inactive until circumstances are favorable for their development. This reservoir of dormant buds is a major hazard, for whenever a stand of shoots is destroyed, some of the dormant buds will be activated and will very soon reestablish the plant.

The rhizomes of quackgrass contain a number of carbohydrates of which triticin is probably present in greatest concentration. Total available carbohydrates vary from about 30 to 50% of the dry rhizome weight according to Pinckney (12), Schirman and Buchholtz (14) and LeBaron and Fertig (7). If one assumes an average concentration of available carbohydrates of 40% and a total dry matter content of 5000 lb/A, it appears that a reserve of 2000 lb/A of readily available carbohydrates is stored in the rhizomes. Such a large reserve, along with the abundant supply of inactive buds, is ample reason why the growth of quackgrass is vigorous and why the regrowth occurs with such persistence.

The trends in total carbohydrate reserves during the year in quackgrass do not show the fluctuations that are found in many herbaceous plants. The work of Pinckney (12) and Schirman and Buchholtz (14) shows that only minor variations in reserve level occur during the year. LeBaron and Fertig (7) found a substantial reduction in fructose content of the rhizomes during the winter, but their data are not fully comparable to the others cited, for it is based only on the content of fructose found in the tissue. Since there appears to be no marked depression in total carbohydrate level during the season, there is no most favorable time at which control measures directed at reducing the carbohydrate content may be initiated.

Stoa, et al. (15) was one of the first to comment that the carbohydrate reserves of quackgrass could be reduced by continual and consistent defoliation. Dexter (2) showed that organic reserves were reduced more readily after fertilization with nitrogen. Defoliation by some tillage operation is no doubt effective, but it is inconvenient and requires the major portion of a season to produce the desired results. Alternative methods involving use of herbicides now appear more promising.

Buchholtz (1), Meggitt (8) and Fertig (3) have all reported on the superior control of quackgrass obtained with atrazine and other triazine herbicides. According to Schirman and Buchholtz (14) and LeBaron and Fertig (7) control results from the drastic reduction in carbohydrate reserves in the rhizomes following the treatment. It appears that respiratory activity is maintained at a high level after treatment even though photosynthesis is interrupted. The result is a faster rate of depletion than can be accomplished by consistent defoliation or any other known method. Depletion appears to proceed more rapidly when the top growth of the quackgrass is allowed to remain intact for a month or more following treatment than when it is removed. This is reasonable for the presence of the top growth increases the total respiratory activity of the plant.

containing fertilizer were applied to the treated area. The application of nitrogen stimulated the foliar growth of the grass and tended to increase the number of shoots produced. Both of these responses accelerated the rate of carbohydrate depletion. The quackgrass plants responded to applications of atrazine as low as 0.5 lb/A, but the effect was transitory, probably because of a short period of residue in the soil. Under conditions favorable for growth an appreciable residue of atrazine was needed in the soil for about 2 months in order to fully deplete the carbohydrates in the rhizomes. This was generally accomplished with applications of 4 lb/A of atrazine and occasionally at the 2 lb/A rate when tillage was used to retard regrowth after a period of depletion.

LeBaron and Fertig (7) also showed that amitrol reduced fructose concentrations in rhizomes of treated plants. The reduction was not as drastic as when atrazine was applied and the plants often made some recovery after several months. There is good evidence that one of the actions of amitrol is reduction in photosynthetic activity. However, the chlorotic response apparently does not always persist long enough to deplete carbohydrates to the lethal point. The amitrol in the tissue is bound or metabolized so that eventually it is not present in sufficient concentration to produce chlorosis. When physiologically active concentrations of amitrol are lost before carbohydrates are fully depleted, the plant recovers.

Since the rhizomes in an infested area are abundant, the carbohydrate reserves normally at a high level, and the dormant buds very numerous, it appeared profitable to determine the factors that influence the activity of these buds. If a means could be devised for increasing the activity of buds on the rhizomes, foliar treatments for the control of quackgrass would be more successful for a greater leaf area would be present at time of treatment. Increased numbers of shoots would also allow for more rapid depletion of the carbohydrate reserves than would otherwise be the case. As an alternative, if the buds could be treated so that they would remain dormant indefinitely, control measures might be devised more readily for the weed would become much less competitive and a large portion of the rhizomes would probably die from natural causes within a year. Consequently, a series of studies were designed to determine more fully the nature of vegetative bud dormancy in quackgrass.

In order to study the activity of the vegetative buds of quackgrass Johnson and Buchholtz (5) developed a method of culturing single-node sections of quackgrass rhizomes in flasks using agar medium. No nutrient was required in the medium for the short period of incubation needed to demonstrate bud activity. The use of the technique allowed studies on influence of environmental factors, specific nutrients and chemicals on the activity of the buds on the rhizomes.

In order to determine the influence of temperature Meyer and Buchholtz (10) maintained cultures at different temperatures. They found that the optimum range for bud activity and shoot growth was from 15 to 25 C. Temperatures above 30 C reduced bud activity sharply. Temperatures of 5 C or below provided very little bud development, but growth occurred promptly when the temperatures were raised. The sensitivity of quackgrass to higher temperatures may account, in part, for its geographical distribution. The weed is most prevalent in the northern states and is not considered a problem genduring the summer is lower and the quackgrass is therefore able to develop more aggressively. In areas where the soils are warm for extended periods during the summer the quackgrass is inactive for long periods. This reduces the reserve of carbohydrates, reduces the vigor of the weed and makes it less competitive. Unfavorably high temperatures may then be considered as one cause of bud dormancy or inactivity.

Another factor of the environment that might influence the activity of quackgrass buds is concentration of CO_2 and O_2 in the soil. A series of trials by Meyer (9) failed to show that these factors were critical. The activity of quackgrass buds can be reduced by high concentration of CO_2, but the concentrations required are substantially higher than those commonly encountered in soil. It appears that 10% or more will be required to reduce bud activity appreciably. This is the extreme limit of CO_2 encountered in soils that are not water logged.

Bud activity was reduced approximately 25% when O_2 was reduced to 15%. Again this does not appear critical for O_2 concentrations of less than 15% are seldom encountered in soils that are not waterlogged. The data support the belief that unfavorable CO_2 and O_2 concentrations in the soil seldom, if ever, are involved in prolonged inactivity of the vegetative buds in the soil.

The buds of quackgrass show a marked seasonal trend in activity. Johnson (4) found that the buds on rhizomes obtained from the field in the early spring were active when assayed in culture. This activity was rapidly reduced and by late May the activity had reached a level of from 0 to 10%. In June recovery in activity gradually returned and by early fall relatively high activity was observed again. This seasonal trend appeared in all stands of quackgrass, but was most prevalent in old, well-established infestations.

The seasonal dormancy is presumably related to the level of nitrogen in the rhizome tissue. An analysis of rhizome tissue collected at intervals during the year showed that the lowest concentrations of nitrogen were reached at the precise time when bud activity was lowest. It appears that the quackgrass plant depletes the rhizome of nitrogen during the period of spring flush growth. The depletion is so extreme that little or no bud activity or new shoot growth is possible until the carbon-nitrogen ratio in the rhizomes has been raised later in the season.

This supposition is supported by the high degree of bud activity which resulted when rhizome sections, with presumably inactive buds, were grown in agar or soil containing available nitrogen. Compost soil or leachate from compost soil stimulated the activity of buds that had made no growth in plain agar. In a similar manner ammonium nitrate, ammonium phosphate, ammonium sulfate, potassium nitrate and calcium nitrate at concentrations of $2 \times 10^{-2}M$ all gave high bud activity. Amino acids such as glutamic, aspartic, alinine, cycteine and serine were also effective, but tryptophan, phenylanine, tyrosine and glutathione were not. It is apparent that a readily available source of nitrogen in nitrate, ammonia or amino groups is necessary for full bud activity.

Meyer (9) showed that the seasonal trends in bud activity could be

June. Applications of 300 lb/A over five dates during the growing season gave somewhat greater activity late in the season, but did not fully overcome the dormancy noted during the early summer months. The second form of dormancy is therefore related to an extremely high carbon-nitrogen ratio in the rhizome tissue.

A third form of dormancy was shown by Meyer (9) to arise from apical dominance. The inhibiting effect was most pronounced when a shoot was present, but this form of dormancy could be demonstrated on rhizomes sections even when the shoot was removed. The buds on nodes distal from the tip end showed the least activity. The fact that all buds possess the same degree of activity inherently was demonstrated by cutting the rhizome into single node sections. When this was done, the buds from the various locations on the rhizome showed equal activity and made equal shoot growth.

While it can be demonstrated that apical dominance exists in quackgrass, it was found this did not account for all of the bud dormancy noted in the field. Meyer (9) removed the shoot growth from a heavily infested sod of quackgrass. The area was then cut into blocks 2 inches square with a sharp spade to a depth of about 5 inches. Ample fertilization was used to supply any nitrogen deficiency. The number of shoots produced on this area was about 20% greater than the number obtained on the area where the rhizomes had not been cut with a spade. It appeared that 70% or more of the buds on rhizomes in the cut area remained non-active even though the rhizome fragments were mostly only two nodes in length. The results suggest that an additional form of dormancy existed in the area observed for the inactivity of the buds could not be accounted for by unfavorable temperature, nitrogen deficiency or apical dominance.

The nature of growth substances involved in apical dominance has been a matter of considerable speculation. Repeated attempts have been made to obtain a bud response with various applications of indole acetic acid (IAA). All results have been negative when IAA was applied at physiological concentrations of 1×10^{-2}M or less. Therefore, it appears that some derivative of IAA is involved or that the apical dominance effect is due to some other growth substance. Mudd et al. (11) were able to show the presence of IAA oxidase in quackgrass rhizomes, but this was not regarded as conclusive evidence that IAA is involved in bud dormancy or apical dominance.

Applications of triiodobenzoic acid (TIBA) applied to leaves of quackgrass appreciably increased the activity of buds on the rhizomes. TIBA applications to the rhizomes of quackgrass also increased the activity of buds and stimulated more to grow than would normally be the case. This suggests that the growth substance present possesses a polar transport mechanism.

Naphthalene acetic acid (NAA) when applied at 1×10^{-2} M consistently reduced bud activity. This response may not be of great significance for herbicides such as 2,4-D, MCPA, 2,4,5-T, IPC and fenac also reduced or eliminated bud activity at similar concentrations when mixed with agar cultures.

Rhizomes treated with dalapon, TCA, 2,2,3-trichloropionic acid and 2, 3-dichloroisobutyric acid exhibited about the same level of bud activity as untreated rhizomes. However, the growth of shoots that followed was much dormancy is often cited as the mechanism involved. A more exact evaluation of the response after treatment with the chlorinated aliphatic acids is that bud activity is in fact maintained, but that the shoot growth is sharply reduced.

The destruction of shoot growth after treatment with dalapon interrupts photosynthetic activity and some reduction in carbohydrate occurs, but at a rate much slower than in the case of plants treated with atrazine or amitrol because the respiratory activity is lower. The residue of dalapon in the soil and in the tissue is dissipated rather quickly and after a period of several months partial regrowth may occur. This regrowth develops from buds that have remained inactive while the dalapon was present. Shoots that do develop are apt to grow vigorously because of the relatively high carbohydrate reserve that has been maintained in the rhizome.

The bud response following treatment with MH is somewhat similar to that observed with dalapon. Zick (16) and Meyer (9) both found that bud activity was not altered materially, but that the shoot growth was greatly reduced. Maximum responses occur only under conditions that favor absorption of the chemical. Applications of MH do not destroy the foliage so carbohydrates continue to accumulate. The maintenance of the shoots also serves to maintain a considerable degree of apical dominance. Eventually inactive buds on the rhizome are released and when this occurs, regrowth is abundant and vigorous.

SUMMARY

1. Quackgrass is a widely distributed and persistent weed in the northern states and in Canada. The plant spreads rapidly by both seeds and rhizome fragments. The rhizomes are abundant in the surface soil and normally maintain a total available carbohydrate content of 40% or more during the year. This, along with an abundant supply of inactive buds on the rhizomes, assures vigorous and persistent regrowth after defoliation.

2. Quackgrass plants treated with atrazine show marked reductions in the total available carbohydrates in the rhizomes. The speed of carbohydrate reduction is accelerated by maintaining shoot growth on treated plants and by adding nitrogen when a deficiency of this element occurs. A major response of quackgrass to amitrol also involves the depletion of carbohydrate in the rhizomes. Amitrol may not persist in the active form in the tissue long enough to deplete the reserves to the lethal point.

3. The activity of vegetative buds on quackgrass rhizomes is reduced or limited by (1) temperatures above 25 C, (2) wide carbon-nitrogen ratios in the rhizome tissue during late spring, and (3) apical dominance of shoots or terminal buds.

4. The growth substances in quackgrass may be some material other than IAA for this compound had no detectable effect on the activity of vegetative buds. TIBA modified polar transport of bud inhibiting factors while NAA and various herbicides inhibited or eliminated bud activity.

5. Dalapon and other chlorinated organic acids, as well as MH, reduced shoot growth of quackgrass drastically, but did not materially reduce bud

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PROMISING NEW CHEMICALS FOR WEED CONTROL

Walter A. Gentner [1]

INTRODUCTION:

The search for and development of promising new chemicals for weed control has continued rapidly. So too has the search for new uses for old herbicides. Treatment method and time, the addition of adjuvants, and the "correct" formulation have found their place in the field of herbicide research and practice. The extended use of new herbicidal chemicals is hardly possible without knowledge and utilization of the above factors.

Physical and chemical combinations of herbicides or herbicides and adjuvants, which are being intensively studied, appear promising as a means of increasing herbicidal activities or extending the selective properties for weed control.

Equipment is being developed and modified to assure proper placement and to take advantage of the physical properties afforded by herbicides formulated on granular materials.

Several chemical families new to weed control have been introduced and appear promising as herbicides in various situations. Only time and use will prove the worth of new herbicides.

NEW CHEMICALS WITH PROMISING USES:

Arylamines - Eli Lilly and Company

Dipropalin (N,N-di-(n-propyl)-2,6-dinitro-4-methylanaline) was tolerated without visible injury by a large number of field and horticultural crops when used as a pre-emergence treatment. Weed control was good to excellent. As with many herbicides it appears that more chemical is required on heavier soils. Field crops which tolerated 6-8 lb/A of this compound were alfalfa, field corn, cotton, flax, peanuts, safflower, soybeans, Sudangrass, and sugar beets. Satisfactory weed control was achieved in the 4-8 lb/A range.

Horticultural crops which tolerated 6-8 lb/A were broccoli, cabbage, cauliflower, collards, endive, field cress, hanover salad, kale, mustard greens, and parsley. Satisfactory control of pigweed, ryegrass, carpetweed, crabgrass, and lambsquarters were achieved by 4 lb/A or less. Soil incorporation did not significantly influence the activity of dipropalin.

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Trifloralin (N,N-di-(n-propyl)-2,6-dinitro-4-trifluoromethylanaline) appears particularly promising in a number of field and horticultural crops as a pre-emergence treatment. Field corn, cotton, flax, peanuts, and safflower tolerated 6 lb/A or more of this herbicide without visible signs of injury, whereas annual broadleaved and grassy weeds were eradicated or controlled at rates of 4 lb/A or less.

Broccoli, cabbage, cauliflower, collards, field cress, hanover salad, kale, lima beans, mustard greens, parsley, peas, snapbeans, sweet corn, and turnips tolerated 8 lb/A of trifloralin applied pre-emergence. Pigweed, ryegrass, carpetweed, crabgrass, and lambsquarters were eradicated on light soil with 1 lb/A or less. Soil incorporation of this herbicide enhances its herbicidal activity. Application of trifloralin as a directed spray or on a granular carrier after clean cultivation at lay-by appears promising.

This compound has done a good job controlling crabgrass in turf. Damage to turf has been reported where high rates of application were used.

Bayer 40557 - Vero Beach Laboratories, Inc.
(research for Farbenfabriken Bayer)

This herbicide appears promising for the pre-emergence control of annual broadleaved and grassy weeds in a wide variety of crops. Buckwheat, cotton, cowpeas, flax, peas, and snapbeans appear to have good tolerance to 4 lb/A whereas corn, lima beans, peanuts, safflower, and soybeans tolerated as much as 8 lb/A. Weed control was excellent. Bayer 40557 may find use as a directed spray or in granular form after clean cultivation at lay-by.

Several grass crops and grassy weeds appear very tolerant to post-emergence applications of 4-8 lb/A.

Diphenamid - Eli Lilly and Company and Upjohn Company

Diphenamid (N,N-dimethyl-α,α-diphenylacetamide) as a pre-emergence treatment shows promise in a number of weed-crop situations and is apparently less active on heavy soils than on light soils; its activity is enhanced by soil incorporation. On heavy soils the following crops tolerated 6-8 lb/A without visible damage: alfalfa, cabbage, field and sweet corn, cotton, flax, lima beans, peanuts, peas, safflower, snapbeans, soybeans, squash, Sudangrass, sugar beets, tomatoes, and turnips. Pigweed and ryegrass were eradicated at 1 lb/A and 4 lb/A, respectively.

On light sandy soils broccoli, cabbage, cauliflower, hanover salad, kale, mustard greens, parsley, and turnips tolerated 2-3 lb/A of diphenamid as a pre-emergence treatment, and 1/4-1 lb/A completely controlled pigweed, ryegrass, carpetweed, and crabgrass. Diphenamid has reportedly looked good as a pre-emergence or post-transplanting treatment in tomatoes and peppers at 3-5 lb/A, and 5 lb/A has looked good as a post-transplanting treatment in annual flowers. Almost full-season control of weeds in strawberries has been reported by treatments with 2-1/2-10 lb/A applied just after setting.

Some damage to runners resulted from the high application rate. Post-emergence treatments with 5 lb/A gave good control of weeds in cucumbers, cantaloupes, watermelons, and squash. Post-emergence treatments at lay-by after clean cultivation would seem promising. This herbicide appears to remain herbicidally active in the soil for extended periods, a characteristic which should be noted.

Du Pont 326 - E. I. du Pont de Nemours Company

The pre-emergence or directed post-emergence application of Du Pont 326 (3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea) gave good weed control in a number of field and horticultural crops.

Field corn, oats, safflower, soybeans, and Sudangrass tolerated 1-2 lb/A as a pre-emergence spray whereas most broadleaved and grassy annual weeds were controlled by application of 1/2 lb/A. This herbicide also looks promising for the pre-emergence control of annual weeds in sweet corn and carrots.

As a directed post-emergence spray, Du Pont 326 reportedly looks good for weed control in corn and cotton at rates of 3/4-3 lb/A. Some contact injury to the lower leaves of corn has been reported but this was short-lived.

HPC 7531 - Hercules Powder Company

Limited trials show that the HPC 7531 is extremely active at 4 lb/A on most crops and weeds as a pre- or post-emergence treatment. Peas, sorghum, and Sudangrass show limited tolerance to pre-emergence treatments. When used as a post-emergence treatment, 4-8 lb/A of HPC 7531 acted as a soil sterilant.

HS-55 - Badische Analin and Soda Fabrik Ag.

HS-55 is a combination of n-cyclooctyl dimethylurea and butynyl N-(3-chlorophenyl)carbamate. As a pre-emergence spray at a rate of 4 lb/A or less HS-55 may be useful for the control of a number of annual weeds in corn, lima beans, and sugar beets. At application rates of 8 lb/A or more HS-55 acts as a soil sterilant.

NFM 5778 and NFM 2995 - Niagara Chemical Division, FMC

Pre-emergence applications of NFM 5778 (4,6-dinitro-2-sec-butylphenol acetate) at rates of 6-8 lb/A are promising for control of annual broadleaved and grassy weeds in field and sweet corn, cotton, peanuts, peas, snapbeans, and soybeans. Few crops show tolerance to over-all post-emergence treatments.

Pre-emergence applications of NFM 2995 (methyl N-(3,4-dichlorophenyl)-carbamate) appear promising for weed control in field corn, cotton, peanuts, soybeans, Sudangrass, sweet corn, lima beans, and snapbeans. These crops tolerated 3 lb/A without visible injury. Annual broadleaved and grassy weeds were controlled by 1 lb/A or less. An over-all post-emergence spray caused some damage to test crops. Granular or directed post-emergence treatments at lay-by may hold promise.

Thiolcarbamates - Stauffer Chemical Company

The thiolcarbamates continue to be promising as excellent herbicides in a number of weed-crop situations. The high activity of several of these compounds as pre-emergence treatments and the low activity as post-emergence treatments add to the versatility of possible uses. Soil-incorporation and formulation studies are continuing rapidly.

R-1607 (propyl di-n-propylthiolcarbamate) and R-1870 (ethyl-di-n-butylthiolcarbamate) appear particularly promising in a series of vegetable, leaf, salad, and cole crops as pre-planting soil-incorporation or pre-emergence treatments. R-1607 is reportedly very promising in soybeans as a pre-emergence treatment, with the granular formulation superior to the emulsifiable concentrate spray formulation.

The 6 lb/A rate of R-2061 (propyl ethyl-n-butylthiolcarbamate) looks good as a post-transplant treatment in tomatoes, peppers, and strawberries at 6 lb/A. The period of control is often extended by soil incorporation.

CELL STRUCTURE AND PLANT GROWTH HORMONE ACTION

Arthur W. Galston[1]

The chemical control of plant growth is largely an empirical art which has only occasionally approached the level of a predictable science. This empiricism is largely a consequence of our imperfect understanding of the nature of the action of growth regulatory chemicals such as the auxins and gibberellins. It is a constant source of embarrassment to plant physiologists and biochemists that roughly 35 years after the discovery of auxins we are still completely unable to describe their mode of action in plant cells. Lest we become too humble and embarrassed about this state of affairs, it is well to recall that nowhere in biochemistry or physiology is there complete understanding of the mode of action of any hormone; even such well known systems as insulin have not been definitely pin-pointed biochemically. This has caused some people to wonder whether if, in investigating the mechanism of hormone action, we have not been barking up the wrong tree. All of us have been looking for chemical effects, and in order to explain the very great efficacy of very few molecules of the hormone, we have tended to assume that the hormone either becomes part of an enzyme system or controls the action of an enzyme system. Only in this way, it has been believed, can we get the proper amplification to permit relatively large biological effects to be produced by a small number of molecules. Nonetheless, this line of reasoning has been most unrewarding in the past and in fact we still know of no hormone whose action can be completely explained with reference to any particular enzyme system.

Perhaps a part of the reason for our ignorance of the mode of action of hormones lies in the fact that we are only now beginning to understand the structure of the very complex machine which we call the living cell. Just as one could not hope to understand the functioning of an automobile engine without knowing in detail the structure of its component parts, so the student of any aspect of cell physiology cannot hope to be able to supply definitive answers without an intimate knowledge of the structure of the cell and of its component parts. In recent years a revolution in our understanding of cell structure has resulted from the systematic application of electron microscopy and ultra-thin sectioning to the study of various cell types. Because I believe that this new information is basic to any discussion of cell physiology and of auxin action, I shall preface my remarks with a brief description of our modern view of the plant cell. In so doing, I would like to remind you that while the ordinary light microscope is able to give us magnifications in the range of 1,000 diameters with a resolution down to 0.2 microns, the electron microscope has already given us clear pictures at 150,000 diameters magnification with a resolution of 0.003 microns. In fact the theoretical limit of resolution, being based on the wave length of the radiation employed, can be improved still further by two orders of magnitude. This clearly brings us down to the range of molecular dimensions. We should therefore expect that within the next several decades, the systematic improvement of electron microscopy and related techniques will permit us to have a fairly detailed view of the

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complex molecular architecture of the cell.

I would like to show you first a picture of a cell in the root tip of maize. This is a transverse section, 175 µ from the apex. The large central body is the nucleus with the darker chromatin areas and numerous pores in the double nuclear membrane. The elongated canals running through the cytoplasm are portions of the endoplasmic reticulum, which represents projections of the nuclear double membrane. The numerous club shaped or rounded bodies with internal projections are the mitochondria with their cristae. The groups of short canals with vesicular ends are Colgi bodies. The lighter stippled-appearing areas in the cytoplasm are the vacuoles. Certainly this is a beautiful and complex machine. It represents a structure to which all physiological data must be referred if, indeed, we are to understand what we are talking about.

In addition to the numerous cytoplasmic structures which we have just seen, the plant cell also possesses a complex cell wall which is physically quite rigid during most of the development of the cell and constrains the protoplast from expanding under the influence of internal turgor pressure. Chemically this cell wall consists of such materials as pectin, polysaccharides of various types (including cellulose), lignins, and proteins. The plant cytologist, using light microscopy, has been able to distinguish a middle lamella which we now believe to be mainly pectin in nature, a primary wall which is primarily cellulosic and a secondary wall which may contain almost anything. This wall structure may be continuous but it is usually perforated by numerous pits and holes and electron microscopy has revealed that cytoplasmic strands and perhaps even branches of the endoplasmic reticulum run from cell to cell through these perforations. Thus, despite its separation into discrete wooden boxes, the living part of the plant body does represent a protoplasmic continuum; there appears to be easy communication between cells by means of their cytoplasmic connections.

In the green cell we have, of course, an additional common organelle, the chloroplast. This is perhaps the most beautifully structured of all of the cell organelles. At maturity, the chloroplast consists of a double membrane within which there are beautifully parallel double layered lamellae which in various places have thickened out to accomodate the chlorophyll-carotenoid-protein complexes which are the seat of the photosynthetic apparatus. These thickened portions of adjacent lamellae constitute the grana and the intervening areas the stroma. In the etiolated plant there is no lamellate system; here instead, the plastids contain a sort of para-crystalline center of canals referred to as the prolamellar body. When such a proplastid is exposed to light, lamellae begin to form, presumably by condensation or a reorientation of the canals of the prolamellar body.

This, then, in brief, is the complex machine we have to work with. Would it not be a reasonable question to ask, when one is confronting the problem of the mode of auxin action, what part of the cell is it which first responds to the auxin? Classically the answer is the cell wall. We have long known, since the beautifully simple and elegant experiments of Heyn, performed as early as 1932, that the administration of auxin to certain types of plant cells results in an increase in the plastic extensibility of the wall. Since, as we have said before, the wall constrains the protoplasmic contents in their growth, a loosening up of wall structure could lead to stretching of the cell under the influence of internal turgor pressure. This is the interpretation usually given to explain the cell extension promoting activity of auxin.

Unfortunately this cannot be the complete answer. We know, for example, that auxin promotes division of many cells in the plant. Many years ago, it became clear that cambial divisions in the spring were initiated by auxin coming from the growing buds above. Tissue cultures of cambial and other cells frequently require an endogenous source of natural or artificial auxin for the continuation of cell division. The initiation of adventitious roots, which involves cell division in the pericycle, is also caused by auxin. Clearly these cell division promoting actions cannot be attributed to the wall. In fact, since one generally thinks of the nucleus as the initiator of the cell division cycle, one is tempted here to regard the nucleus as the intracellular locale of auxin action.

But even this picture is not complete. Almost thirty years ago, Thimann and Sweeney, working with the cells of Avena coleoptiles, showed that the application of auxin to auxin-deficient cells would initiate protoplasmic streaming and that removal of auxin would result in a diminution of protoplasmic streaming. The remarkable aspect of this control is that it can be exerted within several minutes. To what organelle are we to look here? What is it that controls cytoplasmic streaming? In fact we do not know. The closest we can come is to say that cytoplasmic streaming is quite obviously dependent on an energy supply and an external supply of oxygen. Since it is the mitochondrion in which respiratory activity is localized, we are tempted to consider the mitochondrion as the seat of plant hormone action in this instance. Or perhaps we should look to the so-called "structureless cytoplasm."

In fact experiments performed many years ago by Henry Northen showed that the application of auxins to various plant cells resulted in a decrease in the viscosity of the cytoplasm. He deduced this from experiments in which auxin significantly lowered the centrifugal force which was required for the deposition of cellular contents against one wall under the influence of a centrifugal field. This phenomenon could, of course, account for the control of the rate of cytoplasmic streaming since any decrease in viscosity would, under a constant activating force, increase the rate of streaming.

This, then, is our problem. The cell extension promoting activity of auxin would appear to be localized in the wall. The cell division promoting aspects of auxin action would, by inference, appear to be localized in the nucleus and the control of cytoplasmic streaming by auxin could be attributed either to mitochondria or to the "structureless cytoplasm." How indeed can we resolve this problem?

One approach would appear to be by the use of labeled auxins. Since we now have techniques available for homogenizing and differentially centrifuging out the intact organelles of a cell, theoretically at least we could feed a labeled auxin to a plant cell and after spinning out each component of the cell we could count each fraction to see where the radioactivity is localized. I shall return to some experiments on this subject later. This technique is tricky in that the homogenization procedure may, in fact, cause the removal of labeled auxin from a particular organelle or, conversely, may artifactually cause its adsorption on to an organelle to which it is not normally attached.

Perhaps a better technique would be histochemical autoradiography. This technique has been of great utility for the nuclear cytologist, since it has permitted him to localize nucleic acids in the cell with great precision. Unfortunately the plant growth hormone is present in the cell in such low concentrations that this technique cannot be employed. In fact I do not know of any work along these lines which has yielded useful data for the plant physiologist.

I would like now to describe some experiments performed several years ago in collaboration with Dr. Ravindar Kaur and later with Drs. Satish and Nirmala Maheshwari. We decided to attack the problem of the localization of auxin action in the cell by feeding C^{14} carboxyl-labelled 2,4-D to the growing cells of the pea plant and then after homogenization and differential centrifugation of the cell, counting each of the fractions. Since both the fractionation scheme and the basic results have already been published, I will summarize them only briefly here. After the first homogenization we found that the cell walls and unbroken tissue fragments, which deposited at lowest speeds, contained a significant number of counts. These however, were readily removed by regrinding and rewashing. We concluded that, in reality, the wall did not contain firmly bound 2,4-D. Other particulate fractions, such as the chloroplasts, mitochondria and microsomes contained smaller activity, which was very readily removed by gentle washing and recentrifugation. In fact, the results of many such experiments convinced us that the great bulk of the labeled 2,4-D fed to the plant cell does not attach to any particulate fraction but remains in the final centrifugal supernatant fluid after homogenization and centrifugation. This means that it is either in the vacuole or in the clear "structureless" fraction of the cytoplasm.

In order to see whether the 2,4-D localized in this way might possibly be attached to a macromolecule, such as protein, we attempted both dialysis experiments and coagulation of proteins. The dialysis experiments told us that the labelled 2,4-D passed readily out of the bag, although not so rapidly as similar material not in contact with protein. All in all, the data indicated no firm binding of auxin to protein. The precipitation experiments, also, showed some small activity on the coagulated proteins, but whether this occurs *in vivo* or *in vitro* is hard to tell. What interested us most was the finding that auxin markedly depresses the heat coagulability of the proteins in this phase. In fact in certain experiments the coagulability is so altered that there is no protein precipitate at all in the experimental (auxin treated) series, but/the control (auxin free) series a copious precipitate deposits after ten minutes of boiling. Subsequent experiments have revealed that this effect is proportional to the concentration of 2,4-D employed, both in stems, where 2,4-D promotes growth, and in roots, where 2,4-D inhibits growth. The minimal effective concentration appears to be about 10^{-6} molar in both tissues and the effect rises linearly with the logarithm of the concentration employed. There is no evidence of an optimum. Certain of these facts have, of course, compelled us to doubt the physiological significance of this phenomenon, for, as you are aware, a graph relating growth effect to concentration of auxins applied to plant tissues usually shows a sharp optimum concentration, for growth promotion. I believe, however, that this is not a serious stumbling block, for in our laboratory we have obtained evidence that the growth inhibitional phase of auxin action on stems, at least, is quite separable from the growth promotional phase. For example, in experiments with excised pieces of etiolated pea stem, it can readily be shown that when sugar is added to the medium there is an auxin optimum, but when sugar is omitted from the medium there is no auxin optimum. Regarding the lack of differential effect on root and stem in our protein test system as contrasted with differential effects of auxin on root and short in vivo, we need only remark that there is good evidence to believe that the basic action of auxin in all tissues is fundamentally the same. Whether one achieves growth promotion or growth inhibition as a result of auxin application is probably the result of secondary reactions of various types in the different tissues. At any rate, we do not believe, at the moment, that we need to relegate the results we have found to the limbo of the physiologically meaningless.

What evidence do we have that the phenomena we have discovered are in fact biologically meaningful? In the first place, the effect appears to be elicited only by those types of molecules which show auxin activity. For example 2,4-D and indoleacetic acid are most active, phenylacetic acid and 2-3-5-triiodobenzoic acid are moderately active, and the antiauxin p-chlorophenoxyisobutyric acid is completely inactive. Secondly, only those cells of both etiolated and green pea plants which are capable of responding to auxin from a growth point of view show the altered coagulability pattern of proteins. Thirdly, kinetic studies have convinced us that altered heat coagulability may manifest itself as soon as two hours after application of auxin, although the usual time lag is four hours. Since we can first detect growth differences between control and treated tissues in about one hour or so we are at least close to the range in which our effect must operate to be of significance in the control of growth. Fourthly, gibberellin, which produces no marked effect on the growth of excised pea stem tissue, is also without effect on alteration of the heat coagulability of proteins, though it does appear to synergize slightly with auxin, as it does in growth itself.

On the chemical side we have also done certain experiments to try to understand the nature of changes wrought in the proteins. The first question would appear to be this: Is it protein itself which is changed by auxin treatment or can we possibly be altering something else in the tissue which results in an altered stability of the proteins toward heat? The first thing to remark here is that the altered coagulability persists after prolonged dialysis against both EDTA and water. Therefore, whatever is being changed is a macromolecule. The precipitate itself is more than 90% protein but does contain some nucleic acid, some pectin type substances and small quantities of lipid. While we have found that the addition of commercial citrus pectin will, in fact, alter the heat coagulability of pea proteins, the quantities which we have had to add to produce this effect are so large as to be physiologically unimportant in our experiments. The crucial test of the hypothesis that pectins are altering the heat coagulability of proteins would be to isolate the pectins from peas, add them to the proteins and examine the effect of physiological quantities of these materials on the heat coagulability patterns. We are currently performing such experiments.

We have also found that the auxin-induced reaction can be inhibited very markedly by ethionine at about 10^{-3} M. Another inhibitor which seems to work fairly well is p-fluorophenyalanine. Since both those substances are amino acid antagonists (for tyrosine and methionine respectively) we infer that protein synthesis may be involved in this auxin-induced reaction. This is a highly tentative conclusion which must be examined further, especially in view of the fact that ethionine is also a competitor with methionine for methyl group transfer reactions which may involve the pectins. Other general inhibitors which have been found effective are 2-4-dinitrophenol, at about 10^{-4} molar, iodoacetic acid at about 10^{-4} molar and potassium cyanide at about 10^{-3} molar. The reaction also fails to occur in an atmosphere devoid of oxygen.

We have also attempted to obtain evidence for or against the formation of a of a new protein under the influence of auxin by subjecting the partially purified soluble supernatant protein to electrophoresis both on paper and on starch. Our results to date show that approximately four major peaks are present in the electrophoretic patterns of the proteins, at pH 8.6 with veronal buffer. These seem to be altered quantitatively as a result of auxin application, and one new small peak arises as the result of auxin application. The interpretation of these results is somewhat uncertain and must await further work. Our tentative conclusion is, however, that auxin treatment has somehow altered the protein spectrum of the cell, and that such alteration may lead to some or all of the growth effects noted as a result of auxin application.

References

A) Some of the data for the conclusions cited above are found in:

1) Galston, A.W. and Kaur, R. An effect of auxins on the heat coagulability of the proteins of growing plant cells. Proc. Natl. Acad. Sci. (U.S.). 45, 1587-1590, 1959.

2) ______ and ______. The intracellular locale of auxin action: An effect of auxin on the physical state of cytoplasmic proteins. in. Plant Growth Regulation, Proceedings of the IVth Intl. Conference. 355-362. Iowa State College Press, Ames, Iowa. 1961.

B) A general review of the subject is found in:

3) Galston, A.W. and Purves, W.K. The mechanism of action of auxin. Ann. Rev. Pl. Physiol. 11, 239-276. (1960)

C) **An article summarizing the new biological and chemical data will shortly be submitted to the American Journal of Botany.**

THE USE OF HERBICIDES IN FOREST MANAGEMENT

William F. Murison[1]

I am going to make it my business today to throw confusion in your path. I do this not from any feeling of malice towards you or from an inborn pessimism which has as its goal the negation of all constructive thought. Rather my hope is that what I have to say will sharpen your notions about the resource we foresters work with and heighten your appreciation of the problems that confront us.

One of our biggest problems at the moment is deciding what is a weed. Ironic as it may seem, this is actually the case in many parts of the region. Our forests on the Atlantic seaboard are extremely complex biologically. We have many tree species that reach merchantable size and many that have a present or potential use in terms of the wood that they yield. Then too there are wide regional differences among the forests of the Northeast -- from the boreal forests of northern Maine to the pine barrens of New Jersey. Each vegetational region can lay claim to a number of species that are commercially desirable or soon will become so. In one forest with which I am familiar, there are upwards of 20 species that reach tree size. At the moment, one is about as good as the other in terms of the financial returns we can hope to gain by selling them, and I for one would be reluctant to call any of them weeds.

One cannot escape the fact that the Northeast is a forested country. The rural landscape is a forested one and this becomes particularly evident as one travels the hill country to the north of here. Woods we have lots of. And as the miles roll by and the forested landscape unrolls before your eyes, the realization comes to you that this is a wild crop over which man exerts only minor control. Much of it, like Topsy, just grows. The degree of stocking, the species composition and the distribution of age classes is none of our doing; the events that shaped the forests of today are now history and it is sobering to discover that many of the changes that brought about their present condition were similarly beyond our control.

As if the wide extent and the biological complexity of the resource were not enough to deal with, we are sooner or later brought face to face with the ownership pattern that underlies this resource. It too is complex in the extreme. Land ownerships in the region are characteristically small and the land is owned and taxes paid on it by people who have a whole arsenal of reasons for wanting to do so. Even if it were physically possible, let alone financially desirable, to manage these forests intensively over wide areas, management prescriptions would falter and fail in the face of such an ownership pattern. Both socially and economically, then, our control of the resource, crude as it may be, is further constrained and we are reduced to the role of consultants who, by our powers of persuasion, hope to influence others to do what we think to be the right thing in the right place at the right time.

This narrative of ineptitude must be temporarily halted at this point to allow me to draw your attention to the forester's peculiar burden, time. Without appearing to be pedantic, I would like to emphasize that it takes a long time to grow a tree. Commercial hardwoods of sawlog size take upwards of 80 years to reach maturity, while our fastest growing conifers need 35 or 40 years before they become saleable. Whether due to climate, past geological events or man's activity, it is nevertheless true to say that the lengthy time periods involved with the production of mature forest crops in the Northeast constitute for the forest manager, as opposed to the manager of any other enterprise, one of the most serious impediments to management. How is one to plan for an 80-year period? And how are such plans possible when so little is known about the resource we would control and when the climate for control, of even the most modest proportions, is so inhospitable?

But let us proceed. It is an old aphorism that the world is many things to many people and this is nonetheless true of the forest and the people who use it. There are those who work in it, those who live in it, some who hunt or fish in it, many who recreate in it, and appreciable numbers who draw their water supply from it. The forests of the Northeast are experiencing all these uses today in some degree or other. In some cases, these varied uses are complementary; unfortunately, it is more common for them to come into conflict with one another. Use creates value, and it has been our historical experience that use changes with time and with it the values that arise from such use. Ours is a time that breeds change and we are witnessing today rather revolutionary changes that profoundly affect the uses to which we put our forests. These changes have their origin in the large centers of population that separate the forests from the sea and have to do with the geometric nature of population increase and the flourishing development of our urban way of life. The peoples of these heavily populated areas are on an active crusade for "Lebensraum" and they are going to the very place where they can get it easiest, the woods. Their quest is not only one of acquiring living space but also of finding solace and seclusion for short periods of time aside and apart from the press of people that daily surrounds them. By their numbers and the economic power that they wield, these people have created <u>de novo</u> a use for the forests of the region which is both popular in its appeal and pressing in its needs. As foresters, we have not been trained to meet this challenge. Our management techniques are fashioned around the production of wood for uses that are of long standing, such as lumber, pulpwood or poles. We are not equipped to handle the diversity of use that arises from the recreational use of forest land nor are we able to prescribe with any intelligence when confronted by a request for management techniques that would have the effect of upgrading the aesthetic values of forest property. Here again, we are reluctant to say categorically that this or that is a weed tree and should be eliminated. For who is to say what is weed and what is not? We are dealing here with subjective preference which it is beyond our ability to objectively determine. Our present assessment of the greatest good or the highest value that the forests possess may be so altered by the passage of time and the changes that it works that there will be those who, in future time, will seriously question our sanity.

I would like to add insult to injury by dwelling for a moment on the uncertainties that plague the forest manager in the Northeast. I would like to paint for you a verbal picture of Jo Sylva, just recently graduated with a bachelor of forestry degree from a leading school of high repute. Jo has been lucky enough to land a job as manager of a 10,000-acre tract of forest land in southeastern New Hampshire, and he brings to the job all the enthusiasm and knowledge that his training and tender years can muster. His employer's instructions are both terse and to the point -- "operate in such a manner that I get a net return from my investment each year and every year."

Jo has been thoroughly schooled on how to cruise timber and how to measure growth rates, and he proceeds with alacrity to make a detailed inventory of the forests under his jurisdiction. This done, he figures out how much he has in saleable wood products, at what rate his growing stock is increasing, and how much he can afford to cut each year for the next 50 years. Let's assume that he can cut the equivalent of 1000 cords of wood per year. His next job is finding somewhere to sell the wood. He scouts the area within a 100-mile radius of his forest and discovers that he can sell some white pine to a pail and tub factory, some spruce piling to a construction concern, some good grade hardwood logs to a furniture manufacturer, and about 500 cords of spruce to a pulp mill some 75 miles distant. He goes back to his desk and figures out what he has to cut, where and at what season of the year, what the prices must be for him to show a profit on his operation and what size crew he will have to hire to get the work done most efficiently. So far, it all appears straightforward and quite within the compass of his technical ability. So without further ado, Jo begins to operate his woods.

Let's assume now that 10 years have elapsed and that we are paying Jo a visit to see how he is getting on -- after all, like most foresters, he is a likeable chap. Imagine our dismay and horror when we find that Jo is no longer there. He was fired two years ago. It does not take long to find out why. On inquiry, it transpires that the pail and tub factory went out of business in the interim, the construction firm started using aluminum piling, the furniture manufacturer could buy cheaper hardwood imported from Liberia, and the pulp mill had swung over to a semi-chemical process which allowed it to use low-grade sprout hardwoods which it could buy for next to nothing in great quantity from farm woodlots in its immediate vicinity. Poor Jo!

In deference to the current public demand for a happy ending, however, let us continue in time to the year 1980 when, as luck would have it, we happen to pass Jo's old forest again in the course of being taken for a Sunday drive by our married daughter and family. We are surprised by a large sign which says "Tranquil Acres" and goes on to announce that camping facilities are available to the public for a sum of $5.00 per family per night, that swimming and tennis are available as side attractions, and that your friendly host is Jo Sylva. Nothing will do but that we stop and see our friend. We are greeted at the door by a corpulent hunk of cordiality who is all set to sign us up for the week end and we have some trouble identifying ourselves because of the bifocals and receding hairlines that we have acquired in the intervening years since our last encounter. We soon reestablish our relationship, however, and we find that not only does Jo run a recreational facility that is heavily patronized the year around but he also has a portable particle board assembly which he has mounted on a truck and which he moves from one blowdown area to the other. The hurricane of 1971 looked like a major disaster for Jo at the time but this new particle board machine that uses small red maple stems in short lengths as its raw material enabled him to convert a seemingly hopeless situation into his biggest money-making asset overnight almost. Suitably impressed by the resiliency of the man, we take our leave and marvel for the remainder of the day on the magnitude of the changes that have occurred in the short time that we have known Jo and his forest.

My reasons for relating this tale must surely be obvious. I wish to emphasize for you that risks and uncertainties are as much a part of the natural environment in forest management as the trees themselves. If our historical experience is any precedent, we can be sure that the future will bring major changes in price for the products that we have to sell and that these price changes will be affected to a significant degree by technological developments that create new uses for wood and in so doing make suddenly valuable species which hitherto we considered valueless. In short, we can expect present uses to change and new uses to develop for species that we attach no use to at present. The forests within which these species grow are just as likely to change in ways that are not orderly or within our control. It is quite within the bounds of possibility that certain of our more valuable species will succumb to some pathogen such as has happened in the past with birch, chestnut, and now perhaps white ash. Cataclysmic events, such as fire or wind, may affect our growing stock in sudden and serious fashion so that we are impelled to revise our cutting schedules in such a way as to salvage losses or rebuild our inventory. And all of these changes, I would have you note, are extraneous to the forest and have nothing to do with the way the trees grow or how the forest composition changes over time. Their influence is great, and their significance is the greater the more intensive the degree of management. In other words, the more elaborate the management program for a given tract of forest land, the more disruptive is the effect of events of this nature.

It becomes evident, then, that the forest manager is encompassed about with a plethora of variables that he can seldom predict or control. More often than not, he operates from incomplete knowledge of the events which will determine the continued integrity of his enterprise. In this indefinite aura of change and uncertainty he has now been presented with a herbicidal tool that enables him to control with greater efficiency the composition of his forest. All well and good. He knows too from the experience of others that the effects of such herbicidal treatments are not wholly predictable, that they vary with the nature of the carrier, whether oil or water, with the season of the year in which applied, the type of vegetation being treated, the sprouting ability of the species treated, and the intensity of the treatment. To add to his misery, he does not know nor can he learn with any degree of certainty how much such herbicidal treatments will cost when applied to his woods and the sites that they grow on, and there are conflicting opinions as to the best chemical to apply and the best manner in which to apply it -- foliage spray, basal spray or frill by axe or tree injector. Then, too, he has long considered that there are certain sites where it would be feasible, both economically and physically, to release coniferous growth by herbicidal control of the "weedy" hardwoods but no one has given him the means whereby he can identify these sites on the ground. The wonder of it is that so many foresters have used these chemicals at all.

But they have and they have done so with good judgment. I have seen some of this weed control work, and have heard or read about other cases, and I will briefly mention some of the more significant uses as they exist now or as they are likely to develop in the near future.

A singular and widespread characteristic of our natural woodlands in the Northeast is their density of stocking. Invariably there are too many stems per unit area for the forests to develop rapidly, and this dense vegetative cover militates against the natural enjoyment of the woods by man. The natural infertility of the soils that support these dense woods has a limiting effect on the number of stems that reach operable sizes, the consequence being that it is typical for natural forest to be composed of large stems rather widely spaced and for these stems to be interspersed with numerous smaller stems, usually of a different species. In most cases, the productivity of the site is adequately utilized by the larger trees so that the smaller trees become an impediment. If we were uncertain of the ability of the overstory trees to reproduce themselves or were operating in an area where sprouting was not such a characteristic feature of growth, we might hesitate to eliminate this dense understory of smaller trees, for they might then constitute the beginnings of our second generation. In the Northeast, however, we have little difficulty in obtaining reproduction and many of our species sprout vigorously. From a purely silvicultural standpoint, therefore, we are not without justification in contemplating the elimination of this understory by the most efficient means available to us. And herbicides are the best tool we've got.

There are several advantages to be gained from the removal of this understory. First and perhaps most important, ease of access is measurably improved. Not only is one able to move about readily in a stand so treated, but the whole appearance of the forest is considerably improved. It is possible to see through the forest for appreciable distances and the vistas obtainable from within the forest are wider and deeper. The improvement thus effected in the whole atmosphere, for want of a better term, of the forest is both desirable and worthwhile, and it is distinctly possible that many people would be willing to spend money in order that their natural enjoyment of their woods might be thus enhanced. Our limited experience with low thinnings in hardwood stands would seem to indicate that a basal spray of 2, 4, 5 - T in oil is most effective. Present indications are that although we can reduce the degree of stocking rather effectively this way, we do little to accelerate the growth of the residual trees if we limit such thinning to trees that are completely suppressed. My wildlife friends, when they see these woods that have been chemically thinned from below, immediately see in them an excellent potential for raising wild turkeys, for by leaving the canopy relatively undisturbed we have not destroyed cover or the rate of mast production.

Another potential use for chemicals in forest management has to do with the thinning of plantations that are composed of species that are liable to infection by Fomes annosus. This root rotting organism spreads both subterraneally and by spores and is particularly serious in plantations that are in the pole stage. Thinning by the conventional method of cutting creates stumps that are infection sites for the activated spread of the pathogen but it is possible to circumvent this difficulty if the trees to be thinned are poisoned by frilling and allowed to disintegrate in place. Since so many of the earlier thinnings in plantations do not yield usable wood, it is entirely possible that this means of thinning will not only cost less but be productive of fewer hazards.

There are many woodland owners today who are interested in growing Christmas trees. Where there is available open land, there are few problems that a good mowing cannot cure. The situation is somewhat different with those who plan to raise their trees in areas that are already wooded. It is possible for them to clear off a patch of woods and to maintain this area in an open condition at the expense of much time and labor. A more feasible method involves the thinning of the present forest cover to permit enough light on the forest floor to encourage the growth of coniferous transplants. We have tried this and it seems to work. We thinned an oak-maple-hickory stand rather heavily and after sprouting had taken place, treated the cut stumps with a 2, 4, 5 - T solution in kerosene. Some months later we planted the area to 2 x 0 Norway spruce, and after one growing season they appear to be doing well. The competition from what hardwood sprouts remain is inconsequential.

The release of conifers from hardwood competition has always seemed to be a most logical occasion on which to use chemicals. In view of what I have said previously, I hope you will forgive if I do not wholly subscribe to this seemingly obvious contention. I am ready to admit, however, that there are some sites where the relative productive potential of the site under conifers is so superior to anything that we can hope to derive from hardwoods grown on the same site, that little doubt exists as to the advisability of chemical release work. I am immediately reminded of some of the problems that our cohorts to the south are faced with. But there are large areas of the Northeast where conifer release is not justified economically or silviculturally and, as I have tried to indicate previously, we must know more about site quality as it affects growth and be more certain in our predictions that future markets will offer suitable compensation for the costs involved.

There are many other subsidiary uses of chemicals in forest management and, depending on what you do and where you happen to be, they may be of considerable significance to the success of an operation. I have encountered references to the use of chemical weed control in watershed management and in fire protection and both, in their respective local areas, were considered to have great promise. The emphasis, however, continues to be on the herbicidal control of "undesirable" species, and it is this type of blanket prescription which prompted me to enter upon this discussion of change, uncertainty and the insufficiency of our present knowledge about what is or is not desirable.

For if change be our lot and uncertainty sure, then we had better be flexible in our purposes and adept at altering them. We only fly in the face of trouble if we channel our efforts into a single use and sacrifice variety for simplicity of purpose. The complexity of our resource and the opportunities that this complexity creates for variety of use is our greatest strength, and I think we need to be very careful about calling any part of that resource "undesirable," or any tree a "weed."

New approaches in the use of herbicides in turf management

C. Richard Skogley[1]

The control of weeds always has been and probably always will be an important factor in the maintenance of turf. A review of the literature dating back prior to the advent of the introduction of 2,4-D and modern day weed control practices would bear this out.

Some of the earliest reports on selective weed control in turfgrass came from the Rhode Island Agricultural Experiment Station. Experiments had been started in 1905 to compare fertilizer mixtures designed to affect the soil reaction differently. An acid, neutral and alkaline fertilizer was each applied to different grasses. Three years later differences became quite apparent between grasses and by 1910 it was noticed that weeds were least abundant on the plots receiving the acid fertilizer. Although Kentucky bluegrass was favored by decreasing the soil acidity, clover and weeds were more prevalent.

This work was continued for many years and a number of publications were written which included data from these trials (3, 5, 6, 8, 10). It is interesting to note some of the early reactions to the results obtained. Hartwell and Damon (8) in discussing the work stated that "On general principles perennial grasses will be permanent to the extent that their specific requirements are fulfilled either naturally or artificially". They also wrote that "Even when the specific needs of a grass are known, it is not always advisable to maintain these needs because the growth of certain undesirable plants, such as weeds and foul grasses, may be promoted by the same conditions". For quite a number of years the "Rhode Island weedless lawns" received great publicity. Here was an admitted case of penalizing the desirable grasses to aid in weed control. In 1910 with little knowledge available what choice was there?

These investigators continued their efforts, however, until they were convinced that it wasn't soil acidity *per se* but rather differences in plant tolerance to aluminum which increased in the soil solution with increasing acidity.

It wasn't until almost 1940 that Rhode Island gave up trying to control weeds in turf by keeping the soil in an acid condition. It had become too difficult to maintain any kind of grass under these conditions - even Colonial bent.

Sprague and Evaul in a New Jersey bulletin (13) published in 1930 made this statement "In general it seems sensible that fertilization to control weeds should be conducted on the basis of encouraging vigorous growth of the turf so that grasses may successfully compete with weeds. The development of excessive acidity may cause more trouble than the weeds themselves". Researchers in both states seemed to agree that keeping soils very acid to prevent

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weed growth wasn't the best answer. Among professional men in the field today, however, there still are those who are not convinced that the acid soil theory of weed control should be discarded.

Reginald Beale (1), writing in Great Britain about 1930, made this statement: "There are tens of millions of pounds spent on education every year and yet there are still many who cannot understand that when weeds come up in a lawn, or elsewhere, it is a perfectly natural occurance, in fact it would be unnatural if they did not, because every part of the earth's surface contains seeds or spores of some sort of weed or another". He goes on to write "It is essential for the owner of a lawn, no matter if it be sown or turfed, young or old, to fight the weeds year in and year out if he wants anything approaching a good lawn". Mr. Beale then goes on to explain how these weeds are to be battled. Small lawns, those up to about 15,000 square feet, can be handweeded. Weeds in larger areas may have to be suffered in reluctance. He did suggest one chemical treatment if the turf contained a great many weeds. A material called Carterite, or lawn sand, could be broadcast at a certain rate. This notation was made: "Lawn sand being highly caustic will burn everything including the grass, and will kill upwards of 80 percent of the weeds, only the very strong and deep-rooting varieties escaping". Can you imagine a recommendation of this sort today?

In a book written by Dickinson of Massachusetts (4), published in 1930, a few chemicals are suggested for turf weed control. Dusting ammonium sulfate on the leaves of certain weeds, or painting them with a concentrated solution of the chemical is suggested. Iron sulfate spray is suggested where dandelions are numerous.

Another book (2), published in 1933, listed iron sulfate, copper sulfate, sulfuric acid and sodium arsenite as chemicals available for selective weed control in turf.

Other chemicals often suggested through the 1930's for spot treatment of weeds were kerosene, powdered lead arsenate, powdered fertilizer, and sodium chlorate.

This paragraph appeared in a past issue of Turf Culture (7). Can you guess when it appeared? "A few years ago when the news of a cheap, effective, reasonably safe method of controlling weeds in turf with chemicals began to spread, there were many who harbored the allusion that this was the final answer. There would be no more weeds! Simply sprinkle a magic powder over the lawn and presto! - a perfect lawn with no work involved! This idea, more than any other, has retarded the cause of chemical weed control by producing disappointing results. Some illusions are dispelled quickly, others gradually; this one takes no time at all. The first trial convinces anyone that chemical weed control is but one step in the production of beautiful turf". This might logically be from an article written today but actually the date was 1939. The chemical in reference was sodium arsenite.

Just where are we today in turf weed control? First, I believe all turf specialists are in accord that good management is the first and most important step in control. In the recent book on weed control by Klingman (1) this sentence would bear this out". The importance of practices that produce a strong and vigorous turf cannot be overemphasized.

Items that are generally agreed upon as necessary of consideration in management are proper establishment procedures, selection of weed-free seed of the right grasses, correct usage of lime and fertilizers, proper cutting and intelligent use of water.

Proper method of establishment involves several things. The soil itself, soil additives used, if any, slope and drainage all have a bearing on the finished product and the ease of maintenance - including weed control. One procedure that is often recommended, and many times employed, is seedbed sterilization. Haphazard and sloppy procedures for establishment seem the rule rather than the exception. The use of proven soil sterilants such as methyl bromide, calcium cyanamide or sodium methyldithiocarbamate could very well be included as one step in proper lawn establishment. Many lawns are lost or end up in poor condition because of weed competition in the first few weeks after seeding. This is particularly the case since most lawns are started in the spring - despite years of education to the contrary.

The selection and use of good seed is also related to weed control. The seed buying public, it would seem, places most of the blame for lawn weeds on the seed companies. This is hardly the case but the high weed content listed on the label of many of the cheap "supermarket" mixes might make you wonder. We do know that some seed lots contain weed seeds that cause real concern - mouse-ear chickweed, velvet grass and certain Bromus species. Good seed mixtures containing small quantities of tall fescue or Highland bentgrass also add to the list of complaints about weeds in seed mixtures. Most of the cheap seed mixtures contain a large percentage of annual ryegrasses and other coarse textured species that may be temporary under lawn conditions. These temporary grasses often disappear quickly leaving large bare areas in which weeds may flourish. The use of high class, adapted, seed mixtures is very important in the fight against weeds.

Low, wet areas or high, dry ones that might have been eliminated with proper grading or construction often add to the lawn weed problems. The chances are good that certain weeds will adapt to these situations much more quickly than do our good turfgrasses.

It is a most unusual soil, here in the Northeast, that is not inherently deficient in the major plant nutrients and is not considerably acidic in reaction. These are conditions which make turf production within the region a more complicated job than in many other areas of the country. The better turfgrasses, currently available, do not perform at their optimum under the conditions normally prevailing. It is necessary to add nitrogen, phosphorus and potassium to most of our soils. It is suggested that they be added in good quantity when establishing a lawn and at least twice a year thereafter. It is also desirable to lime soils regularly to develop and maintain a pH of 6.0 to 6.5. Unless these amendments are made we can expect persistent weed problems. There are many more weed species, covering a wide range of adaptation, than there are lawn grasses. It is only when the grasses are receiving a reasonable supply of nutrients that they are capable of holding their own against the multitude of competitors.

It might dispel some confusion here to hazard an opinion, shared by numerous turf specialists, regarding fertilizer usage. Many different grades and formulations of fertilizers can be used successfully in a turf management program. There is no single grade, brand, or type that is yet recognized as being superior overall. Certain ratios are often given as guides and application rates are suggested but beyond this it has been clearly demonstrated that dense, vigorous turf can be maintained with many different grades and formulations of complete fertilizers.

Perhaps it should be made clear also that too much fertilizer can be as damaging to a maintenance program as too little or none at all.

There should be little doubt anymore that cutting height of turfgrasses is a critical consideration in the management of lawns. Numerous studies have clearly indicated a close correlation between height of cut and depth and extent of rooting. Roberts and Bredakis (12), in a report from Massachusetts in 1960, reviewed 35 years of root studies. A number of conclusions were drawn on the basis of these many studies. A very important one is as follows: "Regardless of the type of grass under experimentation, clipping or defoliation at regular intervals inhibits the development of new roots in comparison with nonclipped turf. On most species and strains this reduction in root development becomes progressively greater as the height is lowered".

There are differences in cutting height tolerance among the genera, species or varieties of lawn grasses. These have been pretty well determined and every article on cutting management suggests minimum cutting heights for the various grasses. Grasses that are cut consistently shorter than suggested invariably become weaker and are less able to compete with weeds. In addition to this, grasses weakened by too close mowing are less able to tolerate herbicide treatment. The problems encountered in treating close-cut golf course turf with herbicides is a good example.

Another facet of cutting height relates to weed seed germination.

Light intensity minimums must be exceeded before certain weed seeds can germinate. The common crabgrasses, for instance, do not germinate or grow in fairly shaded areas. Keeping the soil surface shaded by maintaining a dense turf, cut at recommended heights most assuredly aids in reducing the weed population.

Water usage in turf management is important in weed control. It has been very enlightening to me to see firsthand many clear cases of weed infestation positively correlated with improper water usage. This has been most clearly shown following the installation of irrigation systems on golf courses and home lawns. <u>Poa annua</u>, crabgrass, bentgrass and even a few of the broadleaved weeds often flourish and gain the upper hand within two or three years following the installation of irrigation systems. This is particularly the case where the grass is cut too short, is thin, or the water is applied lightly and frequently. It is likely that an increased incidence of disease is many times an intermediary in respect to turf density, water usage and weed population. In overly-wet conditions disease is more prevalent and damaging and frequently thins the turf opening it up for invasion by weeds.

More and more each year since the advent of truly selective weed chemicals the public has come to rely on the herbicides as an essentail part of turf management. I doubt if there are many who would argue with this belief. Weeds such as crabgrass, Veronica, mouse-ear chickweed, muhlenbergia, dandelion, plantain and, when out of place, bentgrass are seldom controlled by management alone. There are other weeds in this category also. Many of our common turfgrass weeds are controlled readily with 2,4-D. I would doubt, however, whether there are many turf specialists who still don't have certain qualms, even after many years of research and use, about recommending this widely used herbicide. Injuries are reported every year, as are failures, even when the material is used to the best of our knowledge. Because of the many interactions among the wide range of variables governing the growth of a given piece of turf we still cannot predict with accuracy the response to herbicide treatment. A chemical that is dependable in one area of our region may not be in another. Endothal is recommended for the control of a Veronica species in one state in the Northeast but cannot be made to work safely in another. Chlordane, for crabgrass control, has given erratic results from one location to another and from one season to another. One of the newer crabgrass herbicides, Diphenatrile, has given excellent results in two years of testing within one state but has done poorly in another state only 200 miles distant. Calcium and lead arsenates, although exhibiting real possibilities, have not been promoted because of lack of consistancy. They almost always give excellent control of crabgrass but on occasion they are damaging to the turf.

The reasons for variable results with the many herbicides are numerous. Most of the reasons are not clear or fully established. We know that soil type or texture has a bearing on results with chemicals applied to the soil. The base exchange capacity of the soil, influenced mostly by the clay and organic matter content influences the activity of herbicides. Microbial populations of the soil govern breakdown of certain herbicides. The persistence of these herbicides in the soil, then, would depend on the size of the microbial population and the rate at which they can increase.

Time of application of herbicides - spring, summer or fall, is critical and for various reasons. The growth rate of the turfgrasses and the weeds at the time of herbicide application is most important. This has been documented and reported, on many occasions. Factors governing the growth rate - soil moisture, temperatures and fertility levels must always be adequate for the optimum timing of herbicide application.

A recent study by Rice (11) at the University of Rhode Island indicated that the roots of certain putting green grasses reach their greatest depth and maximum extensiveness during the spring months. Extensiveness and depth both decrease during the summer and roots remain shallow even through the fall months. This study is not complete but if the present indications should be born out by further research or review then mid- to late-spring application of herbicides to turf for selective control of biennial or perennial weeds should prove considerably safer than late summer or fall applications. Currently both seasons are suggested with the fall season frequently being favored. Additional studies of this more basic nature are badly needed in the turfgrass field. Regional projects on turfgrasses, completely lacking in the northeastern region, at the moment, could be most instrumental in consolidating and validating many of the loose-ends and conceptions or mis-conceptions currently existing.

It is interesting to look around within the region to see how many herbicides are presently being recommended for turf weed control. The number is few. This despite the fact that many chemicals of proven potential are available. How many of these interesting chemicals are actually being recommended or promoted: 2,4-D, 2,4,5-T, Silvex, sodium arsenite, phenyl mercury, calcium arsenate, potassium cyanate, the arsonates, Chlordane, Zytron, Dacthal, Diphenatrile, Endothal, Calcium Cyanamide, Vapam, methyl bromide? And there are many others that could be added to this list - both old and new.

There are many obstacles to overcome before we can actually get off the ground and feel that we have a "new approach" in turf weed control with herbicides. Progress in this field has been slow. It is slow for as Dr. Klingman (9) states, "Because millions of consumers and hundreds of turfgrasses and ornamental plants are involved, the job of educating users is more complex than in other areas of weed control". We certainly have come some distance since the introduction of 2,4-D. With closer cooperation among states, with the federal government and among industry the next 10 years could be much more productive in developing the field than has all of the past.

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WEED CONTROL BY DIMETHYL TETRACHLOROTEREPHTHALATE ALONE AND IN CERTAIN COMBINATIONS

L. E. Limpel, Paul H. Schuldt, and David Lamont [1]

Dimethyl tetrachloroterephthalate in pre-emergence application onto freshly cultivated soil possesses remarkable residual activity against many annual grasses, e.g. crabgrass (*Digitaria* spp.), the foxtails (*Setaria* spp.), and barnyard grass [*Echinochloa crus-galli* (L.) Beauv.] and some broadleaved weeds, e.g. purslane (*Portulaca oleracea* L.) and lambsquarters (*Chenopodium album* L.). However, at recommended dosages, it is ineffective for control of ragweed (*Ambrosia* spp.) and *Galinsoga* spp. and usually provides only partial control of pigweed (*Amaranthus* spp.) and smartweed (*Polygonum* spp.). The utility of this chemical would be greatly increased if it effectively controlled these latter weeds, but none of many experimental formulations has enhanced activity. In a continued effort to broaden the uses of this herbicide, it has been combined with several other materials used in pre-emergence applications.

There are two ways in which combinations of weed killers can improve weed control: (1) The mixture may be synergistic, i.e., a given weed species may be far more susceptible to the mixture than it is to either of the components applied alone. (2) The mixture, in a simple additive fashion, may control a broader spectrum of weed species. It would be expected that cases of true synergism would be rare, and unless there was an antagonistic interaction, simple addition of spectra of activity would tend to be the rule. In order to take full advantage of this type of addition, the two herbicides to be combined ought to be as dissimilar in this respect as possible. Obviously, such combinations would be restricted to use on crops which tolerated all components.

MATERIALS AND METHODS

The herbicidal materials used in these studies are listed in the table on the following page.

In the greenhouse test, soil contained in metal flats 12" X 8" X 3" deep was broadcast seeded both to pigweed (*Amaranthus retroflexus* L.) and to barnyard grass. Each species was restricted to a specific area of the soil so that pure stands would be present. The seeds were lightly covered with soil, and the following treatments were then immediately sprayed onto the soil surface: dimethyl tetrachloroterephthalate, CDEC, and NPA each at 2 lb./acre, dimethyl tetrachloroterephthalate + CDEC at 2 + 2 lb./acre, and dimethyl tetrachloroterephthalate + NPA at 2 + 2 lb./acre. The treatments were replicated three times and three untreated flats were included as checks. The flats were retained in the greenhouse untill good growth had occurred in the checks at which time total fresh weight of the aerial parts of each species was determined. Per cent control was calculated on the basis of reduction in fresh weight as compared to the checks.

PESTICIDES USED

Common name	Trade-mark	Active ingredient	Formulation	Source
-	DACTHAL W-50	dimethyl tetrachloroterephthalate	50 W	Diamond Alkali
CDEC	VEGADEX	2-chloroallyl diethyldithiocarbamate	4 lb./gal. E.C.	Monsanto
NPA	ALANAP-1	N-1 naphthyl phthalamic acid	90 W	Naugatuck
CIPC	ORTHO 3-CHLORO IPC EMULSIVE	isopropyl N(3-chlorophenyl) carbamate	4 lb./gal. E.C.	California Spray
DNBP	PREMERGE	dinitro-o-sec-butyl phenol, alkanolamine salts	3 lb./gal	Dow
2,4-D	CROP RIDER AMINE 4D-2	2,4-dichlorophenoxyacetic acid, alkyl amine salt	4 lb. ae/gal.	Diamond Alkali
2,4-D	-	2,4-dichlorophenoxyacetic acid	Experimental	Diamond Alkali
chlordane	CHIPMAN CHLORDANE	octachloro-4,7-methanotetrahydroindane and related compounds	50 W	Chipman

In the field tests, treatments were applied in 50 gallons of water per acre from a one gallon hand operated sprayer equipped with a Teejet nozzle. Weed control was always calculated from 4 or 5 independent estimates of the per cent of each plot covered by weeds, regardless of species, unless otherwise specified. The most common weeds encountered in the field were barnyard grass, crabgrass [Digitaria sanguinalis (L.) Scop. and D. ischaemum (Schreb.) Muhl.], pigweed (Amaranthus retroflexus L.), purslane, smartweed (Polygonum pensylvanicum L.), ragweed (Ambrosia artemisiifolia L.), and galinsoga.

Each plot in the Lima bean test was 3' X 30' and dimethyl tetrachloroterephthalate at 8 and 4 lb./acre, DNBP at 4 and 2 lb./acre and dimethyl tetrachlorophthalate + DNBP at 8 + 4, 4 + 4, and 4 + 2 lb./acre were applied one day after cultivation and planting. There were three replicates in a randomized block design, and the combinations were applied as tank mixes.

Treatments were sprayed onto 3' X 15' plots two days after the onion plants were set. There were four replicates in a randomized block design. The following treatments were applied, the combinations as tank mixes: dimethyl tetrachloroterephthalate at 8 and 4 lb./acre, In the third field test, in which no crops were included, a somewhat different approach was taken. The test area was thoroughly cultivated with a rotovator and then divided into four equal blocks or replicates. Bands 4'6" wide were treated with dimethyl tetrachloroterephthalate at 6 and 2 lb./acre, sprayed in a north-south direction, the length of the replicate, each replicate being treated separately. Also, untreated north-south bands of the same width were included in each block. Bands of the other herbicides, 5'6" wide were then applied in an east-west direction, the width of the replicate, crossing the bands of dimethyl tetrachloroterephthalate at right angles. Dosages applied were: CIPC at 4 and 2 lb./acre, NPA at 4 and 2 lb./acre and 2,4-D at 2 and 1 lb./acre. Again, each block was treated separately and untreated east-west bands were included. This procedure resulted in a series of 4'6" X 5'6" subplots containing all combinations of dimethyl tetrachloroterephthalate with all dosages of the other herbicides. In addition, subplots containing each dosage of each herbicide alone, as well as untreated checks were formed.

Plot size in the crabgrass control test was 7' X 7' with three replicates in a randomized block design. Combinations were applied as tank mixes in 100 gallons of water per acre. Dimethyl tetrachloroterephthalate at 10 and 5 lb./acre, 2,4-D at 0.5 lb./acre, NPA at 10 lb./acre, chlordane at 40 lb./acre, dimethyl tetrachloroterephthalate + 2,4-D at 10 + 0.5 lb./acre, dimethyl tetrachloroterephthalate + NPA at 10 + 10 and 5 + 10 lb./acre, and dimethyl tetrachloroterephthalate + chlordane at 5 + 40 lb./acre were included in the test.

The amount of weed control which could have been expected from the combinations was calculated and is reported in each table. The following formula, which was derived from the literature on insecticide synergism (1), was used to calculate expected weed control assuming complete independent action of the components in the combinations:

x = % weed control by herbicide A at p pounds per acre
y = % weed control by herbicide B at r pounds per acre
E = expected % weed control by A + B at $p + r$ pounds per acre

$$E = x + y - \frac{xy}{100}$$

This equation is considered to be valid only when applied to a given species. When combinations are evaluated against a population of mixed species, the relationships become much more complicated. However, it is assumed that calculations of this sort give a measure of enhanced weed control due to a broadening of the spectrum of susceptible weeds. True synergism, unless very pronounced, would tend to be masked when combinations are evaluated against mixed species.

RESULTS AND DISCUSSION

The results are presented in Tables 1 to 5. There are three instances where certain combinations appeared to provide control of given species greater than expected: dimethyl tetrachloroterephthalate plus CDEC against barnyard grass and dimethyl tetrachloroterephthalate plus NPA against pigweed (Table 1) and dimethyl tetrachloroterephthalate plus chlordane whether or not these apparent cases of enhanced control are meaningful should await further evaluation.

In the field tests (Tables 2 to 4) against populations of mixed species, certain trends seem apparent. Most combinations provided weed control better than expected. In general, greatest benefit seemed to be imparted to the lower dosages of dimethyl tetrachloroterephthalate. Differences between actual weed control and expected control appeared to increase with time. In other words, the combinations responded less to dosage and provided longer control than the herbicides applied alone.

TABLE 1

Relative Effectiveness of Dimethyl Tetrachloroterephthalate Alone and Combined with CDEC and with NPA - Greenhouse Test

Dosage, lb./acre Dimethyl tetrachloro-terephthalate	Dosage, lb./acre Other	Per cent control 1/ Pigweed Actual	Pigweed Expected	Barnyard grass Actual	Barnyard grass Expected
2	CDEC 2	85	81	96	81
0	2	81	-	38	-
2	NPA 2	87	53	93	93
0	2	53	-	78	-
2	- 0	0	-	70	-

1/ = Actual per cent control based on fresh weight.

TABLE 2

Relative Effectiveness of Dimethyl Tetrachloroterephthalate Alone and Combined with DNBP in Field-Grown Lima Beans

Dosage, lb./acre Dimethyl tetrachloro-terephthalate	DNBP	% weed control, days after treatment 1/ 40 Actual	40 Expected	49 Actual	49 Expected
8	0	95	-	80	-
4	0	66	-	30	-
8	4	98	97	89	81
4	4	93	80	73	34
4	2	85	78	54	34
0	4	41	-	5	-
0	2	36	-	6	-

1/ = At 40 days the check was 94 per cent covered by pigweed, purslane,

TABLE 3

Relative Effectiveness of Dimethyl Tetrachloroterephthalate Alone and Combined with CIPC in Onion Transplants - Field Test

Dosage, lb./acre Dimethyl tetrachloro-terephthalate	CIPC	Per cent weed control 28 days after treatment 1/ Actual	Expected
8	0	63	-
4	0	36	-
8	4	97	92
4	2	82	62
0	4	76	-
0	2	41	-

1/ = The check was 94 per cent covered by pigweed, smartweed, ragweed, purslane, galinsoga, and barnyard grass.

TABLE 4

Relative Effectiveness Against Weeds of Dimethyl Tetrachloroterephthalate Alone and Combined with CIPC, NPA, and 2,4-D - Field Test

Dosage, lb./acre Dimethyl tetrachloro-terephthalate	Other	Per cent weed control at days after treatment 1/ 31 Actual	 Expected	 42 Actual	 Expected
6	0	57	-	33	-
2	0	36	-	7	-
6	CIPC 4	81	82	55	48
2	4	86	72	45	28
0	4	57	-	23	-
6	CIPC 2	80	70	49	38
2	2	57	56	16	14
0	2	31	-	8	-
6	NPA 4	86	88	70	52
2	4	91	81	66	33
0	4	71	-	28	-
6	NPA 2	85	72	65	39
2	2	84	58	48	15
0	2	34	-	9	-
6	2,4-D 2	90	88	77	54
2	2	[illegible]	[illegible]	70	36

TABLE 4 (Continued)

Dosage, lb./acre Dimethyl tetrachloro-terephthalate	Other	Per cent weed control at days after treatment 1/ 31 Actual	31 Expected	42 Actual	42 Expected
6	2,4-D 1	86	75	71	41
2	1	84	64	55	18
0	1	43	-	12	-

1/ = At 31 days the check was 97 per cent covered by barnyard grass crabgrass, purslane, pigweed, and galinsoga, and at 42 days the check was 99 per cent covered by the same weeds.

TABLE 5

Crabgrass Control in Turf by Dimethyl Tetrachloroterephthalate Alone and in Certain Combinations - Field Test

Dosage, lb./acre Dimethyl tetrachloro-terephthalate	Other	Per cent control 134 days after treatment 1/ Actual	Expected
10	0	91	-
5	0	43	-
10	2,4-D 0.5	91	91
0	0.5	0	-
10	NPA 10	87	91
5	10	26	43
0	10	0	-
5	chlordane 40	65	45
0	40	4	-

1/ = The check was 23 per cent covered by crabgrass.

SUMMARY

Dimethyl tetrachloroterephthalate has been tested in various combinations with CDEC, NPA, DNBP, CIPC, 2,4-D, and chlordane. In general, the results were quite promising and tend to encourage additional research with these as well as other combinations.

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DIPHENAMID FOR PRE-EMERGENT WEED CONTROL IN HORTICULTURAL CROPS[1]

E. F. Alder and W. L. Wright

Diphenamid is the tentative common name for N,N-dimethyl-α,α-diphenylacetamide. Last year at the regional weed conferences we first reported the selective herbicidal properties of this compound and other substituted diphenylacetamides (1,2,3). Confirmatory evidence has subsequently been published (4). Diphenamid is an effective pre-emergent herbicide against annual weed grasses and several annual broadleaf weeds. It has shown useful selectivity in several horticultural crops. A list of crops which have been tolerant to diphenamid at rates through eight pounds per acre is presented in Table 1.

Table 1. Crops Tolerant to Diphenamid at 8 lb/A

Tomatoes (seeded and transplant)	
Peppers (seeded and transplant)	
Strawberries	Cabbage
Snapbeans	Mustard
Lima beans	Radishes
Peas	Turnips
Potatoes, Irish	Kohlrabi
Potatoes, Sweet	Rutabaga

A list of weeds classified according to their susceptibility to diphenamid at rates of four to six pounds per acre is presented in Table 2. Diphenamid has given excellent control of most annual grass weeds tested. Broadleaf weed control has been promising but variable. Rainfall or irrigation soon after treatment improved the broadleaf weed control performance of diphenamid.

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1. Contribution of Eli Lilly and Co., Greenfield Laboratories, Greenfield, Indiana

2. Head, Plant Science Research, and Plant Physiologist, respectively

Table 2. Weed Susceptibility to Diphenamid at 4-6 lb/A

Susceptible	Moderately Susceptible	Tolerant
Crabgrasses	Wild oats	Jimsonweed
Foxtails	Fall panicum	Velvetleaf
Barnyardgrass	Ragweed	Venice mallow
Goosegrass	Smartweed	
Stinkgrass	Wild mustard	
Cheat	Purslane	
Pigweed		
Lambsquarters		
Carpetweed		
Chickweed		

Field Tests

Tomatoes

Diphenamid was applied to field-seeded and transplant tomatoes in 33 experiments at Greenfield, Indiana and at other Indiana locations. A total of ten varieties of field-seeded and transplant tomatoes were tested. Spray applications were made with either a modified Hahn Hi-Boy sprayer or a sulky spray unit. Plot sizes varied in the different experiments but were usually greater than 50 square feet. Weed control was determined by counts or visual ratings.

Table 3 presents data from a typical pre-emergent experiment on field-seeded tomatoes. Application was made immediately after seeding the tomatoes. Grass weeds were large crabgrass and yellow foxtail.

Table 4 presents typical data from an experiment on transplant tomatoes. In this experiment diphenamid was applied as an overtop treatment on the transplants pre-emergence to the weeds. Grass weeds were large crabgrass and yellow foxtail; broadleaves were pigweed, lambsquarters, smartweed, and ragweed.

In all tests, four pounds per acre was adequate for weed control on light soils. Six pounds per acre was needed for heavy soils. On heavy soils, field-seeded and transplant tomatoes were not damaged by diphenamid at rates through fifteen pounds per acre. In one experiment of the five experiments conducted on sandy soils, moderate early injury to the tomatoes was noted at the ten pound rate. A month later this damage had disappeared. Final yields were not reduced in any of the experiments. It is apparent that diphenamid is safe to apply to seeded and transplant tomatoes

Table 3. Weed Control in Field-Seeded Tomatoes with Diphenamid

Diphenamid lb/A	Percent Weed Control			
	Grasses	Broadleaves		
		Pigweed	Lambsquarters	Others
Wettable Powder				
4	99**	98**	70**	76**
6	96**	99**	67**	87**
8	100**	99+**	85**	95**
12	100**	99+**	96**	92**
Granules				
8	99**	98**	67**	84**
0	0 (8.3) a/	0 (63.4) a/	0 (2.7) a/	0 (3.7) a/

** Significant at 1% level

a/ Number weeds per square foot

Table 4. Weed Control in Transplant Tomatoes with Diphenamid

Diphenamid lb/A	Percent Weed Control	
	Grasses	Broadleaves
Wettable Powder		
2	93**	33
4	97**	78**
6	96**	74**
8	98**	83**
0	0 (23.1) a/	0 (4.3) a/

** Significant at 1% level

a/ Number weeds per square foot

The effect of diphenamid on final tomato yields is demonstrated in Table 5. Two typical experiments are presented which show increased yields obtained from diphenamid treated plots. This increase was probably due to the control of weeds on those plots.

Table 5. Yield Data on Field-Seeded and Transplant Tomatoes

Diphenamid lb/A	Tomato Yields (Tons/Acre)	
	Field-Seeded	Transplants
Wettable Powder		
2	19.5	15.8
4	18.8	20.0
6	19.6	20.4
8	18.7	20.0
0	16.7	11.7

Peppers

In five trials on seeded and transplant green peppers, diphenamid gave no damage to peppers with comparable weed control to that obtained in tomatoes.

Strawberries

In experiments on first-year transplant and established strawberries, diphenamid has given good weed control with no damage to the strawberries at rates through eight pounds per acre. Above eight pounds some leaf burn and decreased runner production was noted.

Table 6 presents data from a typical experiment on first-year transplants. Diphenamid was applied two days after the berries were set. The dominant grass weed was large crabgrass. Lambsquarters and velvetleaf were the dominant broadleaf weeds. The latter species is tolerant to diphenamid as indicated in Table 2.

In several experiments on transplant strawberries the plots were placed under cultivation after the first weed control data were obtained. Subsequent observations indicated that shallow cultivation did not destroy the weed control effectiveness of diphenamid.

Table 6. Weed Control in Transplant Strawberries with Diphenamid

Diphenamid lb/A	Percent Weed Control Grasses	Percent Weed Control Broadleaves	Strawberry Injury Rating[a]
Wettable Powder			
4	98**	57**	0
6	99**	72**	0.7
8	99**	65**	0.3
10	99**	64**	0.7
12	100**	79**	1.0
Granules			
4	98**	76**	0.3
8	100**	87**	1.7
12	100**	92**	1.3
0	0 (12.9) b/	0 (5.6) b/	0

** Significant at 1% level

a/ 0=no effect, 1-3=slight injury, 4-6=moderate injury, 7-8=severe injury, 9=complete kill

b/ Number weeds per square foot

Potatoes

Reports from several investigators indicate diphenamid to be promising for the control of weeds in Irish potatoes and in sweet potatoes at rates of four to six pounds per acre.

Legumes

Lima beans, snapbeans, and peas have shown tolerance to diphenamid at rates through twelve pounds per acre. Table 7 presents data from an experiment in which these crops were included.

Table 7. Weed Control in Legumes with Diphenamid

	Percent Weed Control		Crop Injury Ratings[a]		
Diphenamid lb/A	Grasses	Broadleaves	Lima beans	Snap-beans	Peas
Wettable Powder					
2	93**	58**	0	0	0
4	99**	66**	0	0	0
6	99+**	74**	0	0	0
8	100**	88**	0	0	0
12	100**	93**	0.3	1.0	0.7
0	0 (207.4) b/	0 (12.2) b/	0	0	0

** Significant at 1% level

a/ 0=no effect, 1-3=slight injury, 4-6=moderate injury, 7-8=severe injury, 9=complete kill

b/ Number weeds per square foot

Summary

Diphenamid has shown considerable promise for the control of annual grass and several broadleaf weeds at rates of four to six pounds per acre. Crops on which diphenamid looks particularly promising are seeded and transplant tomatoes, peppers, strawberries, potatoes, the legumes, and some of the cole crops.

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SOME PROMISING USES OF DU PONT 326[1]
A NEW SUBSTITUTED UREA HERBICIDE

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In 1961, the Industrial and Biochemicals Department of the E. I. Du Pont de Nemours and Company, Inc., released to investigators Herbicide No. 326 with the technical name of 3-(3,4-Dichlorophenyl 1)-1-methoxy-1-methyl urea. The company listed such attributes as pre- and post-emergence activity, relatively rapid disappearance from soil, and relatively low toxicity to mammals. The herbicide was suggested primarily as a post-emergence directed spray on corn and pre-emergence on soybeans. Other crops which could be treated with directional sprays were also stated as possibilities. Carrots had been found to be tolerant of herbicidal quantities applied as pre-emergent sprays. Preliminary reports indicated pre-emergence applications could be tolerated by such crops as snap, dry, and lima beans, squash and potatoes. Injury was found on vegetables including cucumbers, red beets, and tomatoes.

The purpose of the tests reported here was to evaluate the performance of 326 on various vegetables and nutgrass. Where pre-emergence tolerance was indicated, post-emergence tests were generally but not always conducted.

Experiments with Carrots

There were four tests with carrots; two were on coarse sand, one on sandy loam, and one on muck. The two on coarse sand were abandoned after preliminary note taking due to severe crop damage from heavy storms. The muck test and the one on sandy loam soil involved both pre- and post-emergent applications of about 25 new chemicals at several rates each. Weed ratings were made at intervals during the season. Although harvest records were taken, yields are of questionable value because of field variability and because weeds were not removed promptly as they became prevalent in the various plots.

Weed and crop ratings of the more significant materials in both the sandy loam and the muck soil tests are presented in table 1. Several materials behaved quite differently on the two soils. In regard to weed control, the pre-emergence applications of CIPC, Dacthal, Zytron, Dipropalin and Diphenamid were much less effective on muck than on sandy loam. However, pre-emergence treatments of Du Pont 326 as well as Trifluralin, Ipazine and EPTC showed no significant influence of soil type on weed control. As was to be expected, post-emergence herbicides were not influenced by soil.

Although carrot response to herbicides in general was not influenced by herbicides, Diphenamid was exceedingly toxic on sandy soil and not harmful on muck soil. Since weed control was exceedingly poor with Diphenamid on the muck, it is probable that this material was either very tightly adsorbed or quickly broken down. Since on mineral soil Diphenamid gave relatively long lasting results, it is unlikely that decomposition was as important as adsorbtion.

Table 1. Ratings[a] of carrot and weed responses to herbicides six weeks following planting.

			Weeds[c]		Crop	
Chemical	Lbs.[b]	Timing	Sandy loam	Muck	Sandy loam	Muck
Amiben	2 gran.	At planting	7.0	2.0	8.5	8.0
	4 "	" "	8.0	3.0	8.0	7.0
CIPC	4	" "	6.5	3.0	8.5	8.5
	8	" "	7.5	4.5	8.5	8.0
Dacthal	8 (9)	" "	8.5	4.5	9.0	8.0
	12	" "	8.5	5.0	9.0	8.5
	24 (-)	" "	9.0	-	8.5	-
Zytron	8 (9)	" "	6.5	3.0	9.0	8.5
	12	" "	7.5	4.0	9.0	7.5
326	1/2(-)	" "	5.0	-	9.0	-
	1	" "	7.5	7.5	7.5	6.5
	1 1/2(3)	" "	9.0	8.5	8.5	6.5
326	1/2(-)	Early Post	9.0	-	9.0	-
	1	" "	9.0	8.5	8.0	6.5
	1 1/2(3)	" "	9.0	9.0	9.0	7.5
Dipropalin	4	At planting	7.5	3.0	9.0	9.0
	8	" "	8.0	5.5	8.5	8.0
"	4	Early Post	5.0	7.0	9.0	7.0
	8	" "	7.5	7.0	8.5	5.5
Trifluralin	4	At planting	8.5	7.5	8.5	7.5
	8	" "	8.5	8.0	9.0	8.0
Diphenamid	4	" "	8.5	3.0	2.0	8.0
	8	" "	9.0	3.5	2.0	8.0
Ipazine (30031)	1/2(-)	" "	6.0	-	8.5	-
	1	" "	5.0	6.5	8.5	7.5
	1 1/2(2)	" "	6.0	8.0	7.5	7.5
	1/2(-)	Early Post	5.0	-	8.0	-
	1	" "	5.0	6.5	8.0	8.0
	1 1/2(2)	" "	5.0	8.5	8.0	5.5
Solan	2	" "	4.5	7.0	8.5	7.0
	4	" "	6.5	8.5	8.0	7.0
	6 (-)	" "	7.5	-	6.5	-
Eptc	2 gran.	Incorp.	5.5	6.0	8.0	6.5
	4 "	"	6.5	6.0	7.0	6.5
Solvent	75 gal.	Early Post	8.5	-	8.5	-
Check	-	-	1.0	2.5	9.0	7.5

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[a] Rating of 9=perfect crop growth; complete weed kill. 7=commercial crop growth; commercial weed control. 5=moderate crop growth; unacceptable weed control. 3=severe crop damage; poor weed control. 1=crop kill; complete weed tolerance.

[b] Figures in parenthesis indicate where rates on muck differed from those on the sandy loam.

Du Pont 326 caused slight early stunting of carrots on muck. However, at harvest no differences in yield could be noted. In the two tests on coarse sand where only early records were obtained, 326 caused marked stunting at three pounds. It was for this reason that rates were kept at 1.5 lbs. maximum in the sandy loam test.

Ragweed is a severe pest not controlled by Stoddard Solvent. The two tests abandoned early, were in fields chosen primarily because of high ragweed population. These tests yielded some data on ragweed control. The following materials failed to control this pest: Chloro IPC, Dacthal, Zytron, Dipropalin (post-emergence) and Trifluralin. Du Pont 326 gave excellent control of ragweed. Other compounds which performed well were Ipazine and Solan.

In the planting on the sandy loam soil annual grasses were a serious problem. Ipazine and Solan gave only fair control of these pests. Du Pont 326, however, performed exceedingly well. Thus for a wide range of weed species on widely different soils under either pre or post-emergent conditions this chemical was outstanding.

Nutgrass Experiments

The activity of Du Pont 326 and other chemicals was studied at two locations heavily infested with nutgrass. The materials were applied pre-planting at both locations. At one location they were also applied in the "spike" stage and when the nutgrass averaged 6 - 8 inches tall. The results of the several tests are presented in table 2.

Timing had a pronounced effect on the response of nutgrass to Du Pont 326. Pre-plant applications whether on the surface or incorporated gave unsatisfactory control. Disappointing results were also had from the "spike" stage applications. At both of these timings the foliage turned somewhat yellow and early growth was slightly retarded. However, after about three weeks the nutgrass foliage returned to a normal color and the plants developed vigorously. When treated at the taller stage, the foliage turned yellow and gradually became necrotic. No regrowth occurred on any 326 plot treated at the 6 - 8 inch stage.

Atrazine performed less satisfactorily at the spike stage than is normally expected. EPTC, however, was consistently excellent. Dalapon gave widely different results at the two pre-plant locations. The authors do not have any explanation for the poor early results with Dalapon at King Ferry. Generally, early applications with Dalapon have given results similar to those obtained at Binghamton.

Response of Additional Crops

In addition to the results already reported Du Pont 326 was used as an at-planting treatment in one test on muck, three tests on sandy loam, and in three tests on stony silt loam. Potatoes appeared to be tolerant, however, no post-emergent tests have been conducted on this crop. Other crops including cucumbers, muskmelons, peas, snap and lima beans, tomatoes, beets and spinach were either severely damaged or killed at rates needed for weed control. Squash were moderately damaged from pre-emergence applications but were killed by

Table 2. Response[a] of nutgrass to several chemicals at various timings.

Chemical	Lbs.	Pre-plant[b]		"Spike"	6-8 inches
		Bing.	King Ferry	King Ferry	King Ferry
Dalapon	5	7.00	3.0	5.0	4.5
	8	-	3.5	6.5	5.0
	10	8.50	-	-	-
Atrazine	2	5.75	5.5	4.5	6.0
	4	7.50	7.0	5.5	8.0
EPTC (Inc.)	2	-	6.5	-	-
	4	8.5	8.5	8.0	-
	6	8.75	-	8.5	-
Du Pont 326	1/2	-	-	-	8.0
	1	2.00	2.95	5.0	8.0
	2	-	-	-	9.0
	3	5.25	3.50	6.5	-
Check	-	1.0	1.0	1.0	1.0

[a] 9=complete control of top growth. 7= commercial control of top growth. 5=unsatisfactory control of top growth. 1= heavy complete ground cover. Ratings made in early August.

[b] All pre-plant treatments at King Ferry were disced. Only the Eptam was incorporated at Binghamton.

post-emergence treatments. Ryegrass cover crops are growing well where 326 was applied in June on sandy loam.

Summary and Conclusions

1. In 14 experiments on soils ranging from coarse sand to muck, Du Pont 326 gave excellent control of a wide range of annual weeds including: crabgrass, *Eragrostis sp.*, barnyard grass, redroot, lambsquarters, purslane, galinsoga, ragweed, *Senecio vulgaris*, and ladysthumb smartweed. Soil type had little or no influence on results.

2. Northern nutgrass was especially susceptible to post-emergence applications of 326, but was not controlled by pre-emergence treatments.

3. Carrots were tolerant of pre- and post-emergence applications of 326 at rates adequate to control either annual weeds or nutgrass. Post-emergence applications were very effective at 0.5 and 1.0 pound to the acre but about twice this quantity was needed pre-emergence.

4. Potatoes tolerated pre-emergence applications, but it is not known if they will tolerate post-emergence treatments.

5. Long residual activity is apparently not a problem on sandy loam. Information is lacking for other soils.

THE EFFECT OF FOLIAR APPLICATIONS OF AMINO TRIAZOLE ON THE GERMINATION OF NORTHERN NUTGRASS SEED[1]

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Introduction

Donnalley and Rahn (3) have reported that they applied C^{14} labeled amino triazole to the leaves of the Northern nutgrass plant. Autoradiograms of treated plants showed that the chemical was translocated in the plant and into the tubers. Subsequent tests showed that this treatment reduced germination of the tubers.

The object of this experiment was to determine whether foliar applications of amino triazole are translocated to the inflorescence and if this treatment has an affect on seed germination.

Materials and Methods

Plants of Northern nutgrass (Cyperus esculentus) were grown in the greenhouse and treated with C^{14} labeled 3 amino-1,2,4 triazole; the tagged atom was on the 5-position of the triazole ring. The specific activity of this chemical was 0.95 millicuries per millimole. A 4500 ppm stock solution, containing 50 microcuries, was prepared by adding distilled water to the sample.

Each treatment consisted of a ten microliter droplet, with an activity of 0.5 microcuries, being placed inside a lanolin ring on the plant. The activity was similar in all cases, but the site of application and the duration of the treatment was varied. Five microliters of a 0.1 per cent Triton B-1956 spreader solution was added to each droplet.

At the end of the various treatment periods, the lanolin was removed with absorbent tissue. The aerial portion of the plant was harvested, sectioned, placed between blotters, bound in a

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plant press and dried in a forced draft oven at 80-90°C. Sectioning of the plants was necessary because of their large size. Immediately following each cut, the ends were immersed in melted paraffin to seal them and prevent leakage of the plant sap out of the tissue during drying. The sections were mounted on white cardboard and enclosed in acetate film. Autoradiograms were made according to methods described by Comar (2). After a twenty-eight day exposure period, the film was developed.

In field studies, single applications of amino triazole were applied to a solid stand of Northern nutgrass at two different stages of maturity, to determine possible "seedicidal" effects. The first application was made on August 17, when the inflorescences were about fifty per cent mature, the second on August 28, when the inflorescences were approximately seventy-five per cent mature.

Three rates of the chemical were applied on each date; two, four, and eight pounds of active material were used in 100 gallons of water per acre. Seed was harvested from the plots on two dates, September 1 and 11. The seed was air dried at room temperature, hand threshed, and cleaned in an air blower.

Germination tests were conducted in the seed laboratory at the University of Massachusetts in the manner prescribed by the Association of Official Seed Analysts (1). All treatments were replicated four times with 100 seeds in each replication. By using a procedure described by Durfee (4), the seeds were placed on moist blotters for sixteen hours of darkness at 20°C and alternated with eight hours of light at 35°C. All seeds were subjected to a twenty-one day germination period.

Results

In the labeled amino triazole translocation studies, a droplet of the material was placed one inch below the umbel, on the stem of a plant estimated to be 75 per cent mature, for a three day treatment period. The image obtained showed that the herbicide moved up into the bract leaves and spikelets. A similar treatment of seven days duration produced the same general effect, except the image was darker, indicating that more herbicide had accumulated in the tissue.

A second treatment involved the placing of the ten microliter droplet six inches from the base of one of the umbel's bract leaves. The umbels were 75 per cent mature and the duration was again three and seven days. Translocation was mostly acropetally. Some did, however, move basipetally to the umbel, where it entered other bract leaves and the individual peduncles and spikes. Similar effects were observed in both treatments, except the seven day treatment produced the darker image.

A third treatment involved the placing of the herbicide on the peduncle, midway between the rachis and peduncle base. The ten microliter droplet was divided into three equal parts and each part applied to different peduncles. Thus three peduncles of the umbel were treated, with the total dosage being 0.5 microcuries. No Triton was used. When applied to a 75 per cent mature umbel for a three day treatment period, it was translocated up the peduncle and rachis and into the spike. None was moved down the peduncle. When similarly applied to a mature umbel, the movement was again into the spikes, but there was also a slight movement down the peduncle.

Field plants which were treated on August 17 exhibited a marked change in their appearance by August 28. In the plot receiving two pounds per acre, the nutgrass had developed a slight chlorosis; plants in the four pound plot were darker yellow, and, those in the eight pound plot were nearly light brown.

At seed harvest time, September 1 and 11, the plants that were sprayed on August 28 had about the same color as those in the check plots but those that had been sprayed on August 17 were still chlorotic. It was noted that the plants sprayed on August 17 had fewer seeds per inflorescence and plants treated with eight pounds of the chemical produced only twenty-five per cent of the yield harvested from the two pound treatment.

Analysis of the data are presented in Table I. It is readily apparent that amino triazole sprays had a deleterious and significant effect on seed germination. When the treatments are compared, it is seen that seed from the check plots germinated significantly greater than those from any of the other treatments. A lineal effect exists among the rates of application, with the higher rates of the chemical giving the poorest germination. Seed from plots treated on August 17 with eight pounds of amino triazole germinated only 25-30 per cent as well as those from the check plots. When comparing the time of applications, it can be seen that the August 17 treatments germinated only twenty per cent as well as those that were treated on August 28. This difference is highly significant. In these tests, the time of harvest had no influence on the rate of germination.

Summary

The autoradiographic technique was used to determine the extent of translocation of C^{14} amino triazole in Northern nutgrass. The images revealed that this chemical is translocated from the point of application to the seed spikes. The amount reaching the spike depends on the distance from the point of application it must travel. The greatest accumulation in the spike occurs when application is to the peduncle, while the least accumulation occurs when applied to the bract leaves.

Table I. THE EFFECT OF AMINO TRIAZOLE SPRAYS AND TIME OF HARVEST ON GERMINATION OF NUTGRASS SEED.

Treatment	Time Of Treatment	9/1 HARVEST Mean Per Cent Germination (Angles)	9/11 HARVEST Mean Per Cent Germination (Angles)
Check		44.56	52.44
2 Lb./Acre	8/17	32.10	33.81
4 Lb./Acre	8/17	30.78	26.14
8 Lb./Acre	8/17	14.25	14.31
Total Minus Check		77.13	74.26
2 Lb./Acre	8/28	34.73	45.57
4 Lb./Acre	8/28	35.94	37.17
8 Lb./Acre	8/28	31.15	35.03
Total Minus Check		101.82	117.77
	Total	223.51	244.47

L.S.D. (.05) = 12.13

L.S.D. (.01) = 19.02

Foliar applications of amino triazole at the rate of two, four, and eight pounds per acre resulted in a decreased germination of the seed. There is also a significant difference between time of application; early treatment, where the seed was in the immature state, resulted in the poorest germination.

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THE INFLUENCE OF PETROLEUM MULCH ON THE PERFORMANCE OF SEVERAL HERBICIDES[1]

George Bayer, Rodger Hargan and Joseph Cialone[2]

For the past several years plastic sheets both black and clear and varying in width have been used commercially as a method of controlling weeds, stimulating plant growth and improving small fruit and vegetable quality.

This report is concerned with the application of a liquid petroleum mulch in combination with herbicides which might serve some of the same purposes as the black plastic sheets but to be applied as a spray after seeding or prior to transplanting. Work done by Kays & Wiggans[3] indicated that the effectiveness of certain herbicides was enhanced when used in combination with asphalt mulch.

Experimental

Four tests were carried out during the 1961 growing season at Ithaca. The sandy loam soil was plowed, disked and harrowed with a meeker to provide a uniformly fine seed bed. The randomized plots were each 3 x 15 feet and replicated two to four times depending on the nature of the test. The herbicides were applied with a CO_2 pressure-operated small-plot sprayer. For ease of operation in the latter two tests the petroleum mulch[4] was applied using a hand operated 1.5 gallon garden-type sprayer connected to a standard spray boom equipped with two 8004 Teejet fan-type nozzles.

In total, seven different chemicals were examined in three categories relating to the mulch: under the mulch, mixed with mulch and no mulch. A fourth or check category was that of no mulch and no herbicide. Application of herbicide and mulch was on an overall basis. In the first test two rates of mulch were tested. Since no differences were observed, only one rate was used in subsequent tests.

Crops were varied according to chemical. Some were chosen on the basis of present herbicidal practices but several sensitive crops were selected as indicators of chemical toxicity or activity.

The four tests were started respectively on June 16, July 7-10, August 17, and September 1.

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[1] Paper No. 469 of the Department of Vegetable Crops, Cornell University, Ithaca, N.Y.

[2] Graduate Assistants, Department of Vegetable Crops, Cornell University.

[3] Kays, W. R. and S. C. Wiggans, Oklahoma State, Stillwater, Oklahoma. Soil stabilizers and herbicide combinations for weed control with horticultural crops. Oral presentation ASHS. August 1961.

[4] Formulation E.A.P. 2000 except as noted.

Part of this research was made possible by a grant in aid from Esso Research and Engineering, Linden, New Jersey.

In general, the soil moisture and tilth did not vary greatly between tests. The one exception in the July 7 - 10 test will be discussed in detail later.

Weed species and population varied somewhat between tests, but included: redroot, purslane, galinsoga, henbit, groundsell, crabgrass and barnyard grass.

The area for test No. 1 was harrowed, planted and treated on June 16. It can be seen from the results tabulated in table 1 that the high and low rate of mulch gave equal results; hence further tests were limited to the 484 gallon rate. When comparing the July and August weed ratings, made approximately one month apart, it was evident that the mulch was increasing the longevity of the herbicidal activity of CDEC and CDAA. The amine salt of DNOSBP was adversely affected by the mulch and gave very poor weed control under the mulch. Three materials, Atrazine 80W, Dacthal 50W and DNOSBP, were not applied as mixtures with mulch due to incompatibility of these materials under "tank mix" conditions. The crop response ratings given in the table were made on August 1. However, earlier observations indicated that EPTC, both mixed and under mulch, caused a temporary benzoic acid-type foliage distortion on beans.

To follow up the indications in test No. 1 that a mulch layer tended to seal in EPTC, a second test was set out on July 7. A complication occurred in that after applying the EPTC and seeding the several crops a heavy rain struck the area so that the mulch application was delayed until July 10. It was then applied on the moist, smooth, rain-packed surface which resulted in an exceptionally tight or continuous mulch film. As shown in Table 2, under these conditions differences in weed control and crop growth were generally slight. However, it is interesting to note that the activity of the EPTC not incorporated was sustained when covered with mulch three days later as evidenced by excellent weed control and toxicity to the indicator crops as compared to the corresponding not-incorporated, not-mulched plots.

A fifth replication (Table 2) was harrowed, seeded and sprayed on July 10. In contrast to those plots which had been rained on, the looser seed bed resulted in a relatively discontinuous film of mulch. In this case the EPTC (EC) when not incorporated gave identical results whether covered or not covered by mulch even though mulching was done immediately after spraying. In both cases weed control was slightly below commercially acceptable and inferior to that in the other replications. Also, the vigor of the test crops was excellent - the best of any treatment.

These differences between replications would seem to indicate that with EPTC (EC) non-incorporation plus mulch maintains activity relative to the completeness of the mulch seal.

Since there were incompatibility problems with certain of the herbicides when mixed with mulch, the Esso Company made up special formulations which were used in tests 3 and 4. A split-plot design - no mulch vs mulch - was used for checks.

Spinach and snap beans were planted but due to rabbit damage only spinach

Table 1. Crop and weed ratings of herbicides applied beneath and mixed with petroleum mulch.

				Rate	Weed Rating[1]		Crop Rating[2]	
	Chemical	lbs/A	Mulch	gal/A	July	Aug.	Beets	Tomatoes
1	CDEC (EC)	4	Mixed	484	7.3	4.0	8.0	7.7
2	" "	"	Under	484	7.3	4.3	6.7	6.0
3	" "	"	No	-	6.3	2.0	8.3	6.7
4	" "	"	Mixed	706	6.7	4.3	8.0	6.7
5	" "	"	Under	706	7.3	4.3	8.0	5.7
							Spinach[3]	Tomatoes
6	CDAA (EC)	4	Mixed	484	9.0	7.0	5.7	8.3
7	" "	"	Under	484	8.0	6.3	3.0	8.7
8	" "	"	No	-	6.3	2.3	8.7	7.6
9	" "	"	Mixed	706	9.0	6.3	4.3	8.0
10	" "	"	Under	706	9.0	6.3	2.7	8.0
							Beans	Corn
11	Atrazine(80W)	2	Under	484	8.3	8.0	1.0	8.3
12	"	"	No	-	9.0	8.7	1.0	8.7
13	"	"	Under	706	8.7	7.7	1.0	8.3
							Beets	Beans
14	EPTC (EC)	4	Mixed	484	9.0	8.3	8.3	7.3
15	" (Inc.)	"	Under	484	9.0	8.7	8.0	8.0
16	"	"	No	-	7.0	7.3	8.0	8.7
17	" (Inc.)	"	Mixed	706	9.0	8.0	7.0	6.3
18	"	"	Under	706	9.0	8.3	6.7	7.3
							Cabbage	Carrots
19	Dacthal(50W)	8	Under	484	5.7	5.3	7.7	8.0
20	"	"	No	-	8.0	8.3	8.7	8.0
21	"	"	Under	706	5.7	3.7	5.0	7.0
							Beans	Corn
22	DNOSBP	4	Under	484	2.0	3.7	6.7	6.0
23	"	"	No	-	8.3	6.0	4.7	6.7
24	"	"	Under	706	3.0	3.7	7.7	6.3
							Corn	Beans
25	Check		No		3.7	5.0	8.3	9.0
							Spinach	Carrots
26	"		No		3.0	1.0	7.3	7.7
							Beets	Tomatoes
27	"		No		2.3	1.7	6.7	4.3
							Cabbage	Corn
28	"		No		2.0	1.0	6.0	7.0

[1] Weed Rating 9 = complete control 7 = commercial control 1 = no control.

[2] Crop Rating 9 = perfect growth 7 = acceptable 5 = stunting 1 = kill.

[3] Poor stand of spinach in all plots.

Table 2. The influence of herbicide formulations, depth of incorporation and petroleum mulch on performance of EPTC.

	Chemical	lbs/A	Type of[1] Incorporation	Mulch[2]	Weed[2] Rating	Crop Rating[3]	
						Beets	Cabbage
1	EPTC (E.C.)	3	Shallow	No	9.0 (8)[4]	1.5 (5)	1.0 (3)
2	"	"	"	Yes	9.0 (8)	1.0 (4)	1.0 (2)
3	"	"	Deep	No	9.0 (7)	1.3 (6)	1.0 (5)
4	"	"	"	Yes	9.0 (6)	1.3 (3)	1.0 (2)
5	"	"	Not inc.	No	7.3 (6)	3.3 (9)	4.0 (8)
6	"	"	"	Yes	9.0 (6)	1.8 (9)	1.8 (8)
7	EPTC (Gran)	3	Shallow	No	8.5 (6)	1.3 (3)	1.3 (2)
8	"	"	"	Yes	9.0 (6)	1.0 (2)	1.0 (3)
9	"	"	Deep	No	8.3 (9)	1.3 (2)	1.5 (2)
10	"	"	"	Yes	8.3 (7)	1.0 (2)	1.0 (5)
11	"	"	Not inc.	No	9.0 (6)	1.0 (4)	1.5 (5)
12	"	"	" "	Yes	9.0 (6)	1.0 (2)	1.0 (5)
13	Check		-	No	2.3 (3)	3.0 (5)	4.3 (9)
14	"			Yes	2.3 (1)	2.3 (8)	2.0 (8)

[1] Shallow incorporation 1/2". Deep incorporation 2 - 3 inches.

[2] Mulch - Rate of 484 gal/A.

[3] Weed and Crop Rating - see footnote table 1.

[4] Figures in parentheses are from a fifth replicate.

was harvested after 40 days of growth. However, early emergence and stand counts on beans indicated a delay and lowering of plant population when Eptam was mixed with or used under the mulch.

The mulch mixed with DNOSBP still resulted in herbicide inactivation as shown by lack of weed control and lack of toxicity toward spinach. The check plots indicate the use of mulch alone increased weed prevalence and also decreased the vigor and growth of spinach. This fourth test included several formulations which had been adjusted to a basic pH level in an attempt to determine if the pH of the mulch was affecting the activity of certain of the herbicides. From the weed control results presented in Table 4, it appears that higher pH did help in the case of the DNOSBP mixture since this is the only test where this compound gave satisfactory weed control when mixed with mulch.

The two Alanap formulations gave essentially no differences in either weed control or crop response.

It is interesting to note that in the checks, the mulch again stimulated the weed growth.

Table 3. Mulch with pre-mixed herbicides[1].

	Chemical	Rate/A lbs.	Mulch	Weed Rating[2]	Crop Yield lbs.spinach
1	EPTC (Inc.)	4	No	8.0	.73
2	" "		Mixed	7.5	.44
3	" "		Under	6.5	1.09
4	CIPC (EC)	6	No	8.5	1.67
5	"		Mixed	9.0	1.06
6	"		Under	9.0	1.37
7	CDEC (EC)	6	No	6.5	1.06
8	"		Mixed	7.0	.57
9	"		Under	6.0	.91
10	CDEC(EC) + CDAA(EC)	3+4 1/2	No	7.5	1.18
11			Mixed	7.0	.52
12			Under	6.5	.61
13	CNOSBP	5	No	8.5	.15
14			Mixed	2.5	1.15
15			Under	4.5	.81
	Av. of 4 checks		No	2.2	1.15
			Yes	1.0	.56

[1] Supplied by Esso.

[2] See footnote 1 Table 1.

Summary and Conclusions

1. Agricultural petroleum mulch frequently enhances weed growth.

2. Herbicides can be effectively used in conjunction with this mulch both mixed with or under the mulch. However, each chemical must be evaluated individually with respect to compatibility and effects on activity.

3. The residual effectiveness of CDEC and CDAA was lengthened when used in conjunction with mulch.

4. Compatibility problems arise with certain herbicide formulations such as Atrazine 80W, Dacthal 50W and DNOSBP amine salt liquid.

5. The physical condition of the soil surface is important when using petroleum mulch since this factor materially affects the type of seal resulting.

Table 4. The pH factor in mulch formulations.

				Weed[2]		Crop Rating[2]	
	Material	lbs/A	Mulch	Rating	Corn	Melon	Beans
1	Atrazine(80W)	2	Mixed B[1]	9.0	8.5	1.0	4.5
2	"		Under	9.0	8.5	1.0	2.5
3	"		No	9.0	7.5	1.0	1.5
4	Alanap 3 (EC)	6	Mixed B	8.0	8.0	9.0	8.0
5	"		Under	7.5	7.5	9.0	8.5
6	"		No	8.0	7.0	8.5	8.5
7	DNOSBP	5	Mixed B	8.0	9.0	9.0	9.0
8			Under	8.5	8.5	9.0	9.0
9			No	9.0	8.5	7.5	8.5
10	Alanap I (WP)	6	Mixed	6.5	8.5	9.0	9.0
11			Under	6.5	8.5	9.0	8.5
12			No	8.0	8.5	8.0	8.0
13	EPTC (EC)	4	Mixed B	8.5	8.5	4.5	6.5
14			Under	9.0	9.0	4.5	7.5
15			No	9.0	8.0	5.0	8.0
16	Check		Yes	6.5	8.0	8.0	7.5
17	"		No	7.0	6.5	7.5	8.0
18	Check		Yes	6.0	7.5	8.5	8.5
19	"		No	7.5	9.0	8.5	9.0
20	Check		Yes	6.0	8.5	9.0	8.0
21	"		No	7.0	7.5	7.5	8.5
22	Check		Yes	5.5	9.0	9.0	8.5
23	"		No	7.5	8.5	8.0	8.5
24	Check		Yes	5.5	8.0	9.0	8.5
25	"		No	7.5	7.0	8.0	8.5

[1] B = A basic mulch pH 7 - 8. All other mulch pH 3-4 (formulation EA 2000)

[2] See footnote table 1.

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6. Although EPTC (EC) normally requires incorporation, it appeared to have equal activity when not incorporated if covered by a continuous petroleum mulch film. EPTC (EC) also performed well when mixed with the mulch.

EFFECT OF COMPOSITION AND VOLUME OF ORGANIC SOLVENTS ON PERSISTENCE OF CARBAMATES IN SOILS AND ON GRANULAR CARRIERS

(Abstract)

L. L. Danielson and W. A. Gentner [1]

Earlier studies (Danielson et al, Weeds 9:463-476. 1961) showed that technical ethyl N,N-di-n-propylthiolcarbamate [EPTC] had long, intermediate, and short persistence when applied in 40 g/A of acetone, No. 2 fuel oil, and kerosene, respectively, in soil-incorporation studies.

Continuation of this research to evaluate the effect of volume of kerosene on persistence of soil-incorporated EPTC showed that persistence is short at 40 g/A and increases as the volume decreases. The period of persistence is not affected in the range of 40 to 138 g/A.

Measurable but limited differences in persistence of soil-incorporated isopropyl N-(3-chlorophenyl)carbamate [CIPC] and 2-chloroallyl diethyldithiocarbamate [CDEC] were observed in greenhouse studies when the herbicides were applied in 40 g/A of acetone, benzene, xylene, No. 2 fuel oil, and kerosene. Persistence of soil-incorporated ethyl N,N-di-n-butylthiolcarbamate (R-1870) was similar to that of EPTC when the same solvents were used.

Fourteen liquid petroleum fractions were evaluated as carriers for impregnation of EPTC on uncalcined 30/60 attapulgite applied as surface and soil-incorporated treatments in greenhouse experiments. Persistence was differentially affected by solvents and placement.

Four petroleum waxes were used at 2, 4, 8, and 16 lb/A in a continuation of the study of petroleum fractions as carriers for impregnation of EPTC on 40 lb/A of 30/60-mesh uncalcined granular attapulgite for use as soil-surface treatments. The persistence of EPTC was differentially affected by the amounts and composition of the waxes. Persistence of EPTC was inversely related to the amounts of waxes used.

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EFFECTS OF NUMBER AND SIZE OF CLAY GRANULES ON PERFORMANCE OF GRANULAR HERBICIDES

(Abstract)

L. L. Danielson and W. A. Gentner [1]

Uncalcined attapulgite granules of 15/30-, 20/35-, and 30/60-mesh sieve sizes were used in greenhouse and growth room studies to determine the effects of size and number of granules per unit of soil area or soil volume on the activity and persistence of soil-surface-applied and soil-incorporated ethyl N,N-di-n-propylthiolcarbamate [EPTC].

EPTC was applied at 2 lb/A on 5, 10, 20, and 30 lb of each clay carrier mesh size. Granules were prepared by dissolving the required amount of technical EPTC in kerosene at a rate of 20 ml of kerosene to each 100 grams of clay carrier. The granular preparations were applied simultaneously as surface treatments to soil in plasticized paper cups and as incorporated treatments in quart plastic containers of soil. The soil used was a 1:1 potting soil-washed pit sand mixture. Nine replicates of each treatment were prepared for bioassays with ryegrass on each of three dates (immediately after treatment and 2 and 4 weeks). The entire experiment was duplicated for concurrent studies under greenhouse and controlled growth-room conditions. All containers were sub-irrigated. Average temperatures in the greenhouse were approximately 80 to 85°F for days and 65 to 70° for nights. Growth-room temperatures were maintained at 70°. Air movement in the greenhouse was slight whereas it was rapid in the growth room. Greenhouse light intensities were relatively high as compared with approximately 1500 foot-candles in the growth room.

In 4 weeks surface-applied EPTC was dissipated in the greenhouse and the growth room irrespective of carrier particle size or number, but none of the soil-incorporated chemical was dissipated. Clay particle size and number therefore do not appear to be critical in the effective use of EPTC in granular form in surface or soil-incorporated treatments. Field experience indicates that similar studies on slightly soluble, highly soluble, and vapor-active herbicides on granules are necessary.

Soil-surface chemical dissipated more rapidly in the growth room in initial and confirmatory experiments. Evaluation of greenhouse and growth-room environments suggests that air movement can facilitate dissipation of soil-surface-applied EPTC.

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A LOGARITHMIC SPRAYER FOR SMALL PLOTS[1]

J. C. Cialone and G. Bayer

Introduction

Many versions of the logarithmic type sprayer have been devised since the advent of the Chesterford Logarithmic Sprayer, introduced by Hartley, Pfeiffer and Brunskill in 1956(3). The uses for this type of sprayer have been covered by Leasure (4). Efforts have been made by some workers to develop a logarithmic type sprayer which would be suitable for small plots (1,2). In the opinion of the authors most of these efforts have failed to give a sprayer which is truly suitable to small plot work. Most of the sprayers developed have used complicated and expensive components (1,2,3,4) and ease of handling with respect to portability has in most cases been overlooked. It is realized that simplification can result in sacrifices in accuracy and other desirable properties, however, if the desired properties plus simplicity can be incorporated, gains can be made in the range of areas where such a piece of equipment can be utilized.

In the work of Ries and Terry (5) with a small plot sprayer, the various desirable properties of small sprayers for experimental work were enumerated. They are:

1. Accurate herbicide applications should be easily attained on "small plots" of either a few or a few hundred square feet.

2. Cost should be low.

3. Construction and operation should be simple.

4. Operation should be accurate and efficient under a variety of soil conditions.

5. Changing from one herbicide to another should be rapid.

6. Contamination between herbicides must be negligible.

7. Agitation of spray liquid should be adequate for a wide range of materials and formulations.

8. Uniform pressure should be maintained.

9. Apparatus should be sufficiently light in weight to permit easy operation by one person without need of wheels, tractors, extra personnel, etc.

It is felt that these features are applicable to any log-sprayer designed for small plot use. In addition, the property of requiring only small amounts of chemical is desirable where new herbicides are being tested. The Ries and Terry sprayer was designed on the basis of the 9 points which they outlined. The size of their sprayer system further allows their sprayer to fill the requirement of using only small amounts of chemical.

With the above in mind a log-sprayer was designed using the Ries and Terry sprayer as the basic component.

Design Features

The authors, using the basic Ries and Terry small plot sprayer (5), have adapted the unit so that a logarithmic dosage curve can be obtained. The modified sprayer consists essentially of two basic units of different size connected in series. The unit closest to the CO_2 source is a quart glass round type milk bottle and serves as the diluent tank or source. The unit nearest the boom is a similar pint bottle and serves as the concentrate chamber. The pressure source is a CO_2 cylinder with a pre-set pressure-regulating valve. (Fig. 1.).

In most log-sprayers elaborate mechanical agitation is provided, however, none is included in the present model. The mixing of the solutions in the concentrate tank is accomplished by the hydraulic force of the diluent entering the pint bottle. The inlet is adjacent to the outlet and this plus the fact that there is only a relatively small volume (1 pint) in the chamber makes adequate mixing possible.

The factors affecting any spray apparatus such as pressure, nozzle size, speed, etc. govern the range of output of this sprayer. Since the sprayer must be carried by hand, walking speed becomes an important factor. Experience has shown that walking speeds for distances up to 40 feet can be controlled quite accurately without the use of any special pace setting devices. For this reason it is best to keep plot sizes within this limit unless special means are used to set a constant pace for the operator. To overcome some of the problems involved with walking speed, a float valve, consisting of a round wooden ball has been put in the diluent chamber. When all the liquid in this chamber is expended the ball seals off the outlet and instantly cuts off the pressure supply. Since the two containers are connected in series, stopping the flow of diluent stops all flow from the nozzles and the dilution of the material in the concentrate tank stops. This marks the end of the plot, which is then measured and dosage calculated.

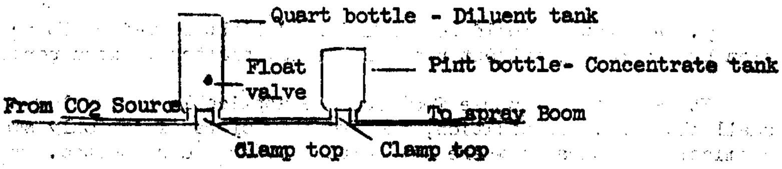

Figure 1. A schematic drawing of the logarithmic concentration sprayer when in position for spraying.

Dosage Calculations

The actual initial concentration of solution in the concentrate chamber is unaffected by distance or area covered, however, the initial dosage rate/a converted from this concentration does vary as to total area covered. In general a given amount of material is placed in the concentrate tank depending on the desired total plot size and the desired dosages. The float valve (wooden ball) on the diluent supply has the advantage of allowing accurate calculation of rates used in case the desired plot length was "missed" by the applicator. With any spray application, speed must be constant. All of the above generalizations regarding dosages with this sprayer are based on the assumption that walking speed is constant. If the desired plot length is not attained, it must be assumed that the speed was incorrect but yet constant. Data by Ries and Terry (5) show that constant walking speeds are readily obtained with relatively little training.

To determine the accuracy of the sprayer, including walking speed, Calcium Chloride solution was placed in the concentrate tank, and sprayed out in the normal manner along a desired plot length. At three foot intervals petri dishes had previously been placed along the plot. Following spraying the solutions in the dishes were read with a hand refractometer. The results of these are summarized in Figure 2. They clearly indicate that this apparatus follows the theoretical log-response curve within very close limits. The lag of 3 feet at the beginning of the plot and the slight drop in concentration is believed to be due to the filling of the boom as the solution begins to flow.

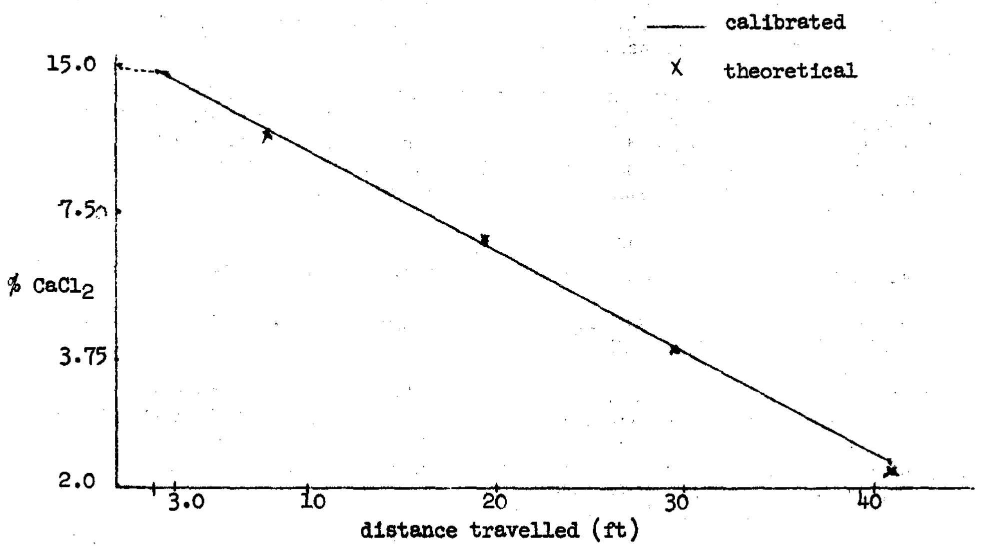

Figure 2. Summary of calibration data on log-sprayer obtained from regrac-

A half-dosage distance of 10-15 feet seems to be best due to the fact that any shorter distance would not give accurate results unless crop and weed populations were heavy and uniform.

Discussion

It is realized that certain limitations are inherent in this sprayer due to the size of the diluent container used. It can be calculated from the formula of Leasure (4) that when one quart of diluent is diluted through one pint of concentrate the initial concentration in the concentrate chamber will be halved two full times and almost a third time.

Even this limit is not reached with this apparatus due to the fact that the float valve stops the flow before one full quart has diluted through the concentrate chamber. The piping in the system accounts for this as it is full at the time the float valve closes.

The properties of needing so little chemical and that operation of the apparatus is so rapid, overcomes to a great extent the fact that limited dilution can be attained, by making it possible to use various initial rates of a chemical and to apply them to several plots in a short period of time.

Experiments in the field with combinations and single chemicals, both wettable powder and liquid formulations, have indicated that these formulations were sprayed in a satisfactory manner.

Summary

A small plot logarithmic sprayer has been designed using the basic sprayer of Ries and Terry. The properties of low cost, portability, ease of operation, ease of cleaning and adaptability to small plots make it extremely valuable where land and time are limited.

The dosage curve of the apparatus follows very closely the theoretical log-response curve. Although no mechanical agitation is provided, no difficulties have arisen with either liquid or wettable powder formulations. Special attention has been given to use with combinations and it is felt that the apparatus has greatest utility with testing of chemical mixtures.

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Selective Herbicides for Several Crucifer Crops[1] [3]

Rodger Hargan, Geo. Bayer, Joseph Cialone[2]

In New York about 16,000 acres of cabbage, 5000 acres of cauliflower, and about 2600 acres of broccoli are grown each season. Almost the entire acreage is transplanted rather than direct field-seeded. For many horticultural and economic reasons research workers and growers are investigating the technique of field-seeding. Whereas with transplants, the need for an herbicide is minor, with field-seeding there is an almost impossible weed problem unless an herbicide is used.

The purpose of the investigations being reported here was as follows:

1. To investigate crop residues with the more promising herbicides under a wide range of soil and weather conditions.

2. To evaluate weed control potential and crop response to the more promising herbicides under the above conditions.

3. To evaluate in a limited fashion chemicals just recently released to research workers for their potential as herbicides in crucifer plantings.

Field Evaluation of Promising Herbicides

For several seasons, research in Virginia and by the staff at Ithaca has shown that CDEC has potential for seeded and transplanted crucifers. In '59 and '60 the authors found Dacthal (DAC 893) to be promising. In 1960 Zytron performed very well in a limited number of tests at Ithaca. In 1960 Dallyn and Sawyer (1) reported Dacthal as promising. That same season Sweet and Cialone (2a, 2b) reported combinations of CDEC and CDAA as being worthy of further trials.

Tests were conducted in 1961 at 15 locations representing up-State New York production areas for broccoli, cabbage and cauliflower. These tests were designed to evaluate the promising materials noted above in regard to crop response, weed control, and chemical residue in the crop under a wide range of soil and environmental conditions. In addition, the factor of field-seeding vs. transplanting, was investigated with broccoli and cabbage. A summary of peritnent conditions for each test is presented in Table 1.

Each test contained 4 replications with treatments randomized within each replication. Plots were one row wide and 20 feet long. All liquid materials were applied with a small plot, CO_2, hand operated sprayer. Granulars were applied with a small hand shaker.

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[1] Paper No. 468. Department of Vegetable Crops, Cornell University, Ithaca,N.Y.
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[3] Much of the work conducted away from Ithaca was supported by a grant in aid from the Diamond-Alkali Company, Cleveland, Ohio.

Table 1. Summary of experimental conditions for field trials on broccoli, cabbage and cauliflower.

Crop and Method of planting	Direct field-seeded broccoli					Transplanted broccoli		
Test no.	1	2	3	4	5	6	7	8
Planted	6/15	6/23	6/28	6/29	6/29	WE	WE	WE
Treated	6/15	6/23	6/28	6/29	6/29	7/26	7/27	7/27
Soil type	Silty clay loem	sandy loam	silt loam	sandy loam	stoney silt loam	silt loam	sand	silty clay loam

Crop and method of planting	seeded cabbage		transplanted cabbage					Transplanted cauliflower	
Test no.	4	5	9	10	11	12	13	14	15
Planted	6/29	6/29	WE	WE	WE	WE	7/1	7/10	WE
Treated	6/29	6/29	7/27	7/27	8/24	6/28	7/7	7/10	7/27
Soil type	sandy loam	stoney silt loam	sandy loam	silt loam	silty clay loam	silt loam	silt loam	sand	sandy loam

WE - plants well-established and growing vigorously.

Table 2. Summary of weed and crop responses to chemicals in 15 field tests.

	Susceptible weeds	Tolerant weeds
Dacthal, Zytron and CDEC+CDAA[1]	lambsquarters, redroot Eragrostis sp. purslane crabgrass,	ragweed, smartweed nutgrass, Equisetum barnyard grass, galinsoga.

	Crop Responses
Dacthal	no symptoms on any crop at any location.
CDEC+CDAA	no symptoms on any crop at any location.
Zytron	Three instances of severe foliage symptoms in 15 tests. Two of these were due to the liquid formulation. One occurred on direct-seeded broccoli.

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[1] Chemicals generally performed similarly on the several weed species. However, in most locations the level of weed control was slightly lower with CDEC+CDAA.

Broccoli and cabbage were combined in alternate rows in experimental fields at locations 4 and 5. All other tests were situated in growers' fields. In these instances the entire crop production with the exception of weed control was according to the commercial practises of the particular grower.

Dacthal WP was applied at 8 and 24 pounds; Zytron either liquid or granular at 8 and 12 pounds; CDEC granular was combined with CDAA granular at 2+2 and 3+3lbs.

Results and Discussion.

A summary of crop and weed response is presented in Table 2. Both Dacthal and granular Zytron at 8 pounds per acre resulted in good weed control, and good crop tolerance on all crops whether direct-seeded or transplanted.

Dacthal proved to be safe under all conditions even at rates three-fold, which were needed for weed control. In the earliest tests, Zytron liquid, however, proved toxic to crucifer foliage. The symptoms were chlorosis in areas of the leaf where spray accumulated; cupping of leaves was also noted. General stunting of growth accompanied these symptoms. Zytron granular was, therefore, substituted in the later tests and no damage to foliage was evident. These symptoms of damage were generally outgrown at harvest and yields were usually satisfactory. Zytron at 12 pounds caused some damage at one location even on the seeded crops. This indicates a possible narrow safety margin. Weed control was generally good with both Zytron and Dacthal. Both materials were effective against redroot pigweed, lambsquarters, purslane, crabgrass and Eragrostis megastachya. Neither material controlled ragweed, smartweed, barnyard grass, gallinsoga, Equisetiem sp., or northern nutgrass.

Combinations of CDEC and CDAA proved safe on crops. However, weed conrol was in most locations slightly lower than that obtained with either Dacthal or Zytron. Weed specie tolerance and susceptibility followed about the same pattern with the combinations as noted above with Dacthal and Zytron.

Yield data of good reliability is not generally available from these tests because of the need for harvesting plots differentially depending on residue sample needs. Incomplete yield records, however, tended to bear out the visual ratings of crop response.

Samples for residue analysis were obtained from all locations. All samples were submitted to the appropriate company laboratory. Detailed results are not yet available, however, the preliminary picture looks very good for Dacthal and for CDEC-CDAA combinations.

Cabbage Variety Responses

A county agent working with the same treatments as those in the 15 tests described above, reported severe damage from Zytron on seeded cabbage. An investigation was made of such factors as soil, environment, rate, etc., but no cause for this trouble was evident. Two factors were suspect: the formulation used in the agent's work was somewhat different from that used in the 1960 Cornell work; the cabbage variety was a newly introduced Yellows Resistant Glory. Tests were immediately conducted on cabbage and broccoli to determine if formulation were a factor. These tests indicated no differential response between 1959 and 1960 formulations regardless of rate. A test involving five varieties of cabbage was then conducted. Marion Market was included because it was the variety on which all previous Cornell herbicide work had been done. In addition to the new Yellows Resistant Glory variety which had been damaged, two standard strains of Danish Ballhead were included, one of which was yellows resistant. Also included was a new hybrid C-2A.

The experimental design for chemicals was a randomized block with 4 replications. Dacthal and Zytron were included at 12 pounds each. Individual plots were 6x20 feet and the five varieties were planted in a systematic order lengthwise of each plot. Plots were fitted, seeded and treated July 11. The sandy loam soil was moist and in excellent physical condition. Light showers followed planting. This plus warm weather promoted rapid germination and an almost perfect stand resulted. When the plants were well-established they were thinned to approximately one per foot of row.

The variety responses are presented in Table 3. It is readily apparent that Dacthal had no adverse effect on any variety. However, Zytron was variable. Marion Market was not injured. Resistant Glory and Resistant Danish, however, gave severe symptoms in certain replicates and not in the others. The other varieties were not influenced. Thus, it appears that the Zytron damage reported from the field was possibly due to differential varietal response.

Table 3. Ratings of Cabbage Varieties Treated with Dacthal and Zytron.

	Dacthal - 12 lbs/A				Zytron - 12 lbs/A			
	Replication				Replication			
Variety	I	II	III	IV	I	II	III	IV
Marion Market	9	9	9	9	9	9	9	9
Danish Ballhead	7	9	8	8	8	9	8	8
Resistant Danish	8	9	9	9	6	8	8	9
Hybrid C2A	9	9	9	9	9	8	8	7
Resistant Glory	9	9	9	9	9	4	9	6

Rating Scale: 9 = no injury. 7 = commercially acceptable crop.
5 = moderate damage. 1 = Crop dead.

New Chemical Evaluation - 1961

There were three tests conducted on fine sandy loam soil at Ithaca in 1961 in an attempt to evaluate new chemicals as possible selective herbicides in field-seeded broccoli, cabbage and cauliflower. All tests were treated the same day as the soil was fitted and seed planted. Each plot was 3 x 15 feet with two replications per test. Sprays were applied by means of a small plot CO_2 sprayer at 30 lbs. pressure. Since formulations of new compounds are almost "unknowns" for field application, they were applied in about 100 gallons of water to the acre in order to minimize possible formulation problems. Granular formulations were applied with a hand shaker. Those compounds known to need soil incorporation for best results, were hand-raked immediately after treating, just prior to crop seeding.

The first test treated July 7 included many new compounds as well as the standard or promising ones from previous year's test. Dacthal was inadvertently omitted frmm this first test. A second test started five weeks later omitted the least promising of the compounds from the first test. A third test treated August 24 expanded the range of rates of certain promising new materials. It also included a few new compounds not previously tested.

Results and Discussion

The rainfall pattern the first week following treating was distinctly different for the three tests. It can be seen in Table 4 that for this period in the first test there were two moderate rains followed by a heavy rain and this was followed by another moderate rain making for a total of about three inches. This spacing out of the rain, yet fairly heavy total possibly caused relatively heavy leaching of any compounds likely to do so. In the second test, however, no early rains occurred that would be of consequence from a leaching standpoint. However, weed and crop seeds were in a moist environment and excellent germination and early growth occurred. In the third test an exceedingly heavy downpour (1.45 in.) occurred within a few hours of treating. This storm was very intense but of short duration, consequently heavy run off occurred, rather than the deep penetration and leaching normally expected from 1.45 inches of rain on a sandy soil.

Table 4. Inches of rainfall for 7 days following application of new chemicals.

Days following treating	Test 1 June 7	Test 2 July 12	Test 3 August 24
0	.00	.00	1.45
1	.65	Trace	.32
2	.01	.05	.00
3	.78	.19	Trace
4	1.08	.07	.03
5	.00	.15	.00
6	.50	.00	.00
7	.03	.02	.02
Total	3.05	0.48	1.82

It can be seen in Table 5 that Diphenamid was exceptionally variable in performance between the several tests. It is thought that the leaching variable may account for these differences. Dacthal gave uniformly good results. There is a suggestion that perhaps Zytron and dipropalin are toxic to crucifers at higher rates. Trifluralin was outstanding in weed control. Except where leaching was probably severe it appears to be safe, even at 3 or 4 times the dosage needed for weed control. CDEC-CDAA performed well with little crop damage and generally good weed control. However, in the second test where no heavy rains occurred, weed control was only mediocre.

Those compounds performing unsatisfactorily either because of poor weed control or because of crop injury are listed in Table 6.

Summary

1. Dacthal has a wide margin of safety on seeded or transplanted broccoli, cabbage, and cauliflower. It is effective on many annual weed species. Three weed species tolerant of Dacthal are ragweed, smartweed and galinsoga.

2. Zytron has approximately the same activity as Dacthal as far as weed species is concerned. However, there seems to be a distinctly narrower margin of crop safety. The granular formulation must be substituted for the liquid if crucifer foliage is present.

3. Cabbage varieties appear to react differentially to Zytron. In one trial two yellows resistant varieties seemed to be more susceptible than non-resistant. However only 5 varieties were included in this study. More work is needed on this aspect.

Table 5. Ratings[1] of field seed crucifers and weed control obtained from Evaluation Tests of new chemicals.

		Test 1			Test 2		Test 3[2]		
Chemical	lbs.	weeds	cab.	broc.	weeds	broc.	cab.	broc.	caul.
Dacthal	8	-	-	-	7.5	7.0	8.5		
	12	-	-	-	7.5	7.5	8.5		
Zytron	8	8.5	8.5	9.0	8.0	8.5	9.0		
	12	9.0	8.5	8.0	8.5	6.5	9.0		
Dipropalin	1	-	-	-	6.0	8.5	-		
	2	-	-	-	6.5	7.0	-		
	4	8.5	8.5	8.0	-	-	8.0		
	8	8.0	6.0	7.5	-	-	8.0		
	12	-	-	-	-	-	7.5		
Upjohn 4513	1	-	-	-	6.0	7.0	-		
	2	9.0	4.5	5.0	7.5	7.0	-		
	4	9.0	2.0	2.0	8.5	7.5	-		
Diphenamid	4	9.0	1.5	1.5	8.5	6.5	6.0		
	8	9.0	1.5	1.5	-	-	8.0		
Trifluralin	1	-	-	-	8.0	7.0	-		
	2	-	-	-	-	-	8.0		
	3	-	-	-	9.0	7.0	-		
	4	8.5	4.0	7.0	-	-	-		
	8	8.0	6.0	8.0	-	-	7.5		
	12	-	-	-	-	-	7.5		
CDAA	2+2	7.0	7.0	8.5	-	-			
+ CDEC	2.5 + 2.5	-	-	-	6.5	7.5			
	3+3	7.5	8.0	8.0	-	-	7.5		
Check	-	2.0	7.0	7.7	3.2	7.3	7.3		

[1] 9 = perfect crop growth and weed control
7 = commercially acceptable crop growth and weed control
5 = commercially unacceptable crop growth and weed control
3 = severe crop damage and very poor weed control.
1 = crop kill and no weed control

[2] ratings identical for all three crops.

Table 6. Newer chemicals unsatisfactory in 1961 for seeded crucifers.

Chemicals lacking crop tolerance but giving adequate weed control		lbs/A	Chemicals lacking weed control and/or crop tolerance		lbs/A
Amchem	61-122	4, 8	Amchem	61-81	2,4
Bayer	30056	2, 4	Stauffer	1856*	2,4
"	35850	2,4	"	1870*	2,4
"	40057	4, 8	"	2007*	2,4
Dacthal & Amiben		4+2, 6+3	"	3415	5,10
Monsanto	13936	4, 6	"	3400+3415	3+3, 5+5
Solan		4	"	3441	5,10
Stauffer	3400	5,10			
"	3408	5,10			
"	Tillam*	2, 4			
Velsicol Banvel T		4, 8			

*raked into soil immediately following application and just prior to seeding crop.

4. Two new compounds Trifluralin and Dipropalin seem to have potential for further study as additional selectives for crucifers. Trifluralin is particularly promising because of its weed killing activity at rates of 1 and 2 pounds an acre.

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Weeding of Lima Beans With Chemical Herbicides

Charles J. Noll[1]

The weeding of lima beans is important in reducing the cost of production of this crop. DNBP has been commonly used but the search continues for a better and less expensive chemical. The experiment reported in this paper is a continuation of work started a few years ago.

PROCEDURE

The seedbed was prepared and pre-planting treatments made June 1. These treatments were incorporated in the soil with a rototiller set shallow. The following day the lima bean variety Fordhook 242 was seeded. The pre-emergence treatments were applied from 1 to 6 days after planting. Post-emergence treatments were made 10 days after planting. Individual plots were 27 feet long and 3 feet wide. Treatments were randomized in each of 6 blocks.

The chemicals were applied with a small sprayer over the row for a width of 12 inches. Cultivation controlled the weeds between the rows. An estimate of weed control was made August 24 on a basis of 1 to 10, 1 being most desirable and 10 being least desirable. Bean harvest was completed September 29.

RESULTS

The results are presented in table 1. All chemicals significantly increased weed control as compared to the untreated check. There were significant differences in weed control between the treated plots but the higher rate of treatment of most chemicals gave sufficient weed control. The stand of plants was unaffected by the treatments. All treatments except U-4513 at the lesser rate resulted in significant increase in weight of beans.

CONCLUSION

Taking into consideration weed control, stand of plants and yield no chemical treatment was superior to DNBP applied post-emergence. Many chemicals did a good job of weeding lima beans without injury to the stand and with increase in yield as compared to the untreated check plot. Some of the most promising of these are Atrametryne, Trietazine, Herb. 326 and Hercules 7531.

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Table 1. Weed control, stand of plants and yield of lima beans under chemical herbicide treatments.

Chemical	Active Rate Per Acre lbs.	Application Days from Seeding	AVERAGE PER PLOT		
			*Weed Control (1-10)	Stand of Plants	Wt. of Beans lbs.
Nothing	--	--	9.2	91	8.4
Tillam	4	Soil Inc. -1	4.7	92	13.6
"	6	" " -1	3.5	85	14.7
Amiben	3	Planting Time 0	3.2	91	14.4
"	4½	" " 0	4.0	93	13.4
Prometryne	2	" " 0	2.2	89	16.1
"	3	" " 0	1.7	90	14.9
Atrametryne	3	Pre-emergence 5	2.3	90	17.3
"	4½	" 5	2.0	91	16.2
Trietazine	4	" 5	2.0	92	16.3
"	6	" 5	1.7	92	16.8
Herb 326	2	" 5	3.0	85	14.3
"	3	" 5	1.3	85	16.1
O.M. 1306	10	" 5	6.2	89	12.7
"	15	" 5	3.7	88	14.5
Hercules 7531	3	" 5	2.2	88	16.1
"	4½	" 5	1.7	83	17.4
CP 17029	3	" 5	4.2	93	14.4
"	4½	" 5	4.0	92	13.7
Nia. 2995	4	" 5	4.5	85	13.1
"	6	" 5	3.8	86	15.6
U-4513	2	" 5	5.3	86	11.1
"	3	" 5	4.0	91	12.7
Dacthal W-50R	8	" 6	3.3	88	15.1
"	12	" 6	2.0	86	12.5
Dacthal W-50	8	" 6	3.8	86	14.6
"	12	" 6	3.0	87	15.2
Diphenamid	6	" 6	2.5	88	14.5
"	9	" 6	2.0	86	15.9
Zytron	10	" 6	4.2	89	15.0
"	15	" 6	2.3	90	16.5
DNBP + Zytron	3 + 6	" 6	4.3	85	16.2
DNBP + Vegadex	3 + 6	" 6	6.0	89	13.4
DNBP (Premerge)	4	Post-emergence 10	2.3	79	17.2
DNBP (Granular)	4	" 10	3.0	86	16.8
"	8	" 10	1.8	86	15.9
Least significant difference 5%			1.8	N.S.D.	4.0
1%			2.4	N.S.D.	N.S.D.

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

EFFECT OF HERBICIDES ON QUALITY AND YIELD OF SWEET POTATOES
(A PROGRESS REPORT)

William V. Welker, Jr.[1]

Weeds are one of the major problems in the culture of sweet potatoes. Four to six cultivations per season plus hand weeding are general practices employed in sweet potato culture. Chemical weed control measures would appear to have considerable economic potential. The project was initiated in 1959 with greenhouse screening of chemicals on four varieties of sweet potatoes. The most promising chemicals were taken to the field in 1960. Most of the treatments were repeated during 1961.

The field experiments were carried out on a sandy loam soil. A randomized complete block design with four replicates was used. Each plot consisted of two rows 30 feet long with a guard row on each side. All herbicides, except NPA (N-1-naphthylphthalamic acid) which was applied as a granular, were applied as sprays. The sprays were applied over the foliage of the sweet potato plants shortly after the plants were set in the field. During 1960 the plots received normal cultivation between the rows beginning three weeks after the herbicides were applied. During 1961 the plots received no cultivation after the herbicide treatments. Weeds were counted several times during each season. All plots were hand-weeded at the normal lay-by time.

The predominant weed species present both years were crabgrass (*Digitaria sanguinalis* (L.) Scap.), pigweed (*Amaranthus retroflexus* L.), lambsquarters (*Chenopodium album* L.), and common ragweed (*Ambrosia artemisiifolia* L.). The data taken included weed control, injury following herbicide application, yield, internal color analysis, organoleptic tests, and herbicide effect on storage and sprouting.

The specific effect of the herbicides upon yields, weed control, and quality factors will be discussed. Amiben (3 amino-2, 5-dichlorobenzoic acid), casoron (2,4 dichlorobenzonitrile), diphenamid (N,N-dimethyl-α-α-diphenylacetamide), and dacthal (dimethyl 2,3,5,6 tetrachloroterephalate) appeared acceptable with respect to all factors studied. NPA was not included in the 1961 experiment because of its harmful effects upon skin quality found in the 1960 experiments. CIPC (isopropyl N-(3-chlorophenyl) carbamate) injured the sweet potato plant and reduced yield. The weed control obtained with CIPC was less satisfactory than that obtained with the other compounds. Diphenamid was included only in the 1961 experiments.

These studies indicated that the solution of the weed control problem without a reduction of sweet potato yields is at hand. Additional investigation of the effects of herbicides on quality is needed.

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PROGRESS REPORT ON CHEMICAL WEED CONTROL
IN LEAF CROPS OF EASTERN VIRGINIA

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Introduction

The vegetable leaf crops still are and will continue to be a major agricultural industry in Tidewater Virginia. The development and use of effective and economical weed control procedures are in large part responsible for their continued success.

The leaf crops of principal importance in this area are spinach and kale, but also include commercial production of collards, turnip greens, mustard greens, cress, Hanover salad, leaf cabbage, and others. All of these crops are grown for both fresh market and processing, are harvested both by hand and mechanically, and may be planted at various times of the year.

For the past several years, Vegadex (CDEC) and CIPC have been the standard herbicides for pre-emergence weed control in leaf crops of eastern Virginia. Previous work by Danielson (1) and Price (2) has led to the more general local use of a mixture of Vegadex (2 lbs/A) plus CIPC (½ lb/A). This combination is not only less expensive but also is safer on most leaf crops and results in more general weed control than either herbicide alone at higher rates.

While these herbicides have generally given very good weed control with little or no crop injury when properly used, they are subject to limitations. Their most serious limitations are (1) the short residual in the soil, and (2) the incomplete range of weeds controlled. Weed problems in leaf crops of this area cover a broad spectrum of weed species and climatic conditions due to the planting of these crops during various periods of the year. The limitations of the standard materials now used are especially important in the crops planted during spring and hot summer periods when weather conditions shorten the herbicide residual and when more resistant broadleaf weeds germinate.

Trial No. 1: Pre-emergence herbicide applications on five leaf crops using the logarithmic sprayer.

Methods and Materials

Crop varieties:

Spinach - Old Dominion Blight Resistant
Kale - Vates Dwarf Blue Curled Scotch
Collards - Vates
Turnip greens - Seven Top Salad
Cress - Upland

Date planted: 9/5/61

Date treated: 9/6/61
Soil moisture: medium below, but dry on surface and in seed zone.
Soil type: sandy clay loam
Plot arrangement: One row of each crop was planted on a 3½ ft. bed 110 ft. long.
Herbicide treatments: All herbicides were applied beginning at the rate of 16 lbs/A and decreasing to 1/2 lb/A with a half dosage distance of 20 ft., using 125 gals/acre at 40 psi. The width of the sprayed area was about 5 ft. There was no cultivation or hand weeding.

Rainfall data: 0.52 in. the day prior to making the beds and planting. Soil surface and seed zone dried out rapidly and remained dry until Sept. 14 when 0.67 in. fell. Subsequent precipitation during the 4 weeks after planting was: Sept. 15, 0.14 in.; Sept. 18-20, 0.35 in., Sept. 28, 0.40 in.; and Oct. 2-4, 1.98 ins.

Results and Observations

Visual observations and measurements are summarized in Table 1. There were several herbicides besides the standard treatments which showed promising degrees of crop-weed selectivity. The material with the widest safety margin on most crops was Dacthal, giving good initial weed control to 1 lb/A while showing no crop injury at the highest rate of 16 lbs/A, except on spinach which was tolerant below 4 lbs/A. R-1870 was equally safe on most crops including spinach, at 16 lbs/A, but 6 lbs/A were required for good weed control. Other materials showing good selectivity on most crops tested were Trifluralin (½ to 3 lbs/A), Tillam (4 to 8 lbs/A) and Eptam (4 to 8 lbs/A except on spinach). Zytron (4 to 6 lbs/A), Randox (3 to 4 lbs/A) and NIA 6370 (8 to 12 lbs/A) showed limited possibilities on specific crops.

It is obvious that the dry and hot weather conditions at the time of application and for 8 days afterward had a major influence on the results. Unusually high rates, especially of the thiolcarbamates, were necessary for good weed control. However, crop tolerance also resulted at correspondingly high rates. Increased efficiency from these materials, as well as Vegadex and CIPC, has consistently been obtained when followed by rain or sprinkling. Trifluralin, Diphenamid, Zytron and Dacthal, on the other hand, are apparently not so subject to volatilization and loss under adverse weather and soil conditions. Other tests show, however, that Dacthal is very dependant on precipitation getting it into the soil before the weed seeds germinate.

Trial No. 2: Pre-emergence herbicide applications on six leaf crops using conventional plots.

Methods and Materials

Crop varieties:

Spinach - Old Dominion Blight Resistant
Kale - Vates Dwarf Blue Curled Scotch
Hanover salad - Early
Collards - Vates
Turnip greens - Seven Top Salad

Table 1. Selectivity Ranges from Herbicide Applications on Five Leaf Crops Using the Logarithmic Sprayer.

Herbicide	Maximum Rate for Crop Tolerance (lbs/A.) Spinach	Kale	Collards	Turnips	Cress	Good Control (lbs/A.) Grasses	Broad-leafs	Residual Weed Control (11/24/61)
R-3400	8	4	6	4	4	10	8	Poor
R-3408	6	4	4	4	4	12	10	Poor
R-3415	3	16	16	16	16	8	10	Poor
R-1870	16	16	16	16	8	6	4	Poor
Tillam	8	8	8	8	6	4	4	Poor
Eptam	4	8	8	8	8	4	4	Poor
CIPC	3	2	2	2	2	1½	½	Fair above 8 lbs/A
Vegadex	10	16	16	16	10	3	4	Poor
Vegadex + CIPC	8 + 2	6 + 1½	6 + 1½	6 + 1½	6 + 1½	3 + 3/4	2 + ½	Fair above 8+2 lbs/A
Randox	4	4	4	3	3	1½	3	Poor
Vegadex + Randox	4 + 4	4 + 4	4 + 4	3 + 3	3 + 3	1 + 1	1½+1½	Fair above 8 + 8
Dacthal	4	16	16	16	16	1	1	Poor
Zytron	6	6	6	2	2	4	3	Good above 6 lbs/A.
NIA 6370	12	8	8	6	6	8	8	Fair above 8 lbs/A.
Trifluralin	3	4	6	4	3	½	½	Good above 2 lbs/A except on carpet cress.
Diphenamid	1	½	½	1	½	1	½	Good above 1 lb/A

Date planted: 9/5/61
Date treated: 9/7 & 8/61
Soil moisture: medium below, but dry on surface and in seed zone.
Soil type: sandy clay loam

Plot arrangement: Plots consisted of two 3½ ft. beds 20 ft. long. One row of each crop was planted per plot, with 3 crops per bed.

Experimental design: Randomized block with 3 reps.

Herbicide treatments: Spray treatments were applied on 9/7/61 in 30 gals/A at 30 psi. Granular materials were applied on 9/8/61 using a small hand duster. There was no cultivation or hand weeding.

Rainfall data: Same as in trial No. 1.

Area harvested: Hanover salad and turnip greens were harvested on 10/31/61 The yield data represent one row, 20 ft. long, of each crop per plot. The other crops will probably be harvested in the spring.

Results and Observations

The visual observations in Table 2 and yield date in Table 3 generally agree with the results reported for trial No. 1.

The most promising material from the standpoint of weed control and crop tolerance in this trial was Trifluralin, although there was significant injury to spinach and cress at 2 lbs/A of the 4 e.c. formulation. Later trials under cool and moist conditions indicate that spinach may be injured even at 1 lb/A of either 4 e.c. or 2 G formulations. Both Trifluralin and Diphenamid gave very good weed control even at 1 lb/A of either formulation. Diphenamid, however, showed no crop selectivity except at 1 lb/A on Hanover salad.

The standard treatments of Vegadex, CIPC and the Vegadex + CIPC mixture gave satisfactory weed control, especially at the high rates, with little or no crop injury except from 2 lbs/A of 4 e.c. CIPC. Under the prolonged hot, dry weather conditions, these and most other herbicides consistently gave slightly better weed control from spray formulations compared to the granules. The opposite was true, however, of R-1870, although even at the rate of 4 lbs/A it did not give as good weed control as the standard treatments.

The use of Dacthal again resulted in good weed control from the 50 WP formulation while showing no significant crop injury except at 4 lbs/A on spinach. Lack of moisture prior to the germination of the first weed seeds probably contributed to the lower degree of weed control from the Dacthal granules.

While Zytron and NIA 6370 gave good weed control even at 8 and 5 lbs/A, respectively, severe crop injury in many cases limits their potential. Zytron appears to be safe only in the granular form at 8 lbs/A, applied to spinach, Hanover salad and collards. NIA 6370 seems to have greater selectivity on these same crops, with no appreciable injury from 5 lbs/A in either the 4 e.c. or 5 G formulation, or from 10 lbs/A in the 5 G formulation.

Table 2. Visual Crop Injury and Weed Control Ratings

			Crop						Weed
Herbicide	Formulation	Rate	Spinach	Kale	Hanover	Collards	Turnips	Cress	Control
R-1870	6 e.c.	2	10	10	10	10	9½	7½	6½
	6 e.c.	4	8½	9	10	10	8½	5	6½
	10 G	2	9½	10	10	10	8½	8	7
	10 G	4	8½	10	9½	9½	9½	6	7½
CIPC	4 e.c.	1	9	8½	9	9½	8½	10	8
	4 e.c.	2	6½	6½	8	7	6½	10	9
	5 G	1	8	7½	9	9½	6½	9	7½
	5 G	2	10	8½	8½	10	7½	9	8
Vegadex	4 e.c.	2	9½	10	10	10	9	9	7
	4 e.c.	4	8½	9	10	9½	8	9	9
	20 G	2	10	10	10	10	9	9½	5
	20 G	4	10	10	9½	10	9	9½	7½
Vegadex + CIPC	4 e.c. + 4 e.c.	2 + ½	10	9½	10	10	9	7	9
	20 G + 5 G	2 + ½	9½	9½	10	10	9½	9½	7
Dacthal	50 WP	2	9	10	10	10	9½	9½	8
	50 WP	4	5	10	9	10	8½	8½	8
	2½ G	2	8½	9½	10	9½	9	10	6
	2½ G	4	10	10	9½	10	9½	9½	6½
Zytron	3 e.c.	8	4	3	5	4½	3½	0	9
	3 e.c.	16	3	1½	3	2	1½	0	10
	25 G	8	8½	5½	9½	8	4½	0	8
	25 G	16	6½	2½	6	6	3	½	8
NIA 6370	4 e.c.	5	8	5½	8½	9	3½	6½	9
	4 e.c.	10	7	0	3½	4	0	0	9
	5 G	5	9½	7	9½	9½	4	6	7
	5 G	10	8	3½	9	6½	4	3	9
Trifluralin	4 e.c.	1	10	10	10	10	10	10	9
	4 e.c.	2	5½	8½	10	9½	7	5	9½
	2 G	1	10	10	10	10	9½	9½	9
	2 G	2	8½	9	9	10	8	9	9
Diphenamid	80 WP	1	3	2	8	3½	4	1	9
	80 WP	2	½	1	6	1½	2	0	9
	5 G	1	5	5	9	6	5	2	9
	5 G	2	4	2	8½	2½	2½	½	9½
Diphenetrile	5 G	5	9½	10	10	10	10	10	7
	5 G	10	10	9	10	10	9	10	8½
Check			9½	10	10	10	8½	9½	0

Table 3. Yield Data on Hanover and Turnips

			Average Yield in lbs/20 ft. of row	
Herbicide	Formulation	Rate	Hanover	Turnips
R-1870	6 e.c.	2	22.7	25.4
"	6 e.c.	4	27.5	21.5
"	10 G	2	28.0	21.8
"	10 G	4	23.4	23.7
CIPC	4 e.c.	1	21.7	21.1
"	4 e. c.	2	25.1	18.3
"	5 G	1	32.0	17.8
"	5 G	2	22.8	16.1
Vegadex	4 e.c.	2	24.8	24.3
"	4 e.c.	4	27.1	21.7
"	20 G	2	28.0	23.2
"	20 G	4	23.0	23.7
Vegadex	4 e.c. + 4 e.c.	2+½	28.3	24.1
+ CIPC	20 G + 5 G	2+½	26.1	23.6
Dacthal	50 WP	2	25.1	22.1
"	50 WP	4	24.2	22.9
"	2½ G	2	25.9	22.1
"	2½ G	4	19.7	21.9
Zytron	3 e.c.	8	18.9	10.9
"	3 e.c.	16	8.2	1.5
"	25 G	8	30.5	14.3
"	25 G	16	23.5	8.6
NIA 6370	4 e.c.	5	30.9	8.3
"	4 e.c.	10	13.7	0
"	5 G	5	27.3	12.8
"	5 G	10	25.2	14.1
Trifluralin	4 e.c.	1	31.3	23.4
"	4 e.c.	2	33.3	23.1
"	2 G	1	26.4	25.0
"	2 G	2	25.4	22.9
Diphenamid	80 WP	1	29.7	14.3
"	80 WP	2	23.4	7.8
"	5 G	1	33.4	14.7
"	5 G	2	25.5	7.8
Diphenatrile	5 G	5	32.1	27.8
"	5 G	10	24.8	23.6
Check			25.2	21.9

Diphenatrile is worthy of further study in both granular and spray formulations. The granular material gave fair to good weed control with complete tolerance of all crops to 10 lbs/A.

Summary and Conclusions

Preliminary investigations with several of the new experimental herbicides offer promising possibilities of alleviating the more serious weed problems still facing leaf crop growers of Eastern Virginia.

Dacthal, R-1870, Tillam, Trifluralin and Diphenatrile appear to be equal, and in some cases superior, to Vegadex and CIPC in crop tolerance. These materials offer possibilities especially during periods of the year or on weed species where the present standard treatments often fail. A longer period of effective control may also be possible from some of these chemicals, e.g., Trifluralin.

Further trials and information are needed at different periods of the year to determine the influence of climatic and soil conditions on the results obtained from these materials on specific crops and weed species.

Literature Cited

(1) Danielson, L. L. Evaluation of pre-emergence spray and granular applications of CDEC on vegetable leaf and cole crops. Proc. N.E.W.C.C. 12: 17-22. (1958)

(2) Price, C. D. Pre- and post-emergence weed control in leaf crops using herbicide combinations. Proc. N.E.W.C.C. 13: 510-516. (1959)

Weeding of Carrots With Pre-planting, Pre-emergence and Post-emergence Applications of Chemicals

Charles J. Noll[1]

Weed control is very important in the early stages of growth of carrots. Most commercial crops of carrots are sprayed for weed control with Stoddard Solvent. Other chemicals have without recent years benn found to be effective. This year's work is a continuation of work started a number of years ago.

PROCEDURE

The seedbed was prepared, pre-planting treatments applied and seeds planted May 2. Pre-planting treatments were incprporated in the soil with a rototiller set shallow. The variety grown was Chantenay, red core. The pre-emergence applications were made 1 or 3 days after seeding and post-emergence applications were made 33 days after seeding when carrots had their first true leaves. Individual plots were 28 feet long and 2 feet wide. Treatments were randomized in each of 8 blocks.

The chemicals were applied with a small sprayer over the row for a width of 12 inches. Cultivation controlled the weeds between the rows. An estimate of weed control was made July 28 on a basis of 1 to 10, 1 being most desirable and 10 being least desirable. Carrot harvest was completed Oct. 6.

RESULTS

The results are presented in table 1. All treatments except the post-emergence Dacthal treatment significantly increased weed control as compared to the untreated check. The best weed control treaments were in the soil incorporation treatments of Tillam at 6 lbs. per acre, in the pre-emergence treatments of Prometryne at 3 lbs. per acre, Ipazine at 3 lbs. per acre, U 4513 at 3 lbs. per acre and Amiben at 5 lbs. per acre and in the post-emergence treatment of Solan at 6 lbs. per acre. The stand of plants was significantly better than that of the untreated check with the post-emergence treatments of Amiben at 5 lbs. per acre and Solan at 6 lbs. per acre. Many other chemicals had a stand equal to the check. Significant increases in yield as compared to the untreated plot were found in the following treated plots: in the soil incorporation treatment R-1856 at 4 and 6 lbs. per acre; in the pre-emergence treatments of Herb. 326 at 2 lbs. per acre, U 4513 at 2 lbs. per acre, Zytron at 10 and 15 lbs. per acre, Amiben at 5 lbs. per acre and Dacthal W-50 at 8 lbs. per acre; and in the post-emergence treatment of Amiben at 5 lbs. per acre and Solan at 4 and 6 lbs. per acre.

CONCLUSION

Taking into consideration weed control, stand of plants and yield the best two treatments were the post-emergence treatments of Solan at 6 lbs. per acre and Amiben at 5 lbs. per acre. Other chemicals that look promising for the weeding of this crop are R-1856, Herb. 326, U 4513, Zytron and Dacthal.

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Table 1. Weed control, stand of plants and weight of roots of carrots under chemical herbicide treatments.

Chemical	Active Rate Per Acre lbs.	Application Days from Planting	AVERAGE PER PLOT *Weed Control (1-10)	AVERAGE PER PLOT Stand of Plants	AVERAGE PER PLOT Wt. of Roots lbs.
Nothing	--	--	9.8	140	5.8
Tillam	4	Soil Inc. 0	4.8	26	2.2
"	6	" " 0	2.9	6	.7
R-1856	4	" " 0	6.1	150	9.2
"	6	" " 0	5.0	135	10.6
Herb. 326	2	Pre-emergence 1	4.6	98	10.9
"	3	" 1	4.5	37	4.4
Prometryne	2	" 1	5.0	54	7.3
"	3	" 1	2.4	29	4.9
Ipazine	2	" 1	6.3	50	5.4
"	3	" 1	4.0	18	2.3
U-4513	2	" 1	6.0	118	9.2
"	3	" 1	3.9	68	7.3
Zytron	10	" 3	6.8	130	12.1
"	15	" 3	6.4	150	11.0
Amiben	5	" 3	2.3	99	10.6
Dacthal W-50	8	" 3	5.8	191	11.8
Amiben	5	Post-emerg. 33	4.3	222	14.9
Dacthal W-50	8	" 33	8.6	173	6.5
Stoddard Solvent	70 gal.	" 33	5.8	160	8.5
Solan	4	" 33	4.3	125	13.0
"	6	" 33	2.9	219	13.1
Ipazine	2	" 33	6.1	126	6.5
"	3	" 33	4.5	130	8.1
Least significant difference 5%			1.8	56	3.4
1%			2.4	74	4.4

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

WEED CONTROL STUDIES IN SEEDED ONIONS[1]

J. C. Cialone, G. Bayer and R.D. Sweet.

Introduction

New York with about 15,000 acres ranks as one of the leading onion producing states, with the majority of the production centered in the muck soil areas where weeds are a serious problem. Growers have shown great interest in herbicides as an aid in reducing weeding costs.

Most of the acreage in New York this year was treated with chloro-N-N-diallyl-acetamide, CDAA, sold as Randox. This program consists of a 6 lb/acre rate of the liquid formulation of CDAA in the crook stage of onion development and subsequent applications of the granular formulation as they are needed throughout the remainder of the season. CIPC (chloro-isopropyl-phenyl carbamate) is used in combination with the CDAA, primarily in situations were purslane (Portulaca sp.) has not been controlled by the CDAA. In general, the above two chemicals have given very satisfactory results over a wide range of environmental conditions on muck soils. CDAA does have the limitation that it will not control purslane other than in the seedling stage of development and does not have a very long period of residual activity in the soil.

Since CDAA often gives injury when applied immediately after planting, if this application is followed by rain, and since liquid formulations may give injury when the onion has reached the flag stage of development, the early period of safe use is a short and crucial one. It can readily be seen that with the great variations in spring weather conditions this period of safe use may not always coincide with the stage of weed growth at which CDAA will be most effective. Any chemical which could eliminate this crucial timing with respect to the crop and still be an effective herbicide would be very valuable. Tests conducted on muck soil in 1960 by Althaus, Langlois and Gleason (1) indicate that a combination of CDAA and TCBC (Trichlorobenzyl chloride) sold as Randox T, was effective against purslane, gave generally good weed control and gave little stand reduction when used at 6 and 9 qt/acre rates. Romanowski in 1960 (4) indicated that this combination of chemicals would control purslane and had a much longer period of activity in the field than CDAA alone. Meadows, Orsenigo and Van Geluwe (3) using this combination on muck soil in Florida in 1960 found no yield reductions and satisfactory weed control.

Tests conducted in 1960 by Cialone and Sweet (2) indicated that combinations of CDEC and CDAA gave good weed control over a wider range of weed species than either chemical used alone, and had a wide range or crop tolerance.

Although the CDAA program is in widespread use it was felt that the CDAA-TCBC and CDEC-CDAA combinations, on the basis of previous work, and the shortcomings of the CDAA program, merited evaluation. Studies were thus made to evaluate the above mentioned compounds, alone and in several combinations, with respect to crop response, weed control in general and control of purslane, in particular. Timing, chemical rate and location were factors included in the tests. The muck areas of Oswego County and Elba were chosen for this study

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because past weather records indicated that these two locations generally have very different climatic conditions.

Standard Chemical, Rate, Mixture and Timing Tests.

General

Identical tests were conducted at Oswego and Elba locations in growers' fields. Individual plots were 5x20 feet having four rows of onions lengthwise in each plot. In Table 1 are presented a list of treatments, rates and timing.

Table 1. Summary of chemicals, rates and timing.

Materials Used		Time of application
Chemical	lbs/A	Oswego
CDAA	4,6	1st-May 1, 2 days after planting
CDEC	4,6	
CIPC	4,6	2nd-May 15, onions in crook
CDAA + TCBC	4,6*	
CDEC + CDAA	3+3	3rd-May 18, 10-20% onions in flag stage
CDEC + CDAA	4+4	
" "	4+2	
" "	2+4	Elba
CDAA + CIPC	6+4	
" "	6+6	1st May 8, same day as planted
		2nd May 17, onions in early crook
		3rd May 25, onions in flag

*rates based on quantity of CDAA applied. (soild as Randox-T)

Each plot was replicated three times with the chemical treatments randomized in each replicate. The timing factor for each chemical treatment, however, was not randomized, so that the three times of application were side by side in a pre-set order. The timing factor, then, is composed of three sub-plots in the main plot which is the chemical treatment. There was a check plot in each tier of each replicate.

Although each treatment was applied at three different times in relation to onion development, it must be stressed that each plot was treated only once, that is, different plots were treated at each of the three timings.

All chemicals used were the commercial liquid formulations and all combinations were tank mixed. Applications were made with a hand CO_2 pressure small plot sprayer.

Visual weed and crop ratings were made in each location throughout the season. At Oswego all plots were hand weeded on July 5th and weights of weeds were taken. Yields and stand counts were taken in September at time of harvest. Stand counts and field records were taken on the 15 feet of the middle two rows in each plot.

Weather conditions at the two locations were quite different. At Elba precipitation came in the form of severe thunderstorms through much of the season. A severe hail storm on June 23rd when the onions were approximately 6 inches tall was extremely detrimental to the crop. Both locations had about the same total precipitation for May, but the precipitation at Elba seemed to have come at a more crucial time in relation to crop emergence. In addition, the particular soil used at Elba, was very subject to compaction, and resulted in poor stands. It was estimated that at the flag stage at Elba 30 percent of the seed which had germinated was still beneath the soil and never emerged, regardless of treatment.

There are several other factors which must be considered before examining the results obtained. At neither location were efforts made to measure the weed competition factor. For this reason yield data from chemical treatments is meaningless when compared with the unweeded check plots. The matter of weed competition is, no doubt, important, but cannot be evaluated properly. When the plots were hand weeded at Oswego on July 5th, many of the plots were completely overrun with weeds, so that a "mechanical" or "weeding damage" factor was introduced in addition to weed competition. Both the particular weed species present and the amount of weeds in a plot influenced this "damage factor". At Elba plots were weeded in July where necessary. The prevalent weed species at Elba were redroot, lambsquarters, purslane and crabgrass. At Oswego the above species were present with the exception of crabgrass and in addition ragweed, barnyard grass and two unusual cruciferous weeds (not identified) growing 1-2 feet tall were also present.

In light of the above mentioned limitations little attention will be given to the yield data obtained.

Results and Discussion

Response

Tables 2 and 3 give the results obtained at both locations concerning crop response. A comparison of the stand counts at the two locations gives a probable explanation of the general difference in yield obtained. This general reduction in stand and yield at Elba can be attributed in large part to heavy shower activity and soil compaction which resulted. Furthermore, yield samples from fields surrounding the test area show that yields averaged 950 bushels per acre in Oswego and only 550 bushels per acre in Elba.

The large amounts of precipitation in short periods at Elba accentuated crop damage when CDEC or CDAA were used at planting. This can be noted from both stand counts and early crop ratings (see Table 3). Both of these chemicals have been shown in the past to be responsive to water added to the soil although each for different reasons. At Elba the CDAA was probably leached into the zone where the onion seeds were germinating and resulted in damage. Although the CDEC is much less subject to leaching than is CDAA this chemical has been shown to be most effective when an irrigation or showers follow its application. It appears that the high precipitation conditions encountered in Elba accentuated activity to the point where severe stand reductions resulted.

Table 2. Crop response at Oswego.

Chemical Treatment	lbs/A	Time of Treatment At Planting Crop[1]	 Stand	 Crook Stage Crop	 Stand	 Flag Stage Crop	 Stand
CDEC	6	7.3	281	6.3	248.6	7.0	268.6
CDAA	6	9.0	296.3	9.0	294.3	8.6	264.0
CDEC	4	7.6	236.0	7.0	268.6	7.6	256.0
CDAA	4	9.0	326.0	8.6	293.0	9.0	304.6
CDAA+CDEC	4+2	8.6	294.0	7.0	223.6	7.3	282.0
" + "	3+3	8.0	284.0	7.6	266.0	7.0	267.3
" + "	2+4	8.3	293.0	8.3*	289.5*	8.6	288.0
" + "	4+4	8.0	271.6	6.3	240.0	6.6	240.3
CIPC	4	9.0	304.3	9.0	265.6	9.0	284.0
"	6	9.0	265.0	9.0	288.3	8.6	271.0
CDAA+CIPC	6+4	8.3	304.6	9.0	300.6	9.0	290.6
" + "	6+6	8.5*	265.0*	8.3	265.6	8.3	283.0
CDAA+TCBC	4+10	8.6	277.6	8.3	265.3	8.6	263.6
" + "	6+15	8.6	278.0	8.6	247.3	7.6	249.0
CK		9.0	264.9	9.0	264.9	9.0	264.9

*means of only 2 replications.

[1] 9 = perfect crop; 7 = commercially acceptable; 5 = moderate damage. 1 = crop completely killed. Data taken June 12.

Table 3. Weed and Crop Response at Elba.

Chemical	lbs/A	Weed Control[1] AP	 C	 F[3]	Crop[2] AP	 C	 F	Stand Counts AP	 C	 F
CDEC	6	6.6	6.3	6.0	4.0	6.0	7.3	71.6	141.5	144.6
CDAA	6	7.6	8.3*	9.0	6.6	7.6*	8.5	105.6	159.3*	190.3
CDEC	4	2.6	4.0	4.6	7.0	7.0	6.3	115.6	143.0	166.3
CDAA	4	7.3	8.0	8.6	7.6	7.6	8.3	139.6	149.3	188.0
CDEC+CDAA	4+2	7.3	7.6	8.0	3.6	7.0	8.0	43.3	148.6	178.0
" + "	3+3	7.3	7.6	8.0	4.6	7.3	8.0	81.0	108.6	148.0
" + "	2+4	8.0	8.3	8.6	4.6	6.3	7.6	69.0	130.6	165.0
" + "	4+4	8.0	8.6	9.0	2.3	6.0	8.0	44.6	146.3	197.6
CIPC	4	2.6	4.0*	4.6	8.3	8.3*	8.3	115.6	143.0*	166.3
CIPC	6	5.0	6.6	7.0	8.0	8.0	8.6	128.0	142.0	178.6
CDAA+CIPC	6+4	7.3	9.0	9.0	7.3	7.3	8.3	137.3	136.0	161.3
CDAA+CIPC	6+6	8.0	8.6	9.0	6.6	7.0	8.0	119.6	152.6	161.0
RDAA+TCBC	4+10	8.0	7.6	7.6	7.6	7.6	8.0	83.0	124.0	123.8
CDAA+TCBC	6+15	8.0	8.3	9.0	7.3	7.3	8.3	90.0	113.3	152.6

[1] 9 = perfect weed control; 7 = commercial control; 1 = no weed control.

[2] See footnote table 2 for explanation of ratings.

[3] AP = Applied at planting
C = Applied at Crook Stage
F = Applied at Flag Stage

In contrast to the damage noted in Elba from applying either CDAA or CDEC at planting, in Oswego CDAA was not toxic at any time of application. CDEC, however, gave some damage at all three times of application, with the crook stage being most severe. A heavy shower followed the crook stage application. It is believed to be the cause of damage, just as in the first application at Elba.

At both Elba and Oswego combinations of CDAA and CIPC followed the general pattern of CDAA alone with respect to both crop response and timing. This is to be expected because experience has shown onions in the early stages to be much more tolerant of CIPC than of CDAA.

CDAA+TCBC (Randox T) was similar in performance to CDAA at both locations. Treatment at the flag stage generally gave less crop injury than did treatments at other times. Much of the data obtained follow the CDAA response. It is difficult to evaluate the effect of TCBC since this chemical was not applied separately.

At both locations, weed control (see table 4) was best at the last two applications. This probably was due to several factors. First, in the period between planting and the third time of treatment, temperatures were quite low and weed development slow. In this same period rainfall was heavy and soil fixation and other forces were active which tend to reduce the effectiveness of herbicides. Later with higher temperatures when weed activity did reach its maximum, many of the chemicals were probably below their maximum level of activity.

Table 4. Purslane Control and weight of weeds removed by hand, July 5, Oswego.

		At Planting		Crook Stage		Flag Stage	
Chemical Treatment	lbs/ A	lbs. Weeds	purslane	lbs. Weeds	purslane	lbs. Weeds	purslane
CDEC	6	19.33	1	9.36	9	6.53	7
CDAA	6	14.96	2	6.46	2	4.53	2
CDEC	4	15.33	1	15.76	6	22.40	7
CDAA	4	10.40	3	8.0	3	8.2	5
CDEC+CDAA	4+2	9.20	2	7.06	4	10.07	4
CDEC+CDAA	3+3	5.10	3	5.30	6	6.63	6
CDEC+CDAA	2+4	16.23	2	5.70*	5*	6.96	5
CDEC+CDAA	4+4	11.40	3	4.46	6	2.93	6
CIPC	4	29.20	2	24.36	2	26.30	2
CIPC	6	29.83	1	21.30	1	14.93	1
CDAA+CIPC	6+4	8.65	6	3.30	7	3.16	7
CDAA+CIPC	6+6	11.25*	7*	6.60	6	4.36	7
CDAA+TCBC	4+10	6.33	9	3.10	9	4.10	9
CDAA+TCBC	6+15	5.03	9	1.46	9	1.03	9
CK		34.97	3	34.97	3	34.97	3

* only two replicates.

At both locations regardless of timing CDAA gave more effective weed control than did CDEC. Where the two chemicals were in combination at Oswego both the 4+4 and 3+3 lb. rates gave effective weed control regardless of timing. The 4+2 and 2+4 combinations of CDAA+CDEC were not consistent in weed control performance.

In Oswego at the latter two times of application CDEC at 4 or 6 pounds gave better control of purslane than did CDAA at similar rates. Combinations of these two chemicals at 3+3 or 4+4 gave fair purslane control.

CIPC was generally inadequate in weed control at both locations regardless of rate or timing. For some unexplained reason CIPC even performed poorly in control of purslane. For purslane control CDAA+CIPC gave better performance than either compound used alone. CDAA+TCBC (Randox-T) at either 4 or 6 pounds gave excellent weed control at both locations at all times of application. Purslane control was virtually complete at all times.

At harvest, CDAA+TCBC plots treated at the third stage were nearly devoid of all weed species. However, an occasional weed did appear. Growth was slight and weed foliage exhibited hormone-like symptoms, which indicates a long residual from the TCBC portion. It should be noted again that TCBC is automatically added at the rate of 10 and 15 pounds when 4 or 6 pounds of CDAA equivalent is applied from the commercial combination. Whenever a chemical exhibits season long activity there is inherent danger it may carry over and cause damage to the succeeding crop if it is susceptible. Most vegetable crops including potatoes fall in the susceptible class.

Summary and Conclusions

Tests were conducted on seeded onions at two muck soil locations using various chemical treatments, at different rates, combinations and times of treatment. Rainfall and soil at these two locations differed markedly.

Results indicate that combinations of CDAA+TCBC give excellent control of purslane and other weed species over a long period of time with only one application.

When applied in the early stage of onion growth, CDAA applications if followed by heavy rains caused severe crop damage.

When applied immediately after planting or in the crook stage CDEC, if followed by rainfall gave crop injury.

CIPC used alone failed to give adequate weed control regardless of rate, timing or rainfall.

CIPC+CDAA combinations performed much like CDAA alone, with respect to crop response, but weed control in general and control of purslane in particular was more effective with the combination than with CDAA alone.

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Chemical Weeding of Onions Grown on Mineral Soils.

Charles J. Noll[1]

Although most onions in the northeast are grown on muck soils, a considerable acreage is grown on mineral soils. The cost of hand weeding onions is so high thatwhere used it limits the acreage. Production costs could be reduced and acreage increased if adequate chemical weeding were developed. This years experiment is a continuation of work started a number of years ago.

PROCEDURE

The onion variety Sweet Spanish was seeded the day the seedbed was prepared. The pre-emergence treatments were applied 1 day after seeding, the emergence treatments 14 days after seeding and the post-emergence treatments 17, 21 or 22 days after seeding. Individual plots were 28 feet long and 2 feet wide. Treatments were randomized in each of 8 blocks.

The chemicals were applidd with a small sprayer over the row for a width of 12 inches. Cultivation controlled the weeds between the rows. An estimate of weed control was made July 24 on a basis of 1 to 10, 1 being most desirable and 10 least desirable. Onions were harvested September 25.

RESULTS

The results are presented in table 1. All chemicals except Exp. R significantly increased weed control as compared to the untreated check. The best weeded plots were treated with Prometryne, Diphenamid and Dacthal and Ipazine at their highest rate. Many treatments significantly reduced the stand of plants. Only two treatments had a stand significantly greater than the untreated check plot. These treatments were Dacthal and CIPC. A significant increase in yield was obtained where Dacthal and CIPC had been applied as compared to all other treatments.

CONCLUSION

Taking into consideration weed control, stand of plants and yield the best treatments in this experiment for weeding onions were Dacthal applied in a pre-emergence application and CIPC applied at time of onion emergence.

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Table 1. Weed control, stand of plants and weight of onions under chemical herbicide treatments.

				AVERAGE PER PLOT		
Chemical	Active Rate Per Acre lbs.	Application Days from Seeding		*Weed Control (1-10)	Stand of Plants	Wt. of Onions lbs.
Nothing	--	--		9.4	61	1.8
Dacthal W-50R	8	Pre-emergence	1	4.0	112	9.4
"	16	"	1	2.3	104	11.9
"	24	"	1	1.8	120	11.0
Exp R	8	"	1	9.5	37	1.5
"	16	"	1	10.0	51	1.4
"	24	"	1	9.6	45	1.5
Zytron	10	"	1	6.3	83	5.5
"	15	"	1	5.3	55	4.8
Diphenamid	6	"	1	1.3	10	1.0
"	9	"	1	1.1	2	.1
U-4513	2	"	1	3.5	67	3.9
"	3	"	1	3.3	58	3.5
Atratone	2	"	1	4.4	27	2.8
CIPC	4	Emergence	14	4.4	116	7.7
"	6	"	14	3.1	141	11.2
Randox T	6	"	14	5.4	81	4.6
"	9	"	14	5.9	71	4.8
KOCN	12	"	14	7.0	68	2.3
"	18	"	14	7.1	45	2.1
Atratone	2	Post-emergence	22	2.9	50	5.8
Prometryne	2	"	21	2.0	8	.9
"	3	"	21	1.1	3	.3
"	4	"	21	1.3	6	.5
Ipazine	2	"	21	4.3	22	1.7
"	3	"	21	2.6	25	1.8
"	4	"	21	2.0	5	.9
Casoron	3	"	17	8.5	37	1.7
"	4½	"	17	7.0	33	1.7
Least significant difference 5%				1.3	31	2.3
1%				1.7	40	3.0

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

WEED CONTROL IN TRANSPLANTED ONIONS[1]

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

Eight years ago when transplanted Sweet Spanish type onions were first grown on eastern Long Island, the main weed pests were chickweed and pussley. Some crabgrass and barnyard grass would come in later in the season but presented no significant problem. Four pounds per acre of CIPC applied in directed sprays at approximately three week intervals, together with a relatively small amount of hand weeding, gave growers good seasonal control.

Changes have occurred during the past three to four years which have required a re-evaluation of our earlier results. Excellent weed control is still achieved up until June 20-25 when the grasses begin to emerge. This date of emergence is apparently at least a week earlier than it used to be, possibly because of higher soil temperature due to lack of weed cover, and in addition, accentuated by a much higher infestation of grass seed. The grass problem, particularly barnyard, has multiplied manifold. With CIPC providing little if any commercial control, growers have had to use considerable hand labor to keep their fields reasonably clean through harvest.

Methods: The two major varieties grown are Early Harvest and Sweet Spanish, and though the latter is decreasing in importance the weed problem in it is greater because it matures later. Seasonal and layby experiments were conducted, therefore, on both. Although CIPC is still satisfactory through most of June, it was felt that other materials should be tried to determine if they would provide better early control of germinating grass. This in turn would allow later application of some layby materials known to be effective against grass but injurious to onions if applied too early.

Early Harvest transplants were set in the field April 12, treated May 8, June 13, July 5, July 28, and harvested August 8; Sweet Spanish were set April 25, treated May 18, June 13, July 5 and 28, and harvested August 17. The herbicides were applied with a two-row tractor mounted sprayer and directed towards the base of the plants. Prior to each application all plots were rated, and established weeds removed -- by hand in the rows and shallow cultivation between rows.

Onions used in the layby experiments were treated at three week intervals during the first part of the growing season with CIPC. All plots were clean cultivated and weeded before the layby treatments were applied -- June 29 on Early Harvest, July 18 on Sweet Spanish. The liquid formulations were handled as described above; the granulars were applied directly over the row and the foliage brushed with a trailing rope. Additional experiments were conducted in cooperation with a commercial grower where the grass problem was much more severe than on the Research Farm. The Early Harvest test, the only one reported here, was applied June 28 and July 6, and the crop harvested August 10.

Results and Discussion: The data, particularly for the herbicides, were similar on both varieties; therefore, only the results on Early Harvest are given in this paper. Differences which did occur in the Sweet Spanish experiments are mentioned in the text.

Results from the seasonal trial are summarized in Table 1.

Table 1. Results from several herbicides used on Early Harvest onions during the growing season. Treatments were applied 5/8, 6/13, 7/5 and 7/28; crop harvested 8/8.

	Weed Control[1]				Yield
Treatment	6/12	7/3	7/27	8/8	Bu/A
1. CIPC 4 lbs/A (3 lbs 5/8)	3.8	4.3	4.0	3.2	515
2. CIPC + Vegadex 4+1 lbs/A (3+1 5/8)	4.3	4.0	4.5	3.2	536
3. Same as #2 but first spray deleted	---	3.0	4.5	3.2	574
4. Vegadex + Randox 3+3 lbs/A (4+4 7/28)	3.8	3.0	4.0	3.0	530
5. Same as #4 but first spray deleted	---	2.8	4.0	3.2	497
6. Zytron 5 lbs/A	4.0	3.8	4.5	3.5	524
7. Zytron 5 lbs/A, first spray deleted	---	3.5	4.2	3.5	526
8. Zytron 10 lbs/A	4.8	4.3	4.7	4.1	451
9. Zytron 10 lbs/A, first spray deleted	---	3.8	4.4	4.1	526
10. Dacthal 8 lbs/A	3.8	4.0	4.0	4.0	503
11. Dacthal 8 lbs/A, first spray deleted	---	3.5	4.0	4.0	520
12. Dacthal 12 lbs/A	4.5	4.3	4.5	4.3	526
13. Dacthal 12 lbs/A, first spray deleted	---	4.0	4.5	4.1	503
14. Check	1.0	1.0	1.0	1.0	499
		L.S.D. 5%			48

[1] 1 - no control
5 - excellent

Treatment #1 was considered the standard and the ratings indicate that good control was obtained through most of the growing period. The low score by harvest time was due almost entirely to the presence of annual grasses. This weakness is in agreement with growers' complaints and under their conditions -- field scale application and higher grass infestation -- even less control could be expected. The addition of Vegadex and Randox to CIPC brought about no consistent response and certainly there was no indication that they improved grass control. The deletion of the first spray (May 8) involving any of these three materials was unacceptable because of reduced control up to July 3 when the third application went on. Zytron at five pounds per acre was comparable to the standard but only the ten pound rate gave good control of grass. This higher rate reduced yield when applied four times but, in treatment #9, where the first application was left out, good grass control was obtained without affecting yield. The material looked promising and should be tried in conjunction with the use of CIPC early in the season. Dacthal looked very good and rates up to 12 pounds per acre were used throughout the season without affecting the onions. None of the treatments had any effect on yield of the Sweet Spanish variety. Prospects are reasonably good that our current seasonal recommendation will be able to be improved.

The data from the layby trial conducted on the Research Farm are given in Table 2.

<u>Table 2.</u> Results from layby treatments on Early Harvest onions. Applied June 29; weed control rated August 10 immediately prior to harvest.

Treatment					Weed[1] Control	Yield Bu/A	Average Bulb Wt.
1. CIPC	6	lbs/A	liq.		2.3	616	0.68
2. CIPC + Vegadex	4+1	lbs.	liq.		1.8	561	.63
3. CIPC + Vegadex	4+4	"	"		2.5	579	.66
4. CIPC + Randox	4+4	"	"		2.7	602	.67
5. Vegadex + Randox	4+4	"	"		3.5	589	.64
6. Vegadex	6	"	"		2.8	588	.65
7. Randox	6	"	"		3.0	598	.67
8. Eptam	4	lbs.	gran.	incorp.	4.5	493	.56
9. Eptam	4	"	"	surface	3.5	535	.60
10. Eptam	4	"	liq.	incorp.	4.0	572	.62
11. Eptam	4	"	"	surface	3.2	599	.65
12. Tillam	4	"	gran.	incorp.	4.5	588	.64
13. Tillam	4	"	"	surface	3.4	600	.68
14. Tillam	4	"	liq.	incorp.	3.2	540	.67
15. Dacthal	16	"	liq.		3.0	628	.68
16. U-4513	4	"	liq.		2.8	568	.63
17. Zytron	5	"	liq.		3.0	585	.64
18. Zytron	100	"	liq.		3.2	521	.62
19. Amiben	4	"	liq.		4.0	557	.63
20. Check					1.0	616	.67
				L.S.D. 5%		60	.05

[1] 1 - no control
5 - excellent control

The grass population in the area of this experiment was considerably higher than that of the previous one, hence control ratings for similar treatments were somewhat lower. None of the treatments involving CIPC, Vegadex, and Randox, singly or in combination, provided satisfactory control until harvest time. Eptam, incorporated into the soil, gave very good control but the granular formulation definitely reduced yield and the liquid, although the difference was not significant, probably had a similar tendency. On the basis of previous experience the effect of the granular was not unexpected but this was the first time the liquid had appeared to have any detrimental effect when used at layby. Tillam, granular incopporated, also gave very good control and had no adverse effect on the crop. On our lighter Sassafrass loams it would be safer either to use Tillam or reduce the rate of Eptam to perhaps three pounds per acre -- on Early Harvest at least. Amiben was effective against grass but its effect on yield requires further testing. Dacthal, U-4513, and Zytron, as used under the conditions of this experiment, were not satisfactory.

Interestingly enough, no treatment had any effect on Sweet Spanish indicating, as in the seasonal experiment, that this variety is considerably more tolerant of herbicides than is Early Harvest.

The most rigorous testing conditions for the herbicides occurred in the experiment summarized in Table 3.

Table 3. Results from layby treatments applied to Early Harvest onions in a commercial field. Treatments 5, 6 and 7 applied to dry soil surface June 28; rest applied July 6 and irrigated. Weed control rated July 25, 7 days prior to onion maturity.

Treatment			Weed Control[1]	Yield Bu/A
1. CIPC	6 lbs. liq.		3.3	598
2. CIPC + Vegadex	4+2 liq.		3.7	625
3. CIPC + Randox	4+2 liq.		3.3	574
4. Vegadex + Randox	3+3 liq.		3.7	584
5. Eptam	4 gran.,	incorp.	4.8	614
6. Eptam	4 "	surface	2.0	542
7. Eptam	4 liq.,	incorp.	4.0	592
8. Dacthal	8 liq.		2.3	555
9. Dacthal	16 liq.		2.8	546
10. Zytron	10 liq.		4.0	588
11. Amiben	4 liq.		4.0	646
12. Check			1.0	603
				N.S.

[1] 1 - no control
5 - excellent control

The results on weed control were in fairly close agreement with those from the work on the Research Farm. Eptam, four pounds incorporated, Zytron, ten pounds, and Amiben, four pounds, gave very good commercial control. None of the other treatments were considered satisfactory. There were no effects on yield, probably because of the soil type -- a medium heavy Sassafrass silt loam.

Summary: An increasing grass problem has made growers dissatisfied with the performance of CIPC during the period June 20-25 through harvest. Seasonal and layby experiments were conducted to study possibilities for improvement of current recommendations.

CIPC, Vegadex, and Randox combinations throughout the growing season did not provide satisfactory grass control. Zytron andDDacthal looked promising.

CIPC, Vegadex, and Randox singly or in combination as layby sprays, were unsatisfactory. Both Eptam and Tillam gave excellent control when incorporated into the soil. Eptam reduced yields of Early Harvest onions on light Sassafrass loam but not on medium heavy Sassafrass silt loam. Amiben looked promising, Zytron was variable, and U-4513 and Dacthal were only fair at the rates used. The Sweet Spanish variety was considerably more tolerant to several herbicides than was Early Harvest.

Weeding of Sweet Corn With Chemical Herbicides

Charles J. Noll[1]

More than half of Pennsylvania's 24,000 acres of sweet corn are weeded with chemicals. Most large growers growing for fresh market use chemical herbicides. As there is no lack of good herbicides to weed corn, this experiment was designed to compare the better known chemicals with the new chemicals thought to be promising for the weeding of this crop.

PROCEDURE

The seedbed was prepared May 15. The pre-planting treatments were applied just ahead of seeding on May 17 and incorporated in the soil with a rototiller set shallow. The variety seeded was NK 199. The pre-emergence treatments were applied 2 days after seeding. The emergence treatments were applied 17 days after seeding when corn was in the spike stage. Individual plots were 36 feet long and 3 feet wide. Treatments were randomized in each of 6 blocks.

The chemicals were applied with a small sprayer over the row for a width of 12 inches. Cultivation controlled the weeds between the rows. An estimate of weed control was made July 24 on a basis of 1 to 10, 1 being most desirable and 10 being least desirable. Corn was harvested August 23.

RESULTS

The results are presented in table 1. All chemicals significantly increased weed control as compared to the untreated check. The best weed control treatments were Atrazine, Herb. 326, Diruon and Falon. The stand of plants was unaffected by the treatments. Only the Atrazine and the 2,4-D treated plots had significantly more marketable ears than the untreated check plot. A highly significant increase in weight of marketable ears as compared to the untreated check plot was found where Atrazine, 2,4-D and the lower rate of Herb. 326 were applied at time of corn emergence and where DNBP at 6 lbs. per acre and Randox at 10 lbs. per acre were applied prior to corn emergence. Many other chemicals had significant increases in weight of marketable ears at the 5% level as compared to the untreated check plot.

CONCLUSION

Many chemicals when applied to corn gave good weed control, no stand reduction, and increases in yield as compared to the untreated check plots. The outstanding chemical in this experiment was Atrazine.

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Table 1. Weed control, stand of plants and number and weight of marketable ears of sweet corn under chemical herbicide treatments.

Chemical	Active Rate Per Acre lbs.	Application Days from Planting	AVERAGE PER PLOT			
			*Weed Control (1-10)	Stand of Plants	No.of Mkt. Ears	Wt.of Mkt. Ears lbs.
Nothing	--	--	8.3	53.7	36.5	23.2
Tillam	4	Soil Inc. 0	4.0	53.0	42.3	31.4
"	6	" " 0	2.7	55.5	40.3	29.8
O.M. 1306	10	Pre-emergence 2	4.8	51.0	38.5	29.2
"	15	" 2	3.7	50.3	43.0	31.9
U-4513	2	" 2	5.5	53.7	39.5	24.9
"	3	" 2	4.0	52.5	30.7	20.2
CP 17029	3	" 2	4.5	52.0	39.7	27.5
"	4½	" 2	2.8	54.2	43.3	31.8
Casoron	3	" 2	5.0	53.0	40.5	27.7
"	4½	" 2	4.2	52.5	38.5	29.1
Randox T	10	" 2	3.7	54.3	43.0	36.8
"	15	" 2	2.2	53.2	40.0	29.9
Randox	10	" 2	4.7	54.3	41.2	30.1
"	15	" 2	3.0	51.2	36.3	27.2
Nia. 2995	4	" 2	3.8	50.0	40.3	30.8
"	6	" 2	2.8	50.3	41.3	31.1
Falon 10G	4	" 2	2.0	50.8	41.5	29.7
"	8	" 2	1.5	51.2	38.5	28.9
Falon 44E	4	" 2	2.7	53.8	39.7	29.3
"	6	" 2	2.3	51.0	40.7	28.0
DNBP (Premerge)	4	" 2	3.7	49.8	39.5	28.6
"	6	" 2	3.2	52.5	42.3	33.2
Atrazine + DNBP	1 + 2	" 2	1.3	51.5	44.5	31.2
Simazine	2	" 2	5.2	53.8	41.3	27.5
Atrazine + Simazine	1 + 1	Emergence 17	1.0	54.2	46.8	36.6
Atrazine	2	" 17	1.0	53.8	45.0	35.4
"	1	" 17	1.0	53.5	45.0	35.3
Atrazine + Surfactant	1 + 8	" 17	1.0	53.7	44.8	34.4
2,4-D Amine	½	" 17	4.5	52.0	45.5	33.4
"	1	" 17	2.7	51.7	43.0	31.8
Herb. 326	2	" 17	1.2	53.2	42.7	32.4
"	3	" 17	1.0	51.2	39.5	27.3
Diuron	2	" 17	1.2	51.2	41.5	31.0
"	3	" 17	1.0	48.2	38.8	28.9
Least significant difference 5%			1.6	N.S.D.	7.2	6.5
1%			2.6	N.S.D.	N.S.D.	8.5

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

WEED CONTROL IN FIELD-SEEDED AND TRANSPLANTED PEPPERS AND TOMATOES[1]

R. B. Seely and E. M. Rahn[2]

Field-seeding peppers and tomatoes is a possible means of reducing the cost of high plant populations which seem necessary for maximum yields. High plant populations appear to be especially necessary for high yields where tomatoes are to be mechanically harvested. However, one of the main obstacles in field-seeding is to prevent weed growth in the pepper and tomato seedlings. Chemicals are needed to control these weeds until the plants are large enough to cultivate. An effective herbicide is also needed to control weeds in transplanted tomatoes and peppers. Weeds become a problem in the row soon after transplanting and between, as well as in, rows after lay-by until the end of harvest. Reported herein are several experiments conducted in 1960 and 1961 in an attempt to solve these problems.

Field-Seeded Experiments

Procedure and Results:

Similar experiments were conducted with both peppers and tomatoes on a Norfolk loamy sand at the Georgetown Substation of the University of Delaware. The principal weeds on this soil were crabgrass (Digitaria sanguinalis), goose-grass (Eleusine indica), nutgrass (Cyperus esculentus), lamb's-quarters (Chenopodium album), pigweed (Amaranthus retroflexus), ragweed (Ambrosia artemisiifolia), and smart-weed (Polygonum hydropiper). Morning glory (Ipomoea hederacea) and carpetweed (Mollugo verticillata) appeared occasionally.

In 1960, 12 herbicides or herbicidal combinations were tested on California Wonder peppers and Del. 13-2 tomatoes. Plot size was a single row 75 feet long. Pepper rows were 4 feet apart while tomato rows were 5 feet apart. There were two replicates in randomized blocks. PCP (pentachlorophenol), KOCN (potassium cyanate) plus TCA (sodium trichloroacetate) and Tillam (propyl ethyl-n-butyl thiolcarbamate) proved to be outstanding. PCP, applied just before crop emergence, and Tillam, incorporated just before seeding by two discings, were applied with a logarithmic sprayer. KOCN, 16 lb/A, plus TCA, 3 lb/A, was applied in a band over the row with a single-nozzle hand sprayer. Results showed that the minimum rate of PCP required to control weeds was 3.6 lb/A, while the maximum rate tolerated by the crop was 6.1 lb/A. Comparable figures for Tillam were 3.5 lb/A and 4.9 lb/A, respectively. Other herbicides tested were: Sun Spirits (Stoddard solvent), TCA plus PCP, TCA, Dalapon (2,2-dichloropropionic acid), CIPC (isopropyl N (3-chlorophenyl) carbamate) plus PCP, Vegadex (2-chloroallyl diethyldithiolcarbamate) plus PCP, Solan (N-(3-chloro-4-methylphenyl)-2-methylpentanamide) and Zytron (O-2-4 dichlorophenyl o-methyl isopropylphosphoro amidothioate).

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Three experiments were conducted in 1961. In the first experiment, the above three outstanding herbicides, or combinations of herbicides, were tested on Calcom peppers and Del. 13-2 tomatoes. Spray applications were made with a single-nozzle hand sprayer. Tillam granular applications were made with a small hand duster. Plot size was 2 rows, 20 feet long. Treatments were replicated three times in randomized blocks. Tillam granular and spray at 4 lb/A, incorporated just before seeding by discing, raking, or by irrigation, caused severe injury, particularly of peppers. PCP, 5 lb/A, and KOCN, 16 lb/A, plus TCA, 3 lb/A, applied just before emergence, gave good weed control with no significant crop injury.

In the second experiment in 1961, the following herbicides were tested on Calcom peppers and Del. 13-2 tomatoes, using a logarithmic sprayer: Diphenamid N, N-dimethyl-α, α-diphenylacetamide), from 10 to 1.5 lb/A; Dacthal (dimethyl tetrachloroterephthalic acid), from 12 to 1.8 lb/A; Stauffer 1870 (ethyl di-n-butyl-thiolcarbamate), from 12 to 1.8 lb/A; Tillam, from 12 to 1.8 lb/A; Zytron, from 20 to 3 lb/A; and Geigy Prometryne (2,4-bis(isopropylamino-6-methyl mercapto-s-triazine), from 10 to 1.5 lb/A.

Plot size was a single row 75 feet long. Treatments were replicated three times in randomized blocks. Rows of peppers were 3½ feet apart and rows of tomatoes were 5 feet apart. Tillam and Stauffer-1870 were incorporated just before seeding, while the remaining herbicides were applied just after seeding. Diphenamid was the only outstanding herbicide in this experiment. The minimum rate required for weed control was 2.6 lb/A, while the maximum rate tolerated by peppers was 4.7 lb/A, and the maximum rate tolerated by tomatoes was 7.1 lb/A.

In the third experiment in 1961, Diphenamid, PCP, and KOCN plus TCA were evaluated on Calcom peppers and Del. 13-2 tomatoes again. Treatments were applied and replicated as described above for the first experiment. No crop injury was produced by any of these treatments (Table 1). All three treatments gave perfect control of broadleaf weeds. Diphenamid gave perfect control of annual grasses, while PCP, and KOCN plus TCA, gave near perfect control of annual grasses.

The following two treatments were super-imposed on the PCP, and KOCN plus TCA plots in the third experiment, to extend the duration of weed control: Tillam granular, 4 lb/A, raked in, or Diphenamid, 5 lb/A, applied as an over-all spray. Both chemicals were very effective for extending the duration of control of both broadleaf weeds and annual grasses. However, Tillam caused considerable stunting of both peppers and tomatoes. Diphenamid, on the other hand, had no adverse effect.

Transplanted Peppers and Tomatoes

Procedure and Results:

These experiments were located adjacent to the field-seeded experiments. Therefore, the soil and principal weeds were similar. Plot size for both the pepper and tomato experiments was 3 rows 36 feet long. Pepper rows were 4 feet apart, while the tomato rows were 5 feet apart. Treatments were replicated four times in randomized blocks. Herbicide treatments used in the 1960 experiments are presented in Tables 2 and 3. Sprays were applied over-all at the rate of 50 gal/A with a 3-nozzle boom attached to a 15 gal. Spartan sprayer. A calibrated Gandy spreader was used to apply the granular material.

Table 1.

COMPARISON OF DIPHENAMID, PCP, AND KOCN PLUS TCA FOR WEED CONTROL IN FIELD-SEEDED PEPPERS AND TOMATOES, GEORGETOWN, DELAWARE, 1961

Herbicide and rate	Time of Application	Weed control 17 days after seeding (percent)			
		Peppers		Tomatoes	
		Broadleafs	Grasses	Broadleafs	Grasses
Diphenamid, 3 and 5 lb/A[1]	Just after seeding	100	100	100	100
PCP, 5 lb/A	Just before crop emergence	100	97	100	95
KOCN + TCA, 16 + 3 lb/A	Just before crop emergence	100	90	100	93
LSD, 5%		NS	NS	NS	1

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[1] Rates of 3 lb/A and 5 lb/A were applied to peppers and tomatoes, respectively.

KC-146 tomato plants and California Wonder pepper plants were set into the field on May 11 and 18, respectively. Four weeks later, after clean cultivation, herbicides were applied to the tomatoes. Five and one-half weeks elapsed between setting and herbicidal application on the peppers. Cultivation was discontinued in all plots but the cultivated check after the herbicides were applied. A second herbicidal application was made on the tomatoes seven weeks after transplanting.

Two herbicidal treatments were superior to other herbicidal treatments on transplanted peppers (Table 2). They were Tillam spray at 6 lb/A and Amiben granular at 5 lb/A. No treatment depressed yields although Eptam granular at 4 lb/A caused early injury which was mostly out-grown.

Table 2. Comparison of Several Herbicides for Weed Control in Transplanted Peppers in 1960, Georgetown, Delaware.

Herbicide and rate[1]	Weed Control on 8/19[2], percent			Marketable Yield, Tons/A	Crop injury on 7/20, percent
	Broadleafs	Annual Grasses	Nutgrass		
Tillam spray[3], 4 lb/A	58	33	85	4.0	0
Tillam spray[3], 6 lb/A	60	71	89	3.9	0
Eptam granular[3], 2 lb/A	55	40	83	4.2	0
Eptam granular[3], 4 lb/A	70	68	95	3.7	28
Amiben granular, 5 lb/A	85	81	64	4.9	0
Dacthal spray, 8 lb/A	71	58	38	4.7	0
Dacthal granular, 8 lb/A	25	53	53	3.7	0
Cultivated check	100	100	100	3.3	0
Unhoed check	0	0	0	3.8	0
LSD 5%	22.8	27	NS	NS	8

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1. Herbicides were applied 6 weeks after plants were set in field.
2. This was 7½ weeks after herbicides were applied.
3. These herbicides were incorporated by two cultivations.

Tillam spray, 6 lb/A, and Dacthal granular, 8 lb/A were superior to other herbicide treatments on transplanted tomatoes (Table 3). Eptam granular, 4 lb/A, caused a burning of the new growth and Amiben granular, 5 lb/A, caused a moderate stunting of plants.

Calcom pepper plants were set in the field on May 18 for the 1961 experiment. Rows were spaced 3½ feet apart in a plot that consisted of 3 rows 25 feet long. Herbicide treatments were replicated three times in randomized blocks. Eight weeks after transplanting, herbicides were applied to cleanly cultivated soil as described above for the 1960 experiment. Cultivation was discontinued except on the cultivated check plots after the herbicides were applied.

Delsher tomato transplants were set in the field on May 10, 1961. Rows were spaced 5 feet apart in plots of 3 rows 25 feet long. Herbicide treatments were replicated four times in randomized blocks, and were applied as described above for the 1960 experiment. After this, as with the pepper experiment, plots were not cultivated, except for the cultivated-check plots.

Most treatments gave good to excellent weed control with no adverse effect on yields of both peppers and tomatoes. Results for the best treatments for peppers and tomatoes are presented in Tables 4 and 5, respectively. Various methods of soil incorporation of the over-all Tillam spray, 6 lb/A, were evaluated in both experiments. Rototilling 3 inches deep, two cultivations, ½ inch of irrigation, or two cultivations followed by ½ inch of irrigation were slightly better methods of soil incorporation, as compared with raking ½ inch deep, or by a single cultivation. Soil incorporation of Tillam granular, 6 lb/A, by ½ inch of irrigation, was superior to incorporation by two cultivations in both peppers and tomatoes. The best spray and granular applications of Tillam were essentially equally effective in each experiment. However, the spray application of Tillam caused a slight burning of foliage, which was presumed to be due to the solvent in the Tillam formulation. This was not noted in 1960.

Amiben granular was more effective when ½ inch of irrigation followed application on peppers. This herbicide was not used on tomatoes in 1961 because of injury caused in 1960. Solan, 4 lb/A, plus Dacthal, 8 lb/A, applied in an over-all spray when weeds were less than ½ inch high, was very effective on tomatoes but gave severe injury on peppers. Stauffer 1870 spray, 6 lb/A, incorporated by two cultivations, was less effective for weed control than Tillam applied similarly.

Conclusions:

The following herbicides were most effective for weed control in field-seeded peppers and tomatoes: Diphenamid, PCP, and KOCN plus TCA. Diphenamid was slightly more effective in the control of annual grasses. This chemical was applied just after seeding at 3 lb/A on peppers and 5 lb/A on tomatoes, and gave excellent control of both annual grasses and broadleaf

Table 3. Comparison of Several Herbicides for Weed Control in Transplanted Tomatoes in 1960, Georgetown, Delaware.

Herbicide and rate[1]	Weed Control on 8/19[2], percent			Marketable Yield, Tons/A	Crop injury on 7/20, percent
	Broadleafs	Annual Grasses	Nutgrass		
Tillam spray[3], 4 lb/A	68	73	75	26.6[4]	0
Tillam spray[3], 6 lb/A	79	83	89	27.3	0
Eptam granular[3], 2 lb/A	78	69	83	24.1[4]	0
Eptam granular[3], 4 lb/A	91	79	91	22.7[4]	28
Amiben granular, 5 lb/A	58	76	48	19.5[4]	13
Dacthal spray, 8 lb/A	75	63	50	23.2[4]	0
Dacthal granular, 8 lb/A	53	53	70	27.4	0
Cultivated check	100	100	100	28.6	0
Unhoed check	0	0	0	24.6	0
LSD 5%	16.4	17.1	23.1	1.8	7

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1. Herbicides were applied 4 and 7 weeks after plants were set in field.
2. This was 7½ weeks after last herbicide application.
3. These herbicides were incorporated by two cultivations.
4. Yields significantly lower than those from the cultivated check plots.

CONCLUSIONS (continued): weeds until crop plants became six inches tall. No crop injury was noted at these rates. PCP, 5 lb/A, or KOCN, 16 lb/A, plus TCA, 3 lb/A, applied a day before crop emergence were almost as effective as Diphenamid.

Tillam spray or granular, 6 lb/A, or Amiben granular, 5 lb/A, were most effective for weed control on transplanted peppers. Tillam spray caused a slight temporary burning of pepper foliage in 1961. The most effective methods of incorporating Tillam spray were the following: Rototilling 3 inches deep, two cultivations, ½ inch of irrigation, or two cultivations followed by ½ inch of irrigation. Tillam granular and Amiben granular were most effective when ½ inch of irrigation followed just after application.

Table 4. Most Effective Herbicide Treatments in Transplanted Peppers in 1961 at Georgetown, Delaware.

Herbicide and rate[1]	Method of Incorporation	Weed Control on 10/16[2], percent		Marketable Yield, Tons/A	Crop injury in Percent
		Broadleafs	Annual Grasses		
Tillam Spray, 6 lb/A	Rototilled 3" deep	95	90	16.1	10
Tillam Spray, 6 lb/A	Cultivated twice	97	90	15.0	10
Tillam Spray, 6 lb/A	½" Irrigation	87	85	16.0	10
Tillam Spray, 6 lb/A	Cultivated twice + ½" Irrigation	97	95	15.0	10
Tillam, Granular 6 lb/A	½" Irrigation	97	93	15.3	0
Amiben, Granular 5 lb/A	½" Irrigation	88	88	16.3	0
Cultivated check	---	100	100	17.0	0
Unhoed check	---	0	0	15.0	0
LSD 5%		5	9	NS	3

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1. Herbicides were applied 8 weeks after transplanting.
2. This was 8½ weeks after herbicide application.

CONCLUSIONS (continued): The treatments described above for transplanted peppers were the most effective for transplanted tomatoes with two exceptions: Amiben granular injured tomatoes to a considerable degree, and an additional treatment, Solan, 4 lb/A, plus Dacthal, 8 lb/A, applied as an over-all spray when weeds were less than ½ inch high, was very effective.

Table 5. Most Effective Herbicide Treatments in Transplanted Tomatoes in 1961 at Georgetown, Delaware.

Herbicide and Rate	Method of incorporation	Weed Control on 8/5[3] percent			Marketable Yield, Tons/A	Crop injury in Percent
		Broadleafs	Annual Grasses	Nutgrass		
Tillam[1] Spray, 6 lb/A	Rototilled 3" deep	91	96	98	15.0	10
Tillam[1] Spray, 6 lb/A	Cultivated twice	81	91	94	11.4	10
Tillam[1] Spray, 6 lb/A	½ inch Irrigation	85	94	98	15.7	10
Tillam[1] Spray, 6 lb/A	Cultivated twice + ½" Irrigation	85	95	96	14.4	10
Tillam[1] Granular 6 lb/A	½" Irrigation	86	94	99	10.9	0
Solan[2], 4 lb/A + Dacthal, 8 lb/A spray	---	96	84	99	15.2	0
Cultivated check	---	100	100	100	14.1	0
Unhoed check	---	0	0	0	11.9	0
LSD 5%		11	9	2	NS	2

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1. Applied 4 weeks after transplanting.
2. Applied 5½ weeks after transplanting when weeds were less than ½ inch high.
3. This was 8½ weeks after first herbicide application.

STUDIES WITH SOLAN 1/ FOR THE CONTROL OF WEEDS IN DIRECT-SEEDED TOMATOES

C. C. Wyatt 2/ and R. J. Condon 3/

Direct-seeding of tomatoes is an important means of securing high tomato plant population especially with small determinate plants destined for use with once-over mechanical harvester.

During the past five years studies of direct-seeded tomatoes have been carried out in the Bowling Green, Ohio area. The principal problem encountered has been slow germination and growth of tomato seedlings as compared to more rapid growth of certain species of weeds in cool soil normally present in late April and early May.

Solan (N-(3-chloro-4-methylphenyl)-2-methylpentanamide) was reported by Sweet and Kubatzky(1) to show promise as a selective pre-emergence herbicide for direct-seeded tomatoes. During 1961 a series of two plantings of direct-seeded tomatoes were made on Mermill Loam soil and subsequently treated with Solan.

Procedure

Following preparation of the soil with a rototiller, varieties Fireball and Heinz 1350 were seeded on May 4. Three replicates 72 feet each received Solan at the rate of four pounds per acre in 60 gallons of water on May 11 and May 15. Applications were made with a hydraulic sprayer. On May 11 a few weed seedlings had emerged and tomato seeds had sprouted but most had not broken through the soil surface. On May 15 twenty-five per cent of the tomato seedlings had emerged and a very large weed population was present. Just prior to cultivation on June 9 tomato seedling and weed counts were made. Following cultivation on June 9 accurate records of the time to weed and block the plots were made.

Following preparation of the soil by harrowing, a second seeding of Fireball was made on June 5. On June 9 Solan was applied to four replicates of 72 feet each at the rate of 4 pounds per acre in 60 gallons of water. Many weeds had broken through the surface of the soil on June 9 and the tomato seed had germinated. Tomato seedling and weed counts were made on June 21.

Results

Tomato and weed counts are reported in Table 1. The predominant weed present in the May 4 seeding was smartweed (<u>Polygonium</u> <u>Persicaria</u> L.) with lambs quarters (<u>Chenopodium</u> <u>album</u> L.), pigweed (<u>Chenopodium</u> <u>paganum</u> Reich.), red-root (<u>Amaranthus</u> <u>retroflexus</u> L.) and crabgrass (<u>Digitaria</u> sp.) also present. The predominant weeds present in the June 5 seeding were of the same type indicated above.

1/ Registered trademark of the Niagara Chemical Division of Food Machinery and Chemical Corporation.
2/ H. J. Heinz Company, Pittsburgh, Pa.
3/ H. J. Heinz Company, Bowling Green, Ohio

Table 1. Seeding and Weed Counts on Field-Seeded Tomato Plots Treated With Solan Premergence.

Treatment	Lbs of Active Chemical/Acre	Seedling Count/ 6 Feet of Row	Broadleaf Weed Count/6 Sq.Feet	Grass Count/6 Sq.Feet
		A. Seeded May 4		
Solan, 1 Week After Seeding	4	55.0	99.6	24.6
Solan, Just Before Seedling Emergence	4	20.0	6.6	56.0
Check	-	46.0	318.0	20.0
L.S.D. 5%		21.9	95.4	N.S.
L.S.D. 1%		N.S.	158.3	N.S.
		B. Seeded June 5		
Solan, Just Before Seedling Emergence	4	51.5	4.8	11.5
Check	4	53.7	109.2	54.5
L.S.D. 5%		N.S.	37.8	27.2
L.S.D. 1%		N.S.	55.9	40.2

Significant control of broadleaf weeds was obtained with all treatments of Solan. Control of grasses was not significant in the May 4 seeding, but was significant in the June 5 seeding, after pre-emergence Solan treatment.

A significant reduction in seedling stand was recorded just prior to emergence treatment, May 15. Following applications of Solan on May 15, emerged tomato seedlings were either killed or severely injured. No reduction in seedling stand was obtained with other treatments.

The man-hours required to hand-weed and block the May 4 seedling stand were recorded on June 9. The man-hours required to block and weed the treatments was 14.2 and 23.8 for 4 pounds Solan just prior to emergence and one week after seeding, respectively, and 31.2 hours for the untreated plots. Because weeds and tomato seedlings were large, it follows that the man-hours required to block and weed the treatments was greater than normally anticipated for all treatments.

Summary

Excellent broadleaf weed control was obtained in plantings of direct-seeded tomatoes with pre-emergence treatments of 4 pounds Solan per acre. No reduction in the stand of tomato seedlings was obtained when Solan was applied prior to emergence of seedlings.

The time required to hand-weed and block direct-seeded tomatoes was reduced by more than one-half when 4 pounds Solan was applied just prior to emergence of tomato seedlings.

Literature Cited

1. Sweet, R.D. and V. Rubatzky. Herbicides for Tomatoes. Proc. of N.E. Weed Control Conf. 13: 84-92. 1959.

WEED CONTROL AND THE IMPROVEMENT OF SEEDLING STANDS IN DIRECT-SEEDED TOMATOES

Colen C. Wyatt 1/ and J. D. Wilson 2/

Introduction

Experiments conducted in 1960 indicated that Vapam and Allyl Alcohol were two chemical compounds that might be expected to give a considerable degree of weed control and at the same time increase the stand of seedlings in the direct-seeding of tomatoes up to the time of blocking and thinning. In the 1960 trials these two materials were mixed with the top three inches of soil with a tractor-mounted rotary tiller in bands approximately 16 inches wide. In some instances the treated band was covered with a polyethylene tarp. About 12 to 14 days later tomatoes were seeded into the treated bands of soil. Because of the favorable results obtained in the 1960 experiments it was decided to continue the experimentation.

Procedure

Vapam (sodium n-methyl dithiocarbamate), Allyl Alcohol and Tillam (propylethyl-n-butythiocarbamate) were included in the 1961 tests. In addition, various types of mulches or sealants were added to the treated bands of soil in an effort to evaluate their effectiveness in slowing down the escape of the Vapam and Allyl Alcohol from the soil and thus improve their performance in killing weeds and fungi in the surface inch or so of soil. Tillam was also mixed with the soil alone and in combination with Vapam and Allyl Alcohol to increase the degree of weed control. The treatments used and the results obtained at Bowling Green and Wooster, Ohio are indicated in Table 1.

The soil was thoroughly disked and harrowed to put it in good physical condition before it was treated. The treatments were applied in cooperation with personnel from the U.S.D.A. Engineering Laboratory located at Wooster, Ohio, with tractor-mounted equipment designed and developed by that laboratory. The chemical compounds used were incorporated (mixed) with the top 3 inches of soil in bands 16 inches wide, where so indicated, by spraying them on the surface just ahead of the tilling equipment. In a few instances where the rotary tiller was not used about 2 inches of soil were thrown over the sprayed band by means of carefully mounted discs. In both methods of application the soil was smoothed and packed somewhat in a rounded mound about 2 inches higher in the center than at the edges. If the treated band was to be covered with a polyethylene tarp, this covering was then laid and the edges covered (sealed) by means of specially mounted discs. After 4 or 5 days the tarp was removed. If liquid sealants were to be employed, these were applied by placing the selected sealant in a paint sprayer operated by compressed air from which it was sprayed on the treated band of soil. These so-called sealants were left in place and the seed drilled through the mulch some 10 or 11 days after the treatments were applied.

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2/ Professor of Plant Pathology, Ohio Agricultural Experiment Station, Wooster, Ohio

Table 1. Tomato Seedling and Weed Counts on Plots Treated With Several Chemicals at Bowling Green and Wooster, Ohio, 1961.

			Chemical Treatment					
Mulch	Chemical Mixed With Soil	Location of Two Plots	Vapam	Allyl Alcohol	Tillam	Tillam & Vapam	Tillam & Allyl Alcohol	None
		A. Seedling Stand/10 Feet of Row						
None	Yes	B.G.	25	24	28	31	32	31
None	Yes	Wooster	23	25	19	18	22	33
Polyethylene Tarp	Yes	B.G.	28	20	-	-	-	-
Polyethylene Tarp	Yes	Wooster	27	23	-	-	-	-
Asphalt	Yes	B.G.	23	35	-	-	-	-
Asphalt	Yes	Wooster	25	23	-	-	-	-
2" Soil & Asphalt	No	B.G.	24	32	-	-	-	-
Latex	Yes	B.G.	23	30	-	-	-	-
Latex	Yes	Wooster	32	24	-	-	-	-
2" Soil & Latex	No	B.G.	29	34	-	-	-	-
Soil Set 60	Yes	B.G.	25	26	-	-	-	-
Soil Set 60	Yes	Wooster	23	28	-	-	-	-
2" Soil & Soil Set 60	No	B.G.	25	36	-	-	-	-
2" Soil	No	B.G.	32	48	-	-	-	-
2" Soil	No	Wooster	36	33	-	-	-	-
		B. Weed Count per 10 Square Feet						
None	Yes	B.G.	125	118	65	32	20	247
None	Yes	Wooster	213	87	28	7	13	370
Polyethylene Tarp	Yes	B.G.	18	25	-	-	-	-
Polyethylene Tarp	Yes	Wooster	18	3	-	-	-	-
Asphalt	Yes	B.G.	159	135	-	-	-	-
Asphalt	Yes	Wooster	98	44	-	-	-	-
2" Soil & Asphalt	No	B.G.	164	90	-	-	-	-
Latex	Yes	B.G.	108	86	-	-	-	-
Latex	Yes	Wooster	130	23	-	-	-	-
2" Soil & Latex	No	B.G.	41	56	-	-	-	-
Soil Set 60	Yes	B.G.	167	126	-	-	-	-
Soil Set 60	Yes	Wooster	43	29	-	-	-	-
2" Soil & Soil Set 60	No	B.G.	124	41	-	-	-	-
2" Soil	No	B.G.	62	76	-	-	-	-
2" Soil	No	Wooster	122	45	-	-	-	-

Following emergence of the tomato seedlings, stand and weed counts were made to determine the comparative effectiveness of the treatments used. At Bowling Green workers experienced in blocking, weeding and thinning vegetables were employed to go over the tomato plots. The average time required to finish each differently treated row was recorded and the data are reported in Table 2.

Table 2. Studies of the Time to Weed and Block Direct-Seeded Tomatoes Treated With Several Chemicals. Bowling Green, Ohio, 1961.

Chemical	Mulch	Chemical Combined With Soil	Hours to Weed and Block One Acre of Direct-Seeded Tomatoes
Vapam	None	Yes	8.50
Vapam	Polyethylene	Yes	5.67
Vapam	Soil Sealants*	Yes	5.67
Vapam	2" Soil & Soil Sealants	No	5.67
Vapam	2" Soil	No	5.67
Allyl Alcohol	None	Yes	9.07
Allyl Alcohol	Polyethylene	Yes	5.67
Allyl Alcohol	Soil Sealants*	Yes	7.09
Allyl Alcohol	2" Soil & Soil Sealants*	No	5.67
Allyl Alcohol	2" Soil	No	5.67
Tillam	None	Yes	5.67
Tillam & Vapam	None	Yes	5.67
Tillam & Allyl Alcohol	None	Yes	7.09
None	None	-	12.28

*Includes Asphalt, Latex and Soil Set 60.

Data on the rate at which the different chemicals and sealants were applied, the dates of treatment, as well as the dates and rates of seeding are presented in Table 3.

Results

As indicated in Table 1, commercial stands of tomato seedlings were obtained in nearly all of the plots. At Wooster where Tillam was used, a slight reduction in stand was noted and an appreciable reduction in plant growth and vigor was observed. Tillam was reported by Sweet and Cialone(1) to cause a reduction in stand of direct-seeded tomatoes planted immediately after soil treatment. At Bowling Green none of the treatments produced apparent damage to stand or plant growth. Damping-off of the seedlings after emergence was at a minimum in these experiments.

Table 3. Rates and Dates of Chemical Treatment and Seeding of Direct-Seeded Tomato Trials. Bowling Green and Wooster, Ohio, 1961.

	Bowling Green	Wooster
Vapam	50 Gallons/Acre	40 Gallons/Acre
Allyl Alcohol	50 Gallons/Acre	60 Gallons/Acre
Tillam	3 Pounds	4 Pounds
Latex*	600 Gallons/Acre as Formulated	600 Gallons/Acre as Formulated
Asphalt*	600 Gallons/Acre as Formulated	600 Gallons/Acre as Formulated
Soil Set*	600 Gallons/Acre as Formulated	600 Gallons/Acre as Formulated
Width of Treated Land	16"	16"
Row Width	48"	48"
Date of Chemical Treatment	May 4	May 23
Date of Seeding	May 15	June 2
Rate of Seeding	4 Seeds/Foot	4 Seeds/Foot

*These soil sealant materials were all emulsifiable and were diluted with an equal volume of water before being applied in a total volume of 1200 Gal/Acre.

The soil sealants (Asphalt[a], Latex[b], and Soil Set 60[c]) maintained the soil under them in excellent physical condition with respect to tilth and moisture, and thus provided an excellent seed bed at the time of planting.

The comparative weed counts that accompanied the application of the different chemical treatments, used (singly or in combination) are summarized in Table 1. The predominant weed in the Bowling Green experiment was smartweed (_Polyganum Persicaria_ L.), with lambs quarters (_Chenopodium album_ L.), pigweed (_Chenopodium paganum_ Reich.), red-root (_Amaranthus retroflexus_ L.) and crab-grass (_Digitaria_ sp.) also present. At Wooster, smartweed, red-root, lambs-quarters, pigweed and galinsoga (_Galinsoga ciliata_ Blake) were the principal weed species present.

Commercial control of the weeds present at each location was obtained with most of the treatments. The lowest weed populations were obtained where Vapam and Allyl Alcohol were mixed with the soil and covered with a polyethylene tarp. Tillam used with Vapam and Allyl Alcohol produced better weed control than when it was used alone. In most instances the use of the soil sealants gave an appreciable reduction in weed populations below those present in unmulched bands, but a choice between the three on the basis of effectiveness in weed control would be difficult to make. As indicated in Table 1, a two inch soil "mulch" over the areas treated with Vapam and Allyl Alcohol produced satisfactory weed control.

A consideration of the time required to block and weed an acre of the differently treated bands of soil in the Bowling Green experiment, Table 2,

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[a] Asphalt as formulated by the Shell Chemical Company.
[b] Latex as prepared by the Dow Chemical Company.
[c] Soil Set 60 as formulated by Alco Oil and Chemical Company

indicates that several of the treatment combinations halved the labor required. The use of Vapam or Allyl Alcohol reduced the time by about one-third, whereas in most instances it was reduced by one-half when polyethylene tarp or one of the sealants was applied. This was true whether Vapam and/or Allyl Alcohol was mixed with the soil or simply covered with soil with a pair of discs.

Literature Cited

1. Sweet, R. D. and J. Cialone. Proc. of N.E. Weed Control Conf. 15: 107-110. 1960.

ADDITIONAL FIELD STUDIES WITH SOLAN
AS A
HERBICIDE FOR TOMATOES

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Solan, N-(3-chloro-4-methylphenyl)-2-methyl-pentanamide has been tested by a number of investigators as a herbicide for tomatoes, over a period of four years.

Sweet and Rubatzky (1) found Solan to give commercial weed control and to be outstanding in lack of crop damage to both transplant tomatoes and field seeded tomatoes. Saidak and Rutherford (2) in 1959 and 1960 trials, found Solan to be reliable and effective as a herbicide in tomatoes when applied as a post-emergence spray, one month after transplanting, to weeds less than 3 inches high. Schubert and Hardin (3) found Solan to give commercial control of broadleaf weeds in post-emergence treatments. Grass control was satisfactory only for about one month if the grass was not more than 1½ inches high at time of spraying.

Results of preliminary field studies of Solan as a post-emergence herbicide for tomatoes have been presented previously by Moore and Dorschner (4). It is the purpose of this paper to summarize performance data which have been obtained over the past two years.

METHODS AND MATERIALS

Tests in 1960 were conducted on the varieties Fireball and Red Jacket. These included both field seeded and field transplant stock. Treatments were applied as broadcast sprays using a knapsack sprayer. Fifty gallons of total liquids per acre were applied. The experimental design was one of randomized complete block with three replications.

In 1961 experimental procedures were similar, but with the following exceptions: Sprays were applied at 40 psi and a volume of 30, rather than 50 gallons of total liquids per acre was utilized. In some instances rather large areas were sprayed with a given treatment. Such plots were not replicated. The formulation of Solan used for all tests was a miscible formulation containing 4.0 pounds of active material per gallon.

DISCUSSION OF RESULTS

Transplant Tomatoes, Experiment No. 1, 1960

The chemical treatments in this trial were five in number, and consisted of the following:

a. Solan at rate of 2.0 pounds/acre;
   4 applications at two week intervals.
b. Solan at rate of 4.0 pounds/acre;
   2 applications one week apart.
c. Solan at rates of 2.0, 4.0, and 6.0 pounds/acre;
   single applications.

Both grasses and broadleaved weed species were less than one inch high when the first treatment was made on June 21. Weed species represented were pigweed (*Amaranthus retroflexus*), lambsquarters (*Chenopodium album*), buckhorn plantain (*Plantago lanceolata*), barnyard grass (*Echinochloa crusgalli*), and yellow foxtail (*Setaria lutescens*). None of the plots was cultivated.

Data on weed control were taken at three intervals throughout the season. The final counts just prior to harvest are reported in Table 1. The most effective treatment was two applications of Solan (4 pound/acre rate) made at 7 day intervals. There was an appreciable reduction in weed population following all single treatments, but in view of the size reached by the surviving weeds, these data may be misleading. Thus, in the case of the 2 pound rate, the escapes developed to such large size as to interfere with growth and yields of crop plants. At both the 4 and 6 pound rate the escape weeds were considerably reduced in size.

The total number and pounds of tomatoes produced for the entire season for each treatment are reported in Table 2. No significant difference was noted in the number of tomatoes produced following any of the 5 control programs and the cultivated check.

Although the untreated check was not included in the analyses of data, it is obvious that all treatments had significantly more fruit than the check.

Considering the total number of pounds of tomatoes for the season, the treatment receiving a single application of 2 pounds of Solan per acre yielded significantly less than the cultivated check in the case of Fireball. This was interpreted to be the result of weed competition.

Transplant Tomatoes, Experiment No. 2, 1961

A test was implemented in 1961 with the purpose of were used, but as already noted, sprays were applied with a tractor-mounted boom sprayer. One treatment consisted of 2 applications of Solan at the 4 pound per acre rate. The first of these was made about 2 weeks after transplanting (July 1), and the second at lay-by (August 1). This program was compared to a single application of 4 pounds per acre made on July 1. Test areas were cultivated on July 11 and July 18.

Data on weed control are reported in Table 3. Weed counts made on August 9 showed no weeds in the area treated with the two applications of Solan. At the same time, there had been 72 and 79 percent control of pigweed and lambsquarters, respectively, in that plot receiving the single treatment. It should be added that the area receiving two applications remained practically clean until after harvest.

Transplant Tomatoes, Experiment No. 3, 1961

Fourteen varieties of tomatoes were transplanted to the field with the idea of determining their tolerance to Solan, and to add to data on the herbicidal properties of the compound. These varieties were Campbell 146, Glamour, Long Red, Marglobe, Roma, Homestead 61, ES 24, H 1370, Homestead 24, Manalucie, Moreton Hybrid, Trellis 22, Valiant, and Rutgers California. Plots consisted of single rows of each variety, with each row being divided into sub-plots, comprising an untreated, Solan at 4 pounds, and Solan at 8 pounds per acre. Applications were made with a tractor-mounted boom sprayer two weeks after transplanting. They were retreated 3 weeks later. At no time did the plots receive any cultivation.

Observations on July 12, six days after the first application, showed slight chlorosis on the varieties Roma and Homestead 24 where Solan had been used at 8 pounds. All others were normal. Observations made on August 3, six days after the second treatment, showed slight chlorosis on the Roma variety at the 4 pound level. At the 8 pound level (a total of 16 pounds per season) slight chlorosis was noted on Campbell 146, Glamour, Long Red, Homestead 61, H 1370, Moreton Hybrid, Trellis 22, Valiant, and Rutgers California. At this dosage level Roma showed some necrosis of older leaves. The chlorotic effect shortly disappeared, and on August 18, three weeks after the second treatment, all varieties including Roma were normal, and remained so for the season.

Predominant weeds were ragweed, plantain, dock (<u>Rumex crispus</u>), wild carrot (<u>Daucus carota</u>), yellow foxtail, and barnyard grass. At the start of the harvest period 85 and 87 percent of all weed species had been controlled by the 4 and 8 pound per acre rate, respectively. Wild carrot was not controlled, a result which was not surprising since Solan has been very promising as a post-emergence herbicide on carrots. The untreated area at harvest was covered with weeds, and tomato plants were very small. Harvesting in this area was very time consuming, compared with either of the treated areas.

Total seasonal yields, both in numbers and pounds of tomatoes for each variety, are summarized in Table 4. All varieties except Roma produced a greater total weight of fruit in the treated than in the untreated. Only in the case of Roma and Homestead 61 were there slightly more fruit in the untreated than the treated. This implies that Solan did not have an inhibiting effect on the set of fruit.

The varieties Homestead 24, H 1370, Manalucie, Valiant and Rutgers California produced somewhat fewer pounds of tomatoes at the 8 pound rate than at the 4 pound rate. The fact that the other varieties produced equal or greater weights of tomatoes at the 4 pound rate suggests that one is working with a good margin of safety when suggesting the lower rate as a commercial practice.

Field Seeded Tomatoes, Experiment No. 1, 1960

Seeds of the varieties Fireball and Red Jacket were planted and Solan at the rate of 2, 4 and 6 pounds per acre was applied to the seeded areas on the day of, and 2, 5 and 7 days after planting. Each treatment comprised a single row 10 feet long and was replicated three times.

Under conditions of the test, "stage of growth" of the tomato plants varied from "not germinated" to "breaking the ground". Weeds at the various test intervals varied from "not germinated" to one inch high. Results of stand counts and percent of weed control, as taken some two weeks after the last treatment, are given in Table 5.

Treatments applied on the day of seeding had no effect on germination of either variety. Control of weeds, while partial, was far from satisfactory. Delaying the treatment even 2 days did not reduce crop stands, and resulted in appreciable control. It was noted that some weeds had germinated at the time of treatment.

When applications were made 5 days after seeding, crop plants had germinated, but had not broken the soil. Weeds had germinated considerably, but were less than one inch in height. Under these conditions the stand of Fireball was reduced when Solan was applied at 4 and 6 pounds per acre, and the variety Red Jacket was reduced only when treated at the 6 pound level. Control of broadleaved weed species was good, but grass control was marginal.

The remaining plots were treated one week after planting, at which time weeds were one inch tall and tomatoes were breaking the ground. There was a significant reduction in crop stand of Fireball following both the 4 and 6 pound per acre treatments. While there was a tendency toward reduced stands of the variety Red Jacket at both the 4 and 6 pound per acre rates, these reductions were not significant. Weed control was considered to be good, ranging from 86 to 99 percent of broadleaved species, and 74 to 85 percent of grasses.

Results of additional tests on tomatoes at various growth stages indicated that they had to be approximately six inches high before a tolerance to Solan was demonstrated.

Field Seeded Tomatoes, Experiment No. 2, 1961

Studies of weed control in field seeded tomatoes was expanded in 1961 to include the varieties Roma and Manalucie, in addition to Fireball and Red Jacket. Treatments were made 3 and 7 days after seeding and were applied with a tractor mounted boom sprayer. One treatment was made on July 10, twelve days after planting. Results are summarized in Table 6.

In essence, applications made when seeds had germinated, but had not broken the ground, did not reduce stands. Applications made at the ground breaking stage reduced the stand of Roma and Fireball, indicating that the tolerance to Solan by seedlings, at this stage of development, is marginal. Applications made when seedlings were about one inch high resulted in severe stand reductions to all varieties. Applications made to tomatoes 1½ inches tall (12 days after planting) resulted in appreciable stand reduction to all four varieties.

The percent of broadleaved weed control was good when using the 4 pound rate of Solan in two applications.

SUMMARY AND CONCLUSIONS

Results from two years of field testing are presented on the use of Solan, both as a pre-emergent herbicide for field seeded tomatoes, and as a post-emergence treatment for field transplant tomatoes.

Solan applied to field seeded tomatoes on the day of planting did not provide satisfactory weed control, nor did it result in any reduction of crop stand. Treatments made after the seed had germinated, but before they started to emerge, resulted in commercial weed control without appreciable crop injury. Treatments made after the crop seeds had reached a ground cracking stage, to the time that plants were 1½ inches in height, resulted in stand reductions which varied in severity with variety. It appeared that the crop tolerance was not good until plants were at least 6 inches in height. Four pounds of Solan per acre were required for good weed control.

An additional 2 years of tests on field transplanted tomatoes have continued to demonstrate the value of Solan as a post-emergence herbicide.

Applications of four pounds of this chemical per broadcast acre made 14 days after transplanting, and again at lay-by, have been well tolerated by the varieties Campbell 146, Glamour, Long Red, Marglobe, ES 24, H 1370, Homestead 24, Manalucie, Moreton Hybrid, Trellis 22, Valiant, and Rutgers California. A slight temporary foliage chlorosis was noted on the varieties Roma and Homestead 61 at the four pound rate. Two applications of Solan, each at 8 pounds, resulted in a temporary chlorosis to Campbell 146, Glamour, Long Red, Homestead 61, H 1370, Moreton Hybrid, Trellis 22, Valiant, and Rutgers California. The minimum seasonal yield increase at either rate over the untreated for all varieties except Glamour, Homestead 61, and Roma ranged from 64 to 243 percent. For the latter three varieties there was an 18 and 9 percent increase, and a 5 percent decrease, respectively.

Solan, when applied at a rate of 4 pounds per acre to broadleaved weeds and annual grasses less than one inch in height, provided excellent results. Repeat treatments were necessary for seasonal control.

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Table 1 Weed Control with Solan in Transplant Tomatoes - 1960

			Average No. Weeds per Square Foot - Aug				
Treatment	Lbs. Active Per Acre	Date of Applications	Pigweed	Lambs-quarters	Plantain	Grass*	O
Solan four applications	2.0	6/21, 7/5 7/14, 8/2	3.3	0.0	0.0	5.0	
Solan two applications	4.0	6/21, 6/28	1.0	0.3	0.0	4.6	
Solan one application	2.0	6/21	3.3	0.3	1.6	4.0	
Solan one application	4.0	6/21	2.6	0.6	0.0	2.3	
Solan one application	6.0	6/21	1.3	1.0	1.3	2.3	
Cultivated Check	---	6/21, 6/28 7/11	8.0	6.6	0.0	3.0	
Untreated Check	---	---	17.3	96.6	4.3	9.0	

*Barnyard grass and yellow foxtail grass

Tomatoes transplanted 6/3/60

Table 2 Average Number and Pounds of Tomatoes per Plot per Season For Tomatoes Receiving Foliar Applications of Solan - 1960

Treatment	Lbs. Active Per Acre	Date of Applications	Average No. Tomatoes Per Plot Per Season		Average No. Lbs Tomatoes/Plot/ Season	
			Fireball	Red Jacket	Fireball	Red Jac
Solan four applications	2.0	6/21, 7/5 7/14, 8/2	82.0	146.0	18.6	37.6
Solan two applications	4.0	6/21, 6/28	75.3	152.0	16.5	34.9
Solan one application	2.0	6/21	75.0	114.0	15.0*	25.2
Solan one application	4.0	6/21	83.0	150.0	17.6	33.0
Solan one application	6.0	6/21	81.7	142.0	16.1	37.9
Cultivated Check	---	6/21, 6/28 7/11	83.7	149.0	21.0	36.4
Untreated Check	---	---	25.6	14.0	2.9	2.2
		LSD .01	25.6	56.0	7.2	16.2
		.05	18.8	41.0	5.3	11.9

*Significantly lower than cultivated check.

Table 3 Results of an Application of Solan on Commercial Scale for Control of Weeds in Transplant Tomatoes - 1961

Treatment	Lbs. Active Per Acre	Date of Applications	Weeds Per Square Foot - August 9,		
			Pigweed	Lambsquarters	Others
Solan two applications	4.0	7/1, 8/1	0.0	0.0	0.0
Solan one application	4.0	7/1	11.0	3.0	1.0
Untreated Check	---	---	39.0	14.3	1.2

Tomatoes transplanted 6/16/61

Plots cultivated 7/11, 7/18/61

Table 4 Total Yields in Number and Pounds of Fruit for Each of Fourteen Tomato Varieties Receiving Foliar Applications of Solan - 1961

Tomato Variety	Rate Per Acre (Lbs.)	No. of Fruit	Pounds of Fruit	Rate Per Acre (Lbs.)	No. of Fruit	Pounds of Fruit	Rate Per Acre (Lbs.)	No. of Fruit	Pour of Fru
Campbell 146	4.0	286	84	8.0	326	101	Untreated	156	4
Glamour		205	65		242	86		177	5
Long Red		364	105		351	103		139	3
Marglobe		331	65		278	67		133	3
Roma		720	93		841	100		910	9
Homestead 61		310	97		349	99		346	8
E.S. 24		492	101		518	110		212	5
H 1370		575	151		570	128		315	6
Homestead 24		342	93		293	81		170	4
Manalucie		345	94		289	85		185	3
Moreton Hybrid		447	120		497	140		280	7
Trellis 22		601	102		638	115		348	6
Valiant		520	149		491	134		322	8
Rutgers California		259	66		210	54		125	2

Date of Treatment: 7/6, 7/28 Date Planted: 6

Table 5 The Effect of a Delayed Pre-emergence Application of Solan on Stands of Field Seeded Fireball and Red Jacket Tomatoes - 1960

Treatment	lbs. Act/ Acre	Date Treated	Stage of Tomato	Avg. Plants/3 ft. of Row Fireball	Avg. Plants/3 ft. of Row Red Jacket	% Weed Control-July 14 Broadleaved	% Weed Control-July 14 Grasses(1)
Solan	2.0	6/22	Not up	21.7	12.0	23.9	58.2
Solan	4.0	6/22	Not up	22.3	15.0	21.4	87.7
Solan	6.0	6/22	Not up	22.0	25.6	43.8	48.4
Solan	2.0	6/24	Not up	14.7	13.7	83.1	98.6
Solan	4.0	6/24	Not up	16.3	18.3	80.9	95.3
Solan	6.0	6/24	Not up	23.0	18.7	85.8	97.2
Solan	2.0	6/27	Not up	12.7	15.7	79.0	78.4
Solan	4.0	6/27	Not up	9.3*	12.0	93.8	53.1
Solan	6.0	6/27	Not up	8.7*	8.3*	84.4	65.7
Solan	2.0	6/29	Breaking	17.3	16.7	85.8	83.1
Solan	4.0	6/29	Breaking	5.6**	9.0	96.6	73.7
Solan	6.0	6/29	Breaking	7.0*	13.7	98.8	84.5
Untreated Check	---	--		18.3	15.3		21.3(2)
			LSD .01	11.5	9.9		
			.05	8.6	7.3		

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(1) Grasses - Barnyard grass & yellow foxtail
(2) No. of weeds per sq. ft. in untreated area.

* Significant difference
** Highly significant difference.

Table 6 Evaluation of Solan for Weed Control in Field Seeded Tomatoes - 1961

Treatment	Lbs. Act./ Acre	Dates Treated	Stage of Tomato	Plants per foot of Row 7/12/61				% Weed Control 9/11 (3)
				Red Jacket	Fireball	Manalucie	Roma	
Solan	3.0	7/1, 7/20	Sprouting Not up	4.4	11.3	6.1	4.0	81.3
Solan	4.0	7/1, 7/20	"	2.6	10.8	5.0	4.4	93.8
Solan	3.0	7/5	Breaking ground	3.3	3.6	6.2	0.6	73.1
Solan	4.0	7/5	Some 1"	0.1	0.8	0.2	0.4	85.6
Solan	8.0	7/5	Some 1"	0.0	2.3	0.3	0.3	91.9
Solan	3.0	7/10	1½" tall	2.1	1.3	0.1	1.9(1)	79.4
Untreated Check				3.2	13.8	5.8	4.4	16.0(2)

(1) Counts made at end of season
(2) No. weeds per sq. ft., mostly broadleaved weeds
Tomatoes planted 6/28/61

An Evaluation of Chemicals Used For the Weeding of Tomatoes.

Charles J. Noll[1]

Weed control is the greatest limiting factor in successful gwowing of direct seeded tomatoes. Mechanical weeding is inadequate and hand weeding too expensive. Until good chemical weeding is developed the growing of direct seeded tomatoes in Pennsylvania will be limited in acreage.

The weeding of transplanted tomatoes by mechanical means is not as difficult but if adequate chemical weeding could be developed it could reduce production costs.

PROCEDURE

In the direct seeded tomato experiment the seedbed was prepared May 24. Soil incorporation treatments were applied and rototilled into the soil May 25. The tomato variety Fireball, was seeded that same day. The pre-emergence treatments were applied 4 days after seeding and late pre-emergence treatments were applied 11 days after seeding. One Solan plot received an additional application 41 days after seeding. Individual plots were 15 feet long and 3 feet wide. Treatments were randomized in each of 6 blocks. The chemicals were applied with a small sprayer over the row for a width of 12 inches. The plots were cultivated. An estimate of weed control was made August 14 on a basis of 1 to 10; 1 being most desirable and 10 being least desirable. No harvest records were taken.

In the transplanted tomatoes the same variety was grown. The seedbed was prepared June 5, the soil incorporation treatments made June 6 and the tomatoes transplanted June 7. Post-planting treatments were made 5 and 22 days after transplanting with the nozzel of the sprayer directly over the tomato plants. Individual plots were 20 feet long and 5 feet wide and consisted of 10 plants each. Treatments were randomized in each of 6 blocks.

The plots were cultivated. An estimate of weed control was made August 14 on a basis of 1 to 10. Tomatoes were harvested twice, August 22 and September 14. Only marketable fruits were harvested.

RESULTS

The weed control results in the direct seeded tomato experiment is presented in table 1. Although the Triazine compounds gave the best weed control, they greatly reduced the stand of tomatoes. The Diphenamid plots had few weeds, the plots receiving 9 lbs. per acre were relatively free of weeds throughout the growing season. The only other treatment that gave any amount

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of weed control without injury to tomatoes was in the Tillam treated plots. Although no yield records were taken it was thought that yields in the best plots would have been good.

The results in the transplanted tomato experiment is presented in table 2. All chemicals significantly increased weed control as compared to the untreated check. The best weed control was in plots treated with Diphenamid at 6 and 9 lbs. per acre, Stam F-34 at 6 lbs. per acre, Prometryne at 3 lbs. per acre, Casoron at 4½ lbs. per acre and Tillam at 6 lbs. per acre.

Only two harvests were made and only ripe marketable fruit taken for record. Plots treated with Diphenamid at 9 lbs. per acre and Tillam at 4 lbs. per acre had a significant increase in yield as compared to the untreated check plot. The yield from the plots treated with the chemical Stam F-34 at 6 lbs. per acre approached significance.

CONCLUSION

In the direct seeded tomato experiment, it looks at this time that chemicals could replace other methods of weed control in the plant row. If this is true, direct seeding of tomatoes is a possibility in Pennsylvania. The best treatments were Diphenamid at 6 and 9 lbs. per acre in a pre-emergence application and Tillam at 6 lbs. per acre in a pre-planting soil incorporation treatment.

In the transplanted tomato experiment, the outstanding chemicals were Diphenamid in the post-planting treatment, Tillam in the pre-planting soil incorporation treatment and Stam F-34 in the delayed post-planting treatment.

Table 1. Weed control results with various chemical herbicides.

Chemical	Active Rate Per Acre lbs.	Application Days from Seeding	AVERAGE PER PLOT *Weed Control (1-10)
Nothing	--	--	10.0
Tillam	4	Soil Incorporation 0	5.7
"	6	" " 0	3.5
Prometryne	2	Planting Time 0	1.3
"	3	" " 0	1.2
Atrametryne	2	" " 0	1.8
"	3	" " 0	1.2
Diphenamid	6	Pre-emergence 4	3.5
"	9	" 4	2.2
KOCN + TCA	16 + 3	Late Pre-emergence 11	8.2
Zytron	10	" " 11	3.7
Vegadex	4	" " 11	9.0
"	6	" " 11	9.5
Solan	4	" " 11	6.2
"	6	" " 11	6.2
"	4	" and Post-emergence Tom. 6" high 11 + 41	4.2
Least significant difference 5%			1.9
1%			2.6

*Weed Control (1-10): 1 Perfect Weed Control.
10 Full Weed Growth.

Table 2. Weed control and weight of marketable tomatoes under chemical herbicide treatments.

Chemical	Active Rate Per Acre lbs.	Application Days from Seeding	AVERAGE PER PLOT *Weed Control (1-10)	AVERAGE PER PLOT Wt. Mkt. Fruit lbs.
Nothing	--	--	9.2	21.8
Tillam	4	Soil Inc. -1	5.2	32.4
"	6	" " -1	3.8	21.2
R-1856	4	" " -1	6.2	29.4
"	6	" " -1	5.2	20.1
Prometryne	2	" " -1	5.2	10.6
"	3	" " -1	3.5	3.3
Atrametryne	2	" " -1	6.0	7.2
"	3	" " -1	4.3	1.3
Casoron	3	Post-Planting 5	5.8	19.2
"	4½	" " 5	3.7	25.0
Diphenamid	6	" " 5	2.5	24.0
"	9	" " 5	2.0	32.9
Stam F-34	4	" " 22	5.2	28.9
"	6	" " 22	3.0	31.7
Least significant difference 5%			2.0	10.5
1%			2.7	N.S.D.

THE EFFECTS OF FORMULATION AND PLANTING DATE ON THE HERBICIDAL ACTIVITY OF PROPYL ETHYL-n-BUTYLTHIOLCARBAMATE

R. D. Ilnicki, T. S. Gill, and T. F. Tisdell [1]

Within the last several years there has been much interest in thiolcarbamate herbicides as evidenced by the many crop-weed situations investigated. To date, there is little or no recorded information on the use of propyl ethyl-n-butylthiolcarbamate (Tillam) either as a pre-planting or pre-emergence herbicide for weed control in spinach. Previous work at this Station and elsewhere has indicated the effectiveness of this herbicide with little or no injury to several horticultural crops. Research has shown that delayed plantings following applications of other thiolcarbamate analogues will reduce injury to horticultural crops. This study was initiated to evaluate the effects on spinach and weeds of several planting dates following pre-planting applications of several formulations of Tillam.

Materials and Methods

Commercial propyl ethyl-n-butylthiolcarbamate (Tillam 6E) and formulations containing two different hydrocarbon carriers were the treatments evaluated. A low volatile, select paraffin fraction having carbons above C_{18}, served as the carrier in one blend (EAP 4160) and a somewhat higher volatile naphthenic fraction above C_{18} was used as a solvent or carrier in the other (EAP 4161). The two experimental formulations contained slow-breaking emulsifying systems and were identical in all other respects.

The three formulations of Tillam were applied as pre-planting treatments on August 29 at rates of 3 and 5 pounds per acre with a knapsack sprayer connected to a boom equipped with five nozzles spaced 20 inches apart. The applications were made in water dilutions of 40 gpa to a finely prepared seedbed of a Sassafras sandy loam soil at Seabrook Farms, Seabrook, New Jersey. Plots were 10 x 85 feet. Only 8-1/3 feet of each plot width was sprayed for the entire 85-foot length. The outside borders served as buffer areas and as checks to allow for any lateral movement of the treated soil at time of incorporation. Immediately after application, the treatments were disked into the upper 2-3 inches with a Meeker harrow in one direction only. Check plots were also included in addition to the border areas between plots. There were two replications of all treatments.

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Spinach was planted with an 8-row commercial seeder, individual rows spaced 12 inches apart, on August 30, September 2, and September 5, giving plantings of 1, 4, and 7 days after herbicidal applications, respectively. Each planting consisted of two or three drill strips across the plots. Prior to each planting, the area was reworked with a Meeker harrow in one direction across the plots. After each planting, an equivalent of ½-inch of rain was applied to the area seeded.

Weed control and crop injury ratings were made on September 28 and October 18 using the scale 0 to 10, where 0 = no effect, 10 = stand or vigor reduced 100 per cent.

Results and Discussion

In tables 1, 2, and 3 are presented summaries of weed control and spinach injury for the plantings made 1, 4, and 7 days, respectively, after applications of the three formulations of Tillam.

From these data it can be seen that the planting made soon after herbicidal applications was relatively safe for spinach and that better than adequate weed control resulted. It is also evident that overall weed control was improved with corresponding decreases in spinach injury by delaying spinach planting. This was especially true for the two experimental formulations with the hydrocarbon carriers. There was a slight decrease in broadleaved weed control with the lower rate of commercial Tillam in the planting made 7 days after application. There was a similar trend with regard to grass control, however, this was not significant.

The experimental formulations were slightly superior to commercial Tillam with regard to weed control and crop safety. The formulation containing the naphthenic hydrocarbon fraction was slightly more effective and safer than the formulation containing the paraffinic hydrocarbon fraction.

All formulations of Tillam exhibited residual herbicidal activity of long duration. This was more pronounced for the grasses than for the broadleaved weeds. Generally, the two experimental formulations effected slightly longer activity than commercial Tillam. Again, the formulation containing the naphthenic fraction was slightly more superior to the formulation with the paraffinic carrier.

Summary

A study was initiated to evaluate the effects on spinach and weeds of several planting dates following pre-planting applications of three formulations of Tillam. Two experimental formulations, one containing a paraffinic hydrocarbon carrier and the other a naphthenic hydrocarbon carrier, were compared to commerical Tillam.

Plantings were made 1, 4, and 7 days after the formulations were applied. Increases in weed control and decreases in crop injury resulted with increasing delays in planting. The two experimental formulations were somewhat superior to commercial Tillam. The one containing the naphthenic carrier was slightly superior to the one containing the paraffinic carrier.

Acknowledgement

The authors wish to acknowledge Dr. Robert H. Salveson of Esso Research and Engineering Company, Linden, New Jersey, for preparing and supplying the two experimental formulations of Tillam. Credit is also due him for the help given in obtaining data in the field.

Credit is also due Stauffer Chemical Company for supplying Tillam 6E used in this study.

Table 1. The residual effects of several formulations of Tillam* applied as pre-planting treatments one day prior to spinach planting on weed control and crop injury.** Formulations applied August 29 and spinach seeded August 30, 1961.

Treatment	Rate, lb/A	Weed Control[1]				Crop Injury			
		Broadleaved weeds		Grassy weeds		Stand[2]		Vigor[3]	
		Days after Application							
		30	50	30	50	30	50	30	50
Tillam 6E	3	6.8	1.0	8.3	8.5	0.5	0.5	0.5	0.0
	5	7.8	5.0	9.0	9.8	1.5	1.5	1.3	0.5
EAP 4160[4]	3	7.1	1.5	9.4	7.0	0.0	0.5	0.0	0.0
	5	8.5	0.5	9.5	9.9	1.0	0.0	0.0	0.0
EAP 4161[5]	3	6.0	0.5	9.0	9.0	1.0	3.5	0.0	0.0
	5	9.5	7.3	9.8	9.7	0.0	0.5	0.0	0.0

* propyl ethyl-n-butylthiolcarbamate

** average of two replications

[1] Based on scale 0 to 10; 0 = no effect, 10 = stand an/or vigor reduced 100%

[2] Based on scale 0 to 10; 0 = no effect, 10 = stand reduced 100%

[3] Based on scale 0 to 10; 0 = no effect, 10 = complete kill

[4] Herbicide dissolved in a select hydrocarbon paraffin fraction above C_{18}

[5] Herbicide dissolved in a select hydrocarbon naphthenic fraction above C_{18}

Table 2. The residual effects of several formulations of Tillam* applied as pre-planting treatments four days prior to spinach planting on weed control and crop injury.** Formulations applied August 29 and spinach seeded September 2, 1961.

Treatment	Rate, lb/A	Weed Control[1]				Crop Injury			
		Broadleaved weeds		Grassy weeds		Stand[2]		Vigor[3]	
		Days after Application							
		30	50	30	50	30	50	30	50
Tillam 6E	3	8.3	0.5	9.8	10.0	0.3	0.0	0.3	0.0
	5	9.4	7.5	9.4	9.9	0.5	1.0	0.0	0.5
EAP 4160[4]	3	8.0	1.0	9.5	9.9	0.0	0.0	0.0	0.0
	5	9.0	3.5	10.0	10.0	0.0	0.0	0.0	0.0
EAP 4161[5]	3	8.0	0.0	9.9	10.0	0.0	0.0	0.0	0.0
	5	9.5	5.5	10.0	9.9	0.0	0.5	0.0	0.0

* propyl ethyl-n-butylthiolcarbamate

** average of two replications

[1] Based on scale 0 to 10; 0 = no effect, 10 = stand and/or vigor reduced 100%

[2] Based on scale 0 to 10; 0 = no effect, 10 = stand reduced 100%

[3] Based on 0 to 10; 0 = no effect, 10 = complete kill

[4] Herbicide dissolved in a select hydrocarbon paraffin fraction above C_{18}

[5] Herbicide dissolved in a select hydrocarbon naphthenic fraction above C_{18}

Table 3. The residual effects of several formulations of Tillam* applied as pre-planting treatments seven days prior to spinach planting on weed control and crop injury.** Formulations applied August 29 and spinach seeded September 5, 1961.

Treatment	Rate, lb/A	Weed Control[1]				Crop Injury			
		Broadleaved weeds		Grassy weeds		Stand[2]		Vigor[3]	
		Days after Application							
		30	50	30	50	30	50	30	50
Tillam 6E	3	7.0	0.0	9.5	10.0	0.8	1.0	1.0	0.0
	5	9.0	3.5	10.0	10.0	0.5	1.5	1.0	1.0
EAP 4160[4]	3	9.3	0.5	10.0	10.0	0.0	1.0	0.0	0.0
	5	9.5	2.0	9.8	10.0	0.5	0.0	0.0	0.0
EAP 4161[5]	3	8.7	1.5	9.8	10.0	0.0	0.0	0.0	0.0
	5	9.5	5.5	9.8	10.0	0.0	0.5	0.0	0.5

* propyl ethyl-n-butylthiolcarbamate

** average of two replications

[1] Based on scale 0 to 10; 0 = no effect, 10 = stand and/or vigor reduced 100%

[2] Based on scale 0 to 10; 0 = no effect, 10 = stand reduced 100%

[3] Based on 0 to 10; 0 = no effect, 10 = complete kill

[4] Herbicide dissolved in a select hydrocarbon paraffin fraction above C_{18}

[5] Herbicide dissolved in a select hydrocarbon naphthenic fraction above C_{18}

FURTHER OBSERVATIONS ON CONTROL OF THE COMMON BRAKE, TERIDIUM AQUILINUM L., IN LOWBUSH BLUEBERRIES WITH POLYBORCHLORATE[1]

W. J. Lord and J. S. Bailey[2]

One of the chief concerns of the managers of lowbush blueberry areas is the control of weed species which crowd out the blueberries and seriously interfere with harvesting. In 1948 a weed survey in the lowbush blueberry fields in the Granville-Blandford area of Massachusetts revealed that the common brake, Teridium aquilinum L., is a serious weed in many places (1).

Previous work (1) has shown that 400 to 600 pounds per acre of polyborchlorate applied prior to "burn" will effectively control the common brake, but this material injures the blueberries. When the polyborchlorate was applied in the fall previous to the year of burn, recovery of the blueberry plants was better than when it was applied in the spring after the burn. The difference was highly significant. The difference in brake kill between the spring and fall applications was not significant. Following either fall 1957 or spring 1958 applications the number of brakes on the plots was less in 1959 than 1958, indicating a carry-over of the chemical.

Whether or not brake reinfestation occurs and how fast the blueberry plants re-establish themselves following the application of polyborchlorate are questions of vital importance to the grower. The work reported here was undertaken to answer these questions.

Methods and Materials

In the fall of 1957, six square rod plots were laid out at each of three locations. Polyborchlorate was applied at 400, 500, and 600 pounds per acre on half the plots at each location on November 13, 1957 and on the other half April 25, 1958. Before treatment a square-yard section of each plot was measured and the brakes in each of these squares counted. The number of blueberry plants was counted on four 1-foot squares chosen at random on each plot. On August 7, 1958 post-treatment counts of brakes were made and on July 14, 1959, July 12, 1960, and September 13, 1961, counts of both brakes and blueberry plants were made. No counts of blueberry plants could be made in 1958 because the fields were burned. From these data the percentage kill of brakes and the percentage recovery of blueberry plants were calculated.

For statistical treatment by analysis of variance the percentages of brake control were transformed to angles (3) and the percentages of blueberry plant recovery to rankit values (2). The means are compared by the method of J. S. Tukey as modified by Snedecor (3). The difference necessary for significance is expressed as D rather than LSD.

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[2] Extension Pomologist and Associate Professor, respectively, Department of Horticulture, University of Massachusetts, Amherst

Results

The percentages of brake control with polyborchlorate at the three locations are given in Table 1. The differences in brake control between location I and locations II and III are highly significant.

Table 1 - Mean per cent brake control from August 7, 1958 to September 13, 1961 following treatment of plots with polyborchlorate at three locations on November 13, 1957 and April 25, 1958.

Location	Per cent control	Angle values
I	85.6	67.7 a
II	70.0	56.8 b
III	67.6	55.3 b

D for 1% level - 7.36. Values with the same letter are not significantly different.

Brake control following spring applications was better than after fall treatment and the difference was highly significant. The mean of the brake control in angles for the fall treatment was 50.58 and the spring treatment 69.89. The LSD value for the 5 per cent level was 5.67 and the 1 per cent level 7.64. However, the interaction between location and time of treatment was highly significant (Table 2).

Table 2 - Mean per cent brake control for the fall and spring treatments of polyborchlorate at three locations.

	Location					
	I		II		III	
Time of treatment	Per cent	Angle values	Per cent	Angle values	Per cent	Angle values
Fall (11/13/57)	62.9	52.5 a	65.8	54.2 a	50.2	45.1 a
Spring (4/25/58)	91.2	84.8 b	69.4	56.4 a	86.4	68.4 b

D for 1% level - 14.54. Values with the same letter are not significantly different.

The data show the difference between means of the per cent brake control in angles obtained from the fall and spring treatments at location II was not significant. On the other hand, at locations I and III the spring treatments were more effective than those applied in the fall. Brake control with the fall treatment applied at location II was as good or better than that obtained at locations I and III.

Table 3 shows that no significant increase in brake population occurred in the plots as indicated by the per cent control from 1959 to 1961. However, the difference between means of the per cent in brake control between 1958 and 1960 was highly significant.

Table 3 - Mean per cent brake control from August 7, 1958 to September 13, 1961 following treatment of plots with polyborchlorate November 13, 1957 and April 25, 1958.

Year	Per cent control	Angle values
1958	66.6	54.7 a
1959	76.3	60.9 a
1960	81.9	64.8 b
1961	75.9	60.6 a

D for 1% level - 9.24. Values with the same letter are not significantly different.

Table 4 shows while no differences existed between rates of application for the spring treatments, the fall treatments did show differences. The differences in brake control between means of the 400 and 500 pound rates of polyborchlorate applied as a fall treatment were significant. Less brake control was obtained with 500 pounds than with 400 pounds. At one location brake control with the 500 pound rate of polyborchlorate was not as effective as the 400 and 600 pound rates.

Table 4 - Mean per cent brake control for the fall and spring treatments of polyborchlorate at 400, 500, and 600 pound rates.

Treatment lbs/acre	Fall (11/13/57)		Spring (4/25/58)	
	Per cent control	Angle values	Per cent control	Angle values
400	68.3	55.7 a	84.6	66.9 a
500	48.5	44.1 b	87.5	69.3 a
600	63.1	52.6 a	91.0	73.5 a

D for 5% level - 11.58. Values with the same letter are not significantly different.

The rate of recovery of blueberry plants is shown in Table 5.

Table 5 - Per cent yearly recovery of blueberry plants following applications of polyborchlorate.

Lbs/acre	Per cent recovery of blueberry plants					
	Fall treatment (11/13/57)			Spring treatment (4/25/58)		
	8/14/59	7/12/60	9/13/61	8/14/59	7/12/60	9/13/61
400	114	94	112	71	75	85
500	106	74	89	75	75	86
600	103	96	115	70	74	84

The recovery following the fall application of polyborchlorate was better than that following spring application, and this difference was highly significant. The rankit values for the mean per cent recovery of blueberry plants on the plots treated in the fall was 10.07; for the plots treated in the spring, -9.48. The LSD at the 5 per cent level was 1.69 and at the 1 per cent level, 2.28. In fact, the blueberry plants in the plots treated in the spring have not completely recovered three years after treatment as indicated in Table 5. The differences between years or rates of application were not significant. The drop in per cent recovery in 1960 for the fall treatments is difficult to explain.

Discussion and Conclusions

The data presented show that the brake control following an application of polyborchlorate persisted over a period of three years and that the control was better following spring than fall applications at two of the three locations. On the other hand, blueberry plant recovery following the fall applications was better than that with spring applications.

Both the amount of brake kill and blueberry injury were variable. This was probably due to differences in rainfall, in soil type and depth, or in soil moisture at different locations. Since wild blueberry plants grow from seed, the clones are sometimes quite dissimilar and may vary in their susceptibility or resistance to polyborchlorate injury.

Although spring application of polyborchlorate results in better brake control, its use at that time is questionable because of injury to the blueberry plants. However, in areas having such heavy populations of this weed that harvesting of blueberries is difficult or impossible, spring applications of polyborchlorate would be feasible. In general, the differences in kill between rates of 400, 500, and 600 pounds of polyborchlorate were not significant; less than 400 pounds may be enough for adequate brake control, particularly for the spring treatments. This is being investigated.

Literature Cited

1. Bailey, John S. and W. J. Lord. 1960. Control of the common brake, *Teridium aquilinum L.*, in lowbush blueberries with polyborchlorate. Proc. 14th Annual Meeting Northeastern Weed Control Conference. pp. 60-65.

2. Fisher and Yates. 1938. Statistical tables for biological, agricultural, and medical research. Oliver and Boyd, Edinburgh.

3. Snedecor, G. W. 1946. Statistical methods. Collegiate Press, Inc., Ames, Iowa. 5th Ed.

The polyborchlorate used in these experiments was supplied by the Pacific

PROGRESS REPORT OF WEED CONTROL IN STRAWBERRIES

R. D. Ilnicki, C. R. Smith, T. F. Tisdell, and C. F. Everett[1]

ABSTRACT

Annual weeds are a serious problem in strawberry production. In the present system of culture it is difficult and time consuming to keep the rows weed-free without seriously affecting the development of plants and runners. At present, there is no safe herbicide with residual activity long enough to allow the plants to become established during their critical time of development. The object of this study was to evaluate some new herbicides for annual weed control during the early stages of development.

Jerseybelle plants were set on April 12, 1961 and on April 28, following an initial cultivation, the following herbicides were applied in quadruplicate:

Herbicide and Formulation	Rate, lb./A
Dimethyl 2,3,4,6-tetrachloroteraphthalate (dacthal)	
50W and 5G	4, 8, 16
Dacthal + isopropyl-N-(3-chlorphenyl)-carbamate (CIPC)	
50W + E.C.	6 + 1
2-chloro-6-bis(ethylamino)-s-triazine (simazine)	
80W	1½
2-chloro-4-ethylamino-6-diethylamino-s-triazine (trietazine)	
50W and 4G	2, 4
N,N-dimethyl-α,α-diphenylacetamide (diphenamid)	
80W and 5G (Eli Lilly and Co.)	2½, 5, 10
50W and 4G (Upjohn Co.)	2, 4, 6
O-(2,4-dichlorophenyl)-O-methylisopropyl phosphoroamidethioate (zytron)	
E.C.	10, 20
Ethyl di-n-propylthiolcarbamate (EPTC)	
E.C. and 5G	3, 6
t-butyl-di-n-propylthiolcarbamate (R-1856)	
E.C. and 10G	3, 6
Ethyl di-n-butyl thiolcarbamate (R-1870)	
E.C. and 10G	3, 6
Propyl ethyl-n-butylthiolcarbamate (R-2061) (Tillam)	
E.C. and 10G	3, 6

In addition, several untreated checks were included per replication. All thiolcarbamate herbicides were incorporated immediately after application.

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[1] Associate Research Specialist in Weed Control; Assistant Professor Pomology; and formerly Research Assistants in

Outstanding treatments included the following herbicides:

diphenamid - all rates were effective but the mid-rate (4-5 lb.) was about optimum. The highest rate had no effect on stand but it decreased the vigor of the transplants and the rooting of runners. The wettable powder was superior to the granular preparations but it also caused greater reductions in vigor.

dacthal - all rates were effective and the mid-rate (8 lb.) was more than optimum. There were slight reductions with the highest rate. The wettable powder was somewhat safer but not as effective as the granular.

zytron - both rates were effective. There was no increase in herbicidal activity with the high rate.

Tillam (R-2061) - both rates were effective. There was a slight increase in broadleaved weed control with the higher rate. The granular preparation was superior to the emulsifiable concentrate but it also produced slightly more injury.

dacthal + CIPC - this combination produced excellent weed control but it caused some injury to stand and vigor of transplants. The rooting of runners was also delayed. The control was comparable to dacthal alone at the mid-rate.

EPTC - this compound was effective at the higher rate but some injury to transplants resulted. The granular was more effective than the emulsifiable concentrate.

The s-triazine herbicides were injurious to strawberries notwithstanding that they produced outstanding weed control. There was no difference between the wettable powder and the granular preparation of trietazine.

All other herbicides were ineffective in this study.

This experiment will be continued through next year. After yield analyses more complete information will be forthcoming.

PRE-EMERGENCE WEED CONTROL TEST IN RED BEETS

S. A. Anderson(1), L. E. Curtis(2), and Alexander Zaharchuk(2)

In 1960 several herbicide treatments looked promising for the control of weeds in red beets. The experiments reported in this paper are a continuation of last years work. In both experiments total yields and grade yields were obtained to determine the effect of treatments on yields.

Procedure

Expt. I was conducted on Ontario silt loam soil at Gorham, N. Y. Detroit Dark Red beets were planted on June 1, 1961. Tillam was applied and worked into the soil with a garden cultivator on May 25. Pre-emergence treatments were applied within two days after planting. Herbicides were applied overall except for the two high rates of Solubor, which were applied in an 8 inch band centered over the row. Sprays were applied with a knapsack sayer equipped with a pressure gauge and six foot boom. Granular applications were made with a special small hand-powered duster.

Weeds were removed by hand from the check plots before mid-July in anticipation of yield performance in relation to any possible reduction or depression of yield caused by chemicals.

Expt. II adjoined Expt. I and conducted on Ontario silt loam soil at Gorham, N. Y. Tillam was applied on May 25, 1961. Detroit Dark Red beets were planted on 5/25/61 and on 5/28/61. Plots in Experiment I and II were 6' X 30' that were randomly replicated 3 times. Tillam was worked into the soil immediately following application with a garden tractor to an estimated depth of 2-4 inches. The soil was prepared for the second planting by tilling with a garden cultivator.

Results

Expt. I Table I gives the results of weed control, beet effect, total yield, and size grade yield. Each rating for crop and weed control represents an average of the three replicates. Total yields and grade yields also are averages of three replicates. This is also true in Expt. II.

Expt. II Table 2 gives the results of weed control and beet effect.

Discussion

Expt. I Treatments worthy of note from the standpoint of weed control and lack of beet injury are as follows: Tillam pre-plant at 4-6 lbs. E. C.; Tillam granular at 3 lbs.; Solubor at 20-40 lbs. of elemental boron; Vegadex at 4 lbs. and ACP 61-81.

(1) Comstock Foods, Inc., Newark, N. Y.

Table 1. Pre-Plant and Pre-Emergence Weed Control on Table Beets

Chemical	Lbs. Active Per Acre	Timing	Method of Application	Rating*		Yield Per Acre (Tons)	Grade Yield — %				
				Beets	Weeds		Under 1"	1 - 1 3/4"	1 3/4" - 2½"	2½" - 3"	3" Up
Tillam	4	Pre-Plant	Spray	1.0	2.7	25.80	2.3	19.5	39.2	16.5	21.2
Tillam	6	"	Spray	0.9	3.9	26.33	2.4	33.2	38.8	13.0	12.7
Tillam	3	"	Gran.Dusted On	0.0	3.3	27.15	3.0	31.3	42.7	18.1	5.0
Vegadex + Randox	3 + 3	Pre.	Spray	2.0	2.5	25.40	2.6	23.4	42.5	11.7	19.7
Solubor **	10	Pre.	Spray	0	2.3	21.37	2.8	28.4	41.2	18.2	9.4
Solubor	20	"	Spray	0.2	2.8	22.80	2.0	39.5	44.6	9.6	4.3
Solubor	30	"	8" Band	1.0	3.1	23.50	1.8	28.8	45.8	15.0	8.7
Solubor	40	"	8" Band	1.3	4.2	23.70	2.4	31.9	45.3	17.5	2.9
Zytron	6	"	Spray	5.0	3.8						
Zytron	12	"	Spray	5.0	5.0						
Vegadex	4	"	Spray	0.8	3.6	24.93	2.1	30.4	50.0	11.8	4.9
Vegadex	6	"	Spray	0.8	3.7	25.73	1.2	22.2	45.7	15.1	16.3
ACP 61-81	8	"	Spray	0.7	3.6						
ACP 61-62	2	"	Spray	5.0	5.0						
Check	-	-	-	0	0	23.50	1.6	28.5	40.8	20.6	8.5

* Visual rating system: 0 - No weed control - no crop injury.
5 - Complete weed control - complete crop destruction.

** The rates given for Solubor are based on elemental Boron and not manufactured product. The 30 and 40 lb. rate of Boron is that for the area in the 8 inch band. The rate per planted acre would be 1/3 of that reported in Table 1 since row width is 24 inches.

Table 2. Tolerance of Beets and Weed Control Obtained with Tillam E. C. and Granular

Chemical	Lbs. Active Per Acre	Timing *	Rating ***	
			Beets	Weeds
Tillam E.C.	3	0	2.8**	3.0
Tillam E.C.	5	0	1.3	4.5
Tillam Gran.	3	0	0.2	3.7
Tillam Gran.	5	0	2.7	4.3
Check	-	0	0	0
Tillam E.C.	3	3	0.4	2.3
Tillam E.C.	5	3	0.7	3.7
Tillam Gran.	3	3	0	3.5
Tillam Gran.	5	3	1.8	3.8
Check	-	3	0	0

* 0 - Applied and incorporated into the soil 5/25/61 — Beets planted 5/25/61
3 - Applied and incorporated into the soil 5/25/61 — Beets planted 5/28/61

** This average reading influenced by one high reading from a questionable replicate.

*** Visual rating system:

0 - No weed control - no crop injury.
5 - Complete weed kill - complete crop destruction.

Tillam E. C. 4 and 6 lbs. as well as Tillam granular 3 lbs. gave fair to very good weed control with some suppression of beets. We would suggest further trial E. C. 4 to 5 lbs. per acre and granular at 3 to 4 lbs. In this material we appear to have approached the level of beet tolerance.

Solubor at 20-40 lbs. of elemental boron gave fair to excellant weed control. There was no apparent suppression of beets at the lower level but suppression increased from the 30 to the 40 lb. rate. Yield data compared to the check plot is very favorable in respect to the weed control at the 30-40 lb. rate. As the season progressed, Beets overcame the earlier suppression effects caused by the Boron. The 30 lb. rate is suggested as the higher rate could leave toxic residues in the soil that would affect other crops grown in rotation with beets.

The 4 lb. rate of Vegadex performed more satisfactorily than the 6 lb. rate because of damage to the stand at the high rate. The grade yield shows this in terms of a greater percentage of beets 3" and up in the 6 lb. treatment.

A C P 61-81 gave good weed control with little damage to the stand of beets and merits further investigation. Yield data was not reported as two of the three replicates were damaged by heavy rains causing doubtful results.

Zytron gave excellant weed control at both rates but also killed the beets. Beets emerged but died within a week.

<u>Expt. II</u> With the Tillam E. C. 3 and 5 lb. rates the weed control was good and beet injury at a low level with the exception as noted in the table. The same is true of the Tillam granular 3 lb. rate. In the case of the granular 5 lb. rate the beet injury was marked. Yield and grades were taken and were found to be rather variable with chemical treatments substantially exceeding check plots. The results would indicate that for this trial, planting immediately following incorporation of the Tillam was an acceptable practice.

Vegadex has been in use for weeding table beets for several years. Results are extremely variable ranging from good weed control and no crop injury to a complete lack of weed control in the absence of moisture. Severe crop injury often results with rates per acre as low as 3 lbs. actual when temperatures rise to 85 and 90° F. Faced with the possibility of hand weeding costs running as high as fifty to seventy five dollars per acre, growers in Central and Western New York treated a substantial acreage of beets with solubor in 1961. Twenty-five pounds of solubor (20.6% Boron) was dissolved in 20 or more gallons of water and applied per acre of beets in 24 inch rows. The spray was applied pre-emergence on the planter in a 4 inch band over the row. This approximates the rate of 30 lbs. per acre of elemental boron in the area actually covered in the 4 inch band and represents an application of slightly over 5 lbs. of actual or elemental boron usually required for nutritional purposes on our alkaline soils.

Results generally were good weed control with only slight crop effect. Severe beet crop injury resulted from boron toxicity on one field with pH below 5.5. Considerable suppression was observed in another field which may have been associated with lighter texture and somewhat lower organic matter. Since solubor is used for weed control when the normal borax supplement is omitted from the fertilizer, the possible danger of Black or dry rot (boron deficiency) should be considered in the complete absence of rain following planting.

EQUIPMENT FOR SPRAYING CHEMICALS FOR LAYBY WEED CONTROL WHILE CULTIVATING POTATOES

Arthur Hawkins[1]

Directing a spray application of chemicals to the soil for weed control after the last cultivation in potatoes is practically impossible with standard potato sprayers when potato vines are large. Special equipment would have to be devised to part the vines and direct the spray on the soil. It was suggested to growers that low pressure spray equipment could be used to spray the chemicals behind the hillers while making the final cultivation.

During the past three years, three Connecticut potato growers equipped their tractors with low pressure power take-off pumps and equipment to spray weed control chemicals on the soil while making the final cultivation with two-row equipment. They obtained control of weeds with the chemicals applied.

One of the growers built a platform at the rear of his tractor to support a 50 gallon metal barrel which was used as a container for the spray solution. Copper tubing was used to make the boom which was located behind the barrel. Two nozzles located behind each rear wheel and three nozzles on a drop pipe between the rows just behind the barrel, were directed to spray the soil. Regular potato sprayer nozzles with No. 3 discs and 30 lbs. pressure were used to apply 8 gallons of solution per acre.

With a different kind of tractor, another grower raised the drawbar sufficiently to make room for the power take off-pump; the barrel was located off-center on the drawbar.

The third grower, using a tool bar (drawbar removed), located two rectangular-shaped metal tanks of 40-gallon capacity between the wheels and the controls; the tanks were bolted to the axle housing. The spray nozzles were attached to the spades held by the tool bar at the rear of the tractor. The nozzles were directed to spray the soil behind the spades. Thirty pound pressure was used to apply 12 gallons of solution per acre. Rubber hose was used to supply the nozzles instead of copper tubing.

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USE OF GRANULAR CHEMICAL APPLICATOR FOR LAY-BY WEED CONTROL IN POTATOES

Arthur Hawkins[1]/

Lay-by weed control in potatoes was obtained with granular formulations of several chemicals when broadcast by hand after the last cultivation in Connecticut in 1960. Hawkins[2]/ reported yield increases of potatoes where chemicals controlled crabgrass and caused little or no injury to potatoes. It appeared desirable to make further comparisons using a commercially available granular chemical applicator.

In 1961 granular formulations of several chemicals were applied broadcast with an eight-foot granular chemical applicator[3]/. The granules were applied within a few hours to one day after the final cultivation of Katahdin potatoes in six commercial fields. The hopper was adjusted to a height of about six inches above the potato foliage to obtain satisfactory spread of the granules.

Burlap bags were attached behind the machine to brush granules from the plants to reduce injury from leaf absorption of certain chemicals. The distribution of granules appeared to be uniform and resulted in uniform control of weeds on the hills and between the rows under 1961 conditions.

Effective control of weeds was obtained with granular formulations of some of the chemicals applied at adequate rates with the granular applicator. Increases in yields of potatoes to 25% were obtained where crabgrass or barnyard grass was controlled. The high yield increase occurred in a field where a heavy population of crabgrass was controlled and potatoes were not killed by frost until October 16.

Since the machine used was of the gravity-feed type, a constant field speed was maintained to obtain a uniform rate of application. It was operated at a field speed of 4 MPH (352 feet of travel in one minute).

When calibrating the machine, it was pulled at field speed for a distance that would give 1/20 acre. The granules were caught in a piece of plastic film; the contents were weighed in a pan on a scale weighing accurately in ounces. It was easier to repeat calibrations for 20 lbs. or more of granules per acre than for lower rates.

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[1] / Agronomist and Extension Potato Specialist, University of Conn., Storrs, Conn.

[2] / Hawkins, Arthur. Post-Hill Chemical Weed Control in Potatoes with Granular Formulations. Proc. NEWCC 15:180-181. 1961.

[3] / Manufactured by Gandy Co., Owatonna, Minnesota

Weed control experiments with Irish potatoes (R.I. 1960-61)[1]

R. S. Bell and Paul B. Gardner[2]

In spite of recent advances in chemical weed control many problems exist due to the great variety of weeds which may be encountered and the varying soil and climatic conditions under which herbicides are used. Bell and Larssen (1) have reported that weed control after hilling is a pressing problem in growing potatoes. The testing of new herbicides to find the tolerance of potatoes and of weeds to these materials is necessary to obtain more efficient management. Trevett, et al (3) have pointed out that to adequately control the broad varieties of weeds present in potato fields, a combination of herbicides is required. Ilnicki, et al (2) have recently reported almost complete weed control with Amiben and the higher rates of R-1607 granular.

1960 Tests

Procedure

The 1960 tests were confined to post-hilling applications of herbicides since weed control after layby is a major problem in growing potatoes.

The test was on Bridgehampton silt loam which was being planted to potatoes for the second time following redtop sod. The plots were 15' x 48' and 4 replicates of each treatment were used.

Sprays were applied with a knapsack sprayer. Sufficient chemical was measured for each plot and applied with water equivalent to 50 gallons to the acre. Granular material for each plot was mixed with sand and spread by hand.

Katahdin potatoes were planted April 21 and fertilized with 2000 lb/A of 8-12-12-2 (LC) in bands.

Insecticides and fungicides were applied as needed. Manzate was used during July and Bordeaux in August to counter the threat of late blight.

Previous to hilling the plots were cultivated 3 times. They were hilled on June 22 and the herbicides were applied at this time with the exception of casoron which was spread just before hilling in order to incorporate it into the soil. The area was overseeded with foxtail and barnyard millets to simulate annual grasses. Due to the steepness of the potato hills much of the seed ended up in the furrow. Some ladysthumb plants (P. persicaria L.) were present on the crowns of the hills at the time of treatment. The steepness of the hill also posed a problem with uniform distribution of herbicides, particularly granular material which may roll. Rainfall was adequate during the growing season. The potatoes were dug on August 31.

Results

The herbicides used, the pounds of active toxicant per acre, bushels of

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U.S. #1 potatoes and weed control estimates are shown in table 1. The sources of the herbicides and their chemical compositions are in the appendix.

Table 1. Average yields of Katahdin potatoes and weed ratings from post-hilling herbicide applications (R.I. 1960).

Herbicide	Lb/A Active Toxicant	Bu/A U.S. # 1	Weed Ratings* 8/24/60	
			Ladysthumb	Annual Grasses
1. Falone spray	4	364	7.4	8.8
2. Falone gran.	4	376	8.6	5.5
3. DNBP gran.	3	379	8.4	4.0
4. Dalapon gran.	2.5	364	7.4	3.8
5. Alanap gran.	4	364	8.0	7.9
6. Dalapon spray	2.5	358	6.5	2.0
7. Zytron spray	10	403	9.4	9.5
8. Zytron gran.	10	387	8.8	7.4
9. Trietazine spray	2	399	9.5	4.8
10. Trietazine gran.	2	373	9.4	6.0
11. Casoron	4	323**	9.4	3.2
12. Casoron gran.	2	329**	9.6	2.2
13. No treatment	-	399	7.1	2.0
14. Dalapon & DNBP gran.	2.5 + 3	342	9.0	3.8
15. Falone & DNBP gran.	3 + 4	361	9.0	7.9
16. Alanap & Falone gran.	4 + 4	352	8.8	8.5
LSD at 0.05		56		

*10 = no weeds, 1 = no control **some physical damage to tubers

Some weeds were already established on the crowns of the hills previous to applying the herbicides. These were disregarded in the estimates of percent weed control. Only the weeds which sprouted from the freshly stirred soil after hilling were rated. The annual grass population was mostly foxtail and barnyard millets from the broadcast seeding. Ladysthumb was the prevalent broadleaved weed.

The following chemicals produced a marked reduction of the ladysthumb population: zytron spray at 10 lb/A, trietazine spray or granular at 2 lb/A, and casoron at 2 and 4 lb/A. The casoron which was applied before hilling caused considerable pitting of the potato tubers. Granular DNBP alone, or combined either with dalapon or falone, produced fair control of ladysthumb. Alanap, falone or dalapon alone were not effective in preventing growth of this weed.

Results with the herbicides that usually inhibit grasses were disappointing in the control of the millets. Falone spray at 4 lb/A of toxicant gave good control while the granular preparation was only fair. A combination of granular alanap and falone each applied at a rate of 4 lb/A produced a satisfactory reduction of the annual grasses. Dalapon at the 2.5 lb/A was ineffective during the 1960 season. Likewise 2 lb/A of trietazine was not as effective as in former seasons. Zytron spray at 10 lb/A produced a marked reduction

The yield of U.S. #1 Katahdin potatoes from the untreated plots was 309 bushels per acre. Statistical analyses of the yields indicated that a difference of 56 bushels was significant at the 5% level. Inspection of the results shows casoron was the only material which significantly reduced yields. It can also be seen that in 1960 with adequate rainfall and fertility the heavier stand of weeds did not reduce the potato yields. This is probably due to the fact that the annual weed crop in late potatoes usually does not become established until the vines mature, flatten out on the ground and lose many of their leaves. The principal objection to late, annual weeds is the difficulty they cause in the use of mechanical diggers, the increased tuber loss in the field and the amount of soil and debris that must be handled at the grading shed.

Pre-emergent herbicide trials, 1961

Procedure

The area of silt loam available for weed control during this season was not uniform with some low, moist spots and higher, drier ones. The large size of the plots, 15' x 48', helped to bridge some of these areas but some variability was inevitable. The land was in redtop sod the previous 2 years. Redtop sod always exerts a favorable effect on the succeeding potato crop. Delus and Kennebec potatoes were planted on April 26 with 1600 lb/A of 10-10-10-2 (IC) fertilizer. The pre-emergent herbicides were applied on May 16-17 using a calibrated low gallonage sprayer drawn by a tractor. The rate per acre was 40 gallons of spray. The granular materials were weighed for individual plots and spread by hand after mixing with coarse sand. The area was not cultivated until June 26.

The rainfall was scanty during July but the crop showed no evidence of drought injury.

Results

The amounts of herbicides per acre, weed estimates and yields of U.S. #1 tubers are shown in table 2. The principal weeds were ladysthumb and ragweed. Random weed counts of several one foot square areas for each treatment indicated that the triazine compounds, atrametryne, ipazine, prometryne and trietazine at the rate of 3 lb/A of toxicant reduced weed stands considerably. The herbicides such as dalapon, falone and zytron when used alone were not effective on the broadleaved weeds. The falone and zytron, however, slowed the initial growth of ladysthumb. DNBP used with these later materials reduced the stands of ragweed and ladysthumb. There were very few native annual grass seedlings at this time, and no conclusions were reached about their control. Foxtail and barnyard millet broadcasted over the area after hilling did not become established due to heavy vine cover and the dry July weather.

Just prior to hilling on June 26 the weeds were pulled from random one foot square areas and their dry weights determined. The weights were largely of ladysthumb with occasional ragweed and a few annual grass seedlings. The dalapon plots had a thick cover of ladysthumb. The check, the dalapon and falone treatments still showed considerably ladysthumb at harvest time. Those combined with DNBP were fairly clean at harvest. The potatoes were dug on

Table 2. Pre-emergent weed control experiments with Kennebec and Delus potatoes (R.I. 1961).

Material	Active Toxicant Lb/A	Average Bu/A U.S. #1 Kennebec	Delus	Av. # weeds per sq. ft. June 12, 1961 Ladys-thumb	Ragweed	Annual grasses	Gms. Dry weight Weeds/sq. ft. June 26	Rating Ladys-thumb 9/26/6
1. DNBP+Zytron	3+5	646	491	3.0	1.9	2.8	0.21	9.1
2. DNBP+Dalapon	3+3+(4 post-)	674	433	7.2	0.2	5.4	0.22	9.3
3. DNBP+Dalapon	3+3	573	464	0.6	0.2	3.1	0.43	9.2
4. Zytron	8	508	407	13.4	6.2	1.9	2.93	7.9
5. Amiben (gran.)	5	525	388	9.7	4.2	1.5	2.06	7.4
6. Zytron	5	509	414	12.8	5.8	2.2	3.18	7.8
7. Falone	4	534	388	14.2	5.3	0.3	9.04	4.1
8. Falone	4+(4 post-)	566	390	16.2	6.9	6.1	9.07	1.8
9. Dalapon	4	589	388	24.4	9.3	4.0	22.32	2.5
10. Prometryne	3	654	459	0.6	0.3	1.6	0.48	8.1
11. Atrametryne	3	539	436	0.3	1.1	1.4	0.33	8.5
12. Ipazine	3	517	461	0.0	0.0	2.4	0.08	9.2
13. Trietazine	3	661	441	0.0	0.8	2.5	0.05	9.3
14. Trietazine	3+(2 post-)	612	406	0.4	0.7	1.2	0.04	9.8
15. No cultivation	-	579	390	11.2	6.0	5.6	11.05	1.5
16. Cultivated	-	590	438	-	-	-	-	7.8
LSD at 0.05		NS	NS					

*low numbers = high weed cover, 10 = no weeds

Yields of U.S. #1 Delus potatoes ranged from 388 bushels to 491 bushels per acre; and those of Kennebec from 508 to 646 bushels per acre. The variability of the individual yields was such that no statistically significant differences between treatments were found. The specific gravity of the Kennebec potatoes averaged 1.078 and the Delus 1.083.

Post-hilling and layby herbicide applications, 1961

Procedure

These tests were randomized in blocks which alternated with the pre-emergent blocks. They were planted at the same time and received the same fertilization and management except that they were cultivated on May 31, June 6, 16, and 20, with preliminary hilling on June 26 and final hilling on June 30. Ladysthumb and ragweed were eliminated from the tops of the hills by the cultivating process. The field was overseeded with millets but the heavy foliage cover and dry weather minimized the stand.

The post-hilling herbicide sprays were applied June 26 with a calibrated sprayer at the rate of 40 gallons to the acre. The granular materials were weighed out individually and mixed with sand before spreading by hand. A few plots received vine-down applications on August 15. The vines were green and leafy but had opened up enough so herbicides could reach the soil. Trietazine spray produced a little yellowing on the older leaves but this effect disappeared within two weeks.

Results

The materials used, stands of weeds and yields of U.S. #1 Kennebec and Delus potatoes are shown in table 3. The yields of Kennebecs ranged from 500 bushels per acre where the double application of trietazine was used to 631 on the falone plots. The controls averaged 590 bushels. The maximum and minimum yields of Delus potatoes were 481 and 341 bushels per acre for these same two treatments, respectively. The check plots of Delus produced 438 bushels per acre. Unfortunately, the variation within blocks was such that significance could not be established at the 5% level. It is suspected, however, that the lowest average yields obtained from the combined application of trietazine at layby and vine-down is in part due to the heavy application of this herbicide. When tubers of the Kennebec variety were dug in August for trietazine analysis, smaller potatoes than in the check plots were found. Next season it is planned to harvest potatoes at several periods to see whether the post-hilling spray retards tuber development.

The weed stand was rather light. Proper cultivation in June produced a nearly weedfree area. Ladysthumb (Polygonum persicaria) and some of the annual millets were present.

The data in table 3 show that granular falone, alanap, zytron, eptam, dalapon, and amiben were effective in reducing the stand of annual grasses. Falone spray and trietazine spray were also effective.

Repeating the application of falone or trietazine at vine-down was no more effective than the post-hilling treatment alone. The repeat application of

Table 3. Post-hilling weed control experiments with Kennebec and Delus potatoes (R.I. 1961).

	Active toxicant lb/A		U.S. #1 Bu/A		Weed rating*		
Material	Layby	Vines down	Kennebec	Delus	Ladysthumb	9/26/61	Annual grasses
Falone	4	-	631	481	7.2		9.3
Falone	4	4	629	440	8.1		9.5
Falone (gran.)	4	-	554	421	7.7		9.0
Falone (gran.)	4	4	514	406	7.4		9.1
Alanap (gran.)	4	-	458	391	6.0		9.0
Dalapon (gran.)	5	-	505	428	5.8		8.5
Zytron	5	-	598	445	5.0		8.6
Zytron	8	-	589	416	5.3		8.6
Zytron (gran.)	8	-	621	461	5.6		9.1
Eptam (gran.)	5	-	571	445	6.6		8.7
Eptam (gran.)	5	4	550	428	9.0		9.6
Trietazine	3	-	506	405	9.0		9.2
Trietazine	3	2	500	341	9.4		9.5
Amiben (gran.)	5	-	593	465	8.6		9.5
No chemical**			590	438	6.3		7.8

*low numbers = poor control, 10 = no weeds **regular cultivation

eptam seemed somewhat more effective in reducing the stand of ladysthumb. Where eptam was used at post-hilling and vine-down the plots were nearly free of this pest.

Falone retarded the growth of ladysthumb while the other "grass" herbicides did not materially effect it. Trietazine prevents the development of this weed rather well.

Summary

The grass herbicides, such as falone or alanap at 4 lb/A, eptam, dalapon or alanap at 5 lb/A and zytron at 8 lb/A reduced the stands of grasses without altering the yields of U.S. #1 potatoes. Dalapon and zytron at 5 lb/A did not appear quite as effective as the others during 1961. Repeat applications of falone or trietazine at vine-down did not increase the effectiveness this year. A repeat application of granular eptam was more effective than one application. Trietazine is an effective herbicide for annual weeds. Its effect on the rate of development of potato tubers needs further investigation.

Literature Cited

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Appendix

Alanap	Naugatuck	10% sodium N-1-naphthylphthalamate
Amiben (gran.)	Amchem	10% 3-amino-2,5-dichlorobenzoic acid on 24-48 attaclay
Atrametryne	Geigy	2-ethylamino-4-isopropylamino-6-methylmercapto-s-triazine
Casoron	Niagara	50% 2,6-dichlorobenzonitrile
Casoron (gran.)	Niagara	4% 2,6-dichlorobenzonitrile
Dalapon (gran.)	Dow	10% salt of sodium,2 2-dichloropropionic
Dalapon	Dow	85% salt of sodium 2,2-dichloropropionic
DNBP	Dow	3 lb /gal. alkalamine salt 4,6-dinitro-o-sec-butyl phenol
Eptam (gran.)	Stauffer	5% ethyl N,N-di-n-propylthiolcarbamate
Falone	Naugatuck	4 lb /gal. tris-(2,4-dichlorophenoxyethyl phosphite)
Falone (gran.)	Naugatuck	10% tris-(2,4-dichlorophenoxyethyl phosphite)
Ipazine	Geigy	25% 2-chloro-4-(diethylamino)-6-(isopropylamino)-s-triazine
Prometryne	Geigy	2,4-bis (isopropylamino)-6-methymercapto-2-triazine
Trietazine	Geigy	2-chloro-4-(ethylamino)-6-(diethylamino)-s-triazine
Zytron	Dow	2 lb /gal. O-(2,4-dichlorophenyl) O-methyl isopropyl phosphoramidothioate
Zytron (gran.)	Dow	25% O-(2,4-dichlorophenyl) O-methyl isopropyl phosphoramidothioate

CHEMICALS FOR WEEDING POTATOES[1] ON MUCK AND UPLAND SOILS

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Potatoes are one of the leading inter-tilled crops of the Northeastern United States. New York is second to Maine in total production. Although the most concentrated area of production in New York is on Long Island, significant concentrations of production exist in several upstate areas so that in total there is about the same acreage, currently 44,000, in each region.

Generally speaking, the Upstate regions have shorter spring and fall seasons than Long Island. Consequently, the crop is in the ground for only three or four months as compared to four to six months on Long Island. Furthermore, weeds such as annual grasses and nutgrass which germinate and grow vigorously only at warm temperatures start fairly soon after planting in Upstate areas, but may not start for one or two months after planting on Long Island. Upstate the potato plant especially on muck grows fairly rapidly and is likely to provide heavy shade early in the season and continue to provide shade until just prior to harvest. In contrast, Long Island potatoes start slowly and, in addition, are often left in the field a month or two after the foliage has been drastically reduced in vigor.

The purpose of these tests was (A) to investigate under Upstate field conditions the relative merits of selective herbicides which have been previously reported satisfactory and (B) to evaluate new chemicals for their potential as selective herbicides.

Field Testing of Herbicides

Commercial fields at two locations, one muck and the other gravelly loam were chosen as sites for testing the relative merits of several herbicides which had been reported as selective and effective in potato weed control. At both locations treatments were made pre-emergence and early post-emergence. In the pre-emergence treatments, no cultivation was given except at hilling. The other plots were cultivated normally. Post-emergence application was made a week prior to "lay-by" on the muck, but on the mineral soil treating was actually at lay-by as far as the plots were concerned even though the crop was only 1 - 4 inches tall. On muck, however, the plants were knee-high and almost touching between rows. The crop was planted on mineral soil about May 22 and treated June 1 and June 15. The muck crop was planted May 5, and treated May 24 and June 28. There were four replications with individual plots 3 x 15 feet planted to one row of crop.

Results of the pre-emergence applications on both soils are presented in table 1. It can be seen from these data that muck soil greatly reduced the relative herbicidal effectiveness of several compounds, namely, Hercules 8043, Dacthal, Zytron, and Rohm and Haas F-34. Moderate reduction in herbicidal effectiveness was noted for Tillam, Hercules 7531 and Dinitro granular and liquid. Trietazine was inconsistent. On the other hand, CDEC+CDAA was more

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[1] Paper No. 470, Department of Vegetable Crops, Cornell University, Ithaca, N.Y.

Table 1. Potato and weed[1] responses to pre-emergence herbicides.

		Weed Ratings[a]				Crop Yields	
		Muck		Mineral		Muck	Mineral
Chemical	Lbs.	B.L.	Grass	B.L.	Grass	bu.	bu.
Amiben	4	7.9	7.7	5.2	7.7	541	330
EPTC	6	6.5	7.0	7.7	7.0	580	439
Tillam	6	5.0	5.0	7.5	7.0	530	340
Herc. 7175	3	8.0	8.0	8.5	8.0	360	150
" 7531	4	5.5	5.5	6.7	7.7	537	387
" "	8	6.6	6.3	8.5	8.2	555	386
" 8043	5	2.2	3.0	7.7	6.0	---[b]	425
CDEC+CDAA	4+4	8.2	7.7	6.5	6.0	565	334
DN gran.	5	4.2	6.3	8.2	6.5	678	360
DN+Dal	5+7.5	7.6	7.0	8.2	7.0	590	420
Trietazine	4	4.5	7.6	8.5	6.2	582	384
Dacthal	10	4.5	4.7	6.5	6.2	602	340
Zytron	10	3.0	3.0	5.5	4.7	---[b]	350
R&H F-34	6	3.0	3.0	6.0	3.7	---[b]	398
DN liq.	5	5.2	6.0	7.7	6.2	540	361
Check	-	1.2	2.0	2.7	2.0	534	356

[1] = Lambsquarters, smartweed, redroot, barnyard grass and foxtail.
[a] 9=complete control; 7=commercial control; 5=unacceptable control; 3=poor control; 1=heavy rank weed growth.
[b] =Yields not taken because of poor early performance.

effective on muck than on mineral soils. In fact, this treatment was truly outstanding for both broadleaf and grass control on muck soil.

Potato response was generally favorable. The only significant reduction was from Hercules 7175. This compound had previously shown promise on mineral soils under conditions of low rainfall.

In the post-emergence tests a few changes were made in chemicals and rates used. CDEC+CDAA granular and Falone granular were added on mineral soil. Zytron, F-34, and H-8043 were eliminated from the muck test because of poor performance pre-emergence.

In table 2 are presented weed and crop responses to post-emergence applications. One of the most striking weed results occurred on muck. Here, no weeds developed after lay-by. This was undoubtedly due to the rapid heavy foliage growth of the potatoes plus the relatively early harvest. The weed ratings which are in the table were taken approximately six weeks following treating. Ratings taken at harvest are not presented in the table, but were practically identical. This indicates that early chemical activity plus crop shading can give sufficient control of weeds under Upstate conditions.

Table 2. Potato and weed[1] responses to post-emergence herbicides.

		Weed Ratings[a]				Crop Yield	
		Muck		Mineral		Muck	Mineral
Chemical	Lbs.	B.L.	Grass	B.L.	Grass	Bu.	Bu.
Amiben	4	No weeds[b]		7.2	7.2	536	424
EPTC	6	"		7.2	7.7	---[c]	---[c]
Tillam	6	"		7.0	7.2	526	360
Herc. 7175	3	"		8.7	9.0	195	93
" 7531	4	"		7.5	8.5	387[d]	423
" "	8	---		7.5	9.0	---	390
Falone gran.	4	---		6.0	5.7	---	390
CDEC+CDAA	4+4	"		7.0	6.5	454	422
DN gran.	5	"		8.5	7.5	658	405
DN+Dal.	5+7.5	"		8.7	7.7	406	395
Trietzaine	4	"		7.7	6.7	401	450
Dacthal	10	"		7.0	7.2	615	392
Zytron	10	---		4.0	5.2	---	317
R&H F-34	6	---		7.0	7.5	---	404
CDEC+CDAA (gran.)	4+4	---		6.7	7.0	---	447
Check	cult.	"		5.7	5.5	534	356

[1] See table 1 for species.

[a] 9=complete control; 7=commercial control; 5=unacceptable control; 3= poor control; 1=heavy rank growth.

[b] Thorough tillage plus rank top growth prevented subsequent weed development.

[c] Parts of these plots were harvested at 3 intervals for residue analyses, hence accurate yields are unavailable.

[d] 6 lbs. instead of 4 lbs. of 8043.

There was less difference between chemicals on mineral soils as compared to those obtained on muck. Almost all chemicals gave adequate weed control. However, Falone at 4 lbs. and Zytron at 10 lbs., were inferior. CDEC+CDAA was only borderline in effectiveness. This is in contrast to its excellent performance on muck.

The crop was not seriously reduced by any chemical except Hercules 7175.

Experiments to Evaluate New Chemicals

In 1961 two tests were conducted with potatoes in an attemtt to evaluate crop and weed response to new chemicals. One of these was located in stony silt loam and the other on muck. Each plot was 3 x 15 feet and was replicated twice. All treatments were made shortly after planting. Chemicals known to require incorporation were hand raked.

Potatoes responded favorably to almost all chemicals. Two exceptions were Hercules 7175 and Randox T both of which injured the crop. The weed population was limited primarily to redroot on the mineral soil. Many compounds were active against this pest. The muck test was heavily infested with perennial or swamp smart weed, <u>Polygonum</u> <u>coccineum</u>. No chemical provided any control.

A summary of redroot response to the various chemicals is presented in table 3.

Table 3. A summary of redroot response to chemicals applied pre-emergence in potatoes.

Susceptible			Tolerant		
Chemical		Lbs.	Chemical		Lbs.
Dalapon		5+10	Amchem 61-81		2+4
DN		3+ 5	Diphenamid		4
Amchem 61-122		4+8	Bayer	35850	2
Amiben		3+4	Hercules	7531	2
Dacthal		8+12	Monsanto	17029	2+4
Zytron		8+12	EPTC gran.		3
Diphenamid		8	Tillam		3
Trifluralin		4+ 8	Stauffer	1607	3+6
Dipropalin		4+ 8	"	1870	3+6
Bayer	30056	2+ 4	"	2007	3+6
Bayer	35850	4	"	1856	3+6
Du Pont	326	1+ 2	"	3400	5+10
Geigy	27901	2+ 4	"	3415	5+10
"	30031	2+ 4			
"	34161	2+ 4			
"	34361	2+ 4			
Hercules	7175*	2+ 4			
"	7531	4			
EPTC		6			
Tillam		6			
Stauffer	3408	5+10			
Randox T*		4+ 6			

*Toxic to potatoes; all others relatively safe for pre-emergence applications.

Since redroot is only one of the many weed species present in potato fields, the results are not particularly definitive. If, however, redroot is the principal pest, certain chemicals can either be elimintted or tried at much higher rates. The principal value of the data is to point out that for pre-emergence use, the research worker has a wide lattitude in choosing chemicals whic probaly will not be toxic to potatoes.

Judging from the weed results obtained with these compounds in other tests, the authors suggest that particular attention be paid to the following new compounds: Diphenamid, Trifluralin, Du Pont 326 and Hercules 7531.

Summary and Conclusions

Two experiments were conducted on the effectiveness and safety of pre- and post-emergence applications of several herbicides on potatoes. One test was on muck, the other on graveely loam. Two tests were conducted to evaluate new chemicals as to their potential for selective weeding of potatoes. One of these was conducted on muck and one on mineral soil.

1. Muck soils greatly reduced the herbicidal effectiveness of Hercules 8043, Dacthal, Zytron, and Rohm and Haas F-34. On the other hand CDEC+CDAA activity was much improved on muck as compared to that obtained on mineral soil.

2. In contrast to previous work by the authors Hercules 7175 was toxic to potatoes.

3. Both chemicals and crop shading markedly influence weed populations at harvest.

4. No chemical was found to be toxic to swamp or perennial smartweed, Polygonum coccineum.

5. A large number of distinctly different chemicals are safe for pre-emergence and post-emergence use on potatoes.

6. Of the newer chemicals, Diphenamid, Trifluralin, Du Pont 326, and Hercules 7531 are especially outstanding for pre-emergence use. It is not known how potatoes will react to Du Pont 326 and Trifluralin if they are used post-emergence.

LAY-BY CHEMICAL WEED CONTROL IN POTATOES WITH GRANULAR FORMULATIONS OF CDAA, DALAPON, AND OTHER CHEMICALS

Arthur Hawkins[1]

Granular formulations of CDAA, Dalapon and other chemicals were applied after the final cultivation in several fields of Katahdin potatoes where crabgrass or barnyard grass was expected and occurred later. A Gandy granular chemical applicator was used to apply the materials in most of the tests.

Materials and Methods

Granular formulations containing 5 to 20% active chemicals were applied within a few hours to one day after final cultivations of Katahdin potatoes in several commercial fields during the period July 6 to July 15.

Comparisons of rates of CDAA (Randox) were made with hand-spread application on plots 3 rows wide x 16 feet long, replicated 3 times at each of two locations. In other tests granules of CDAA, Dalapon and other chemicals were broadcast with a Gandy Lo-Hi 8-foot granular chemical applicator in plots 8 feet x 60 to 80 feet long. The treatments were replicated 2 to 4 times at each location. The gravity-feed type machine was calibrated at the field speed used, 4 MPH, before entering the fields. Provision was made to brush granules off the plants. See details in previous article, Use of Granular Chemical Applicator for Layby Weed Control in Potatoes.

In most instances the silt loam to fine sandy loam soils were moist at the time the granules were applied; in all cases nearly one inch of rain occurred within three days after application. Nearly three inches of rain occurred at most of the locations during the period August 22-24; this reduced residual effect of some chemicals especially at locations with sandier soils.

Results and Discussions

Rates of CDAA: In comparisons of CDAA (Randox) at 2, 3, and 4 lbs. per acre at several locations, the 3 lb. rate provided good to very good control of crabgrass during the early part of the season at all locations. Following the heavy rainfall August 22-24, the 4 lb. rate was superior to the 3 lb. rate for crabgrass control in most of the tests. Where a heavy population of crabgrass was controlled with 3 and 4 lbs. of Randox per acre and potatoes were not killed by a freeze until late in the season, increases of 20 to 25% in yield of potatoes were obtained over adjoining untreated plots, Table 1.

Control of barnyard grass with CDAA varied with locations. Under the more moist soil conditions at Farm D, 60 to 75% control of barnyard grass was obtained

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with 3 and 4 lbs. of Randox per acre respectively, while 85 to 95% control was obtained at Farm S. Increased yields of potatoes were obtained with control of barnyard grass and some lambsquarter control at location S, Table 2.

Table 1 - Effect of Granular Formulations of CDAA, and Dalapon Applied at Lay-by on Control of High Population of Crabgrass and on Yield of Katahdin Potatoes - Farm G - Connecticut 1961

Chemical	Active Rate lbs/A	Crabgrass Control % of Check 8/10	9/22	Yield 1/ % of Check
CDAA 20G	3	95	85	121
(Randox)	4	100	95	125
Dalapon 10G	4	(All	70	2/
	5	wilted)	95	124

1/ Yield, on single plots 2 rows x 50 feet, in percent of adjoining check.
2/ Adjoining check damaged by spray tracks.

<u>Rate of Dalapon</u>: In a field with a heavy population of crabgrass the use of Dalapon at 5 lbs. per acre resulted in nearly 95% control and was far superior to the 4 lb. rate. Control of crabgrass with 5 lbs. Dalapon resulted in a 24% increase in yields of potatoes over yields on untreated plots, Table 1. The crabgrass seedlings on treated plots grew 3 to 4 inches in height before death occurred.

Moderate control of barnyard grass was obtained with Dalapon at 4 and 5 lbs. per acre and resulted in increased yield of potatoes at two locations where this grass was the primary problem, Table 2.

Table 2 - Effect of Granular Formulations of CDAA and Dalapon Applied at Lay-by to Potatoes, on Barnyard Grass and Yields of Katahdin Potatoes, Connecticut - 1961

	Active Rate lbs/A	Farm D Barnyard Grass Control 9/22	Yield 1/ % of Check	Farm S Barnyard Grass Control 9/22	Yield 1/ % of Check
		%	%	%	%
CDAA 20G	3	60	2/	85	111
(Randox)	4	75	2/	95	2/
Dalapon 10G	4	50	112 3/	70	128 4/
	5	75	99 4/	80	107 5/

1/ Yield, 2 rows x 50 feet, in percent of yield of adjoining check.
2/ No adjoining check for comparison
3/ Average of 3 comparisons 4/ single comparisons 5/ average 2 comparisons

Other chemicals: Falone at 4 lbs. per acre gave good early control of grasses and broadleafed weeds at all locations. Following heavy rains, August 22-24, this rate was not sufficient in some cases.

Zytron at 7.5 lbs. per acre looked promising for crabgrass control early in the season but this rate was not sufficient later. Good control of crabgrass was obtained with 10 and 15 lb. rates in 1960.

Tested at one location, granular formulations of Eptam and Stauffer R-1607 applied at 4 lbs. active per acre gave good and very good control respectively, of grasses when the granules were cultivated into the soil soon (20 minutes) after application. Control was not as good where cultivation occurred before rather than after application. Fairly good control of lambsquarter and pigweed was obtained.

Summary

Granular formulations of herbicides were applied at two or more rates with a commercially available applicator after the final cultivation of Katahdin potatoes at several locations; rates of CDAA (Randox) were also compared in small plots at two locations.

Better crabgrass and barnyard grass control was obtained with 4 lbs. CDAA per acre than with the 3 lbs. rate in most cases, following leaching conditions in August.

Dalapon at 5 lbs. active per acre gave considerably better control of crabgrass and barnyard grass than the 4 lb. rate.

Falone at 4 lbs. per acre gave good control of grasses and broadleafed weeds early in the season but this rate was not sufficient under conditions favorable for leaching.

Eptam and Stauffer R-1607 applied at 4 lbs. active per acre gave better control of grass and broadleafed weeds when the granules were cultivated into the soil.

Control of a heavy population of crabgrass with granular formulations of some chemicals resulted in a 20 to 25% increase in yield of potatoes.

Acknowledgement is made to the following companies who supplied materials: Monsanto Chemical Co., Dow Chemical Co., Naugatuck Chemical Div., U.S. Rubber Co., and Stauffer Chemical Co.

CONTROL OF ANNUAL WEEDS IN POTATOES

M.F. Trevett, H.J. Murphy, and Robert Littlefield[1]

Introduction

This paper is a report on the effectiveness of the herbicides listed in Table 1 on the control of annual broadleaf weeds and annual grasses in potatoes. Comparisons were made between herbicides applied singly, Block II, and between various combinations of herbicides, Block I. Combination treatments were applied to determine the likelihood of complementary action that would either increase percent total weed control or lengthen the period of effective weed control.

Procedure

Two blocks of Katahdin potatoes were planted in a sandy loam soil in late May, 1961. Block I was planted 22 May, Block II was planted 26 May. Seed pieces were spaced 12 inches apart in rows 42 inches apart. "Planting" treatments were applied 24 May in Block I and 29 May in Block II, two and three days after planting. Emergence treatments were applied when about 5% of the plants had emerged: 12 June in Block I, and 13 June in Block II.

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

The principal broadleaf weeds were: Wild Rutabaga (<u>Brassica rapa</u> L.), Red-root Pigweed (<u>Amaranthus retroflexus</u> L.), Lambsquarters Pigweed (<u>Chenopodium album</u> L.), Ragweed (<u>Ambrosia artemisiifolia</u> L.), and Smartweed (<u>Polygonum pensylvanicum</u> L.). The annual grasses present were: Barnyard Grass (<u>Echinochloa crus-galli</u> L.) and Foxtail (<u>Seteria viridis</u> L.). Weed counts and ratings were made approximately twelve weeks after treatments.

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Because of space limitations in this paper, significance arrays derived from Duncan's Multiple Range Test are not given for annual weed control. Annual grass control, however, was estimated by number of plants surviving treatment in quadrats, 6 inches wide and 25 feet long. For statistical analysis, number of plants per quadrat were converted to $\sqrt{x + .05}$. For statistical analysis, percent annual broadleaf weed control was converted to angles. Significance was determined at the 5% level.

Results

In both blocks, yield was related more closely to broadleaf weed control than to annual grass control: the higher the percent broadleaf weed control, the higher the yield. Yield was not closely related to annual grass control because of low potential stand compared to the relatively high potential stand of annual broadleaf weeds: check plots averaged 2.6 annual grass plants per square foot in Block I and 2.8 per square foot in Block II, compared to 30.5 annual broadleaf weeds in Block I and 15.7 per square foot in Block II.

Although a comparison between planting application and emergence application was not intended in the experimental design of these blocks, in Block I all emergence treatments outyielded planting treatments, Table 2. The higher yield following emergence treatments is related to percent broadleaf weed control: all emergence treatments gave higher percent control than all planting treatments. Because all combinations of herbicides were not applied at both planting and emergence, it is not possible to conclusively ascertain whether the differences in weed control resulted from characteristics of the herbicides or resulted from differences in rainfall following application: 3.29 inches of rain fell during the first four days after the planting application, 0.50 inches fell during the first four days after the emergence application. Data from Block II, however, indicate that part of the difference, at least, was due to rainfall. The planting applications in Block II were made 29 May, 1961, after the heavy rains following Block I applications. In Block II where comparisons between planting and emergence application of the same herbicide can be made, in contrast to Block I, neither yield nor percent broadleaf weed control is associated with time of application. This conclusion applies for yields to 6 and 9 pounds Niagara 5778, 2 and 4 pounds of Atrametryne, and 4 pounds Prometryne, and for percent broadleaf weed control, to 3, 6, and 9 pounds of Niagara 5778, 2 and 4 pounds of Atrametryne, and 4 pounds of Prometryne.

No single herbicide or combination of herbicides in either Block I or Block II gave significantly higher potato yields or gave significantly higher broadleaf weed control than the standard treatment of 4.5 pounds DNBP.

The following comments on the various herbicides are based on observations made in 1961 and in previous years:

ATRAMETRYNE AND PROMETRYNE: appear to control annual grasses better than trietazine; may be less effective on ragweed than DNBP; in the absence of leaching rains may be applied either at planting or at emergence, and at a 2-4 pound rate may be as effective as DNBP on annual broadleaf weeds and more effective than DNBP on annual grasses.

CASORON: one pound per acre does not effectively control annual weeds; 2 and 4 pounds in previous years has significantly reduced yield..

DALAPON: in combination with DNBP has usually increased annual grass control over DNBP alone; frequently the period of residual weed control is unacceptably short.

DIPHENAMID: more effective on annual grasses than DNBP, but at 2 and 4 pound rates is less effective on annual broadleaf weeds; requires reinforcement with other herbicides for acceptable total annual weed control.

DIURON: applied alone, has not consistently given acceptable weed control; applied with DNBP, has frequently given a longer period of residual weed control than DNBP alone. The residual period was not lengthened in 1961 tests.

DNBP: percent control of annual broadleaf weeds is not usually exceeded by other herbicides but often has a short residual period of satisfactory control; controls annual grasses about half as effectively as it controls annual broadleaf weeds; in heavy infestations of annual grasses, usually will not give adequate control but usually has given more nearly satisfactory control than other selective herbicides.

DUPONT 326: the most promising candidate herbicide for potatoes that has been tested in several years from the standpoint of annual weed control, yield, and length of the residual period of weed control.

FALONE: controls annual weeds more effectively when applied at planting than when applied at emergence. In 1961, potato yields following a six pound rate applied at emergence were significantly lower than following application of DNBP; in 1961, spurry and smartweed were not satisfactorily controlled at the 6 pound rate applied at emergence.

NIAGARA 5778: in general, appears to have the weaknesses and strength of DNBP; in 1961, 9 pounds of Niagara 5778

SOLAN: Solan has controlled annual broadleaf weeds as effectively as DNBP, but has not consistently controlled annual grass better than DNBP; Solan has been safely applied post-emergence at a 6 pound rate; annual weed control has been satisfactory following post-emergence application if weeds had not developed more than one or two true leaves and if annual grasses were less than one-half inch tall.

TRIETAZINE: at a 3 pound rate, trietazine has not usually differed significantly from DNBP in either annual broadleaf weed control or in annual grass control; trietazine may be less effective on ragweed than DNBP.

ZYTRON: controls annual grass more effectively than annual broadleaf weeds, but in 1961, tests did not differ significantly from DNBP in annual grass control.

COMBINATION TREATMENTS: as of 1961, except for DNBP-Diuron, CDEC-DNBP, and Dalapon-DNBP mixtures, combination treatments have not usually given significantly higher control of both annual broadleaf weeds and annual grasses than has been obtained with the more effective component of the mixture. Undoubtedly this situation obtains first, because herbicides of truly complementary action have not always been combined, or second, because one of the components by itself satisfactorily controls both annual broadleaf weeds and annual grasses, or third, because one of the components is not applied at the proper time for maximum effectiveness. Instances of these can be found in Table 3: a mixture of DNBP and Trietazine, for example, is essentially a combination of two herbicides that individually at selective rates, ordinarily do not adequately control annual grasses. Dupont 326, in 1961, so effectively controlled annual weeds that combining another herbicide with it could not possibly improve weed control. Finally a mixture of DNBP and diphenamid (as is also true of DNBP and trietazine) is a combination of herbicides with different time of application requirements. To be most effective at the rates used, DNBP should be applied at emergence, diphenamid at planting.

For currently available materials, evidently increased annual weed control obtained following application of mixtures or combinations of certain herbicides, results from complementary and not from additive action.

Summary and Conclusion

No herbicide or combination of herbicides tested gave significantly higher yields of Katahdin potatoes than the standard treatment of 4.5 pounds DNBP per acre appoied at emergence.

Herbicides that did not differ significantly in effect on yield from 4.5 pounds DNBP included planting applications of 3 pounds Trietazine, 4 pounds Prometryne, 6 and 9 pounds Niagara 5778, 4 pounds Atrametryne and emergence application of 4 and 6 pounds Solan, 2 and 4 pounds Prometryne, 2, 3, 4, 5 pounds Dupont 326, 3, 6, 9 pounds Niagara 5778, and 4 pounds Atrametryne.

Combinations of herbicides that did not differ significantly in effect on yield from 4.5 pounds DNBP included emergence applications of mixtures of Dupont 326 and Prometryne or Diphenamid or Atrametryne or Zytron or Trietazine, mixtures of DNBP and Atrametryne, or Zytron or Diphenamid or Dalapon or Prometryne or Trietazine or Diuron, and mixtures Solan and Diphenamid or Trietazine.

Yields and annual weed control tended to be significantly lower when heavy rains followed application.

Herbicides giving significantly lower annual broadleaf weed control than 4.5 pounds DNBP when heavy rains did not follow application included emergence application of 4 pounds Falone and planting application of 1 pound Casoron, 2 and 4 pounds Diphenamid, and 2 pounds Prometryne. Herbicides giving significantly lower annual broadleaf weed control when heavy rains followed application included planting application of 3 pounds Prometryne, a mixture of 8 pounds Niagara 5778 and 10 pounds Zytron, 3 pounds Atrametryne, 1 pound Casoron, 8 pounds Niagara 5778, 2 pounds Diphenamid, and 10 pounds Zytron.

Herbicides giving significantly higher annual grass control than 4.5 pounds DNBP when heavy rains did not follow application included planting application of 2 pounds Diphenamid, 2 or 4 pounds Prometryne, 2 and 4 pounds Atrametryne, 4 and 6 pounds Solan, and 2, 3, 4, and 5 pounds Dupont 326. Herbicides giving significantly higher annual grass control than 4.5 pounds DNBP when heavy rains followed application included emergence application of 3 pounds Dupont 326, mixtures of Dupont 326 and Atrametryne or Diphenamid or Prometryne or Zytron or Trieetazine and a mixture of DNBP and Atrametryne.

The most promising new herbicides tested in 1961 are Dupont 326 for either planting or emergence application and Solan for either emergence or early post-emergence application.

It is suggested that the infrequency with which combinations of herbicides control annual weeds significantly better than the more effective component alone results from failure to combine herbicides that are complementary or because one or the other component may not have been applied at a proper time for maximum effectiveness, or because one of the components gives adequate control of both annual broadleaf weeds and annual grasses -- assuming that adequate control may not necessarily always mean 100% control.

Table 1. Herbicides Used in Potatoes.

Designation	Active Ingredient
Atrametryne	2-methylmercapto-4-(ethylamino)-(isopropylamino)-s-triazine
Casoron	2,6-dichlorobenzonitrile
Dalapon	2,2-dichloropropionic acid
Diphenamid	N,N-dimethyl-diphenylacetamide
Diuron	3-(3,4-dichlorophenyl)-1,1-dimethylurea
DNBP	4,6-dinitro-o-secondary butylphenol
Dupont 326	3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea
Falone	tris-(2,4-dichlorophenoxyethyl)phosphite
Niagara 5778	4,6-dinitro-2-sec-butylphenyl acetate
Prometryne	2-methylmercapto-4,6-bis(isopropylamino)-s-triazine
Simazin	2-chloro-4,6-bis(ethylamino)-s-triazine
Solan	n-(3-chloro-4-methylphenyl)-2-methyl-pentanamide
Trietazine	2-chloro-4-diethylamino-6-ethylamino-s-triazine
Zytron	0-(2,4-dichlorophenyl)-o-methyl isopropylphosphoroamidothioate

Legend for Tables 2 and 3:

EM = applied at emergence; PL = applied at planting.
Rank of 1 = essentially complete control of annual weeds;
Rank of 32 = lowest control.

Because of space limitations, in this paper significance arrays derived from Duncan's Multiple Range Test are not given for annual weed control. Annual grass control was estimated by number of plants surviving per row using a quadrat 6" wide and 25' long. For statistical analysis, number of plants per quadrat were converted to $\sqrt{x + .05}$.

In statistical analysis of percent annual broadleaf weed control, percent was converted to angles. Significance was determined at the 5% level.

Table 2. Potato Yields Following Application of Various Combinations of Herbicides, Block I.

Acre rate of herbicide (active ingredient)		Bushels/acre	Rank	
			Annual grass control	Broadleaf weed control
4.5# DNBP	EM	467.3a	20	17
4.5# DNBP + 3# Atrametryne	EM	463.8ab	7	15
3# Dupont 326 + 3# Prometryne	EM	437.0ab	5	1
3# Dupont 326 + 2# Diphenamid 80W	EM	432.7ab	6	1
4.5# DNBP + 10# Zytron	EM	425.5ab	15	1
4.5# DNBP + 2# Diphenamid 80W	EM	422.7ab	13	1
3# Dupont 326	EM	422.5ab	4	1
3# Dupont 326 + 10# Zytron	EM	421.7ab	3	1
4.5# DNBP + 2.22# Dalapon	EM	421.3ab	9	1
3# Dupont 326 + 3# Trietazine	EM	414.8abc	2	1
4# Solan + 2# Diphenamid 80W	EM	409.7abc	14	1
3# Dupont 326 + 3# Atrametryne	EM	409.2abc	1	1
4.5# DNBP + 3# Prometryne	EM	406.2abcd	10	1
4# Solan + 3# Trietazine	EM	393,9abcde	17	1
4.5# DNBP + 3# Trietazine	EM	385.5abcde	8	1
4.5# DNBP + 0.6# Diuron	EM	377.2abcde	12	1
4# Solan	EM	357.5abcdef	18	16
3# Trietazine + 2# Diphenamid 80W	PL	355.7 bcdef	22	19
3# Trietazine + 3# Prometryne	PL	310.8 cdefg	24	22
8# Niagara 5778 + 2# Diphenamid 80W	PL	296.8 defg	16	21
3# Trietazine + 1# Simazin	PL	295.8 efg	29	20
3# Trietazine	PL	263.3 fgh	32	23
3# Trietazine + 8# Niagara 5778	PL	257.8 fgh	31	18
3# Trietazine + 10# Zytron	PL	255.3 fgh	27	24
3# Prometryne	PL	252.8 fgh	23	25
3# Atrametryne	PL	229.8 ghi	25	27
1# Casoron	PL	186.5 hij	28	28
2# Diphenamid 80W	PL	170.5 hijk	21	30
8# Niagara 5778	PL	159.3 hijk	26	29
8# Niagara 5778 + 10# Zytron	PL	149.3 ijk	19	26
10# Zytron	PL	112.5 jk	30	31
Untreated		73.8 k	11	32

Table 3. Potato Yields Following Planting and Emergence Applications of Various Herbicides, Block II.

			Rank	
Acre rate of herbicide (active ingredient)		Bushels per acre	Annual grass control	Annual broadleaf weed control
6# Solan	EM	512.7a	8	1
2# Prometryne	EM	503.5a	10	1
3# Dupont 326	EM	500.7a	1	1
6# Niagara 5778	EM	490.5a	18	1
4.5# DNBP + 2.22# Dalapon	EM	489.5a	16	1
4# Solan	EM	485.3a	9	1
3# Trietazine	PL	480.7a	22	1
4# Atrametryne	EM	472.3ab	7	1
3# Niagara 5778	EM	467.5abc	25	1
4# Prometryne	PL	464.8abc	13	17
4# Dupont 326	EM	461.8abc	4	1
4# Prometryne	EM	461.5abc	5	1
9# Niagara 5778	PL	461.0abc	28	19
4# Atrametryne	PL	460.0abc	6	18
6# Niagara 5778	PL	456.2abc	21	23
5# Dupont 326	EM	451.5abc	3	1
2# Dupont 326	EM	450.8abc	2	1
4.5# DNBP	EM	433.5abc	27	1
9# Niagara 5778	EM	427.0abc	14	1
2# Atrametryne	PL	413.7abcd	19	22
2# Atrametryne	EM	412.5abcd	11	1
2# Prometryne	PL	377.7 bcde	20	24
4# Diphenamid 50W	PL	374.7 bcde	17	26
3# Niagara 5778	PL	370.8 cde	30	20
4# Diphenamid-50W	PL	369.0 cde	12	25
2# Diphenamid-80W	PL	325.7 def	15	27
Untreated		322.8 def	24	32
4# Falone	EM	318.8 def	31	30
6# Falone	EM	318.5 def	26	21
1# Casoron	PL	309.7 ef	32	29
2# Diphenamid-50W	PL	306.2 ef	23	28
Untreated		240.2 f	29	31
L.S.D. 5%		81.2		

Residue analysis of potatoes treated with trietazine for weed control.[1]

C. E. Olney, R. S. Bell and T. W. Kerr[2]

The compound trietazine, 2-chloro-4-diethylamino-6-ethylamino-s-triazine, is a new herbicide being tested for the control of annual grasses and other weeds in potato fields. The present investigation was undertaken to determine whether measurable amounts of this herbicide would accumulate in potato tubers following applications in the field.

The tubers analyzed were obtained from an experiment on herbicidal weed control reported by Bell et al (1) elsewhere in this journal. The potatoes were planted in late April, 1961 using four randomly replicated plots per treatment. While both the Delus and Kennebec varieties were exposed to the treatments, residue data were obtained from the latter variety only. The treatments and the amounts of trietazine (active ingredient) applied as sprays and the occasions when tuber samples were taken for residue analysis are presented in table 1. The pre-emergence treatment was made on May 16, the post-hilling on June 27, and the vines-down on August 15. Harvest of the potatoes was September 27 and 28.

On each of the 4 sampling dates, 4 pounds of potatoes were obtained at random from each of the 4 replicates. These were then halved lengthwise and the halves diced into half-inch cubes, from which a representative 200 gram sample was taken. After homogenizing in a blender, each sample was tumbled with chloroform and filtered through anhydrous sodium sulfate. The extracts were stored at 25°F. for future analysis.

The analytical method was supplied by the Geigy Chemical Company (2). It is based on the conversion of trietazine to hydroxytrietazine by acid hydrolysis and the determination of the latter by its absorption at 247 mu using a base line technique.

Table 1. Residues of trietazine in potato tubers following application in various treatments. Kingston, R.I. 1961.

Treatment	Active toxicant	Residue (p.p.m.) in tubers on dates indicated:			
		7/20	8/15	8/18	9/30
Pre-emergent	3	≤ 0.05			<0.05
Pre-emergent plus post-hilling	3 + 2	≤ 0.05			<0.05
Post-hilling	3	<0.05			<0.05
Post-hilling plus vines down	3 + 2	<0.05	<0.05	<0.05	<0.05

The results presented in table 1 show that on all sampling dates residues in all treatments were less than 0.05 ppm, the limit of sensitivity of the method.

Literature Cited

1. Bell, R. S. and P. B. Gardner. 1962. Weed control experiments with Irish potatoes (R.I. 1960-61). Proc. NEWCC.
2. Personal communication, 1961. Analytical Department, Geigy Chemical Corporation, Ardsley, New York.

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[1] Contribution #1044 from the Rhode Island Agricultural Experiment Station. A contribution from Regional Research

POTATO VINE KILLING IN MAINE - 1960

H. J. Murphy and M. J. Goven[1]

This paper is a progress report of potato vine killing studies made in Maine during the 1960 growing season. Evaluation of harvested tubers was made during the 1960-61 storage season.

MATERIALS AND METHODS:

Five new chemicals which had been reported to be of some value for desiccation of crops other than potatoes, and two standard potato vine killing materials were tested at Aroostook State Farm, Presque Isle, Maine in 1960-61. The primary purpose of these trials was to determine the rate and the completeness of kill, and the possible effects on internal tuber quality.

All materials were applied in 100 gallons of water per acre to green potato vines on the dates indicated in the various tables.

Using the rating system given in Footnote 2 of Table 1, kill ratings were made at seven, and again at fourteen days after materials were applied.

Triplicate samples of tubers were taken at harvest, from each of the six replicates for post-harvest studies. One set of samples was used for residue analysis. The remaining samples were stored at 45°F. and at 50°F. for examination during the winter months. Storage examinations consisted of snipping the stem end from each tuber and classifying each tuber as to percent of vascular ring showing discoloration. From these ratings, weighted values were computed as reported in tables 1, 2, and 3.

RESULTS AND DISCUSSION:

Table 1 and 2 indicate the effect of several desiccants on vines and tubers of the Katahdin and Kennebec potato varieties. Data in these tables indicate that all materials were of some value in killing potato vines. Methylated napthalene, however, was not particularly effective. Ammonium thiocyanate and Reglone (diquat) at all rates caused considerable internal tuber discoloration. Discoloration was more severe with the Kennebec than with the Katahdin variety, probably because of higher air and

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soil temperatures at the time the materials were applied to the Kennebec vines.

Table 3 shows the effect of several rates of sodium arsenite and of premerge on rate of kill and tuber discoloration. Rates of sodium arsenite above six pounds per acre, and Premerge at the 2 quart rate caused considerable internal discoloration. Some of this internal vascular discoloration is not caused specifically and only by the chemicals tested but appears to be associated with death of tops, whether death is brought about by chemicals, or mechanically by vine beaters, or even by drenching with ice water.

Of the five new materials tested in 1960-61 Reglone, known commercially in the United States as Diquat, and ammonium thiocyanate are worthy of further testing.

Table 1. Effect of Several Chemicals Used for Vine Killing on Katahdin Potatoes - Aroostook Farm - 1960[1]

Desiccant	Rate/acre	Activator	Killing index[2]	Tuber discoloration index[3]	Chip color index[4]
No treatment	--	--	1	0.3	4.8
Sodium arsenite	8 lbs. (As_2O_3)	--	3	0.2	5.0
"	"	Sodium silicate 1½ gals.	4	0.0	5.2
"	"	4 oz. Plyac	3	0.5	5.2
Premerge	2 qts.	5 gals. fuel oil- 4 oz. Plyac	2	0.6	6.2
Ammonium thiocyanate	2½%	3 oz. sulfonated activator	5	5.8	7.8
Penta-Chlorophenol	2 lbs.	5 gals. fuel oil	3	0.8	5.2
Arsenic acid	2 pts.	4 oz. Plyac	3	0.0	5.0
Methylated Napthalene	6 gals.	4 oz. Plyac	1	0.0	4.8
Reglone (diquat)	2 lbs.	4 oz. Plyac	5	6.0	6.3

[1] Materials applied August 30, 1960.

[2] Relative rating used for vine killing.
1. Poor kill of both stems and leaves.
2. Most leaves killed but poor stem kill.
3. All leaves killed and poor stem kill.
4. All leaves killed and fair stem kill.
5. Good kill of both leaves and stems.

[3] Discoloration readings made on January 25, 1961.

[4] Read on N.P.C.I. Color Chart 1=light: 10=dark.

able 2. Effect of Several Chemicals Used for Vine Killing on Kennebec Potatoes - Aroostook Farm - 1960[1]

Desiccant	Rate/acre	Activator	Killing index[2]	Tuber discoloration index[3]	Chip color index[4]
o treatment	--	--	1	0.0	4.6
odium arsenite	8 lbs.(As_2O_3)	--	5	2.1	4.2
"	8 lbs.(As_2O_3)	½ gal. sodium silicate	5	1.6	4.2
"	8 lbs.(As_2O_3)	1 gal. sodium silicate	4	1.4	4.5
"	8 lbs.(As_2O_3)	1½ gals. sodium silicate	4	2.9	6.1
mmonium thiocyanate	2½%	3 oz. sulfonated activator	5	23.9	5.8
"	5%	3 oz. sulfonated activator	5	57.1	6.4
"	7½%	3 oz. sulfonated activator	5	56.4	6.6
"	10%	3 oz. sulfonated activator	5	59.6	7.2
enta-Chlorophenol	2 lbs.	GR-7 plus acetone	5	0.8	4.2
"	2 lbs.	5 gals. fuel oil	5	1.8	4.2
rsenic acid	2 pts.		3	0.0	3.7
"	3 pts.		5	1.5	4.2
"	4 pts.		5	4.3	4.4
ethylated Napthalene	2 gals.	4 oz. Plyac	1	0.5	4.4
"	4 gals.	"	2	0.5	4.0
"	6 gals.	"	2	0.5	4.0
eglone (diquat)	2 lbs.	"	5	15.8	4.5
"	4 lbs.	"	5	23.7	4.4
"	6 lbs.	"	5	30.2	4.4

[1] Materials applied August 23, 1960 in 90 gallons of water per acre.

[2] Kill ratings were made at 10 and 14 days after materials applied.

[3] Discoloration readings made on January 23, 1961.

[4] Read on N.P.C.I. Color Chart 1=light: 10=dark.

Table 3. Potato Vine Killing Discoloration Studies - Maine-1960 - Katahdin and Kennebec Varieties

				Discoloration Index2/	
Desiccant	Rate/acre	Activator	Killing index1/	Katahdin	Kennebec
No treatment	--	--	1.0	0.0	0.2
Sodium arsenite	1 lb.(As_2O_3)	4 oz. Plyac	3.0	0.3	0.3
"	2 lbs. "	"	4.0	0.8	0.5
"	3 lbs. "	"	5.0	1.2	0.8
"	4 lbs. "	"	5.0	1.6	1.4
"	6 lbs. "	"	5.0	3.0	3.0
"	8 lbs. "	"	5.0	16.2	26.0
"	10 lbs. "	"	5.0	31.4	42.5
Premerge	1 qt.	5 gals. fuel oil plus 4 oz. Plyac	5.0	6.2	5.8
"	2 qts.	"	5.0	15.0	16.2
Roto-beater only	--	--	3.0	0.3	0.5
Ice water	100 gals.	--	3.0	0.5	0.8
Fuel oil	5 gals.	--	4.0	0.5	0.5

1/ Average of two dates 7 and 14 days after chemicals applied on August 24, 1960.

2/ Weighted average of six replicates of each variety or a total of 3600 tubers. Examination of tubers made at two dates December 7, 1960 and January 25, 1961.

PROBLEMS IN THE APPLICATION OF HERBICIDES BY SMALL SCALE USERS

Arthur Bing[1]

INTRODUCTION

Applied herbicide research is carried out to develop newer and better methods that can be used by the commercial farmer and possibly the home owner to control weeds in his plantings. Chemical control of weeds in ornamental crops has been investigated for several years and many reports have been presented at this conference. These reports included data on the herbicidal activity of many compounds and the tolerance of a wide variety of ornamental plants to these compounds. Much of this information has been utilized in formulating useful and successful weed control practices. Usually growers, with the advice of their county agricultural agent or commercial representative, try the more promising herbicides on a small scale on their crops under their own specific conditions. Then, if the small scale treatments are encouraging, the grower uses the chemicals on a larger scale.

The encouraging results of the experimenter or successful usage by a few growers occasionally is followed by poor, if not disasterous, results by other growers or home owners. This paper will be concerned with some of the failures and what we think are their causes. We readily tell of our successes but conceal our failures. However, detailed information on the failures is essential to the development of a sound weed control program.

GLADIOLUS

Experimental preemergence treatments of plantings of small gladiolus corms on sandy loam on Long Island in 1959 (2) with simazine granular and liquid resulted in fairly good control of most weeds at the 2, 3, and 4 pound per acre rates. The gladiolus foliage showed some burning after emergence but leaves that developed later were normal. A highly significant delay in flowering and a significant reduction in cut flower yield resulted from all rates. There were no significant reductions in corm yield. Similar results were obtained by other research workers in other states. Consequently, in the 1960 Gladiolus Weed Control Summary published in the North American Gladiolus Council Bulletin (3) simazine was not recommended for use on gladiolus by any of the experiment stations. Simazine is not recommended for use on gladiolus by the manufacturer. However, included in the 1960 summary were grower reports of good weed control with simazine under their conditions. On the basis of the favorable grower reports, one New Jersey grower band treated all plantings of corms and cormels with a preemergence spray of 1 pound actual simazine per acre. There was good weed control. On the rolling land there were several knolls of sandy soil with heavier soil on the flat ground around them. Gladiolus plants on the sandy knolls were severely damaged or killed. Gladiolus on the heavier soil were not affected. A check on the amount of material used, by looking at the amount of material

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left in the container from which the herbicide came, only verified the grower's estimate of the rate used. We assume an even application was made. Simazine applied on sandy soil low in organic matter is harmful to gladiolus.

A home garden gladiolus enthusiast treated corn in 1960 with 1 to 2 pounds of simazine per acre. The following year he planted gladiolus cormels on this same soil. The gladiolus foliage was badly burned and many plants died.

In the same years, at the Ornamentals Research Laboratory, gladiolus cormels were planted in the spring of 1961 in soil treated in 1960 with a 10 pound rate of simazine in the spring followed by a 5 pound rate in the fall. Corm yield in the treated soil was 346 grams of corms per 4 foot plot compared to 454 grams from the previously untreated soil. This reduction in yield from a soil receiving a high rate of simazine was less severe than that sustained by the home gardener who used a much lower rate. In soil treated in 1960 with atrazine at the same rates as the simazine, the 1961 yield was reduced to 129 grams of corms from a 4 foot plot. Atrazine is reported to be much more harmful to gladiolus than simazine (2).

JUNIPER

Most evergreens are quite tolerant to simazine. This information has been reported many times in papers from experiment stations and in reports from commercial nurseries. This has been summarized in a new bulletin by Ahrens (1). On Long Island, two experimental plantings of Hetz juniper were tolerant to two yearly applications of simazine at 6 to 10 pounds per acre. These plantings received treatments starting 1 or 2 weeks after the small liners were transplanted into the field. A landscape gardener made a planting of Andorra juniper and some small ornamental trees on a steep bank in the rear of a customer's house. The soil was a poor, sandy subsoil normally used as backfill. To control weeds, the landscaper applied granular simazine to the planting at which he thought was the recommended rate. There was excellent weed control. Soon most of the junipers were dying and some of the new foliage on the small trees, especially cherry, showed symptoms of simazine injury. The lawn below the bank had streaks of dead grass where simazine had washed from the bank. Careful investigation showed that the actual amount used was never measured but a conservative estimate was at least 16 pounds actual simazine per acre.

ENGLISH IVY

On another bank of sandy soil a planting of English ivy was carefully treated by a home owner with simazine granular at 8 pounds actual per acre. The high rate was used to elimate quackgrass. Severe injury resulted except where much peat moss had been incorporated into the soil. Preliminary tests at the Cornell Ornamentals Research Laboratory and at Salisbury Park by the Nassau County Agricultural Extension Service showed simazine to be a promising herbicide for English ivy and several other ground covers. Ivy at the park received 12 pounds of simazine one year and 4 more the next. This was on heavy Hempstead loam to which peat moss had been added. Large scale tests on 2 commercial plantings on heavy soil showed some initial burning but later recovery.

PEONY

A peony planting at the State University Agricultural and Technical Institute at Farmingdale has received annual winter treatments of diuron up to 4 pounds per acre and simazine up to 10 pounds per acre for successive 4 years. The treatments were made on a planting of mixed varieties. Tolerance to the chemicals and weed control at the various rates have been good. Results on commercial plantings usually have been successful. Although there have been some reports of uneven weed control and injury to peonies where granular simazine or diuron had been used. The rates were in the range of 2 to 3 pounds of diuron or 3 to 4 pounds actual simazine per acre. Usually injury has been due to uneven distribution of granules. Some of the crop injury may be due to a variation in the tolerance of a few of the many varieties to simazine or diuron. Where simazine had been used for 3 years on peonies and day lilies a reduction in vigor was noted.

SUMMARY

Soil type is one of the factors apparently responsible for some of the injury when herbicides are used at high rates. With any chemical herbicide growers should determine how low a rate they can use on their crops and still get adequate weed control. Recommended rates for lighter soils are usually considerably lower than for heavier soils. Herbicides are selective and should be tested on a few plants of a variety before large scale usage. Herbicides must be used at a safe rate and be evenly applied. The users frequently need help in selecting the proper herbicide, calculating dosages, and selecting proper application equipment to avoid disappointing results from the use of herbicides.

Although large scale tests have demonstrated clearly that herbicides can be used safely on some crops for one season, some growers of perennials have noted a reduction of growth after two or three seasons use of the same herbicide. This again emphasizes the value of using lower rates alternating with other chemicals and/or cultivation.

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EFFECTS OF SOIL FERTILITY ON SIMAZINE INJURY TO NURSERY PLANTS: PRELIMINARY RESULTS[1]

By J. F. Ahrens, D. V. Sweet, and J. R. Havis[2]

Simazine has become useful for weed control in woody ornamentals. Considerable variation in plant tolerance has been reported, however, both in rates of simazine and among plant species. Soil type is recognized to influence plant injury from a given rate of application. Soil fertility could conceivably influence injury also. Experiments designed to test this theory were planned jointly by workers at the Connecticut and Massachusetts Agricultural Experiment Stations.

MATERIALS AND METHODS

The greenhouse trial was conducted at Waltham, Massachusetts, and the field test was conducted at Windsor, Connecticut.

Greenhouse Experiment

The soil mix consisted of 2 parts of fine sandy loam, 2 parts native peat and 1 part bank sand. Dolomitic limestone was added at the rate of 1/2 cupful per bushel. Fertilizer rates were 0, 625, and 1250 pounds of 8-16-16 fertilizer per acre, calculated on an area basis. Simazine rates were 0, 1, 2, and 4 pounds actual per acre, calculated on an area basis, from 4% granular formulation. Fertilizer and simazine were thoroughly mixed with soil, and the mixtures were placed in wooden flats 1 foot x 2 feet x 3 inches deep. Each treatment was replicated three times.

Five plants each of the following were set bare-root in each flat.

Taxus media Hicksi	(rooted cuttings)
Ligustrum ibolium	(rooted cuttings)
Tsuga canadensis	(1-year seedlings)

The experiment was set up on June 22, 1961. At this time composite soil samples of each of the fertilizer treatments were submitted to the Morgan quick test.

Soil samples were also taken on August 1 from the 2-pound rate of simazine. Following are the results of the August 1 tests:

Rate of Fertilization	pH	NO_3	NH_4	P_2O_5	K_2O	Soluble Salts (1-5)
0	6.3	VL	L	M	VL	0
625	6.2	L	L	MH	L	2
1250	6.0	MH	L	MH	M	10

These quick test measurements show that differences in fertility levels existed during the period of observation.

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[1] Contribution No. 1333 Massachusetts Agricultural Experiment Station.

[2] Connecticut Agricultural Experiment Station, Windsor; University of Massachusetts Field Station, Waltham (deceased), and University of Massachusetts, Amherst, respectively.

Field Experiment

A factorial experiment with 3 replications was conducted on a Merrimac sandy loam, part of which had not been fertilized for several years. The soil was limed in April 1961 to bring it up to a pH of about 6.0. A 10-6-4 fertilizer, with 50 percent of the nitrogen in organic form, was applied to the 9 ft. x 21 ft. plots at rates of 0, 333 or 1,000 lbs. per acre and disked in. Three days later (April 18, 1961), three to five plants of the following types and ages were planted into the plots:

Taxus cuspidata	- once (2 yr.) and twice (5 yr.) transplanted
Taxus media hicksi	- once transplanted (2 yr.)
Taxus canadensis	- twice (4 yr.) and three times (5-6 yr.)transplanted
Ligustrum ovalefolium	- once transplanted (2 yr.)
Euonymus radicans	- once (2 yr.) transplanted

Granular simazine was applied over the soil at rates of 2, 4, and 8 pounds of active ingredient per acre with a lawn spreader. Simazine applications were made either at 2 or 7 weeks after transplanting. Injury evaluations were made by three persons on July 14 and growth of some plants was measured in the fall. Control plots not treated with simazine were hoed at 4- to 6-week intervals during the season and at the same times escaped weeds were removed from the simazine treated plots.

RESULTS AND DISCUSSION

Greenhouse Experiment

Two weeks after initiation of the test, Ligustrum began to exhibit chlorosis in the no fertilizer treatments. By the first of August marked differences in shoot growth and size and color of leaves of Ligustrum were seen. The plants without fertilizer had small, chlorotic leaves and weak shoots. The plants in the medium fertility level made vigorous growth, leaves were normal size and medium to light green in color. The Ligustrum plants in the high fertility level made vigorous growth, leaves were large and dark green. Neither Taxus nor Tsuga exhibited foliage differences or growth response to the fertilizer levels.

Characteristic simazine injury symptoms on Ligustrum were loss of chlorophyll on leaf edges, developing to browning of the edges, and death of entire leaves in extreme injury. Ratings of degree of injury were made on August 10. The ratings in Table 1 show that the amount of injury to Ligustrum was markedly influences by the fertility treatments. The most striking influence of fertility levels was seen at the 2-pound rate of simazine where severe injury was exhibited at the lowest fertility and no injury at the highest fertility level. It was also interesting to note that one pound of simazine at low fertility gave comparable injury to four pounds of simazine at high fertility.

Taxus and Tsuga failed to exhibit injury symptoms from any of the treatments.

TABLE 1. RESPONSE OF LIGUSTRUM GROWING IN SIMAZINE-TREATED SOIL AS INFLUENCED BY FERTILITY IN GREENHOUSE. RATINGS MADE ON AUGUST 10.

Simazine lbs./A	Fertilizer Rate[1] lbs./A	Injury Rating[2]	
0	All levels	0.00	a[3]
1	0	1.43	bc
1	625	0.00	a
1	1250	0.00	a
2	0	3.10	d
2	625	0.80	ab
2	1250	0.00	a
4	0	4.50	e
4	625	4.50	e
4	1250	1.87	c

[1] 8-16-16 fertilizer

[2] 0=no injury; 5=plants dead

[3] Figures with different letters are significantly different at p=.01

Field Experiment

No significant injury was found in the Taxus or larger Tsuga even at 8 pounds of active simazine per a cre. Slight injury was observed in the smaller Tsuga (4 yr. bed-grown plants) at all rates of simazine but fertility levels had no apparent effects. Although it is reportedly a plant of borderline tolerance to simazine, Ligustrum showed pronounced discoloration only in one replication where rain fell as the granular simazine was being applied. In this case the discoloration was much more severe at the lowest fertility level. Simazine affected growth of the Ligustrum only at the 8 lb. per acre rate.

Euonymus proved to be the best indicator of simazine in the soil. Discoloration of Euonymus, although confined to leaf margins in many cases, was found in all the simazine-treated plots. Although no Euonymus plants were killed by simazine, severe yellowing and loss of leaves was evident on plants treated with the 8-pound per acre rate. This discoloration was somewhat reduced at the higher fertility levels, as shown in Table 2.

Time of simazine application after planting had no significant effect on the injury rating and the data from the 2- and 7-week treatments are combined in Table 2. Where the weeds were controlled by periodic hoeing, growth of the fast growing Euonymus and Ligustrum was affected very little by added fertilizer.

Simazine at 4 lbs. per acre appears to stimulate growth despite the foliage discoloration. To properly separate competitive effects of weeds with chemical effect, per se, future work should involve removing weeds from plots at shorter intervals (2 to 3 weeks) throughout the season. Even with sensitive plants such as *Euonymus*, deleterious competitive effects of weeds appear to outweigh simazine effects.

TABLE 2. EFFECT OF FERTILIZER ON SIMAZINE INJURY TO *EUONYMUS RADICANS* IN THE FIELD.

Simazine Rate Lbs./A	Fertilizer Rate[1] Lbs./A	Discoloration Ratings[2]	Growth above 6"[3] g./plot
0	0	.26	164
0	333	.28	168
0	1000	.19	150
2	0	.80	156 d[4]
2	333	.54	223
2	1000	.55	177
4	0	1.1	205
4	333	1.2	215
4	1000	.99	189
8	0	2.4 b[4]	156
8	333	1.7 c	180
8	1000	1.4 c	172

[1] 10-6-4 fertilizer, 50% organic nitrogen

[2] 0 = no injury; 5 = dead plants.

[3] Average of 13 plants.

[4] Figures with different letters are significantly different at p=.05.

Higher fertility levels tended to reduce the injury symptoms from simazine on sensitive plants. Although the trends were similar, the magnitude of difference was not the same in the field and the greenhouse. The following factors may have contributed to the differences in results between field and greenhouse:- ages of plants, analyses of fertilizers, growing temperatures, methods of simazine applications, and range of effective fertility levels as demonstrated by deficiency symptoms.

Further work should be done to determine which nutrients are responsible for the effects observed. It would be desirable also to evaluate other nursery plants of variable tolerances to simazine for their response to fertility levels.

SUMMARY

Evidence is offered to indicate that soil fertility can affect the response of certain nursery plants to simazine. *Ligustrum ibolium* in a greenhouse experiment, and *Euonymus radicans* in a field experiment were injured more by simazine at low soil fertility levels. *Taxus* sp. and *Tsuga canadensis* seemed to be affected very little by fertility level at all rates of simazine.

Chemical Weed Control in Taxus

Chiko Haramaki[1]

Cultivation in fields of established woody ornamentals results in good weed control in areas between plant rows. However, attempts to cultivate very close to plant rows results in mechanical injury to plants.

In areas where clean cultivation is not possible, it would be desirable to apply a herbicide which has both a post-emergence and a pre-emergence herbicidal activity.

The herbicides used in woody ornamental plants are mainly of the pre-emergence type. Although a few can be used as a post-emergence or as both a pre- and post-emergence herbicide.

Several herbicides and herbicide combinations were tested for pre- and post-emergence weed control in an established *Taxus* planting.

MATERIALS AND METHODS

A mature *Taxus* planting heavily overgrown with annual and perennial weeds was rototilled to a depth of 5-6 inches. Five chemicals at three rates of application plus an untreated check were replicated four times in a split plot design. Each plot contained six mature *Taxus* plants in 120 square feet area.

On May 23, 1961 the herbicides were applied with a portable sprayer at the rate of 180 gallons per acre. A directional spray was used covering only the soil and the base of the *Taxus* plants.

The herbicides used were:

1. Amizine (Amchem) - 15% amino triazole and 45% simazine.
2. Atratone (Geigy) and Simazine (Geigy)
3. Atrazine - 8G (Geigy)
4. Simazine - 4G (Geigy)
5. APC 60-39 (Amchem) - 12½% amino triazole and 37½% amiben.

RESULTS AND DISCUSSION

On July 5, and August 18, 1961, six and twelve weeks after treatment the plots were examined for weed control. The performance of the pre- and post-emergence herbicides on weed control is summarized in Table 1.

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Table 1. Effect of pre- and post-emergenct herbicides on weed prevalence. Treated May 23, 1961.

Herbicide	Active Rate	Weed Prevalence*	
		July 5, 1961	Aug. 18, 1961
Amizine	0	8.50	9.75
	2#/A	2.25	6.00
	4#/A	2.00	5.50
	8#/A	1.00	1.75
Atratone + Simazine	0	7.50	9.75
	½ + 1½#/A	6.00	9.25
	1 + 3#/A	3.75	6.50
	2 + 6#/A	2.75	3.75
Atrazine-8G	0	7.75	9.25
	2#/A	4.50	8.75
	4#/A	3.00	7.25
	8#/A	1.00	2.75
Simazine-4G	0	9.00	9.75
	2#/A	4.75	8.25
	4#/A	4.00	7.25
	8#/A	2.00	3.50
APC 60-39	0	9.50	10.00
	2#/A	6.50	9.00
	4#/A	4.50	9.00
	8#/A	3.75	8.25

* 1 = No Weeds
10 = 100% Weed Coverage

The following treatments gave satisfactory weed control: Amizine at 2, 4, and 8 pounds per acre; Atratone and Simazine at 1 + 3, and 2 + 6 pounds per acre; Atrazine-8G at 4 and 8 pounds per acre; Simazine-4G at 8 pounds per acre; and APC 60-39 at 8 pounds per acre.

After 12 weeks plots treated with these herbicides still showed good weed control: Amizine at 8 pounds per acre; Atratone and Simazine at 2 + 6 Atrazine-8G at 8 pounds per acre; and Simazine-4G at 8 pounds per acre.

The predominant weeds were yellow foxtail, quackgrass, dandelion, chicory, mustard, green foxtail, lambsquarter, winter cress, Canada thistle, tumbleweed, Pennsylvania smartweed, dog fennel, and green pigweed. Other weeds were timothy, common ragweed, yellow woodsorrel, wild carrot, prickly lettuce, barnyard grass, three seeded mercury, nodding spurge, white cockle, ground cherry, purple lovegrass, wild buckwheat, milkweed, blackseed plantain, curled dock, whitetop, burdock, rough pigweed, and downy bromegrass.

No herbicidal injury was observed on any of the *Taxus* plants even though the basal foliage, which was sprayed, was in an active stage of growth.

SUMMARY

Five pre- and post-emergence herbicides and combinations were applied to partially-clean, cultivated plantings of mature *Taxus* plants. Three rates of application plus an untreated check were replicated four times in a split plot design.

After 12 weeks the following treatments gave good weed control with no injury to actively growing established *Taxus* plants: Amizine at 8 pounds per acre, Atratone and Simazine at 2 + 6 pounds per acre, Atrazine-8G at 8 pounds per acre, and Simazine-4G at 8 pounds per acre.

EVALUATION OF DACTHAL* HERBICIDE ON TREES, SHRUBS AND HERBACEOUS ORNAMENTALS

Albert DiDario, H. H. Harris, T. L. Curry and L. G. Utter[1]

Field studies were initiated in 1959, at Painesville, Ohio, and expanded in 1960 and 1961 to determine both the weedicide activity of DACTHAL herbicide (dimethyl ester of tetrachloroterephthalic acid) and the tolerance exhibited by ornamentals to treatments with this material. During this three-year period, a wide range of seeded, transplanted and established ornamental crops in 90 genera were evaluated and found to be completely tolerant to DACTHAL herbicide at rates up to 15 pounds active per acre. Such broad crop tolerance would permit spray and granular treatments to be made in seed beds, lining out of nursery stock and in landscaped plantings when these crops are grown on mineral soils.

Details on the procedures and results of these tests follow.

Materials and Methods:

Ornamental species listed in the following categories were treated with DACTHAL up to 15 pounds active per acre in the three-year trial. The listing shows plant species and year(s) included in the field test program. (1) indicates inclusion in the 1961 test, while (0) is for 1960 and (9) for 1959 test periods, respectively:

WOODY ORNAMENTAL LINERS

Abelia grandiflora 1
Buxus sempervirens 1
Cotoneaster salicifolia 1
Deutzia gracilis 1
Euonymous alatus compacta 1
Forsythia intermedia 0, 1
Hedera Helix 0, 1
Hydrangea sp., Nikko Blue 1
Ilex Aquifolium 0, 1
I. crenata convexa 9, 0, 1
Juniperus chinensis, Hetzi 1
Kalmia latifolia 1
Ligustrum vulgare 0, 1
Magnolia Soulangeana 0, 1
Mahonia nervosa 0, 1
Parthenocissus tricuspidata 9, 0, 1
Philadelphus virginalis 1

PERENNIAL HERBACEOUS LINERS

Achillea spp. (mixed) 0, 1
Ajuga genevensis 0, 1
Anchusa myosotidiflora
Aquilegia spp. (hybrids)
Artemesia albula 1
Aster spp. (mixed) 0, 1
Campanula persicifolia 1
Chrysanthemum spp. (mixed) 0, 1
Coreopsis verticillata 0, 1
Dianthus sp., Her Majesty 0, 1
Dicentra spectabilis 0, 1
Delphinium spp. (mixed) 0, 1
Echinacea purpurea 1
Erica carnea 0
Heuchera sanguinea 0, 1
Hosta undulata 1
Iberis sempervirens 0, 1

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* Registered Trademark of Diamond Alkali Company

[1] Senior Research Biologists, Formulation Chemist, and Manager, Agricultural Chemicals Research, respectively, T. R. Evans Research Center, Diamond Alkali Company, Painesville, Ohio

Acknowledgment is given to Joseph Rudnor for his assistance in the

WOODY ORNAMENTAL LINERS (cont.)

Picea glauca 1
Pieris japonica 0, 1
Pinus sylvestris 1
Pseudotsuga taxifolia glauca 1
Rhododendron catawbiense 0, 1
R. molle 9, 0, 1
Rosa multiflora japonica 0, 1
R. spp. Radiance 0, 1
Spirea vanhouttei 1
Syringa vulgaris 1
Taxus cuspidata 9, 0, 1
T. cuspidata capitata 9, 0, 1
Thuja occidentalis nigra 1
Tsuga canadensis 1
Weigelia sp., Java Red 1

SHADE TREE PLANTINGS

Acer rubrum 1
Cercis canadensis 1
Cornus florida 1
Magnolia soulangeana 0, 1
Malus sp., Hoppa 1
Quercus borealis maxima 1
Robinia hispida 1

ANNUAL FLOWERING SEED

Cosmos sp., Sensation 1
Delphinium sp., Giant Imperial 1
Dimorphotheca pluvialis 1
Helianthus sp., Sun Gold 1
Helichrysum bracteatum 1
Impatiens balsamina 1
Ipomea purpurea 1
I. sp. Mexicana alba 1
Lathyrus odoratus (mixed) 1
Mirabilis Jalapa (mixed) 1
Quamoclit sloteri 1
Tagetes sp., Naughty Marietta 1
Tropaeolum majus 1
Zinnia sp., Illumination 1

PERENNIAL HERBACEOUS LINERS (cont.)

Iris sanguinea alba 0, 1
Lavandula officinalis 0, 1
Lupinus spp. (mixed) 0, 1
Lythrum sp. 1
Pachistima Canbyi 0
Pachysandra terminalis 1
Physalis Alkekengi 1
Potentilla aurea verna 1
Scabiosa caucasica 0, 1
Sedum spectabilis 1
Stokesia sp. 1
Thymus serphyllum coccineus 1
Tradescantia sp., Purple Dome 1
Verbena canadensis 0, 1
Veronica longifolia subsessilis 0, 1
Vinca minor 0, 1
Viola sp., Catherine Sharp 0, 1

ORCHARD PLANTINGS

Malus sp. 1
Persica sp. 1
Pyrus sp. 1

PERENNIAL FLOWERING SEED

Achillea filipendulina 1
Ageratum sp. 1
Alyssum saxatile compactum 1
Anthemis tinctoria 1
Aster spp., (mixed) 1
Chrysanthemum Leucanthemum 1
Coreopsis spp. 1
Cuphea Llavea miniata 1
Dahlia sp., Unwins 1
Gaillardia sp., Burgundy 1
Kniphofia Uvaria 1
Salvia splendens 1

BULBS AND TUBERS

Dahlia sp. 1
Gladiolus sp. (mixed 1

The 1959 and 1960 replicated field plots varied in size and design, depending upon the availability of species, plant characteristics and the number of replications. Plot sizes ranged from 9 to 27 square feet and replications from 2 to 14. All plant materials were grown on well-drained sandy loams.

The formulations used included DACTHAL W-50, DACTHAL G-5F, a five percent fast water disintegrating granular and one and one-half percent granulars in two formulations, DACTHAL G-1.5F and DACTHAL G-1.5S. DACTHAL G-1.5F has the property of relatively fast water-disintegration in comparison with DACTHAL G-1.5S. These granular formulations were applied at rates to give 10 and 15 pounds active per acre on the herbaceous ornamental group and 5, 10 and 15 pounds active on the woody ornamental species.

The wettable powder was mixed with water for application at the rate of 150 gallons per acre with a small plot sprayer. The granular formulations were applied by hand with a perforated shaker for ease of application and to obtain uniformity in distribution. The plots were treated as soon as possible after transplanting, usually the following day. In some instances, where treatments were delayed because of inclement weather, the plots were hand-hoed before pre-emergence treatments.

Weed control data were obtained by making weed counts of the entire plot area, except in the case of *Rhododendron molle* plots, where the high purslane population dictated counting a measured small plot sector. Weed counts were made twice at approximately 5 and 11 weeks after applications.

Plant response or injury evaluation was based on observational ratings on a scale of 0 = no injury to 11 = entire plant dead. These ratings were made at the time of the two weed counts.

During 1961, woody shrubs, bare-rooted tree liners and perennial herbaceous transplants were planted in two adjacent areas of approximately three-fourths acres each. The ornamental species in each of these areas were planted in double rows with three of each species opposite one another in adjacent rows. This gave a total of six plants of each species grouped together. The plantings were replicated four times in each area for a total of 48 plants of each species. Seeded annual and perennial flowering species were planted in one and one-half foot sections within each row. The two areas were on a poorly-drained Caneadea silt loam.

One area was sprayed with DACTHAL W-50 at the rate of 10 pounds active per acre and the other with the same formulation at 15 pounds active per acre. A 50-gallon, tractor-mounted low pressure PTO-driven field sprayer was utilized for applying DACTHAL herbicide under actual field conditions. It had a boom containing a Tee Jet 8006 nozzle and the sprayer was operated to deliver 56 gallons of water per acre. All crops except the trees were treated with a topical application pre-emergence to the weeds. Application was made on a band 20 inches wide. The trees were sprayed on each side of the row pre-emergence to weeds with the nozzle placed on the end of the boom to cover a swath 20 inches wide from two sides. Some overlapping in this application occurred.

Results and Discussion:

The weed spectra in the 1959-1960 test plots consisted primarily of crabgrass, purslane and lambsquarters, which were recorded separately, and of common chickweed, red sorrel, ragweed, smartweed, pigweed and horsenettle, which were lumped together in the miscellaneous column of the table which follows, since these were minor compared with the overall weed populations. Ragweed, smartweed and horsenettle were not found to be susceptible, at least to the rates of DACTHAL herbicide used in these tests. Intermediate to variable control of pigweed was obtained in the tests. Data shown in Table I are from the Boston ivy plots.

TABLE I

Average Weed Control Exhibited by DACTHAL
Formulations Applied on *Parthenocissus tricuspidata*

		Percent Weed Control							
DACTHAL Form.	Rate lb Active/A	Crabgrass 6/29	Crabgrass 8/5	Purslane 6/29	Purslane 8/5	Lambsqtrs. 6/29	Lambsqtrs. 8/5	Miscellaneous 6/29	Miscellaneous 8/5
W-50	5	98	96	99	94	99	95	68	65
	10	100	100	100	100	100	100	52	52
	15	100	100	100	100	100	100	42	45
G-1.5F	5	99	95	99	94	100	90	44	65
	10	100	98	100	96	100	92	50	47
	15	100	99	100	99	100	99	64	61
G-1.5S	5	92	91	99	90	100	88	71	48
	10	99	96	98	95	100	93	64	41
	15	99	99	100	99	91	99	57	47
G-5	5	92	82	100	72	90	65	51	25
	10	99	88	98	88	78	70	62	27
	15	99	88	100	86	74	78	64	29
Weeds/ft^2 of Check Plots		12	23	23	39	7	16	6	11

Treatments applied 6/7/60

It is apparent that the five-percent granular is the least effective formulation. This undoubtedly is due to incomplete coverage, because of fewer particles per unit area, obtained with the higher concentrated formulation. The control of lambsquarters was less than that of crabgrass and purslane.

The data shown in Table II summarize the results of weed control in the Japanese holly test.

TABLE II

Average Weed Control Exhibited by DACTHAL
Formulations Applied on Ilex crenata convexa

		Percent Weed Control							
DACTHAL Form.	Rate lb Active/A	Crabgrass		Purslane		Lambsqutrs.		Miscellaneous	
		7/8	8/5	7/8	8/5	7/8	8/5	7/8	8/5
W-50	5	100	100	98	96	94	100	48	52
	10	100	100	100	100	98	95	46	37
	15	100	100	100	100	99	100	42	46
G-1.5F	10	100	100	100	100	95	99	53	46
	15	100	98	100	100	92	100	36	45
G-5	5	97	94	99	99	90	92	36	38
	10	100	99	100	100	93	96	36	41
	15	98	98	100	96	91	94	47	50
Weeds/ft^2 of Check Plots		4	6	2	3	1	3	1	2

Treatments applied 10/23/59 and 6/10/60

Crabgrass, purslane and lambsquarters were the predominant weeds in these plots. Ragweed, common chickweed and grape from pomace are included in the miscellaneous column. Good weed control was secured in these plots throughout late fall. The effectiveness of the two treatments could be observed in the long period of weed control and a sharp delineation was observed in the fall between them, and the untreated checks, created by the germination and invasion of Poa annua at the extremities of the plots. The absence of Poa annua in the treated areas strongly suggested effective control of this weed.

The results reported from Parthenocissus tricuspidata and Ilex convexa plots are typical for all the herbaceous and woody ornamentals under test during 1959-1960.

As can be seen from the list of ornamentals which tolerated treatments with DACTHAL herbicide, plant response is quite favorable. However, during 1960 seven herbaceous species exhibited some degree of phytotoxicity as shown in Table III.

TABLE III

Plant Response Exhibited by Seven Herbaceous Ornamentals to Formulations and Rates of DACTHAL

Herbaceous Ornamentals	Evaluation 6/28/60				Evaluation 8/5/60			
	W-50		G-1.5F		W-50		G-1.5F	
	10 lb	15 lb	10 lb	15 lb	10 lb	15 lb	10 lb	15 lb
Ajuga	2	0	0	2	0	0	0	0
Dianthus	1	1	1	1	0	0	0	0
Iris	5	10	5	5	5	8	5	6
Lavandula	1	2	1	2	0	0	0	0
Teucrium	1	0	0	2	0	0	0	0
Veronica	4	2	1	4	0	0	0	0
Viola	2	2	2	2	0	0	0	0

The 1961 tests, however, do not confirm that these species, when transplanted and treated, are injured. *Iris* planted in 1960 were from divisions while those transplanted in 1961 were not. It is suggested that the primary cause of unfavorable response to this species resulted from poor divisions rather than to phytotoxicity from chemical treatment.

All woody shrubs, trees and perennial herbaceous transplants lined out in 1961 exhibited no phytotoxicity from treatments with DACTHAL herbicide.

Data from seeded flowering annuals were surprisingly favorable. Only the following species appeared to be injured: poppy, canterbury bells, larkspur, scarlet runner, cockscomb, Virginia stock and sweet rocket.

In the extensive 1961 trials, weed control was estimated by three observers. Observations showed that crabgrass, purslane, common chickweed, lambsquarter and foxtails were controlled at 10 and 15 pounds active DACTHAL per acre all season. Smartweed appeared in abundance in the check plots but not in the treated areas. Variable control of red sorrel was obtained. Ragweed and horsenettle were not susceptible to DACTHAL at either rate.

SUMMARY:

It was shown in 18 field tests over a three-year period that a large number of herbaceous and woody ornamentals, annual flowering seed, perennial flowering seed, gladiolus and dahlia tolerated treatment with formulation of DACTHAL herbicide at rates up to 15 pounds active per acre. This indicates that DACTHAL can be safely applied to these crops on mineral soils in established beds, nurseries and landscaped plantings. Furthermore, DACTHAL can be safely applied to these crops immediately following transplanting and pre-emergence to weeds. It is also indicated from the data that this crop tolerance is favorable even when more than one application is made on a number of crops. The data indicate that no unfavorable or accumulative residue remains in the soil from treatments with DACTHAL up to 15 pounds active per acre over a two-year period.

Where the weed complex consists of annual grasses and of certain annual broadleaved weed species, DACTHAL herbicide can be economically utilized in commercial nursery plantings.

It is evident that economical control of broadleaved weeds such as ragweed, horsenettle and smartweed cannot be obtained with DACTHAL at the rates used in these tests. This confirms previous findings of their lack of susceptibility to DACTHAL.

It was also demonstrated from the data that the wettable powder and G-1.5 formulations were more effective than the G-5 granular because optimum coverage of the treated areas with the higher concentrated granular formulation could not be obtained.

Pre-Plant Weed Control in Marigold Plantings

Chiko Haramaki[1]

During 1960, promising results were obtained in the use of pre-plant herbicides in the control of weeds in petunias planting. The tests were expanded this year by including marigolds in the tests. Two of the more promising chemicals in 1960 were kept and three others added.

MATERIALS AND METHODS

The tests were made in a Hagerstown silt loam, which was rototilled several times to a depth of 5-6 inches. Five herbicides at three concentrations plus an untreated check were replicated three times in a split plot design. Each plot had an area of 100 square feet.

The herbicides were applied on June 5, 1961. The air temperature was in the 80's and the soil temperature at 6 inches depth was 68°F. The herbicides used included Casoron, EPTC, Stauffer R-1607, Tillam and Vorlex. Each of the first four chemicals were applied by first mixing the chemical with a sufficient amount of water to make a gallon of mixture and then sprinkling this amount on each plot.

These plots were rototilled to a depth of 2-3 inches immediately after herbicide application. Vorlex was injected into the soil with a fumigun. One hundred eighty one injections, each approximately 9 inches apart were made in each plot. All of the plots were heavily watered after treatment.

Spry, a dwarf double French marigold was planted in all of the plots at different dates following soil treatment. Eight plants were transplanted in each plot at the following interval after treatment: one day, two days, one week, two weeks, three weeks, and four weeks. Another planting was made in the fifth week in the Vorlex treated plots.

RESULTS AND DISCUSSION

The plots were checked for weed prevalence on July 5, and August 17, 1961, which were approximately 4 and 10 weeks after treatment. The data on weed prevalence is summarized in Table 1. After four weeks weed control in all treatments was good except in the check plots and those treated with Vorlex at ¼ and ½ quart per 100 square feet. After 10 weeks good weed control was observed in the plots treated with Casoron at 2, 4 and 8 pounds per acre, EPTC at 10 pounds per acre, and R-1607 at 5 and 10 pounds per acre.

The predominant weeds were: tumbleweed, greep pigweed, green and yellow foxtail, lambsquarter, winter cress, Pennsylvania smartweed, and hairy crabgrass. Lesser frequent weeds included: Canada thistle, bitterdock, dog fennel, three seeded mercury, purslane, common ragweed, black

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Table 1. Effect of pre-plant herbicides on weed prevalence. Treated June 5, 1961.

Herbicide	Active Rate	Weed Prevalence*	
		July 5, 1961	Aug. 17, 1961
Casoron	0	2.33	6.67
	2#/A	1.00	1.67
	4#/A	1.00	2.00
	8#/A	1.00	1.00
EPTC	0	2.67	7.67
	2½#/A	1.33	6.67
	5#/A	1.00	4.00
	10#/A	1.00	1.00
R-1607	0	2.67	7.00
	2½#/A	1.00	3.00
	5#/A	1.00	2.33
	10#/A	1.00	2.00
Tillam	0	2.00	6.33
	2½#/A	1.67	5.00
	5#/A	1.33	3.67
	10#/A	1.00	3.67
Vorlex	0	4.00	8.00
	¼ Qt./100 sq. ft.	4.00	10.00
	½ Qt./100 sq. ft.	3.67	10.00
	1 Qt./100 sq. ft.	1.00	6.67

* 1 = No Weeds
10 = 100% Weed Coverage

bindweed, nodding spurge, cheese mallow, henbit, Rugel's plantain, shepherds purse, quackgrass, milkweed, velvetleaf, pokeberry, burdock, yellow woodsorrel, mustard, common nightshade, white campion, wild lettuce, chicory, groundcherry, thyme-leaved sandwort, yarrow, dandelion, mouse eared chickweed, and creeping spurge.

On August 22, 1961, approximately eleven weeks after herbicide application the marigolds were examined for injury and plant height. These data are summarized in Table 2 and 3.

In the Casoron treated plots, the plants in the 2 pound per acre treatments showed little or no necrosis regardless of the day of transplanting, although there was a slight stunting of plants transplanted within 2 days after treatment. The plants in the 4 pounds per acre plots exhibited little or no necrosis but were all stunted to some extent. The severity of stunting decreased, with a delay in planting. In the 8 pounds per acre plots the plants which were transplanted one day after treatment showed very severe stunting, necrosis we were killed; the plants which were planted on the second day after treatment showed moderate to severe injury and were stunted; and those which were transplanted one week after treatment showed slight to moderate necrosis and some stunting; the others which were transplanted at a later date showed some necrosis and stunting.

In the EPTC treated plots, there was little or no injury exhibited by the plants regardless of the concentration applied or the date transplanted.

In the R-1607 treated plots, there was little or no stunting or injury to the marigolds regardless of the concentration used or the day of transplanting.

In the Tillam treated plots little or no injury was observed on the marigolds regardless of concentration or date of transplanting.

In the Vorlex treated plots, the marigolds which were transplanted into the ¼ quart per 100 square feet plots showed severe necrosis and stunting, or death when transplanted one and two days after treatment. The plants which were planted at a later date showed moderate injury. The marigolds which were transplanted in the ½ quart per 100 square feet plots showed severe injury and stunting or death when transplanted within 2 days after treatment. Those which were transplanted at a later date exhibited moderate injury. The marigolds in the 1 quart per 100 square feet plots exhibited severe stunting and moderate necrosis when planted one day after treatment. Those planted 2 and 7 days after treatment showed some injury and stunting. Those planted later showed very little or no injury. The injury exhibited by the marigolds in the ¼ and ½ quart per 100 square feet treatments was due to a combination of weed competition and herbicide action.

Effective weed control with little or no injury to the marigold transplants were obtained with EPTC at 10 pounds per acre, and R-1607 at 5 and 10 pounds per acre. Casoron at 2 and 4 pounds per acre gave good weed

Table 2. Effect of pre-plant herbicides and weed competition on marigolds. Checked eleven weeds after treatments.

Herbicide	Active Rate	Time of Transplanting After Treatment 1 day	2 days	1 week	2 weeks	3 weeks	4 weeks	5 weeks
Casoron	0	0.83	1.04	0.38	0.58	0.58	1.25	
	2#/A	1.21	0.67	0.50	0.63	0.17	0.25	
	4#/A	1.50	1.88	1.33	1.00	1.33	1.25	
	8#/A	4.50	3.71	2.29	1.67	1.17	2.25	
EPTC	0	1.13	1.63	1.21	0.79	1.00	2.08	
	2½#/A	0.67	0.25	0.71	0.42	0.46	0.17	
	5#/A	0.29	0.33	0.25	0.08	0.04	0.08	
	10#/A	0.33	0.46	0.71	0.42	0.21	0.54	
R-1607	0	0.92	1.54	1.50	0.79	0.96	0.88	
	2½#/A	0.38	0.33	0.13	0.29	0.13	0.33	
	5#/A	0.75	0.50	0.04	0.13	0.38	0.38	
	10#/A	0.08	0.71	0.21	0.17	0.17	0.13	
Tillam	0	0.71	0.54	0.58	0.63	0.54	0.75	
	2½#/A	1.13	1.08	0.71	0.50	0.58	0.47	
	5#/A	0.29	0.38	0.33	0.42	0.00	0.38	
	10#/A	0.83	0.67	0.58	0.21	0.71	0.13	
Vorlex	0	2.13	2.33	2.00	1.33	1.83	1.38	1.83
	¼ Qt./100 sq. ft.	4.58	4.25	3.21	2.58	2.88	2.79	2.83
	½ Qt./100 sq. ft.	4.25	3.71	3.21	3.44	3.06	2.83	2.92
	1 Qt./100 sq. ft.	3.17	2.42	2.29	1.00	0.92	1.42	1.33

Plant Injury Scale:

0 - No Injury
1 - Very slight chlorosis or necrosis
2 - Slight chlorosis or necrosis
3 - Moderate chlorosis or necrosis
4 - Severe chlorosis or necrosis
5 - Dead

Table 3. Height of marigold plants in inches, eleven weeks after treatment.

Herbicide	Active Rate	Time of Transplanting After Treatment						
		1 day	2 days	1 week	2 weeks	3 weeks	4 weeks	5 weeks
Casoron	0	10.25	10.13	11.42	10.71	10.21	9.71	
	2#/A	7.71	8.71	9.92	9.42	9.00	10.25	
	4#/A	6.25	6.00	7.67	8.08	8.13	7.92	
	8#/A	1.08	2.83	5.58	7.21	7.96	7.92	
EPTC	0	9.42	8.75	9.33	10.13	9.63	7.58	
	2½#/A	10.88	10.50	10.58	10.58	9.83	9.75	
	5#/A	10.92	11.08	11.17	11.75	11.38	11.54	
	10#/A	10.08	10.79	10.58	10.38	10.21	10.08	
R-1607	0	11.04	9.17	9.42	10.08	8.71	9.96	
	2½#/A	10.38	11.21	10.88	10.38	10.83	10.25	
	5#/A	10.67	10.54	11.13	11.17	10.17	11.13	
	10#/A	10.25	9.00	10.75	10.21	10.71	11.25	
Tillam	0	10.33	11.38	10.79	10.67	10.08	9.88	
	2½#/A	9.58	9.88	10.08	10.33	10.08	10.46	
	5#/A	10.71	10.33	10.25	10.58	10.08	10.58	
	10#/A	10.21	10.13	10.67	9.86	10.79	11.00	
Vorlex	0	9.79	8.79	10.29	11.13	9.38	10.67	10.13
	¼ Qt./100 sq. ft.	2.08	4.21	8.38	9.75	8.58	9.75	8.96
	½ Qt./100 sq. ft.	4.13	5.38	7.71	9.54	9.46	9.17	8.04
	1 Qt./100 sq. ft.	3.63	6.29	8.08	9.00	9.04	9.13	10.21

SUMMARY

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

After 10 weeks Casoron at 2, 4 and 8 pounds per acre, EPTC at 10 pounds per acre and R-1607 at 5 and 10 pounds per acre still produced good weed control.

The results indicate that marigolds can safely be transplanted in the EPTC, R-1607, and Tillam treated plots one day after treatment. A few days delay was needed in the Casoron and Vorlex treated plots.

Effective weed control with little or no injury to the marigold transplants were obtained with EPTC at 10 pounds per acre, and R-1607 at 5 and 10 pounds per acre. Casoron at 2 and 4 pounds per acre gave good weed control but at least a week after treatment was necessary before transplanting.

Pre-Planting Herbicide Applications for Weed Control in Petunia Plantings

Chiko Haramaki[1]

In the 1960 trials two chemicals, Casoron and EPTC gave highly promising results as pre-plant herbicides for petunia plantings. The two chemicals were continued in tests in 1961, together with new chemicals thought to be promising for the weeding of this crop.

MATERIALS AND METHODS

The experiment was conducted on a Hagerstown silt loam soil. The soil was rototilled several times to a depth of 5 to 6 inches prior to treatment. The plots were 100 square feet in area. The pre-plant herbicides were applied at three different rates together with a untreated check. The treatments were replicated three times in a split plot design.

The herbicides used:

Casoron (Niagara) - was applied at the rate of 2, 4 and 8 pounds of active ingredient per acre. A gallon of each solution was applied to each plot.

EPTC (Stauffer) - was applied at the rates of 2½, 5, and 10 pounds of active ingredient per acre. The concentrate was mixed with a sufficient amount of water to make a gallon of mixture, which was applied to each plot.

R-1607 (Stauffer) - was applied at the same rates and the same manner as EPTC.

Tillam (Stauffer) - was applied at the same rates and concentration as EPTC and R-1607.

Vorlex (Morton) - a 100% active material was applied at the rates of ¼, ½ and 1 quart per 100 square feet. The Vorlex was injected into the soil with a Fumigun. 100 injections were made per plot at a spacing of 12 inches by 12 inches.

The herbicides were applied on June 1, 1961. All of the plots except those treated with Vorlex were rototilled to a depth of 2-3 inches after application. All plots were heavily watered after treatment. On the day of treatment, the air temperature was in the 80's and the soil temperature at 6 inches depth was 60°F.

The variety grown was Silver Medal, an F_1 hybrid multiflora single petunia. Eight plants were transplanted into each plot on each of the dates following treatment: one day, two days, four days, one week, two weeks,

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Table 1. Effect of pre-plant herbicides on weed prevalence. Treated June 1, 1961.

Herbicide	Active Rate	Weed Prevalence*	
		July 5, 1961	Aug. 22, 1961
Casoron	0	7.33	10.00
	2#/A	1.67	8.33
	4#/A	1.33	4.00
	8#/A	1.00	2.00
EPTC	0	7.00	6.67
	2½#/A	4.33	7.33
	5#/A	2.67	6.00
	10#/A	2.33	7.67
R-1607	0	8.67	10.00
	2½#/A	6.33	9.67
	5#/A	1.00	5.33
	10#/A	1.00	1.67
Tillam	0	8.00	10.00
	2½#/A	7.67	8.67
	5#/A	5.00	8.00
	10#/A	2.33	5.67
Vorlex	0	8.00	10.00
	¼ Qt./100 sq. ft.	8.33	10.00
	½ Qt./100 sq. ft.	8.33	9.67
	1 Qt./100 sq. ft.	4.67	9.33

* 1 = No Weeds
10 = 100% Weed Coverage

and 3 weeks. In the Vorlex treated plots an additional planting was made the fourth week following treatment. All of the plants were watered at the time of transplanting and throughout the growing season rainfall was supplemented by overhead irrigation.

RESULTS AND DISCUSSION

The plots were checked for weed control July 5 and Aug. 22, 1961, approximately 5 and 12 weeks after treatment. Table 1 summarizes the performance of the pre-plant herbicides on weed control. The following chemicals showed good weed control after 5 weeks; Casoron at 2, 4 and 8 pounds per acre, EPTC at 5 and 10 pounds per acre, R-1607 at 5 and 10 pounds per acre, and Tillam at 10 pounds per acre. After 12 weeks the following chemicals showed good weed control; Casoron at 8 pounds per acre and R-1607 at 10 pounds per acre.

Predominant weeds in the plots were lambsquarter, yellow foxtail, green pigweed, Canada thistle, Pennsylvania smartweed, and purslane. Weeds of lesser frequency included dandelion, yellow woodsorrel, three seeded mercury, stinkgrass, barnyard grass, velvetleaf, black bindweed, common ragweed, green foxtail, hairy crabgrass, purple lovegrass, mustard, rough pigweed, Rugel's plantain, groundcherry, timothy, burdock, wild lettuce, and tumbleweed.

On September 13, 1961, approximately 15 weeks after herbicide application, the petunias were examined for any detrimental effects due to herbicide and from weed competition. The data on the type of plant growth produced is summarized in Table 2.

The petunias in the check plots were moderate to severe stunting due to weed competition. The plants in the Casoron treated plots were from slight to moderately stunted. The petunias in the 2 pound per acre plots exhibited slight to moderate injury due to weed competition. Slight stunting and necrosis was observed in the 4 pounds per acre plots, this injury was due to a combination of weed competition and herbicidal action. Plants in the 8 pound per acre plots showed moderate stunting and necrosis due to the herbicide. The herbicide in the 4 and 8 pounds per acre treatments appeared to have long residual activity.

The petunia plants in the EPTC treated plots exhibited slight to moderate stunting because of weed competition. No injury from herbicide was observed even when they were transplanted one day after treatment in the highest rate per acre plots.

The plants in the R-1607 treated plots had slight to severe reduction in growth where weeds were not controlled by the chemical. The petunias in the 10 pound per acre plots were not injured. The petunias showed no herbicidal injury even when planted one day after treatment.

The petunias in the Tillam treated plots exhibited little to moderate reduction in growth due to weed competition. This injury decreased as the herbicide concentration was increased. No injury was observed due to

Table 2. **Effect of pre-plant herbicides and weed competition on petunias. Checked fifteen weeks after treatment.**

Herbicide	Active Rate	Time of Transplanting After Treatment						
		1 day	2 days	4 days	1 week	2 weeks	3 weeks	4 weeks
Casoron	0	3.00	3.33	4.00	3.83	3.33	3.08	
	2#/A	2.33	3.00	3.04	2.88	2.46	2.13	
	4#/A	2.46	2.33	2.79	2.17	2.21	1.42	
	8#/A	2.58	2.92	3.29	2.42	3.08	3.13	
EPTC	0	3.08	3.13	2.54	3.17	2.79	2.17	
	2½#/A	2.38	3.13	2.96	3.25	3.00	3.33	
	5#/A	2.17	3.46	3.33	2.67	2.50	1.79	
	10#/A	2.29	2.04	2.29	2.71	2.58	2.79	
R-1607	0	3.02	3.79	3.71	3.71	2.88	2.96	
	2½#/A	2.92	4.46	3.59	3.50	3.29	2.54	
	5#/A	1.25	1.92	2.17	2.83	1.71	1.46	
	10#/A	0.63	1.71	0.92	0.33	0.75	0.63	
Tillam	0	3.04	3.33	3.78	3.42	3.00	3.33	
	2½#/A	2.50	3.17	2.54	3.04	2.96	2.08	
	5#/A	2.17	2.75	2.29	2.75	2.92	1.79	
	10#/A	0.88	1.21	1.50	2.00	1.54	1.17	
Vorlex	0	3.21	3.63	3.46	3.58	4.04	3.75	3.71
	¼ Qt./100 sq. ft.	4.04	4.13	3.58	3.63	3.38	3.38	4.50
	½ Qt./100 sq. ft.	4.83	4.50	3.88	3.79	3.67	3.58	4.00
	1 Qt./100 sq. ft.	5.00	5.00	5.00	4.54	4.17	3.79	3.54

Plant Injury Scale:

0 - No Injury
1 - Very slight necrosis or stunting
2 - Slight necrosis or stunting
3 - Moderate necrosis or stunting
4 - Severe necrosis or stunting
5 - Dead

The plants in the Vorlex treated plots exhibited moderate to severe injury and death due to weed competition and herbicidal action at ¼ and ½ quart per 100 square feet. In the 1 quart per 100 square feet plots most of the petunias which were transplanted within the first week were killed by herbicide, those which were transplanted two to four weeks after treatment were killed or severaly stunted by a combination of herbicidal injury and weed competition.

The plots treated with R-1607 at 10 pounds per acre exhibited the best weed control and the transplanted petunias had very little or no damage even when transplanted one day after treatment. Plots treated with Casoron at 8 pounds per acre had good weed control but showed some injury to the petunias.

SUMMARY

Casoron, EPTC, R-1607, Tillam, and Vorlex were applied at three rates. Petunias were transplanted on each of the dates following treatment; one day, two days, four days, one week, two weeks, three weeks, and four weeks.

Petunias could safely be transplanted in the EPTC, R-1607 and Tillam plots one day after treatment. Plants in the Casoron treated plots were injured by the herbicide. Petunias in the Vorlex treated plots were injured by the chemical if planted within the first two weeks following treatment. Petunias transplanted in plots showing poor weed control were moderately to severely injured by weed competition.

Effective weed control with little or no damage to the petunia plants was found in plots treated with R-1607 at 10 pounds per acre. Plots treated with Casoron at 8 pounds per acre had good weed control but petunia plants had some injury by the herbicide.

EVALUATION OF THREE HERBICIDES ON PERENNIALS AND ANNUALS[1]

DALE V. SWEET[2] AND JOHN R. HAVIS[3]

Production of field grown herbaceous ornamentals in the northeast has been handicapped by lack of economical weed control practices. Recent reports suggest that simazine may have a use on perennials (1) and casaron on annuals, (2). Field trials were conducted at Waltham, Massachusetts, to evaluate these two herbicides and CIPC on 22 perennials and 11 annuals (18 families represented).

MATERIALS AND METHODS

The plants (see Table 2 for list) were started in the greenhouse and shifted to cold frames for conditioning prior to setting in the field plots. The field soil was fine sandy loam on which slightly raised beds four feet in width were formed. Four plants of each species were set one foot apart in each plot. The plots of perennials were 24 feet long; the annuals, 12 feet long. The treatments were replicated three times.

The herbicides, attaclay granules of 4% simazine, 4% casaron, and 5% CIPC, were applied immediately after plants were set May 29-31,1961. The rates used are listed in Table 1. Light rain followed the next day after applications to the perennials, and 1/2 inch irrigation was applied two days after application to the annuals.

The important weeds were henbit, pigweed, crabgrass and lambsquarter.

All replications of a treatment were hand weeded at one time, when at least two of the three replicates were judged to need weeding. The time required to weed each plot was recorded.

Herbicide treatments were repeated after the first hand weedings. Observations of plant injury were made on June 23 and on August 5, when the experiments were terminated.

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RESULTS

The data on number of weedings required and total time of weeding, presented in Table 1, suggest that the three herbicides gave comparable weed control at their lowest, middle and highest rates respectively. An exception is noted in the perennials, that the time required to weed the lowest rate of casoron was nearer that of the check than the low rates of the other chemicals. The shorter times recorded for annuals as compared with perennials was due to the smaller plot sizes and probably better soil preparation before the herbicides were applied.

TABLE 1. NUMBER OF WEEDINGS AND TIME REQUIRED FROM MAY 31 TO AUG. 3, 1961. PLOTS WERE 96 SQUARE FEET FOR PERENNIALS AND 48 SQUARE FEET FOR ANNUALS.

HERBICIDES AND	RATE (lbs./A)	PERENNIALS NO. OF WEEDINGS	PERENNIALS TOTAL WEEDING TIME (Minutes)*	ANNUALS NO. OF WEEDINGS	ANNUALS TOTAL WEEDING TIME (Minutes)*
None		3	181	2	53
CIPC	7 1/2	2	73	2	27
CIPC	15	2	55	1	12
CIPC	30	1	30	1	11
SIMAZINE	1	2	72	2	22
SIMAZINE	2	2	58	2	13
SIMAZINE	4	1	34	1	9
CASORON	2	2	141	2	22
CASORON	4	1	46	1	9
CASORON	8	1	24	1	15

*Average of three replications.

The response of each species to each rate of the herbicide at the two dates of observation has been prepared but has not been included in this paper in order to conserve space. Anyone interested in obtaining these details may request copies from the junior author. Table 2 summarizes the results by showing the highest rate of each chemical that was tolerated by the plants.

None of the chemicals tested was safe for all plants. In fact, eight species could not tolerate even the lowest rate of any of the three herbicides. More plants could tolerate CIPC than simazine and casoron. The data presented in Table 2 would allow one to choose certain plants on which one or more of the herbicides might be used successfully for controlling weeds. It is believed, however, that wide acceptance of chemical weed control on these herbaceous ornamentals will depend upon development of materials, formulations or application techniques that will be safe for a wider variety of species.

This work was partially supported by a grant from the Columbia Southern Chemical Company.

TABLE 2. THE HIGHEST RATE OF HERBICIDES AT WHICH THERE WAS NO INJURY TO THE PERENNIALS AND ANNUALS

PERENNIALS	SIMAZINE Lbs./A	CASORON Lbs./A	CIPC Lbs./A
Alyssum saxatile	0	2	0
Aquilegia Crimson Star	0	0	7 1/2
Arabis rosea	0	0	0
Campanula carpatica	0	0	7 1/2
Chrysanthemum coccineum	0	0	15
Delphinium Summer Skies	2	2	15
Dianthus deltoides erecta	0	0	0
Digitalis gloxinoides	2	0	7 1/2
Dimorphatheca aurantiaca	1	0	15
Euphorbia splendens	1	2	15
Fatshedera lezei	1	0	15
Gaillardia grandiflora	1	0	15
Gypsophila pacifica	1	0	0
Hedera Helix	1	0	15
Hemerocallis hybrids	2	4	30
Heuchera sanguinea	1	0	0
Myosotis sylvatica	0	0	0
Primula hybrids	0	0	7 1/2
Primula veris	0	0	7 1/2
Rudbeckia gloriosa	1	0	15
Veronica spicata	0	0	0
Viola cornuta	0	0	0
ANNUALS			
Aster Ball Mix.	0	0	30
Browallia grandiflora	0	0	0
Celosia cristata	0	0	7 1/2
Coleus Ball Mix.	1	0	7 1/2
Dianthus barbatus	0	0	0
Lobelia ilicifolia	0	0	7 1/2
Marigolf Naughty Marietta	2	0	30
Petunia Double Mix.	1	2	0
Phlox Twinkle	0	0	0
Verbena Dwarf	1	0	7 1/2
Zinnia Giant Cactus	0	0	15

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Chemical Control of Quackgrass and Nutgrass in Nursery Liners

by John F. Ahrens [1]

Quackgrass (Agropyron repens) is widely distributed in nursery plantings and occasionally has resulted in the abandonment of fields for ornamentals. Nutgrass (Cyperus esculentus) is less frequent in Connecticut nursery plantings but also has been difficult and expensive to control. The use of simazine for controlling annual weeds in nursery liners is becoming an accepted practice. The objective of this study was to evaluate chemical means of controlling quack- and nutgrass in nursery liners with and without the use of simazine for annual weed control.

Materials and Methods

The area selected for the test was infested with a dense stand of quackgrass. Although nutgrass plants were not in great abundance, the soil was infested with tubers. The soil texture was a silt loam. The heavy growth of grass was mowed, raked and fertilized with 560 lbs./A of 8-12-12 fertilizer on October 12, 1960. The quackgrass was growing vigorously on October 26 when the fall treatments were applied on 6' x 12' plots replicated three times. The following materials were used in this test:

a) amitrol (3-amino-1,2,4 triazole) 50% water soluble powder
b) atrazine (2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine) 80% W.P.
c) dalapon (2,2 dichloropropionic acid) sodium salt
d) EPTC (ethyl di-n-propylthiolcarbamate) 5% G.
e) propazine (2-chloro-4,6-bis (isopropylamino)-s-triazine) 50% W.P.
f) simazine (2-chloro-4,6-bis (ethylamino)-s- triazine) 80% W.P. and 4% G.

The fall treatments were applied in 70 gallons of solution per acre with a knapsack sprayer. Dupont spreader-sticker was added to each solution at a rate of ½ teaspoon per gallon of spray.

The area was disked on April 9, and again on April 20, after granular EPTC was applied by hand to the moist soil in one set of plots. The ground was plowed and disked on April 22, and on April 24, the following kinds and numbers of nursery stock were planted in each plot and trimmed to uniform sizes:

Forsythia intermedia, 1 to 2 year old - 5 plants per plot
Pieris japonica, 2 year liners - 3 plants per plot
Tsuga canadensis, 3 year seedlings - 6 plants per plot
Taxus media browni, 2 year liners - 5 plants per plot

Eleven days after planting, the rows were cultivated and granular simazine was applied over half the plots at a rate of 3 lbs./A. A lawn spreader with large wheels was used to apply the granular simazine.

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Because of the lush growth of quackgrass, nutgrass and annual weeds in some plots, all plots were cultivated with a tractor on May 25, June 19 and August 1. Counts of quackgrass and nutgrass were made in June and September by taking four one-square-foot samples from each plot. After the ratings were made in June and July, weeds were removed from all the plots, including controls. All of the plots were weeded, cultivated and seeded to oats in September.

The nursery plants were evaluated by three persons in August and the new growth of forsythia was measured in September.

Air temperatures were slightly below normal and rainfall was above normal in April and May of 1961.

Results and Discussion

Control of Nutgrass As shown in Table 1, only EPTC at 5 lbs.A controlled nutgrass appreciably on June 14. At that time nutgrass control was almost complete with some small and deformed plants remaining. The rating of 9.2 is the better measure of control on June 14, because the counts included the stunted plants. Had the plots not been weeded and cultivated at that time perhaps EPTC would have continued to control nutgrass. The ratings on July 18 and the counts in September show that EPTC no longer was effective.

Although simazine as a fall or post-planting treatment had no effect on the first crop of nutgrass in the spring, the data clearly indicate a suppression of the second crop of nutgrass with all of the simazine treatments. In nursery plantings, where hoeing every three to four weeks is a rule, any suppression of nutgrass such as that by simazine would be of definite value.

The final counts of nutgrass in September indicate that none of the herbicide treatments had any lasting effects on the development of nutgrass from tubers. All of the treatments, in fact, had more nutgrass than the controls, most likely because the treatments all controlled quackgrass which appears to suppress nutgrass germination.

Control of Quackgrass The data for quackgrass are given in Table 2. Fall application of simazine at 3 or 5 lbs./A, atrazine at 4 lbs./A and propazine at 4 lbs. provided about 90 percent or better control at all counts and ratings. Amitrol and dalapon alone were somewhat less effective. The pre-planting treatment with EPTC provided 93 percent control of the first crop of quackgrass but later evaluations indicated a reduction in control, whereas most other treatments provided better control at later evaluations.

Although granular simazine alone at 3 lbs./A provided relatively poor control of quackgrass, it greatly increased the effectiveness of all treatments except EPTC. The combination of fall applications of atrazine at 4 lbs./A or simazine at 5 lbs./A with a post-planting treatment of simazine resulted in almost complete control of quackgrass for the season.

Table 1. Effects of Herbicides on Nutgrass

Treatments[1]		June 14		July 18	Sept. 12
Fall Herbicide lbs./A	Spring Herbicide lbs./A	Shoots per sq.ft.	Rating[2]	Rating[2]	Shoots per sq.ft.
Weedy Controls		96	0	0	19
	Simazine 3	161	2.2	6.4	41
Simazine 3		110	3.4	6.5	26
Simazine 3	Simazine 3	172	2.5	7.2	25
Simazine 5		207	.5	5.0	43
Simazine 5	Simazine 3	129	4.7	8.4	27
Atrazine 2		232	.2	2.7	45
Atrazine 2	Simazine 3	148	1.7	7.2	28
Atrazine 4		239	.7	1.0	52
Atrazine 4	Simazine 3	138	2.9	6.5	36
Propazine 4		151	1.5	3.5	40
Propazine 4	Simazine 3	126	4.5	8.0	37
	EPTC 5	32	9.2	2.0	73
	EPTC 5 + Simazine 3	22	9.5	6.2	78
Amitrol 8		103	2.0	2.3	35
Amitrol 8	Simazine 3	136	2.3	6.5	30
Dalapon 10		75	1.8	1.7	39
Dalapon 10	Simazine 3	102	4.2	5.7	35

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[1] Rates given in terms of active ingredients.

[2] Visual ratings, 0 - no control, 10 = 100 per cent control.

Table 2. Effects of Herbicides on Quackgrass

Treatments		June 14		July 18	Sept. 12	
Fall Herbicide lbs./A	Spring Herbicide lbs./A	Shoots per sq.ft.	Per cent control[1]	Rating[2]	Shoots per sq.ft.	Per cent control[1]
Weedy	Controls	68.0	0	0	26.8	0
	Simazine 3	28.2	59	7.1	6.0	78
Simazine 3		6.9	90	9.1	0.9	97
Simazine 3	Simazine 3	2.4	97	9.7	0.6	98
Simazine 5		5.8	92	8.2	1.6	94
Simazine 5	Simazine 3	1.9	97	9.8	0	100
Atrazine 2		10.9	84	6.3	5.8	78
Atrazine 2	Simazine 3	5.7	92	9.4	0.6	98
Atrazine 4		4.5	94	8.6	1.1	96
Atrazine 4	Simazine 3	1.3	98	9.8	0	100
Propazine 4		7.9	88	9.7	0.7	97
Propazine 4	Simazine 3	3.2	95	9.4	0.6	98
	EPTC 5	4.8	93	5.8	4.8	82
	EPTC 5 + Simazine 3	3.8	95	8.5	6.3	77
Amitrol 8		26.3	61	6.2	10.9	59
Amitrol 8	Simazine 3	10.5	85	9.2	1.7	94
Dalapon 10		41.6	39	4.0	8.9	67
Dalapon 10	Simazine 3	14.6	79	8.2	3.0	89
L.S.D. p=.05		7.7	11		4.2	16
p=.01		10.5	15		5.7	21

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[1] Per cent control based on shoots per sq.ft.

[2] Visual rating, 0 - no control, 10 - 100 per cent control.

Undoubtedly the three cultivations and the two hoeings on the weedy plots during the season added to the effectiveness of the chemical treatments. The stands of quackgrass in the control plots were reduced by about 60 percent from June to September as a result of these operations.

Control of Annual Weeds An abundance of annual weeds and bindweed (Convolvulus arvensis) invaded the plot areas. The annual weeds were predominantly ragweed (Ambrosia artemsiifolia), crabgrass (Digitaria sanguinalis) and yellow foxtail (Setari lutescens). Ratings of these and other annual weeds are shown in Table 3.

Fall applications of amitrol, simazine, atrazine and propazine all appeared to decrease the stands of annual weeds, especially in June. Because of the competition offered by the nutgrass in plots of these treatments, however, little can be said of their real value. Dalapon had little effect on the annual weed population although EPTC appeared to control bindweed.

Granular simazine, applied at 3 lbs./A after planting provided satisfactory control of annual weeds for the season. Bindweed did not persist in plots treated with combinations of atrazine, propazine or simazine in the fall and granular simazine in the spring.

Effects of Treatments on Nursery Plantings None of the treatments injured any of the nursery plants seriously. The forsythia were slightly discolored by the atrazine treatments but the injury appeared to be temporary. The forsythia grew vigorously, and made more growth in the treated plots than in the controls (Table 3). The forsythia grew poorly in these plots where annual weeds and/or nutgrass were not controlled.

The oats sown in September yielded information on residual activities of the triazine herbicides. Oats are very sensitive to the triazines. The only plots with pronounced injury to the oats were the combinations of simazine at 3 or 5 lbs./A in the fall with simazine at 3 lbs./A in the spring.

Summary

Combinations of fall and spring pre-planting treatments with a post-planting application of simazine in the spring were tested for their effects on quackgrass and nutgrass in nursery liners. A pre-planting, soil-incorporated treatment with EPTC at 5 lbs./A controlled the first crop of nutgrass but had little effect on nutgrass germination after two months. Repeated applications of EPTC may be needed for seasonal control. Simazine greatly suppressed growth of nutgrass during the summer.

With periodic cultivation and weeding, fall applications of atrazine and propazine at 4 lbs./A and simazine at 3 or 5 lbs./A provided good control of quackgrass for the season. Seasonal control of annual weeds and excellent control of quackgrass was obtained when these treatments were followed by a post-planting application of granular simazine at 3 lbs./A.

None of the herbicide treatments seriously affected the newly-planted nursery stock.

Table 3. Effects of Herbicides on Annual Weeds and Forsythia

Treatments		Weed Control Rating[1]		Forsythia	
Fall Herbicide lbs./A	Spring Herbicide lbs./A	June 14	July 18	Discoloration[2] Aug. 10	Growth above 30 cm. g/plot Sept. 13
Weedy Controls		0	0	0	651
Clean Controls		-	-	0	1229
	Simazine 3	9.2	9.2	0	1239
Simazine 3		8.5	5.6	0	848
Simazine 3	Simazine 3	9.9	9.4	0	1440
Simazine 5		8.4	6.4	0	856
Simazine 5	Simazine 5	9.9	9.9	0	1008
Atrazine 2		5.3	5.5	0	1250
Atrazine 2	Simazine 3	9.7	9.3	0.3	1139
Atrazine 4		8.7	6.2	0.3	952
Atrazine 4	Simazine 3	9.3	9.4	0.4	1130
Propazine 4		7.0	5.6	0.1	1197
Propazine 4	Simazine 3	9.8	9.9	0	1212
	EPTC 5	3.7	2.7	0	1290
	EPTC 5 + Simazine 3	9.7	8.5	0.1	1005
Amitrol 8		7.0	1.0	0	721
Amitrol 8	Simazine 3	8.8	8.8	0	1262
Dalapon 10		0.8	1.7	0	702
Dalapon 10	Simazine 3	8.5	8.8	0	1461

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[1] Visual rating, 0 - no control, 10 - 100 per cent control.

[2] 0 - no injury, 1 - slight injury, 5 - dead plants.

PRELIMINARY STUDIES ON A GROWTH INHIBITOR FROM *ARTEMISIA VULGARIS*

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The production of toxic substances by certain plants was noted as early as 1832 when DeCandolle observed flax was inhibited spurge and oats by horsemettle. Since that time, considerable circumstantial evidence supporting the presence of these substances has appeared and more convincing evidences are now accumulating. The literature on this subject has been comprehensively reviewed by Livingston (1907), Loehwing (1937), Bonner (1950), Börner (1960), and Woods (1960).

Artemesia vulgaris is rapidly spreading over many areas of Eastern Virginia. It has few, if any, natural enamies and has the ability to choke out crops and other weeds if allowed to grow undisturbed. Funke (1943) included *Artemesia vulgaris* in an experiment designed to compare inhibition of various plants near hedges of species thought to secrete toxic substances into the soil. Plants were inhibited up to 100 cm. from *Artemesia absinthium* with the effect gradually tapering off in the last 50-60 cm. There was uniform inhibition up to 60 cm. from the *Artemesia vulgaris* beyond which the plants were normal. Funke attributed this effect to mechanical oppression of the vigorously growing *vulgaris* branches. Plants growing near *Atriplex hortensis* were not affected. In another experiment, seeds were placed in shallow bowls containing either soil or soil mixed with the leaves of *Artemisia absinthium* or *Artemesia vulgaris*. There was reduced germination in the bowls containing plant material of both plants, but the effect was greater from the leaves of *Artemesia absinthium*.

In this paper, we are presenting the results of the extraction of a substance from *Artemesia vulgaris* which is inhibitory to the growth of alfalfa seedlings.

Materials and Methods

Artemesia vulgaris used in this study was air dried and ground in a 40 mesh whiley mill. Five g. of the ground meal was placed in a column and leached with 300 ml. water. The solution was evaporated under reduced pressure at 45° C. and the residue dissolved in 100 ml. distilled water. This was diluted to make a series of concentrations which were prepared for assay.

Extract of green *Artemesia vulgaris* was prepared by placing fixe g. green leaves and stems in 100 ml. water in a Waring blender. There it was ground 20 minutes and filtered with a Bachner funnel.

1/ Assistant Professor and Professor of Plant Physiology.

The inhibitory activity was assayed according to the method of LeFevre and Clagett (1960). This consisted of placing 5 alfalfa seeds in 5 ml. beakers containing a filter disk wetted with .5 ml. test solution. The seedlings were grown 4 days and the percent inhibition was calculated in relation to controls grown in distilled water.

In later experiments, ground meal was placed in dialysis tubing with one end open and autoclaved. The meal was saturated with water, the other end of the tubing was tied, and the bag was placed in a soxhlet extractor and extracted with water. With this method extraction and dialysis were accomplished simultaneously.

Results and Discussion

Green vs. Dry Plant Material

The results of the alfalfa seedling inhibition test showed inhibition was present in both green and dry *Artemesia vulgaris* (Table 1).

Table 1. Inhibition from green *Artemesia vulgaris* compared with extract from dry meal.

	Percent inhibition of Seedling growth			
	* 5g./100	2.5g./100	1.4g./100	5/8g./100
Green	92	71	44	50
Dry	95	95	92	73

* Concentration of extract in grams plant material extracted per 100 ml. solution.

Extraction from Flowers, leaves, roots, and stems

Extracts from soxhlet dialysis extraction of leaves, stems, roots, and flowers all produced 100 percent inhibition of alfalfa seedlings at the concentration comparable to extract from 5g. meal in 100 ml. solution.

Table 2. Inhibition from flowers, leaves, roots, and stems.

	mm. total growth	Percent inhibition
Control	43	00
Flowers	0	100
Leaves	0	100
Roots	0	100
Stems	0	100

Since the inhibitor was found in all parts of the plant any plant material could be used in further extractions, thus a mixture of the above ground parts were used in the remainder of the study.

Effect of heat

When a column packed with the dryed meal was autoclaved before extraction, there was no loss of inhibition (Table 3).

Table 3. Effect of autoclaving on inhibition of alfalfa seedling growth.

Concentration	Percent Inhibition * 5g./100 ml.	2½ g./100	1¼ g./100	5/8 g./100	5/16/100
Autoclaved	100	87	89	71	
Non-Autoclaved	88	90	85	71	56
Volatile	-17				

* See footnote Table I

This showed that the inhibitor is stable at 120° C and 20 psi for 20 minutes.

When the first 100 ml. passed through an autoclaved column it was evaporated and the water condenced under an ice pack. The assay showed alfalfa seedling growth slightly greater than that of the controls. It is evident from this experiment that the active principle is non-volatile.

Soxhlet extraction

A comparison of extraction efficiency of several solvents was made using the Soxhlet extractor. *Artemesia vulgaris* meal was extracted 48 hours.

Table 4 Soxhlet Extraction

	Percent germination	Percent inhibition
Control	95	00
Water	00	100
Methanol	15	79
Acetone	45	88
Benzene	85	68
Xylene	95	13
Pet Ether	95	16
Chloroform	50	71

The solvents were evaporated and the residuums shaken with water with a wrist action shaker for 20 minutes.

The results showed the inhibition was most soluable in non-polar solvents (Table 4). However, there were inhibitory substances extracted by some of the non-polar solvents. Table 5 shows that an inhibition extracted with chloroform can be separated from the chloroform by shaking with water in a separatory funnel. Similar results were obtained with benzene.

Table 5. Removal of activity from chloroform with water in a separatory funnel.

	Percent germination	Percent inhibition
Extracted Chloroform	80	24
Water Extract	30	70

Ash

When one g. dry meal was ashed at 625°C. for 4 hours and 20 ml. water added to the ash to make up a test solution, alfalfa seedlings grew as well as controls (Table 6). The ash solution was basic (pH 12.2). HNO_3 was added to bring the solution to pH 7. However, seedlings grew well in both solutions. Growth in the basic solution is explained by secretion of organic acids from the alfalfa seedlings as the pH in the basic test had come down to near pH 7 at the end of 4 days seedling growth.

Table 6 The effect of ash on inhibition of alfalfa seedlings.

	mm growth	%inhibition
Control	37	00
Ash (No neutralization treatment)	42	-13
Ash (Neutralized with HNO_3)	39	- 5

Dialysis

Autoclaved extract was placed in cellophane dialyzer tubing and the tubing inserted in a cylinder. Water in the cylinder was changed about 10 times during three days treatment. All material outside the cylinder and the heavy concentrate which did not pass through the casing were concentrated and diluted for assay. Table 7 shows most of the activity passed through the cellophane tubing.

Table 7 **Effect of dialysis on the inhibition**

	Percent germination	Percent inhibition
Dialyzed	10	96%
Non dialyzed	95	7%

As a result of this experiment and stability to heat, further extractions were made by placing autoclaved meal in dialyzer tubing and extracting in a Soxhlet extractor, thus extracting and dialyzing in one operation.

Ion exchange

Table 7 shows the inhibitor is not absorbed to either cation or anion exchange resins. There was very little loss of activity on passage through Amberlite 1R-120 or after having passed through both this resin and Amberlite 1RA-400.

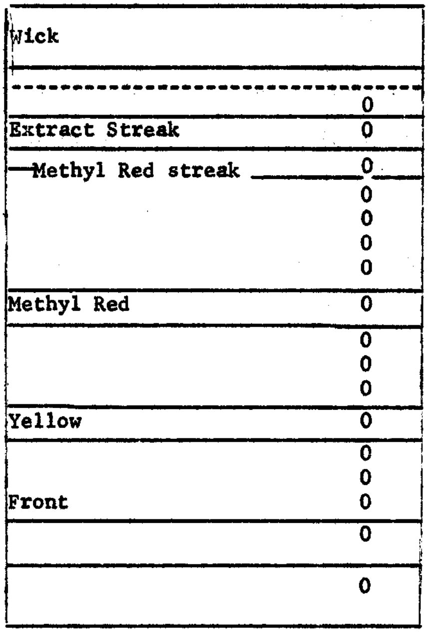
Table 8 Effect of ion exhange resins on inhibitor

	Percent germination	Percent inhibition
Through Amberlite IR-120	0	100
Through Amberlite IRA-400	0	100

Paper chromatography

Deionized and dialyzed extract from 5 g. *Artemisia vulgaris* was streaked on one 19 x 19 S&S 470-A filter paper having a Whatman No. 7 wick. The solvent used was isopropanol water (90-10$^{v}/_{v}$) in an ammonia atmosphere. Discs were cut out of the chromatograph with a cork borer and placed in 5 ml. beakers . Each disk was wetted with .5 ml. water and 5 seeds were added for assay. Most of the inhibtor was found between Rf values 56-72 (Figure I). This was ahead of methyl red which had a Rf value of about 47.

Figure I Bioassay of chromatographed extract



Rf	Percent Inhibition
Control	0
0	16
9	-1
17	-4
24	54
31	-9
37	16
43	14
48	-21
57	100
64	60
71	80
77	77
84	22
92	-27
98	-31
	11

Summary and Conclusions

Agueous extracts of 5/16 g. *Artemesia vulgaris* when diluted to 100 ml. inhibited alfalfa seedling growth over 50%. The inhibitor was found in green and in dry plant material and could be extracted from either leaves, roots, stems, or flowers. It was stable to autoclaving at 20 p.s.i. for 20 minutes, but was destroyed completely when ashed. It was dialyzable and nonvolatile. It was soluable in polar and semipolar solvents and partly soluable in some nonpolar solvents. Inhibition extracted with nonpolar solvents could be removed by shaking with water in a separatory funnel. The substance was not absorbed to either strong cation or anion exchange resins. Paper chromotographs run in isopropanol and water (90 - 10 /) in an ammonia atmosphere showed the inhibitor or inhibitors to have an Rf value between 56 and 76.

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Weed Control and Residual Effects of Simazine and of Atrazine Applied to Soil Prior to Planting Nursery Stock

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Simazine and atrazine have both been used in wettable powder and granular formulation in two series of tests since 1957 in plantings of evergreens (*Taxus* and *Thuja*) in Cornell nursery areas.

The 1957 series of plants were rototilled and replanted in 1959. Rototilling has continued through 1961. The original plan of the plots is no longer visible from the weed growth or lack of it. Evergreen crop growth is normal.

Red kidney beans were planted in July 1961 in soil that had not been treated with triazines as well as in the old plot areas. Germination and growth were similar in both sections of the field, indicating that the soil was essentially free of triazines in the area of the bean root zone.

A second nursery area was treated in 1959 to kill sod before planting nursery crops. Simazine and atrazine were applied June 21 and 22, 1959 at two rates, 5 and 10 pounds of active ingredient from each of two formulations (wettable powder and granular) as well as surface application and incorporation of the herbicide by rototilling 3-4 inches immediately following planting.

During the summer of 1959 timothy sod was eliminated from treated plots except when simazine was used on the sod surface in granular form without rototilling. Dandelion was stimulated in size and dark green color. Bindweed was released but re-invasion by seedling weeds was of minor proportions.

In 1960 half of each 10 x 10' plot was rototilled and the nursery indicator plants, *Ligustrum ovalifolium*, *Euonymus fortunei*, *Pachysandra terminalis* and *Forsythia intermedia* were planted in the freshly rototilled soil. The indicator crops oats, buckwheat and later red kidney beans were also planted.

Typical growth response of these test crops to triazines was found only at the 10 pound level. Not all plants of an indicator group responded within a plot. Growth of beans was normal in soil samples taken to the greenhouse in fall 1960 for testing indoors under soil moisture at field capacity from intermittent misting.

June observations in 1961 indicated very little residual response in test crops. *Euonymus fortunei* foliage in granular simazine plots at 10 pound level showed yellow margins on a few leaves in young growth typical of triazine injury in this and other crops including *Buxus* and *Taxus*.

A single strip was rototilled in June 1961 at right angles to 1959 and 1960 rototilling. Red kidney beans were planted in a single row through each rototilled strip. Growth and color of the red kidney beans in the untreated controls and in the triazine plots were very similar. Samples of 10 bean plants at flowering stage were cut at the soil level and green weight taken immediately. The weights are given in Table 1 and show no consistent trend nor statistically valid difference even at the 5% level. Under these circumstances the plots may be regarded as having a triazine content lower than that phytotoxic to nursery crops tested.

Table 1. Green weight in grams of 10 red kidney bean plants at first flower stage following June planting in control plots and in treated plots.

Soil treatment	No. of plots	Type of application Surface	 Rototilled
Control	16	214.25	204.56
Eptam	8	246.13	220.12
Simazine	8	233.75	248.75
Atrazine	8	215.00	206.50
Mean weight		224.69	216.95

Simazine and atrazine have given good control of established stands of Agropyron repens. Reinfestation, however, follows unless some additional control measures are maintained. Spot spraying, cultivation, plowing or weeding may be selected but prolonged residual action is not adequate to prevent re-establishment of some weeds and release of others from a minor to a dominant position. Hedge bindweed, Convolvulus sepium, was present in minor amounts in 1959 but all plots showed some bindweed in autumn 1961 -- 70% of all the plots rated 5 or more on a scale of 0 through 9. Grass stand was also rated on stand density. Agropyron repens was present to 50% or more in rototilled plots.

Table 2. Stand of perennial grasses present at the close of the third season after a single application of atrazine and simazine based on rating 0-6 total for 3 replicates and duplicate ratings (hence 6 x 3 x 2 = 36 maximum).

Herbicide	Rate lbs. A/A	Not rototilled 1959-61	Rototilled 1959 only	 1960 only	 1959 & 1960
Control	0	27	18	18	17
Atrazine	5	26	22	23	17
	10	30	24	22	13
Eptam	5	30	20	21	20
	10	28	23	17	18
Simazine	5	20	15	20	13
	10	25	11	19	12

Rototilling was done in June so that the 1959 and 1960 data represents re-establishment over the period June 1960 to November 1961. In the fall of 1959 three months after treatment little Agropyron repens was present in the plots receiving simazine or atrazine. This was true also in November 1961 following June 1961 rototilling.

Summary

In a Dunkirk silty clay loam simazine and atrazine applied on the surface at 5 pounds or at 10 pounds of active ingredient per acre are effective in controlling Agropyron repens and seedling weeds for one and possibly two growing seasons. Rototilling 2-3 times at the close of the second season largely reduces any herbicidal value and permits normal growth of red kidney beans during the sensitive juvenile leaf stage on through to flowering stage. Normal growth of all indicator plants tested is taken to indicate that the soil is free of herbicidal levels of the herbicide applied. Incorporation of simazine or atrazine at the time of application increases the initial efficiency of the herbicidal action. It is likely that incorporation assures placement within the soil and minimizes loss through run off or spreading to adjacent plots. Rototilling once a year in present tests appears to be as effective as herbicidal application used once in a three year period. Weed control value is lost and phytotoxic effect to indicator plants was not evident after the second year following application.

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WEED CONTROL IN STRAWBERRIES WITH EPTAM, NEBURON, TRIETAZINE AND ZYTRON[1]

John S. Bailey[2]

In the northeast strawberry fields are customarily fruited only once. One of the chief reasons for this is the failure of growers to keep weeds under control. The use of Sesone has helped but under some conditions results have been disappointing. Several other chemicals have been tried but none has been widely used (1,2,3,5,6). Therefore, the search for a better weed control chemical for use in strawberry fields continues.

Materials and Methods

In mid-April, 1960, virus-free plants of the variety Surecrop were set in plots 5 feet by 12 feet. The mother plants were set 2 feet apart, 5 to a plot and allowed to form matted rows. The materials tested and rates per acre were as follows: Eptam 5% granular at 2 and 4 pounds; Neburon 18.5% W.P. at 1 and 2 pounds; Trietazine 50% W.P. at 2 and 4 pounds and Zytron 25% on clay at 10 and 20 pounds. Each treatment was replicated four times.

The plots were hoed and cultivated until June 10 so that the plants would be thoroughly established before any treatments were applied. On June 10, after thorough cultivation and hoeing the Trietazine and Neburon were sprayed over the plots using one pint of water per plot. On June 13 the Eptam and Zytron for each plot was mixed with a double handful of dry sand and broadcast by hand. These two materials were then cultivated in lightly with an iron rake.

By mid-July some of the plots were getting very weedy, especially the untreated plots. Therefore, all the weeds on each plot were counted. Since very little grass appeared in any of the plots at this time or later, all the data will cover broadleaf weeds only. Those present were mostly purslane, Portulaca oleracea; red root pigweed, Amaranthus retroflexus; lambsquarters, Chenopodium album; and smartweed, Polygonum hydropiper.

After the weed counts were made all plots were thoroughly cultivated, hoed and on July 26 and 27 all plots were re-treated.

By September 23 some plots had become very weedy again. Therefore, the plots in each block were ranked for weed population so that the results could be tested statistically by the rankit method (4). The most abundant weed at this time was common chickweed, Stellaria media. After the ranking all plots were cultivated and hoed and no more chemicals applied either in the fall or

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in the spring of 1961 preceeding the picking of the crop.

Results

The results of the weed counts on July 15 are given in Table I. The treatment means are compared by the method of J. S. Tukey as modified by Snedecor (7). The difference necessary for significance is expressed as D rather than L.S.D.

Table I. Percentage Weed Control on July 15, 1960 Following Herbicide Applications on June 10, 1960.

Treatment	Rate (lbs/a) (a.i.)	Average No. weeds per 60 sq. ft. plot	% Control	Transformation to angles average value
Untreated	--	139.0	----	----
Trietazine	2	2.7	98.1	82.33a*
Trietazine	4	4.0	97.1	81.05a
Eptam	4	20.0	85.6	67.94ab
Neburon	1	29.0	79.1	63.58b
Neburon	2	27.3	80.4	63.46b
Eptam	2	44.3	68.1	54.75b
Zytron	10	47.3	66.0	54.41b
Zytron	20	51.7	55.6	51.85b

D at 5% = 16.62

*Differences between means having the same letter are not significant.

Most of the materials gave good to excellent weed control. The outstanding material is Trietazine. The two pound rate seems to be just as good as the four pound. Eptam at four pounds per acre also gave such good control that there is no significant difference between it and the two rates of Trietazine. The difference in weed control between the two rates of Trietazine and the other materials is significant but the differences between Eptam at four pounds per acre and the others is not.

Table II gives the results in rankit values (4) of the plots on September 23.

Table II. Results from Ranking on September 23, 1960 of plots treated a Second Time on July 26, 1960.

Treatment	Rate (lbs/a) (a.i.)	Rankit value	Treatment	Rate (lbs/a) (a.i.)	Rankit value
Trietazine	2	1.12a*	Eptam	4	-0.01bc
Trietazine	4	1.12a	Neburon	1	-0.11bcd
Neburon	2	0.76ab	Zytron	10	-0.40cd
Zytron	20	0.06abc	Untreated	--	-1.11d
			Eptam	2	-1.14d

D at 5% = 1.10 D at 1% = 1.32

The Trietazine plots were almost entirely free of weeds while the untreated plots had a heavy infestation. Again, Trietazine rated the highest and there is no difference between rates. However, there is no significant difference between Trietazine at either 2 or 4 pounds per acre, Neburon at 2 pounds per acre and Zytron at 20 pounds per acre.

In the summer of 1961 the yields of fruit from the plots were obtained. These data when treated by analysis of variance give no significant difference between treatments. Therefore, comparisons between treatments are omitted. This result suggests that none of the herbicides changed the yield of fruit significantly.

Conclusions

When dealing with herbicides, it is never safe to draw hard and fast conclusions from the results of one year or one crop cycle. However, the data presented show that during the one two-year cycle for strawberries, most of the materials did a reasonably good job of controlling broadleaf weeds, but that Trietazine was outstanding in this respect. The yields indicated no adverse effects of the herbicides tried.

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WEED CONTROL AROUND THE TRUNKS OF APPLE TREES WITH SIMAZINE AND DALAPON[1]

John S. Bailey[2]

Chemicals for weed control in orchards in New England have a limited use because most of the orchards are in sod culture. The principal use, and this is an important one, is to control grass and other weeds around the trunks to assist in the prevention of girdling by mice. Numerous materials and combinations of materials have been tried.(1,2,3,4,5,6,7). In most cases the trials have not been continued over a long enough period to be sure of the effects of continued use on various varieties or on the tolerance of various rootstock. The present investigation was undertaken principally to determine the effects of Simazine alone and in combination on weed control and tree response.

Materials and Methods

Experiment I.

This experiment was started in the spring of 1959. The apple orchard used was planted in 1951. Two varieties on three stocks were used: Richared and Early McIntosh on East Malling II, Malus torringoides, and Malus sikkimensis. The plots consisted of two trees with two replicates, one on each variety.

The pear orchard used was the remnant of an orchard planted in 1921 to miscellaneous varieties introduced by the USDA. There were two trees per treatment with no replicates.

The treatments were as follows: 1) Dalapon at 10 pounds per 100 gallons of water, 2) Simazine at 8 pounds a.i. per 100 gallons, 3) Dalapon 10 pounds plus Simazine 8 pounds a.i. per 100 gallons, and 4) Dalapon 10 pounds plus Simazine 8 pounds a.i. plus diuron 2 pounds a.i. per 100 gallons. Applications were made on May 20 to a circular area 5 to 6 feet in diameter around the trunk of each tree. The spraying was done with a 3-gallon compressed air sprayer. Each area received 1/3 to 1/2 gallon of spray, a much larger dose than was planned. This would be in excess of 500 gallons per acre.

Simazine gave excellent grass and weed control. The addition of other materials resulted in no improvement. Dalapon gave good control of grass until late September but no control of broadleaf weeds. There were no signs of injury to either apple or pear trees.

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Experiment II.

In 1960 a second experiment was started to compare several rates of Simazine and the usually recommended rate of Dalapon. The plots were laid out in an orchard planted in 1958. This orchard contained five trees each of 21 new varieties all on East Malling VII rootstocks.

The treatments consisted of Dalapon at 10 pounds per 100 gallons of water and Simazine at 10, 15, 20, 25 and 30 pounds a.i. per 100 gallons. Applications were made on June 16, 1960 with a 3-gallon compressed air sprayer to an area 4 to 5 feet in diameter around each tree. About 2 quarts of spray were used for 7 trees. The Dalapon plots were given a second application on August 18, 1960.

The experimental layout consisted of 6 treatments replicated 7 times. Single tree plots were used. Treatments were spaced so that there was at least one untreated tree between treated trees. Therefore, in each block there were 6 treated trees and 8 to 10 guard trees.

On September 7, 1960 estimates were made of the effectiveness of the treatments by rating the plots from 0 to 10, 0 representing no control and 10 representing perfect control (no weeds or grass present). The average ratings for the treatments are given in the table.

Rating of Weed Control following Applications of Dalapon and Simazine

Treatment	Rate lb/100 gals.	Approx. rate/a	Rating September 7, 1960	Rating May 11, 1961
Dalapon	10	8-10	9.3	5.6
Simazine (a.i.)	10	8-10	9.1	6.6
" "	15	12-15	9.8	9.4
" "	20	16-20	9.4	9.7
" "	25	20-25	10.0	9.9
" "	30	24-30	9.9	9.8

On September 7, 1960 both materials and all rates appeared to be very effective. However, quack grass, <u>Agropyron repens</u> had started regrowth on the Dalapon plots which had been resprayed 5 weeks before the estimates were made.

In the spring of 1961 it was observed that most of the plots were still quite free of weeds. Therefore, the plots were again rated for weed control on May 11, 1961 (See table). At the time of this rating the following observations were made: 1) Some grass and many broadleaf weeds were coming into the Dalapon plots. 2) Most of the weeds coming back into the Simazine plots were quack grass, <u>Agropyron repens</u>. 3) Grass coming into the Simazine plots looked stunted and yellow. 4) Simazine was not effective against cinquefoil, <u>Potentilla sp</u>. 5) The effectiveness of Simazine for weed control was still evident 11 months after application, especially at rates of 15 to 30 pounds per 100 gallons of water.

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CONTROL OF ANNUAL WEEDS IN CARROTS WITH SOLAN, ZYTRON, AMIBEN, DIPHENAMID, AND PROMETRYNE

M.F. Trevett and Robert Littlefield[1]

Introduction

This paper is a report on the effectiveness of the herbicides listed in Table 1 on the control of annual broadleaf weeds and annual grasses in carrots.

Procedure

Long Chantenay carrots were planted in a loam soil 12 June, 1961, and were eventually thinned to two inches. Treatments were replicated seven times in a randomized block of single-row plots paired with untreated plots. Sprays were applied with one pass of a small plot sprayer at 40 pounds pressure and 50 gallons per acre volume. Herbicides were applied to different series of plots at planting (12 June), at the cotyledonary stage (26 June), and at the true leaf stage (3 July).

The principal broadleaf weeds were: Wild Rutabaga (Brassica rapa L.), Lambsquarters (Chenopodium album L.), and Spurry (Spergula arvensis L.). The annual grasses present were: Foxtail (Setaria viridis L.), and Barnyard grass (Echinochola crusgalli L.). Weed counts and ratings were made ten weeks after treatment.

Results

Hand weeded plots, and plots receiving 4 pounds of Solan per acre either at the cotyledonary stage or at the true leaf stage of carrots, and 2 or 4 pounds of Prometryne applied at planting, produced significantly higher yields of cut-off carrots than all other treatments except 4 and 6 pounds of Amiben applied at planting, Table 2. Highest numerical yields were produced in hand weeded plots, and in plots receiving 4 pounds of Solan at the cotyledonary stage.

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Treatments giving unsatisfactory yields included: planting application of 6 pounds of Solan per acre, 10 pounds of Zytron, 4 pounds of Diphenamid, and 4 pounds of Diphenamid plus 4 pounds of Amiben, Table 2.

Low yields were associated either with inadequate weed control or with herbicide induced crop injury. Low yields following application of 6 pounds of Solan at planting presumably resulted from inadequate annual broadleaf weed and annual grass control, Tables 3 and 4, and from a stand of carrots numerically but not significantly lower than in higher yielding treatments. Six pounds of Solan at planting may inhibit growth of carrots, since weight of cut-off carrots averaged 0.143 pounds compared to 0.200 pounds or more per carrot in the higher yielding treatments, Table 6. Four pounds of Solan applied either at the cotyledonary or at the first true leaf stage did not significantly reduce average weight per cut-off carrot below the average of any other treatment. To satisfactorily control annual weeds, four pounds of Solan per acre must be applied at the cotyledonary stage of carrots when weeds are relatively small, Tables 3 and 4. Higher percent weed control was obtained at the cotyledonary stage when weeds had barely emerged or when they were in the one or two true leaf stage than at the true leaf stage (T1), when spurry was 2 to 2.5 inches tall, Lambsquarters had 4 to 5 true leaves, Brassica species were 4 inches tall, and annual grass one-half to three-quarters of an inch tall.

Zytron did not satisfactorily control annual broadleaf weeds, Table 3. Zytron did not reduce a carrot stand, but reduced average weight of cut-off carrot, Table 6. This reduction in weight may have been due to weed competition and not to Zytron induced injury.

The low yields in Amiben plots resulted from poor control of Brassica species present; other broadleaf weeds and annual grasses were satisfactorily controlled, Tables 3 and 4.

Diphenamid at 4 pounds per acre gave unsatisfactory annual broadleaf weed control, Table 3, but gave excellent annual grass control, Table 4. Diphenamid apparently reduced both stand of carrots, Table 5, and average weight of cut-off carrot, Table 6. As in the case of Zytron, however, the design of the experiment does not permit isolation of herbicide inhibition from the effect of broadleaf weed competition in reducing average weight of cut-off carrot.

Prometryne at 2 and 4 pounds per acre, gave excellent control of both annual grasses, Table 4, and annual broadleaf weeds, Table 3. Four pounds of Prometryne significantly reduced stand of carrots compared to hand weeding, 4 pounds of Amiben, and 4 pounds Solan. The effect of Prometryne on carrot stand needs further study.

Summary and Conclusions

In 1961, as in previous years, Solan applied in carrots at either the cotyledonary or at the first true leaf stage, satisfactorily controlled annual weeds and annual grasses without reduction in yield compared to hand weeded plots. Satisfactory control depends upon applying Solan when weeds are small, preferably before more than one or two true leaves have developed.

Planting application of either 2 or 4 pounds of Prometryne or 6 pounds of Amiben produced yields not significantly different from 4 pounds of Solan.

Table 1. Herbicides Used in Carrots.

Designation	Active Ingredient
Amiben	3-amino,2,5-dichlorobenzoic acid
Diphenamid	N,N-dimethyl-diphenylacetamide
Prometryne	2-methylmercapto-4,6-bis (isopropylamino)-s-triazine
Solan	N-(3-chloro-4-methylphenyl)-2-methylpentanamide
Zytron	0-(2,4-dichlorophenyl)-0-methyl isopropylphosphoroamidothioate

Table 2. Yield of Carrots Following Application of Various Herbicides.

Acre rate of herbicide (active ingredient)		Pounds of cut off carrots per 25' of row	Rank (1 = highest, 11 = lowest)			
			Annual grass control	Broadleaf weed control	Number of carrots per 25' of row	Weight cut of carrot
Hand weeded		24.8a[2]	2	1	4	1
4# Solan	Coty[1]	24.1a	8	4	3	4
4# Solan	Tl	20.6ab	10	5	5	6
4# Prometryne	Pl	20.3ab	1	2	9	2
2# Prometryne	Pl	20.3ab	3	3	7	3
6# Amiben	Pl	19.4abc	6	6	6	5
4# Amiben	Pl	16.9 bcd	5	10	2	7
6# Solan	Pl	13.4 cd	11	8	8	9
10# Zytron	Pl	11.3 de	9	9	1	10
4# Amiben + 4# Diphenamid 80W	Pl	6.0 ef	4	7	11	8
4# Diphenamid 80W	Pl	5.4 f	7	11	10	11
L.S.D. 5%		5.3				

[1] Coty = applied at cotyledonary stage of carrots, 26 June, 1961.
Tl = applied at true leaf stage of carrots, 3 July, 1961.
Pl = applied at planting, 12 June, 1961.

[2] Means having the same letter designations do not differ significantly at the 5% level (Duncan's Multiple Range Test).

Table 3. Percent Broadleaf Weed Control in Carrots Following Application of Various Herbicides.

Acre rate of active ingredient		Percent broadleaf weed control
Handweeded		100.0
4# Prometryne	Pl[1]	100.0
2# Prometryne	Pl	96.4
4# Solan	Coty	95.0
4# Solan	Tl	86.1
6# Amiben	Pl	77.4
4# Amiben + 4# Diphenamid 80W	Pl	72.6
6# Solan	Pl	70.6
10# Zytron	Pl	64.9
4# Amiben	Pl	62.1
4# Diphenamid 80W	Pl	52.9
L.S.D. 5%		17.9

[1] See Footnote #1, table 4.

Table 4. Percent Annual Grass Control in Carrots Following Application of Various Herbicides.

Acre rate of herbicide (active ingredient)		Percent control of annual grass
4# Prometryne	Pl[1]	99.2a[2]
Hand weeded		98.4a
2# Prometryne	Pl	96.9a
4# Amiben + 4# Diphenamid 80W	Pl	96.1a
4# Amiben	Pl	95.0a
6# Amiben	Pl	94.6a
4# Diphenamid	Pl	94.2a
4# Solan	Coty	85.6a
10# Zytron	Pl	84.4a
4# Solan	Tl	64.6 b
6# Solan	Pl	57.6 b
L.S.D. 5%		14.9

[1] Coty = applied at cotyledonary stage of carrots, 26 June, 1961.
Tl = applied at true leaf stage of carrots, 3 July, 1961.
Pl = applied at planting 12 June, 1961.

[2] Means having the same letter designations do not differ significantly at the 5% level (Duncan's Multiple Range Test).

Table 5. Number of Carrots Per 25 Feet of Row.

Acre rate of active ingredient		Number carrots per 25 feet of row
10# Zytron	Pl[1]	113.4a[2]
4# Amiben	Pl	112.6a
4# Solan	Coty	111.7a
Handweeded		104.7ab
4# Solan	Tl	101.1ab
6# Amiben	Pl	96.4ab
2# Prometryne	Pl	93.4ab
6# Solan	Pl	90.7ab
4# Prometryne	Pl	85.1 b
4# Diphenamid 80W	Pl	40.3 c
4# Amiben + 4# Diphenamid 80W	Pl	39.4 c
L.S.D. 5%		21.1

[1] See Footnote #1, table 6.

[2] See Footnote #2, table 6.

Table 6. Weight Per Cut-Off Carrot Following Application of of Various Herbicides.

Acre rate of active ingredient		Average weight per cut-off carrot (lbs.)
Handweeded		.239a[2]
4# Prometryne	Pl[1]	.239a
2# Prometryne	Pl	.223a
4# Solan	Coty	.214a
6# Amiben	Pl	.207a
4# Solan	Tl	.204a
4# Amiben	Pl	.149 b
4# Amiben + 4# Diphenamid 80W	Pl	.147 b
6# Solan	Pl	.143 bc
10# Zytron	Pl	.100 c
4# Diphenamid 80W	Pl	.094 c
L.S.D. 5%		.044

[1] Coty = applied at cotyledonary stage of carrot, 26 June, 1961.
Tl = applied at true leaf stage of carrots, 3 July, 1961.
Pl = applied at planting, 12 June, 1961.

[2] Means having the same letter designations do not differ significantly at the 5% level (Duncan's Multiple Range Test).

CONTROL OF ANNUAL WEEDS IN SWEET CORN WITH ATRAZINE, DICHLOROPHENYL-METHOXY-METHYLUREA, DINITRO-SEC-BUTYLPHENYL ACETATE, DIPHENAMID, AND SEVERAL PYRIMIDINES

M.F. Trevett and Robert Littlefield[1]

Introduction

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

Procedure

Seneca Golden sweet corn was planted in a sandy loam soil 5 June, 1961. Treatments were replicated seven times in a randomized block of single row plots paired with untreated plots. Sprays were applied with one pass of a small plot sprayer at 40 pounds pressure and 50 gallons per acre volume. Planting applications of herbicides were made 6 June, 1961, preemergence applications were made 13 June, 1961.

The principal broadleaf weeds were: Wild rutabaga (*Brassica rapa* L.), Spurry (*Spergula arvensis* L.), Ragweed (*Ambrosia artemisiifolia* L.), and Smartweed (*Polygonum pensylvanicum* L.). The principal annual grass was Barnyard grass (*Echinochloa crusgalli* L.).

Results

Treatments that did not differ significantly in effect on yield at the 5 percent level from the standard treatment of 2 pounds of atrazine per acre were: 6 and 8 pounds of Niagara 5778 applied preemergence, planting application of 10 pounds of either R-3408 or R-3400, or 3 pounds of Casoron, and hand weeding, Table 2.

Treatments producing lower yields than the six best treatments did so because of either inadequate broadleaf weed control or a reduction in stand of corn, Table 2.

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Annual grass, averaging 2.8 plants per square foot in untreated plots, did not seriously compete with corn for moisture and nutrients. Broadleaf weeds, on the other hand, principally Brassica rapa L., averaging 20.5 plants per square foot in untreated plots, sharply reduced yields when candidate herbicides gave less than 80 percent control. Six pounds of Niagara 5778 per acre did not differ significantly from 8 pounds in broadleaf weed control, Table 3. Ten pounds of either R-3408 or R-3400 gave significantly better broadleaf weed control than 5 pounds of either herbicide. Ten pounds per acre of R-3441 did not differ significantly from 10 pounds of R-3408, Table 3. Two pounds per acre of diphenamid gave unsatisfactory control of Brassica species, but gave fair control of ragweed.

Herbicides giving significantly highest annual grass control included Dupont 326 at 3 and 6 pound acre rates, 3 pounds of Dupont 326 per acre plus 2 pounds of diphenamid, 2 pounds of atrazine, and 8 pounds of Niagara 5778. Eight pounds of Niagara 5778 per acre did not differ significantly from 2 pounds of diphenamid, Table 4. R-3400 and R-3408 did not differ significantly in annual grass control, Table 4.

Plots that had received a 6 pound per acre rate of Dupont 326 had significantly fewer corn plants per 25 feet of row than plots receiving any other treatment, Table 5. Plots that had received a 3 pound per acre rate of Dupont 326 either alone or in combination with 2 pounds of diphenamid had significantly fewer corn plants per 25 feet of row than all remaining treatments except 2 pounds per acre of diphenamid alone. Hence, in spite of the near maximum annual weed control obtained, 3 pounds per acre of Dupont 326 is too high a rate for preemergence application in sweet corn on sandy loam soils.

Summary and Conclusions

For nine weeks after application, 2 pounds per acre of atrazine (wettable powder), 3 and 6 pounds of Dupont 326, and 6 and 8 pounds of Niagara 5778 gave complete control of annual broadleaf weeds in sweet corn. Two pounds per acre of atrazine, 6 pounds of Dupont 326, 3 pounds of Dupont 326 with or without 2 pounds of diphenamid, and 8 pounds of Niagara 5778 gave complete control of annual grasses for nine weeks after application.

Compared to all other herbicides tested, 6 pounds per acre of Dupont 326 significantly reduced stand of corn. Three pounds per acre of Dupont 326, 2 pounds of diphenamid, and a mixture of 3 pounds of Dupont 326 and 2 pounds of diphenamid significantly reduced corn stand compared to 2 pounds of atrazine, 6 and 8 pounds of Niagara 5778, and 5 and 10 pounds of either R-3400 or R-3411. Corn stand in plots receiving either 1 pound of Banvel T or 3 pounds of Casoron per acre was statistically exceeded only in plots receiving 2 pounds of atrazine.

Two pounds of atrazine per acre and 6 pounds of Niagara 5778 produced significantly higher yields than all other herbicides tested except 8 pounds of Niagara 5778, 10 pounds of either R-3408 or R-3400, and 3 pounds of Casoron.

Table 1. Herbicides Used in Sweet Corn.

Designation	Active Ingredient
Atrazine	2-chloro-4-ethylamino-6-isopropylamino-s-triazine
Banvel T	2-methoxy-3,5,6-trichlorobenzoic acid
Casoron	2,6-dichlorobenzonitrile
Diphenamid	N,N-dimethyl-diphenylacetamide
Dupont 326	3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea
Niagara 5778	4,6-dinitro-2-sec-butylphenyl acetate
R-3400	2-benzylmercapto-4,6-dimethylpyrimidine
R-3408	2-(4-chlorobenzylmercapto)-4,6-dimethylpyrimidine
R-3441	2-(3,4-dichlorobenzylmercapto)-4,6-dimethylpyrimidine

Table 2. Sweet Corn Yield Following the Application of Various Herbicides.

Acre rate of active ingredient		Tons snapped ears per acre	Rank (1 = highest, 16 = lowest)[3]				
			Annual grass control	Broad-leaf weed control	Number of plants 25' of row	Number of snapped ears per 25' of row	Weight per snappe ear
2# Atrazine (wettable powder,WP)	Pl[1]	5.61a[2]	3	1	1	3	1
6# Niagara 5778	Pre	5.56a	8	6	2	1	5
8# Niagara 5778	Pre	5.19ab	5	1	3	2	6
10# R-3408	Pl	4.71abc	14	9	9	6	7
10# R-3400	Pl	4.50abcd	9	7	5	5	8
3# Casoron	Pl	4.23abcde	7	8	11	7	4
1# Banvel T	Pl	3.73 bcde	11	14	10	4	14
5# R-3408	Pl	3.29 cdef	13	13	8	11	2
10# R-3441	Pl	3.16 cdef	12	10	4	9	11
3# Dupont 326 + 2# Diphenamid 80W	Pre	3.11 cdef	1	1	13	13	3
5# R-3400	Pl	2.94 def	15	11	6	10	12
5# R-3441	Pl	2.83 ef	10	12	7	8	13
3# Dupont 326	Pre	2.69 f	2	1	14	14	10
2# Diphenamid 80W	Pl	1.83 f	6	15	12	12	15
6# Dupont 326	Pre	0.29 g	4	1	15	16	9
L.S.D. 5%		1.37					

[1] Pl = applied at planting; Pre = applied preemergence.

[2] Means having the same letter designations do not differ significantly at the 5% level (Duncan's Multiple Range Test).

[3] Treatments with a 1 rating gave essentially 100% control.

Table 3. Percent Control of Annual Broadleaf Weeds in Sweet Corn Following Application of Various Herbicides.

Acre rate of active ingredient		Means converted to angles	Means reconverted to percent
2# Atrazine	Pl[1]	90.00	100.0a[2]
3# Dupont 326	Pre	90.00	100.0a
6# Dupont 326	Pre	90.00	100.0a
8# Niagara 5778	Pre	90.00	100.0a
3# Dupont 326 + 2# Diphenamid 80W	Pre	90.00	100.0a
6# Niagara 5778	Pre	88.15	99.9ab
10# R-3400	Pl	75.05	93.3 bc
3# Casoron	Pl	66.83	84.5 cd
10# R-3408	Pl	65.19	82.4 cd
10# R-3441	Pl	57.68	71.4 de
5# R-3400	Pl	46.39	52.4 ef
5# R-3441	Pl	46.37	52.4 ef
5# R-3408	Pl	37.58	37.2 f
1# Banvel T	Pl	36.10	34.7 f
2# Diphenamid 80W	Pl	19.40	11.0 g
L.S.D. 5%		11.83	

[1] Pl = applied at planting; Pre = applied preemergence.

[2] Means having the same letter designations do not differ significantly at the 5% level (Duncan's Multiple Range Test).

Table 4. Percent Control of Annual Grass in Sweet Corn Following the Application of Various Herbicides.

Acre rate of active ingredient		Means converted to angles	Means reconverted to percent
3# Dupont 326 + 2# Diphenamid 80W	Pre[1/]	87.61	99.8a[2/]
3# Dupont 326	Pre	79.45	96.7a
2# Atrazine (Wettable powder)	Pl	79.18	96.5a
6# Dupont 326	Pre	77.25	95.1a
8# Niagara 5778	Pre	75.96	94.1ab
2# Diphenamid 80W	Pl	55.08	67.2 bc
3# Casoron	Pl	45.16	50.3 c
6# Niagara 5778	Pre	34.71	32.4 cd
10# R-3400	Pl	23.02	15.4 de
5# R-3441	Pl	18.34	9.9 de
1# Banvel T	Pl	17.40	8.9 de
10# R-3441	Pl	15.55	7.2 de
5# R-3408	Pl	14.96	6.7 de
10# R-3408	Pl	12.95	5.0 e
5# R-3400	Pl	5.38	0.9 e
L.S.D. 5%		18.38	

[1/] Pl = applied at planting; Pre = applied preemergence.

[2/] Means having the same letter designations do not differ significantly at the 5% level (Duncan's Multiple Range Test).

Table 5. Number of Corn Plants Per 25 Feet of Row.

Acre rate of active ingredient		Means converted: $\sqrt{x + .05}$	Means reconverted to numbers
2# Atrazine	Pl[1]	6.70	49.4a[2]
6# Niagara 5778	Pre	6.55	42.4ab
8# Niagara 5778	Pre	6.48	41.5ab
10# R-3441	Pl	6.35	39.8ab
10# R-3400	Pl	6.18	37.7ab
5# R-3400	Pl	6.18	37.7ab
5# R-3441	Pl	6.13	37.1ab
5# R-3408	Pl	5.97	35.1abc
10# R-3408	Pl	5.95	34.9abc
1# Banvel T	Pl	5.93	34.7abc
3# Casoron	Pl	5.81	33.3 bc
2# Diphenamid 80W	Pl	5.35	28.1 cd
3# Dupont 326 + 2# Diphenamid 80W	Pl	4.87	23.2 de
3# Dupont 326	Pl	4.72	21.8 de
6# Dupont 326	Pl	1.85	2.9 f
L.S.D. 5%		.638	

1/ Pl = applied at planting; Pre = applied preemergence.

2/ Means having the same letter designations do not differ significantly at the 5% level (Duncan's Multiple Range Test).

EVALUATION OF FIVE HERBICIDES FOR KILLING ESTABLISHED POISON IVY IN AN APPLE ORCHARD FOUR YEARS FOLLOWING A SINGLE TREATMENT.

Oscar E. Schubert[1]

This study is being continued to determine the number of years a single herbicide application will give a significant reduction in poison ivy when compared with unsprayed checks. Additional details of the experiment and yearly results have been reported in the Proceedings of the Northeast Weed Control Conference (1,2,3).

Seventy-two plots (1/100th-acre in area) were classified according to the relative density of poison ivy, and then grouped into twelve replications, each with similar poison ivy stands. Six replications composed of six plots each were laid out around trees, and another six replications were laid out in spaces between tree plots in the tree row. The herbicides were applied at random within each replication.

Between August 13 and 17, 1957, ATA, 2,4,5-T Ester, Silvex, 2,4,5-T Amine, and Ammate were applied to well established poison ivy in a mature apple orchard. All herbicides, except Ammate, were applied at the rate of 4 pounds active ingredient per acre. Ammate was applied at the rate of 150 pounds of formulated Ammate per acre. The herbicides were applied with a power sprayer at the rate of 200 gallons of spray per acre. An operating pressure of 75-80 pounds was applied to the three nozzle boom which delivered the spray in a flat fan pattern.

All sprayed plots were free of poison ivy when observations were made in October, 1957. In the fall of 1958, 1959, 1960, and 1961, the density of poison ivy was recorded for each of the 72 plots as the number of leafy stems that were visible. Stem counts of 20 to 50 would generally be considered light. The apparent decrease in average stem counts in 1960 compared with 1959 may have arisen from less frequent mowing of the orchard cover, hence a smaller number of branched stems. Differences in weather may also have influenced the stem counts. Since stem counts or stand are not normally distributed it is necessary to transform the stem counts by adding one to each count and then taking the square root when making statistical analyses.

In Table 1, the average number of poison ivy stems is given one, two, three, and four years following the application of herbicides.

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[1] Horticulturist, West Virginia University. The author is indebted to Dr. R. S. Dunbar, Statistician, for the analyses of the data. He is also grateful to the Dow Chemical Company for 2,4,5-T herbicides and to the American Cyanamid Company for the ATA used in this study.

Table 1. Average number of poison ivy stems in six 1/100th-acre replicated plots one, two, three, and four years following a single herbicide application (August, 1957) to established poison ivy in an apple orchard.

	Average number of poison ivy stems per plot					
Year	ATA 4 lb/A[a]	2,4,5-T Ester 4 lb/A	Silvex 4 lb/A	Ammate 150 lb/A	2,4,5-T Amine 4 lb/A	Check
			Treatments around trees			
1961	30.1*	63.8*	70.3*	106.2*	124.0*	454.2
1960	22.5*	33.8*	52.3*	54.8*	69.0*	187.8
1959	26.0*	42.2*	76.3*	90.5*	111.5*	477.0
1958	0.3*	12.5*	12.0*	5.8*	12.5*	136.7
			Treatments between trees			
1961	55.2*	34.0*	67.8*	74.5	50.5*	273.2
1960	15.3*	21.2	17.0*	31.7	30.2	112.5
1959	27.5*	35.0*	46.2*	44.2*	48.2*	233.0
1958	0.3*	2.8*	11.2*	2.2*	6.3*	55.0

[a] All herbicide rates were applied in 200 gallons of water per treated acre. Rates of all herbicides, except Ammate, are expressed as pounds per acre of active ingredient. Ammate is given as the number of pounds of formulated herbicide per acre.

*Denotes significance from check at the 5% level.

In each of the four years following the single application, ATA, 2,4,5-T Ester, Silvex, 2,4,5-T Amine, and Ammate have given a significant reduction in number of poison ivy stems in plots around trees when compared with the check. The foregoing treatments have also given a significant reduction in poison ivy stems in plots between trees during 1958 and 1959, one and two years after treatment. In 1960 and 1961, there are indications that poison ivy is becoming reëstablished in some of the herbicide treatments.

LITERATURE CITED

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[2] __________. 1960. Evaluation of five herbicides for killing established poison ivy in an apple orchard one and two years following a single treatment. Proc. 14th Annual Meeting NEWCC: 219-220.

[3] __________. 1961. Evaluation of five herbicides for killing established poison ivy in an apple orchard three years following a single treatment. Proc. 15th Annual Meeting NEWCC: 183-184.

STRAWBERRY HERBICIDE INVESTIGATIONS FOR 1961.

Oscar E. Schubert[1]

The 1960 strawberry herbicide investigations for a combination of herbicides to control weeds with a minimum of hand-weeding were continued in 1961.

Experiment 1

Catskill strawberry plants were set in early April, 1960, and weeded by hand-hoeing and a rotary cultivator until June 19. On June 20-21, and on July 21, seven herbicides, or combinations thereof, were applied at random to four replicated plots (9 feet wide and 12 feet long). Information about average weed weights, kind of weeds controlled, and number of runner plants formed during the first season's growth were reported (1).

It was not entirely feasible to fulfill one of the original purposes of the experiment--to determine if herbicides alone could be used for adequate weed control without any additional hand-weeding--since the weeds had to be removed for weighing. In Treatments 2 and 6, the quantity of weeds removed last year was small (0.43 and 1.45 pounds per plot compared with 112 pounds in the non-hoed check plot) so these treatments may approach the goal.

On September 28-29, 1960, about three weeks after weeds were removed and weighed, the plots were divided into three subplots (4 feet wide and 9 feet long). Two subplots in each plot were treated at random with additional herbicides on September 28-29 and/or November 4, 1960. The entire series of treatments are presented in Table 1.

The planting was mulched with wheat straw in early December. The strawberry plants came through the light covering of mulch the following spring; therefore, it was not necessary to remove the mulch.

On June 14, 1961, careful observations were made in all the plots regarding plant vigor, stand, berry size and set, and possible herbicide injury. The vigor of each subplot was estimated as a percentage of the most vigorous hoed-check plants (rated as 100). The average per cent vigor of the two subplots which were treated in September and/or November is given for each treatment in Table 2. The analysis of variance and all comparisons among means were computed on the percentage data after the percentages were transformed to angles (angle = arcsin $\sqrt{\text{percentage}}$).

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[1] Horticulturist, West Virginia University. The cooperation of the following companies in supplying the herbicides used in these investigations is gratefully acknowledged: Amchem Products, Inc., Diamond Alkali Company, Geigy Chemical Corporation, Niagara Chemical Division of Food Machinery and Chemical Corporation, and Stauffer Chemical Company. The author also wishes to acknowledge a grant in aid from the Geigy Chemical Corporation which partially supported this work.

Table 1. Herbicide treatments applied to Catskill strawberry plants.

Treatment number	Herbicides applied June 20-21, 1960		Herbicides applied as a spray on July 21, 1960		Herbicides applied September 28-29, 1960[c]		Herbicides applied as spray November 4, 1960	
	Herbicide and Formulation[a]	Rate[b] lb/A a.i.	Herbicide and Formulation	Rate lb/A a.i.	Herbicide and Formulation	Rate lb/A a.i.	Herbicide and Formulation	Rate lb/A a.i.
1	None (non-hoed check)		None		None		Simazine-80W + Karsil-2EC	1.5 +4.0
2	Eptam-5G[d]	6.0	Simazine-80W + Karsil-2EC	1.5 +4.0	Eptam-5G	6.0	Simazine-80W + Karsil-2EC	1.5 +4.0
3	Casoron-4G	4.0	None		Casoron-4G	2.0	None	
4	Simazine-80W[e] + Karsil-2EC	1.5 +4.0	Karsil-2EC	4.0	None		Simazine-80W + Karsil-2EC	1.5 +4.0
5	Karsil-2EC	4.0	Simazine-80W + Karsil-2EC	1.5 +4.0	None		Karsil-2EC	4.0
6	Simazine-80W	1.5	Karsil-2EC	4.0	Simazine-80W	2.0	Karsil-2EC	4.0
7	Dinoben-10G	4.0	Simazine-80W + Karsil-2EC	1.5 4.0	Dinoben-10G	4.0	Simazine-80W + Karsil-2EC	1.5 +4.0
8	None (Hoed check--hoed as needed for weed control to August 30, 1960)				None		Simazine-80W + Karsil-2EC	1.5 +4.0
9	Simazine-80W + Dacthal-1.5G	1.5 8.0	None		Simazine-80W + Dacthal-1.5G	2.0 16.0	None	

[a] G = granular, EC = emulsifiable concentrate, W = wettable powder.

[b] Rate expressed as active ingredient in pounds per acre.

[c] Herbicide applications on September 28-29, 1960, and/or November 4, 1960, were made at random to two of the three subplots of the plot originally treated as a unit. One subplot remained untreated so as to serve as a check.

[d] Granular herbicides were broadcast on surface as evenly as possible with a salt shaker. Eptam 5G was raked into soil to a depth of about 1.5 inches.

[e] All Karsil and Simazine applications (either alone or in combination) were applied as a spray.

Table 2. Effect of herbicide treatments on plant vigor and weed control.

Treatment	Vigor[a] June 14, 1961	Weed Control[b] October 24, 1961	Total pounds of herbicide applied		
			Simazine	Karsil	Other
	(Mean %)[c]	(Mean %)[c]			
1	16 de	20 c	1.5	4.0	
2	45 bcd	70 ab	3.0	8.0	12.0-Eptam
3	6 e	15 c	---	---	6.0-Casoron
4	35 cd	42 bc	3.0	12.0	
5	78 ab	71 ab	1.5	12.0	
6	81 a	74 ab	3.5	8.0	
7	60 abc	76 ab	3.0	8.0	8.0-Dinoben
8	71 ab	76 ab	1.5	4.0	
9	51 abc	88 a	3.5	---	24.0-Dacthal

[a] Expressed as percentage of the most vigorous hoed-check plots (rated as 100%).

[b] A weed-free plot would be given a 100% rating and a complete weed cover a 0% rating.

[c] Average of four replications. Means in a column with the same letter do not differ significantly at the 5% level of probability. The percentages were transformed to angles (angle = $\arcsin\sqrt{\text{percentage}}$) before making statistical analysis since the variable consists of the proportion of individual plots affected where the distribution tends to be binomial in force.

The vigor of plants in Treatment 8 (the former "hoed check" which received only one application of Simazine and Karsil) did not differ significantly from plants in Treatments 5, 6, 7 or 9 which received greater quantities of herbicides. Only plants in Treatment 3 (Casoron alone) and Treatment 1 (the former non-hoed check) were significantly poorer in vigor than most of the treated plants.

Plants in Treatment 4 (in which a total of 12 pounds of Karsil plus 3 pounds of Simazine were applied) were lower in vigor than Treatments 5, 6, and 8. Many of the plants in Treatment 4 had both chlorotic and necrotic areas on leaves. The leaves were often "tattered" in appearance since portions of the hecrotic tissues were broken off.

The vigor of plants in the "check" subplot (with reference to September and November treatments) did not differ significantly from each other. The stand in Treatments 3 and 1 was poorer than in all other treatments.

Interveinal and marginal chlorosis, presumably due to higher levels of Simazine, was observed in Treatments 6 and 9 where a 2-pound application was made on September 29, 1960. No chlorosis was detected in Treatments 2, 4, 7 or 8 where only a 1.5-pound application was made on November 4, 1960. All of the above plots, except Treatment 8, were given a 1.5-pound application of Simazine in June or July. "Simazine" injury was more prevalent in Treatment 6 than in Treatment 9. It seems as though either the Karsil following the Simazine application intensified the amount of injury, or the Dacthal applied at the same time decreased the amount of chlorosis. No chlorosis was found in any of the subplots receiving only the June or July application of Simazine.

Plants in subplots receiving the additional 2-pound application of Casoron (Treatment 3) on September 29, had many reddish-purple leaves, whereas those in the "untreated" subplot were normal in color. Most of the plants were killed in the subplots with a total of 6 pounds of Casoron, and very few runner plants survived in the 4-pound subplots.

Berry set and size were similar in all treatments except Treatments 1, 3, and 4. Although it was not possible to obtain yield records in each of the 108 subplots, there is no doubt that yields were decreased in Treatments 1, 3, and 4. In some of the other treatments increased berry size tended to offset any decreases in berry numbers, so large yield differences were not apparent.

The strawberry planting was not weeded at any time in 1961 (the only hand-weeding being done prior to June 19, 1960 or during the August 30 to September 8, 1960 period when all weeds were removed for weighing). On October 24, 1961, the per cent of weed control was estimated for each plot. At this time some plots were still almost completely weed-free. The average per cent of weed control is presented in Table 2. The percentages were transformed to angles, and the statistical analysis made. The comparisons among means showed no differences between Treatments 2, 5, 6, 7, 8, and 9 although the average per cent weed control varied from 70 to 88 per cent. Weed control was significantly poorer in Treatments 3 and 1 than in all other treatments, except Treatment 4. The only major shift in degree of weed control from 1960 to 1961 occurred with Treatment 9. In 1960, Treatment 9 was one of the poor herbicide treatments whereas, in 1961, it rated as well as five other treatments. It is probable that the 8-pound rate of Dacthal (plus 1.5 pounds of Simazine) was not sufficient to control all the weeds, especially grasses, but the 16-pound rate in November (plus 2.0 pounds of Simazine) was effective in controlling weeds.

Experiment 2.

In 1961, five herbicide treatments were applied at random to three varieties of strawberries (Catskill, Pocahontas, and Surecrop) replicated four times. The treatments were:

1. Hoed check.
2. Simazine 80W at 1.5 lb/A a.i. applied as a spray.
3. Trietazine 50W at 3 lb/A a.i. applied as a spray.

4. Tillam 10G at 5 lb/A a.i. raked in 1/2 to 1 inch plus Trietazine 50W at 2.5 lb/A a.i. applied as a spray.
5. Trietazine 50W at 2 lb/A a.i. plus Simazine 1 lb/A a.i. applied as a spray.
6. Dacthal 5G at 15 lb/A a.i. applied on surface plus Trietazine 50W at 2.5 lb/A a.i.

Treatment 4 was the only herbicide treatment that gave good weed control throughout the 1961 season.

From the information presented here and observations in the field it appears encouraging that herbicides or combinations of herbicides will be able to control weeds in strawberries for at least one or two full seasons.

LITERATURE CITED

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WEED CONTROL IN CERTAIN VEGETABLE CROPS - 1961[1]

W. H. Lachman and H. F. Vernell[2]

The purpose of this paper is to report results of tests conducted during 1961 to field-screen certain chemicals as potential weed killers in fields of carrots, tomatoes, sweet corn and asparagus. The soil where these tests were conducted is classed as a fertile Scarborough very fine, sandy loam. The land is well drained, has a high water holding capacity and is infested annually with a vigorous growth and very heavy stand of annual weeds consisting mainly of a mixture of pigweed, galinsoga, crabgrass, shepherd's purse, smartweed, lamb's quarters and purslane. Ample rainfall during the period when the chemicals were being applied seemed to provide conditions that are generally considered ideal for killing weeds by these methods.

Sweet Corn

Earliking sweet corn was planted on June 16 and the chemicals were sprayed on the plots in pre-emergence applications on June 19. Plots treated with chemicals were not cultivated at any time. Weeds in the uncultivated check plots covered the ground completely and were about four feet tall by August 11. In contrast to this, many of the plots that had been treated with chemicals were completely weed free. The effects of the chemicals on weeds and yield of corn are presented in Table I. A rating of 7.0 indicates commercially acceptable weed control. Best among the chemicals for controlling weeds were Atrazine, Simazine and Urea 326. Intermediate results were obtained with Randox T and Premerge; Casoron was poorest among the materials tested. Tests for significance among the mean yields were made using Duncan's Multiple Range Test (1). The cultivated Check was highest yielding among the treatments although not significantly better than certain treatments with Atrazine, Simazine and two rates of Urea 326. The uncultivated Check and Casoron treatment yielded poorest of all lots. It was apparent that 3.0 pounds of Urea 326 gave excellent weed control but depressed yield significantly.

Some exploratory tests using Atrazine in post-emergence applications in both 1960 and 1961 indicate that corn was not injured at rates of two to four pounds (active) of this chemical. Annual broadleafed weed control was excellent both years but crabgrass control was unsatisfactory.

When "Plyac", a spray adjuvant containing a non-ionic surfactant was added to Atrazine, no significant increase in control of crabgrass was noted.

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[1] Contribution No. 1339, Massachusetts Agricultural Experiment Station.

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Asparagus

The results of weed control tests in asparagus are presented in Table II. Crabgrass was perhaps the most persistent weed present in the plots.

Zytron was included in the tests because this chemical is considered to be very specific for controlling crabgrass. Where Zytron was used, weed control was satisfactory for several weeks but long before the end of the cutting season these plots were badly infested with pigweed, lamb's quarters and crabgrass. Atrazine, and more particularly Simazine, was very effective in controlling weeds in these tests. This was also true in the 1960 tests (3). No significant differences were displayed among means of the plots as far as total or marketable yield of asparagus spears was concerned.

Last year we reported that where monuron had been applied yearly for four years an oat bioassay test indicated that none of the chemical persisted in the soil over winter (3). A cucumber bioassay in the spring of 1961 corroborated the earlier findings and also indicated no toxic residues from 2.5 to 5.0 lb. applications of Atrazine and Simazine made one year prior to the test.

Tomatoes

Certain chemicals that have some herbicidal properties have been reported as being selective for tomatoes. Results from testing some of these are presented in Table III.

Tillam was incorporated into the soil with a rototiller just prior to planting; Amiben was applied as granules and Casoron, Solan, Diphenamid and Dacthol were applied as sprays at lay-by. Only one application was made of the chemicals. Although Solan appears to be the most promising of the materials that have been tested, in 1960 when two applications were made, considerable foliage injury resulted to the crop. Broadleafed weeds were controlled well in those tests but crabgrass grew rampant. The one application in 1961 reduced growth of broadleafed weeds without perceptible foliage injury. Weed control was not good, however, and crabgrass was abundant and vigorous. Yields were not affected in the 1961 tests here but in 1960 Moran (4) reported highly significant reductions in yield and fruit size in tests conducted on two different soil types.

Seedling tomato plants three to four inches tall were killed with a Solan spray at the rate of four pounds per acre in 50 gallons of water.

TABLE I. WEED CONTROL AND YIELD IN EARLIKING SWEET CORN

Planted June 16, 1961 - (3 Replications)

Rate	Chemical	Source	Time Applied 6/19/61	Weed Control 1-Poor to 9-Excellent 8/10/61	Yield-Lb. Mktable. Ears 8/29/61 [1]
Check-Cultivated				9.0	46.7
4.0 Lb.	Atrazine	Geigy	Pre-emerg.	9.0	45.6
4.0 "	Simazine	"	" "	9.0	44.3
2.0 "	Atrazine	"	" "	8.0	43.7
3.0 "	Simazine	"	" "	9.0	43.5
1.0 "	Urea 326	DuPont	" "	8.0	43.5
3.0 "	Atrazine	Geigy	" "	9.0	43.0
2.0 "	Urea 326	DuPont	" "	9.0	42.8
2.0 "	Simazine	Geigy	" "	9.0	42.5
4.5 Qts.	Randox T	Monsan.	" "	4.3	40.3
9.0 Lb.	Premerge	Dow.	" "	5.0	37.2
6.0 "	"	"	" "	1.3	34.5
3.0 "	Urea 326	DuPont	" "	9.0	33.0
7.5 "	Casoron	Niag.	" "	2.7	32.8
5.0 "	"	"	" "	1.3	30.7
Check-Not Cultivated				1.0	25.2

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[1] Means included in brackets are not significantly different at the 5% level. (Duncan's) Multiple Range Test.

TABLE II. WEED CONTROL AND YIELD IN ASPARAGUS

(4 Replications)

Rate	Chemical	Source	Time Applied 5/11/61	Weed Control 1-Poor to 9-Excellent 7/7/61	Yield-Lb. 5/11/61-6/1/61
1.6 Lb.	CMU	DuPont	Pre-emerg.	5.3	7.2
2.4 "	"	"	" "	7.3	7.7
3.2 "	"	"	" "	8.0	8.3
2.5 "	Atrazine	Geigy	" "	7.8	7.0
3.75 "	"	"	" "	8.8	7.6
5.0 "	"	"	" "	9.0	7.4
9.0 "	Zytron	Dow	" "	2.3	8.2
15.0 "	"	"	" "	5.8	9.1
2.5 "	Simazine	Geigy	" "	8.8	8.4
3.75 "	"	"	" "	9.0	9.0
5.0 "	"	"	" "	8.8	6.5
Check				1.0	7.8
					N.S.

TABLE III. WEED CONTROL AND YIELD IN TOMATOES

(4 Replications)

Rate	Chemical	Source	Time Applied	Weed Control 1-Poor to 9-Excellent 9/11/61	Yield-Lb.
3.0 Lb.	Casoron	Niag.	Lay by 8/4/61	2.0	21.1
4.0 "	"	"	" "	2.0	27.7
4.0 "	Solan	"	" "	5.8	22.9
4.0 "	Diphenamid	Lilly	" "	3.5	23.3
6.0 "	"	"	" "	4.3	24.5
4.0 "	Dacthol	Dia. Alk.	" "	3.3	25.0
8.0 "	"	" "	" "	2.5	22.6
12.0 "	"	" "	" "	2.5	22.9
4.0 "	Amiben (Gran.)	Amchem	" "	3.5	25.9
6.0 "	" "	"	" "	5.0	21.2
8.0 "	" "	"	" "	5.0	20.8
Check				1.0	18.4
0.66 Gal.	Tillam(incorp.)	Stauffer	6/5/61	2.3	24.4
					N.S.

TABLE IV. WEED CONTROL AND YIELD IN CARROTS
(3 Replications)

Rate	Chemical	Source	Time Applied Pre-emerg. 5/17/61 Post-emerg. 6/12/61	Weed Control 1-Poor to 9-Excellent 6/23/61	Crop Appear. 1-Poor to 9-Excellent 6/23/61	Yield- Lb.1/ 10/20/61
8.0 Lb.	Dacthol	Diam. Alk.	Pre-emerg.	5.7	7.4	111.9
5.0 "	Amiben	Amchem	" "	8.0	4.7	110.7
1.0 "	Ipazine	Geigy	" "	5.7	6.3	110.3
4.0 "	Dacthol	Diam. Alk.	" "	6.3	7.0	104.9
9.0 "	Zytron	Dow	" "	8.0	7.0	104.0
2.0 "	Hercules 843	Herc. Powd.	" "	7.4	6.0	99.2
4.0 "	Solan	Niag.	Post-emerg.	7.7	7.0	96.8
1.0 "	Ipazine	Geigy	" "	4.7	6.7	95.9
100.0 Gal.	Stoddard Solvent	Socony	" "	7.4	6.0	95.9
3.0 Lb.	Amiben	Amchem	Pre-emerg.	6.7	7.4	95.2
12.0 "	Dacthol	Diam. Alk.	" "	7.4	6.3	95.2
1.5 "	Ipazine	Geigy	Post-emerg.	5.0	5.0	93.8
2.0 "	Solan	Niag.	" "	6.7	5.7	91.4
1.0 "	Hercules 843	Herc. Powd.	Pre-emerg.	6.3	6.3	89.4
6.0 "	Zytron	Dow	" "	7.4	7.4	88.4
6.0 "	Solan	Niag.	Post-emerg.	8.3	5.0	86.9
4.0 "	Hercules 843	Herc. Powd.	Pre-emerg.	8.3	5.3	86.4
4.0 "	Amiben	Amchem	" "	7.4	6.7	85.4
1.5 "	Ipazine	Geigy	" "	6.3	4.3	78.5
4.0 Qt.	Randox T	Monsan.	" "	4.0	2.3	36.6
6.0 "	" "	"	" "	5.7	1.0	24.2
5.0 "	" "	"	" "	6.3	1.3	17.6

1/ Means included in brackets are not significantly different at the 5% level. (Duncan's) Multiple Range Test.

Carrots

Seeds of Royal Chantenay were planted using Planet Jr. plate hole number 9 in the drill seeder. The plants were not thinned other than the thinning that resulted as injury from the herbicides. Results of the tests are presented in Table IV. It is evident that Randox T is least adapted as a potential herbicide in carrots. This treatment resulted in poorest weed control, greatest crop damage and lowest yield. Using the same criteria for evaluation, the chemical with most promise was Zytron; this was also true in the 1960 tests (2). Four pounds of Solan also performed well. It is interesting that 100 gallons of Stoddard Solvent caused some crop injury and affected yields adversely in both the 1960 and 1961 tests.

Conclusions

The results published here should not be interpreted as a final assessment of the chemicals involved in the tests since the balance of environmental influences are extremely important in determining the value of all herbicides. Either plus or minus minor to major variations may be expected from trials conducted under other conditions. Therefore, tests conducted over a period of years are necessary to evaluate the potential of each product.

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WEED CONTROL IN TRANSPLANT TOMATOES
(A PROGRESS REPORT)

W. V. Welker, Jr. and T. J. Monaco[1]

Two experiments were conducted on transplanted tomatoes during the 1961 season as a continuation of a project initiated in 1957. The objective of these experiments was to evaluate herbicides for the control of weeds from the last cultivation through the harvest season.

The variety Rutgers was used in an experiment at New Brunswick on a Sassafras sandy loam soil. The plants were set May 31 and the herbicides were applied July 18 as granular formulations. The plots were maintained weed-free by cultivation up to the time of treatment. Half of each plot was cultivated immediately before application of the herbicides. None of the herbicides were worked into the soil. The major weed species that developed after application of the herbicides were crabgrass (*Digitaria sanguinalis* (L.) Scap.) and fall panicum (*Panicum dichotomiflorum* Michx.). The minor weed species were pigweed (*Amaranthus retroflexus* L.) and lambsquarters (*Chenopodium album* L.).

A randomized complete block design with three replications was used. Each plot consisted of two rows 30 feet long with 7 feet between plots. Three pickings were made during the season. Weeds were counted to determine the degree of weed control.

The herbicides used may be placed in three categories as follows:

Excellent Weed Control

amiben	(3-amino-2,5-dichlorobenzoic acid)	4 & 8 lb/A
tillam	(Propyl ethyl-N-butylthiocarbamate)	4 & 8 lb/A
diphenamid	(N,N-dimethyl-α-α-diphenylacetamide)	3 & 6 lb/A

Intermediate Weed Control

dacthal	(dimethyl 2,3,5,6 tetrachloroterephalate)	12 lb/A
CIPC	(isopropyl N-(3-chlorophenyl)carbamate	6 lb/A
CDEC	(2-chloroallyl diethyldithiocarbamate)	8 lb/A

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Unsatisfactory Weed Control

CDEC	(2-chloroalkyl diethyldithiocarbamate)	4 lb/A
plus		plus
CDAA	(2-chloro-N,N-diallyacetamide)	4 lb/A
CDEC	(2-chloroallyl diethyldithiocarbamate)	4 lb/A
plus		plus
CIPC	(isopropyl N-(3-chlorophenyl)carbamate)	4 lb/A
dacthal	(dimethyl 2,3,5,6 tetrachloroterephalate)	6 lb/A
plus		plus
CIPC	(isopropyl N-(3-chlorophenyl)carbamate)	4 lb/A

None of the herbicide treatments listed caused plant injury or reduced yield.

The second experiment was conducted on a lighter sandy soil in southern New Jersey with the variety Campbell 146. The major weed that developed in the experimental area was crabgrass, and minor weeds were lambsquarters and pigweed. The herbicide treatments were applied as granulars at lay-by to freshly cultivated soil. A randomized complete block design with four replications was used. Three pickings were made during the season. Visual ratings of weed control and plant injury were made three times during the season.

The herbicides used may be placed in three categories as follows:

Excellent Weed Control

amiben	(3-amino-2,5-dichlorobenzoic acid)	2 & 4 lb/A
EPTC	(ethyl N,N-di-n-propylthiocarbamate)	3 & 6 lb/A
tillam	(propyl ethyl-N-butylthiocarbamate)	3 & 6 lb/A

Intermediate Weed Control

R-1870	(ethyl di-n-butylthiolcarbamate)	3 & 6 lb/A
R-1856	(t-butyl di-n-propylthiolcarbamate)	3 & 6 lb/A
dacthal	(dimethyl 2,3,5,6 tetrachloroterephalate)	8 lb/A
CIPC	(isopropyl N-(3-chlorophenyl)carbamate	8 lb/A

Unsatisfactory Weed Control

CIPC	(isopropyl N-(3-chlorophenyl)carbamate)	2 & 4 lb/A

None of the herbicides used in the second experiment reduced yield. EPTC at 3 and 6 pounds per acre caused visible injury late in the season.

From these experiments amiben, tillam, and diphenamid appear to

QUACKGRASS CONTROL

S. M. Raleigh[1]

Variation in genetic strains of quackgrass was very evident in 1961. These strains can best be observed by applying treatments across areas where corn has been grown. Cultivation tends to spread strains up and down the row. These strains have been observed especially with Atrazine, but also with Dalapon and Amitrol-T.

Plowing, preparing a seed bed, and planting the same day the land is plowed followed by good cultivation will reduce the stand of quackgrass considerably, especially if a chemical is used which is injurious to quackgrass and not to the corn.

The pre-emergence application of Atrazine at two pounds per acre, (data in Table II) with Amitrol-T, Dalapon or Atrazine reduced the stand of quackgrass very little. In other fields where Atrazine was applied as pre-emergence the day of planting, the quackgrass was reduced considerably. Under these conditions rates of four pounds and higher did not give much better control than the two pound rates.

The control of quackgrass with Dalapon (Table II) is rather poor. In another field of twelve acres where Dalapon was used with and without wetting agents, the control was much better. There were six replications. The results were: Dalapon, 5.92 pounds alone (Dowpon, 8 pounds) 93%, with Dash added, 96%; Dynawet, 97%; Fab, 95%; liquid All, 93%; and Tritton x 100, 92%. Four pounds of Atrazine in this test gave 90% control.

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Table I. Fall and Spring applications of herbicides on quackgrass
Corn Planted--May 25, 1961
University Park, Pennsylvania

Chemical	When applied	Rate lbs./A	Rating			
			Plowed May 25	Plowed May 16	Plowed Dec. 9	Plowed Nov. 10
			(0, No control; 10, Complete control)			
Amitrol-T	Nov. 4	4	8.5	6.8	4.7	2.0
	May 13	4	9.5	5.5	6.0	1.7
Amitrol-T	Nov. 4	2	7.7	6.8	5.7	4.3
	May 13	2	8.8	7.0	5.3	3.7
Atrazine	Nov. 4	4	8.9	8.6	8.3	7.3
	May 13	4	9.3	8.0	7.8	8.0
Atrazine	Nov. 4	2	8.0	6.7	5.0	2.3
	May 13	2	8.3	5.3	5.0	6.0
Ammitrol-T and Atrazine	Nov. 4	2 ≠ 2	9.0	6.3	5.7	2.0
	May 13	2 ≠ 2	9.0	6.3	7.0	3.7
Dalapon	Nov. 4	11.1	7.3	7.7	6.7	3.3
	May 13	5.92	9.0	6.7	5.7	4.0
Geigy 34162	Nov. 5	4	5.3	4.7	3.0	1.0
	May 13	4	7.0	6.5	3.0	1.0
Geigy 32293	Nov. 5	4	9.0	6.5	5.7	1.3
	May 13	4	9.0	6.2	4.3	2.7
Check			4.0	2.0	3.0	.0

Table II. The control of quackgrass with spring applications
Applied May 24 and 25

Chemicals			Rating (0, No control; 10, Complete control)		
Constant rate (lb/A)	Logged rate (lb/A)		Full rate	1/2 rate	1/4 rate
	Amitrol-T	8	9.3	8.3	5.0
Atrazine 2*	Amitrol-T	8	9.3	8.5	5.0
Atrazine 1	Amitrol-T	8	9.5	8.5	7.0
Atrazine 2	Amitrol-T	8	9.6	9.3	7.7
	Atrazine	8	9.5	7.5	2.0
Atrazine 2**	Atrazine	8	9.5	7.8	2.0
Amitrol-T 1	Atrazine	8	9.5	8.3	7.2
Amitrol-T 2	Atrazine	8	9.6	8.8	8.3
Amitrol-T 2 Atrazine 2			9.0		
	Dalapon	11.1	7.5	6.2	3.0
Atrazine 2*	Dalapon	11.1	7.5	6.3	3.5
	Geigy 34162		7.0	4.7	8.0
	Geigy 32293		9.2	8.0	4.7
	Fenac	8	9.6	9.0	5.7
	ACP 823	8	8.3	6.3	2.7
	Dupont 326	8	0	0	0
	Zytron	16	2.3	.3	0
	Upjohn U4513	16	0	0	0
	Hercules 7531**	16	8.0	5.0	0
	Banvel D**	8	8.5	8.0	6.0
	Banvel T**	8	5.0	2.0	.5
	ACP 827**	8	9.5	7.0	2.0

* Pre-emergence application made the day of planting corn.
** 1 plot only

CHEMICAL QUACKGRASS CONTROL[1]

Jonas Vengris[2]

Atrazine (2-chloro-4-ethylamine-6-isopropylamino-s-triazine) and other herbicides are available which appear to provide reliable means of controlling quackgrass (Agropyron repens). Atrazine suppresses this weed significantly but often recommended rates fail to eradicate it completely. The persistence of this weed is related to its primary mode of reproduction, i.e. its rhizomes which usually are distributed in the plow layer. Rhizomes vary in length and depth and this, as our tests indicate (2), is at least part of the explanation for failures in controlling quackgrass with chemicals. Atrazine should be applied as close as possible to the rhizomes. It is reasonable to conclude that mixing the herbicide with the soil should be advantageous. The chemical will be closer to the rhizomes and under dry surface soil conditions mixing may provide better moisture conditions for atrazine to be taken up by rhizomes and kill them.

The main objective of our trials in 1960/1961 was to investigate the importance of mixing atrazine with the soil by rototilling versus leaving the material on the surface. Comparisons were also made between fall and spring applications. In addition to atrazine, other promising herbicides or their combinations were included.

Procedure

Trials were conducted on a well drained gravelly sandy loam. The area had a good uniform stand of quackgrass. Plots were 12 ft. by 28 ft. Three replicates were used. Time of application and rates are given in Table II. Fall applications were made on October 10, 1960 and spring applications on April 27, 1961. The quackgrass was from 5 to 7 inches tall. On May 19 the experimental area was plowed, disked, fertilized and prepared for field corn planting. On May 22 after seedbed preparation, atrazine and EPTC were applied as shown in Table II. Treatments 10, 11, 12 and 20 were rototilled about 4-5 in. deep immediately following application of the material. The next day on May 23, Ohio M-15 silage field corn was planted. Thus treatments applied on May 22 may be considered as being made at planting. Atrazine is only slightly soluble in water (70 ppm in water) and moisture conditions in the soil at the time of application and for the first ten days after application are critical for the effectiveness of treatment. In Table I rainfall and temperature data are shown for the various treatment dates. With each date of application, the moisture conditions were favorable for the action of atrazine. On June 5 the whole experimental area was sprayed with 6 pounds per acre of dinitro (DNBP) for annual weed control. There was

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no cultivation during the growing season. All herbicide rates presented in Table II are expressed in pounds of acid equivalent or active ingredient per acre. Quackgrass and field corn response to different treatments was observed throughout the growing season. Quackgrass stand estimates were made on July 29. Quackgrass control as well as silage corn yield data are presented in Table II.

TABLE I. Rainfall and temperature prior to and after the 1960/61 Treatments

Applications	Total Rainfall inches	Average Mean Temperature °F
Applied on quackgrass foliage 10/10/60		
14 days prior to treatment	0.92	54.5
7 days prior to treatment	0.06	51.9
7 days after treatment	0.04	55.4
14 days after treatment	1.68	50.3
Applied on quackgrass foliage 4/27/61		
14 days prior to treatment	2.66	45.7
7 days prior to treatment	0.81	51.2
7 days after treatment	1.39	44.8
14 days after treatment	2.23	48.2
Applied on prepared seedbed 5/22/61		
14 days prior to treatment	0.67	58.1
7 days prior to treatment	0.09	53.8
7 days after treatment	1.06	55.2
14 days after treatment	1.37	57.4

TABLE II. Quackgrass Control in Field Corn
Relative Values Check= 100

Treatments	Quackgrass Stand 7/29/61	Silage Corn Yields
1. Check	100	100
2. Atrazine 2 lb/A 10/10/10 + 2 lb/A 5/22/61	17	164
3. Atrazine 4 lb/A 10/10/60 + 2 lb/A 5/22/61	4	180
4. Atrazine 4 lb/A 10/10/60	19	167
5. Atrazine 6 lb/A 10/10/60	10	184
6. Atrazine 2 lb/A 4/27/61 + 2 lb/A 5/22/61	11	175
7. Atrazine 4 lb/A 4/27/61 + 2 lb/A 5/22/61	5	170
8. Atrazine 4 lb/A 4/27/61	22	148
9. Atrazine 6 lb/A 4/27/61	21	167
10. Atrazine 2 lb/A 5/22/61 and rototilled in	20	184
11. Atrazine 4 lb/A 5/22/61 and rototilled in	14	169
12. Atrazine 6 lb/A 5/22/61 and rototilled in	6	162
13. Atrazine 2 lb/A 5/22/61	36	150
14. Atrazine 4 lb/A 5/22/61	28	157
15. Atrazine 6 lb/A 5/22/61	23	180
16. Dalapon 8 lb/A 10/10/60 + Atrazine 2 lb/A 5/22/61	16	171
17. Dalapon 8 lb/A 4/27/61 + Atrazine 2 lb/A 5/22/61	9	174
18. Amitrol-T 2 lb/A 4/27/61 + Atrazine 2 lb/A 5/22/61	16	166
19. G-34162 2 lb/A 4/27/61 + Atrazine 2 lb/A 5/22/61 a)	18	165
20. EPTC 6 lb/A 5/22/61 and rototilled in b)		

Results and Discussion

The check plots produced a heavy growth of quackgrass which strongly competed with corn for plant nutrients and especially for water. All treatments increased silage corn yields significantly.

EPTC gave excellent control of quackgrass but corn was significantly injured and yields affected. The combination treatments of dalapon, amitrol-T, and G-34162 with atrazine were also promising in controlling quackgrass in field corn.

In general all treatments effectively controlled quackgrass. It seems that the optimum rate of atrazine to control quackgrass is around 4 lb/A. Although atrazine can be applied successfully in the fall, early spring or planting time applications seem most practical. These should be split applications - 2 lb/A on foliage in April and 2 lb/A 2-3 weeks later on prepared seedbed at corn planting time. Similar results have been obtained elsewhere(1). Results from this experiment also substantiated previous findings (3) that mixing the atrazine immediately after applications with the soil improves quackgrass control. By mixing the chemical with the soil it comes in closer contact with the mass of rhizomes and soil moisture conditions are better to facilitate absorption of atrazine by the roots. In 1961 studies were made on rhizome depth in the soil and the effectiveness of atrazine. Wooden boxes 1'x1'x1' were set in the field at ground level. Three-inch and 9-inch rhizome cuttings were planted horizontally 1-inch and 4-inches deep in the soil. In order to simulate field conditions, rhizomes were planted also at almost vertical angles of 60-70° so that the top ends were one inch from the surface. Immediately after planting, atrazine at 1 lb/A and 3 lb/A was applied as surface treatment. The average relative results of four replicates are presented in Table III. Atrazine at the rate of 1 lb/A as a surface application did not affect rhizomes planted four inches deep. At the 3 lb/A rate atrazine gave complete control of all rhizomes planted one inch deep in horizontal or vertical position but some rhizomes survived which were 4 inches away from the applied atrazine. For the greatest effect of atrazine, it is of first importance to get the material as close as possible to the rhizomes. It is of interest to note that rhizomes placed at a 60-70° angle with the top ends one inch deep were affected in the same way as those planted one inch deep in a horizontal position. It was thought that the deeper buds, e.g. of 9-inch rhizomes, might not be affected and would eventually produce some shoots. On the contrary, close inspection showed that the whole rhizome was killed. Rhizomes at a 60-70° angle were planted with the tips, i.e. youngest buds, up.

TABLE III. The Affects of Surface Applied Atrazine on the Growth of Quackgrass Rhizomes of Different Lengths Buried at Different Depths in a Soil Relative Values. Check = 100

Treatments	Check	Atrazine	
		1 lb/A	3 lb/A
1. 12 three-inch rhizomes, 1" deep	100	19.1	0.0
2. 12 three-inch rhizomes, 4" deep	100	99.6	2.1
3. 12 three-inch rhizomes, vertical	100	45.6	0.0
4. 4 nine-inch rhizomes, 1" deep	100	26.0	0.0
5. 4 nine-inch rhizomes, 4" deep	100	106.2	4.0
6. 4 nine-inch rhizomes, vertical	100	32.9	0.0

Summary and Conclusions

1. A quackgrass control in field corn experiment was conducted on a well drained gravelly sandy loam. Atrazine, methymercapto analogue of atrazine, dalapon, amitrol-T, and EPTC were used.

2. Atrazine was effective and most promising in controlling quackgrass in field corn. The optimum rate was 4 lb/A of active ingredient. It may be applied in the fall or early in the spring on quackgrass foliage or at planting on a prepared seedbed. These preliminary trials indicate that the most practical way to apply atrazine is as a split treatment 2 lb/A on foliage early in the spring and 2 lb/A at planting. Mixing the atrazine with the soil increased the effectiveness significantly. To get conclusive results more tests should be conducted.

3. EPTC and combination treatments of dalapon, amitrol-T, and G-34162 with atrazine were also promising in controlling quackgrass in field corn. EPTC at 6 lb/A rate injured the corn and resulted in decreased yields.

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A SUMMARY OF QUACKGRASS CONTROL STUDIES FOR 1961

Stanford N. Fertig[1]

Introduction:

Quackgrass competition can be a major factor in the yield of corn for silage or for grain. If a reduction in stand of quackgrass and reduced competition is to be obtained by cultural operations alone, they must be frequent and properly timed. The use of a single chemical or combination of chemicals plus cultural operations has proven highly effective in controlling quackgrass. The combination of plow-down plus pre- or early post-emergence herbicide treatments will eliminate quackgrass competition in corn for the growing season and where moisture is limiting can result in yield increases of silage or grain by 50 - 100 percent.

Method and Procedure:

The quackgrass control studies conducted during 1961 were 8 different locations on the Agronomy Research Farm. Four of the locations were corn stubble plots used in 1960 and had received the same or a different combination of chemicals in 1960. Where the stand of quackgrass was significantly reduced by the 1960 treatment, the same chemicals were used again in 1961. On those plots where the stand of quackgrass was comparable to the check treatment, a different chemical or combination of chemicals was used.

The other four locations used in the 1961 studies were in sod at the time the plow-down treatments were applied. These areas had been in alfalfa-grass for the previous 3 years.

To indicate the nature of the results obtained, this paper will summarize the results of one location on corn stubble and one location on sod ground.

The experimental design was a split plot with four replications of each treatment. The plot size was 18 x 40 feet. The chemicals were applied in 30 gallons of water per acre, 10-12 days prior to plowing.

All pre-emergence treatments were made 1 day after corn planting and the post-emergence treatments 10-15 days after planting. One-half of each plot received two cultivations, the first 3 weeks and the second 5 weeks after planting.

The combination of chemicals used, the rates per acre, the yields of silage corn and the yields of quackgrass foliage are summarized in Tables I and II. The quackgrass yields were obtained by harvesting 3 - 2 sq. ft. quadrats at random from each plot during the last 2 weeks of August. Botanical separations were made by species and the quackgrass separates were oven dried. The yields, as an indicator of reduction in top-growth of quackgrass,

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are reported in pounds per acre of 20 percent moisture hay equivalent.

The corn silage yields were calculated from the harvest of 2 - 10 foot sections of row taken from the center area of the cultivated and from the center area of the non-cultivated portions of each treatment. A random sample was drawn from the harvested plants, chopped and a 2,000 gram sample of chopped material was oven dried to determine dry matter content. The yields of silage in tons per acre at 75 percent moisture were calculated from these values.

Discussion:

All chemical treatments on the corn stubble plots (Table I) when combined with cultivation resulted in a significant reduction in the competitive effects of quackgrass as indicated by the silage yields. As shown by the yields of quackgrass foliage on many treatments, however, the effect was due to a reduction in the vigor and growth of quackgrass rather than effective kill.

When the plots were harvested in September there was an excellent cover of quackgrass on treatments 3, 5, 6, 10, 12 and to a lesser extent 14. Even though the yields of silage were not significantly reduced on these treatments, the kill of quackgrass was rated fair to very poor. It is fair to assume that had moisture conditions been less favorable throughout the growing season, the yields would have been reduced by several tons per acre.

A complete kill of quackgrass is possible by repeated applications of plow-down and pre- or post-emergence chemical treatments. The same total amount of chemical in split applications has been far more effective in killing quackgrass compared to a single application. Where kill of quackgrass is desired, the cost of an additional spray treatment is justified.

The silage yields from treatments on the sod area (Table II) are also quite uniform within the cultivated and non-cultivated plots. A significant yield difference at the 5 percent level does exist between some treatments. Considering the combination of compounds and treatments used, however, these differences are small.

Also, based only on the yields obtained from the cultivated and non-cultivated, the value of cultivation would be questioned. Visual ratings on the control of quackgrass at the time of harvest, however, showed a definite advantage for cultivation in killing quackgrass. Even though the yields do not reflect it, treatments 6, 10, 13, 15, 21 and 23 were rated poor control and treatments 14, 18 and 22 were rated fair control.

If or where farmer acceptance of a chemical treatment is based on visual observation or the absence of vegetation, the above treatments would be considered unsatisfactory even though the yields may not be affected. Including the cultivated and non-cultivated treatments, 18 yield values are represented in the above treatments rated as poor or fair in control. The yields from 9 of these plots are, however, in the first 20 highest yields obtained in the experiment. A clear distinction should be made between seasonal suppression, reduced stands and kill or elimination of quackgrass when writing for or

Table I. Chemical Treatments Used on Corn Stubble Area and Yields of Corn Silage and Quackgrass Foliage. 1961

	Plow-down Chemical		Pre-emergence		Post-emergence		Tons of silage corn at 75% moisture		Lbs/A of quackgrass foliage at 20% moisture	
Treat. No.	Chemical	Rate/A lbs.a.e.	Chemical	Rate/A lbs. a.e.	Chemical	Rate/A lbs.a.e.	Cultivated	Not Cultivated	Cultivated	Not Cultivated
1*	Atrazine	2.0	Atrazine	2.0	------	-------	18.2	17.1	None	None
2*	Atrazine	3.0	Atrazine	3.0	------	-------	16.5	18.5	None	None
3*	Simazine	2.0	Simazine	2.0	------	-------	18.1	17.2	290	440
4*	Simazine	3.0	Simazine	3.0	------	-------	17.0	16.6	25	130
5	G-34698	2.0	G-34698	2.0	------	-------	16.7	13.3	775	1367
6	G-34361	2.0	G-34361	2.0	------	-------	15.5	12.2	1075	1260
7	Amitrol-T	2.0	Atrazine	2.0	------	-------	18.2	21.0	105	175
8*	Propazine	2.0	Propazine	2.0	------	-------	18.6	18.2	20	5
9*	Propazine	3.0	Propazine	3.0	------	-------	19.0	18.0	None	None
10	G-34360	2.0	G-34360	2.0	------	-------	15.3	9.3	1501	615
11	Atratone	2.0	Atratone	2.0	------	-------	17.4	15.6	235	495
12	-------	----	Atrazine	2.0	------	-------	15.5	14.7	780	1280
13	-------	----	Atrazine	4.0	------	-------	16.6	18.5	210	340
14	-------	----	--------	----	Atrazine	2.0	16.3	15.5	160	310
15	-------	----	--------	----	Atrazine	4.0	18.8	18.0	265	255
16	Check	----	--------	----	--------	------	9.1	4.1	1816	1410

*Same chemical, rate per acre and method of treatment used in 1960. On all other treatments the chemical was changed

Table II. Chemical Treatments Used on Sod Area and Yields of Corn Silage and Quackgrass Foliage. 1961

	Plow-down Chemical		Pre-emergence		Post-emergence		Tons of silage corn at 75% moisture		lbs/A of quackgrass foliage at 20% moistu	
Treat. No.	Chemical	Rate/A lbs.a.e.	Chemical	Rate/A lbs.a.e.	Chemical	Rate/A. lbs a.e.	Cultivated	Not Cultivated	Cultivated	Not Cultivate
1	Atrazine	1.0	Atrazine	1.0	------	------	21.5	19.9	60	70
2	Atrazine	1.0	Atrazine	2.0	------	------	21.3	21.1	331	0
3	Atrazine	2.0	Atrazine	1.0	------	------	22.1	21.1	---	20
4	Atrazine	2.0	Atrazine	2.0	------	------	21.2	20.5	15	5
5	Atrazine	3.0	Atrazine	1.0	------	------	23.9	22.8	None	15
6	Amitrol-T	1.0	Atrazine	1.0	------	------	19.4	20.9	455	400
7	Amitrol-T	2.0	Atrazine	1.0	------	------	23.3	20.5	None	40
8	Amitrol-T	2.0	Atrazine	2.0	------	------	20.2	21.3	50	110
9	Amitrol-T	3.0	Atrazine	1.0	------	------	23.7	26.0	35	130
10	Propazine	1.0	Propazine	1.0	------	------	21.4	23.2	265	710
11	Propazine	2.0	Propazine	1.0	------	------	21.4	25.7	37	175
12	Propazine	2.0	Propazine	2.0	------	------	25.6	18.0	15	150
13	Dalapon	2.0	Atrazine	2.0	------	------	21.2	27.3	195	255
14	Dalapon	3.0	Atrazine	2.0	------	------	24.8	24.4	55	290
15	Dalapon	1.0	Atrazine	2.0	------	------	23.7	22.7	190	485
16	Atrazine	2.0	--------	---	Atrazine	2.0	23.2	23.1	0	10
17	Atrazine	2.0	--------	---	Atrazine	1.0	24.9	18.8	10	0
18	Amitrol-T	2.0	--------	---	Atrazine	2.0	22.5	22.4	55	145
19	Dalapon(w.a)	2.0	Atrazine	2.0	--------	---	22.0	21.8	55	45
20	Dalapon(w.a)	3.0	Atrazine	2.0	--------	---	20.1	23.1	110	90
21	Dalapon(w.a)	1.0	--------	---	Atrazine	2.0	24.9	26.7	120	230
22	Dalapon(w.a)	2.0	--------	---	Atrazine	2.0	24.2	23.5	105	300
23	---------	---	Atrazine	2.0	--------	---	23.4	19.3	340	335
24	---------	---	Atrazine	4.0	--------	---	19.6	24.6	20	75
25	Atrazine	4.0	--------	---	--------	---	24.0	23.2	15	20
26	Amitrol-T plus Atrazine	2.0 2.0	Atrazine	2.0	--------	---	23.6	21.8	5	5
27	Check	---	--------	---	--------	---	23.5	10.6	1961	2056
28	Check	---	--------	---	--------	---	18.6	12.9	1945	1480

THE EFFECTS OF CHEMICAL AND CULTURAL TREATMENTS ON THE SURVIVAL OF RHIZOMES AND ON THE YIELD OF UNDERGROUND FOOD RESERVES OF QUACKGRASS[1]

H. M. LeBaron and S. N. Fertig[2]

Introduction

In order to control or eradicate a perennial weed, it is necessary, either directly or indirectly, to induce the destruction of those organs which perpetuate the plant. In the case of quackgrass, the plant parts responsible for its perenniality are the mass of underground stems called rhizomes.

The normal life of individual quackgrass rhizomes is probably not much over a year. It is not always appreciated that this characteristic is one of the few important weaknesses inherent in quackgrass. This becomes of special interest in the use of herbicides for the control or eradication of quackgrass. A chemical, to be effective, may not necessarily kill the plant outright or directly cause death and decomposition of the rhizomes. Control may be effected indirectly by inducing dormancy or preventing production of new rhizomes until the natural death of the organs have taken place. However, the assumption that a direct relationship exists between the effect of a treatment on topgrowth and its affect on survival and activity of the rhizomes may be subject to error, especially when quackgrass control from different chemicals are being compared.

This investigation was carried out to obtain a more complete knowledge of the physiology of the quackgrass rhizome, especially as it is affected by herbicides and modern control recommendations. A previous paper reported on the effects of treatments on the food reserve content of quackgrass rhizomes (2). The extent of rhizome carbohydrate reduction was found to be more a characteristic of the herbicide used than it was correlated to topgrowth survival and regrowth. It is reasonable to suppose that similar results could also be expected from the rhizome survival data.

Materials and Methods

A description of the experimental design, sampling schedule and procedure, and laboratory methods has been given in previous papers (1, 2). The field plots were located near Ithaca, N.Y., on a Mardin silt loam soil which had a uniform and heavy quackgrass infestation. The treatments were replicated four times in a 3 x 6 split-plot factorial.

Samples of quackgrass rhizomes were collected periodically using a steel cylinder. All soil and foreign matter were removed by washing in a cement mixer. The rhizomes were then dried, weighed, ground, mixed thoroughly, and analyzed for carbohydrate content. Since fructose polymers, i.e., fructosans, were found to be the principal food reserve constituent of quackgrass rhizomes, quantitative carbohydrate determinations were based on the free fructose content following acid hydrolysis. On the basis of the rhizomes obtained from one square foot of

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[1] This includes part of the work done on the Ph.D. study at Cornell University.

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soil per plot at each sampling date, the yield of rhizomes and their food reserve content were determined. The yield of fructose per unit area was subsequently calculated as the product of these two determinations.

Results and Discussion

Main effects of cultural treatments:

The main effects of cultural treatments on the yield of quackgrass rhizomes are given in Table I. Both the plowing and fallow treatments resulted in an early decrease in the yield of rhizomes of about 40 per cent. The effect of the single spring plowing tended to decrease throughout the experiment as regrowth of foliage occurred, although it continued to show lower yields than the uncultivated quackgrass. The effect of continuous fallow, on the other hand, increased and resulted in a decrease of about 75 per cent in rhizome yields by late autumn.

The depletion of total carbohydrate yield due to cultural treatments was especially severe as shown in Table II. The data show that the first plowing is by far the most important single cultural treatment, resulting in an early and rapid decline of over 70 per cent in the fructose yield. Where no further tillage was applied, however, the food reserves were gradually replenished. By late autumn the plowed plots were no longer significantly lower than the uncultivated plots, and by the following spring the reduction of total carbohydrate was only 24 per cent. The fallow treatment continued a gradual depletion of fructose yield to 94 per cent by late autumn, which persisted to the next spring.

Main effects of chemical treatments:

The effect of herbicides on the dry weight yields of rhizomes was always significant throughout the experiment, as seen in Table III. All of the herbicides with the exception of Dalapon caused an early and marked decrease in rhizome yields. Although only Atrazine showed a significant reduction of about 50 per cent by the first sampling date, the rhizome yield reductions from Simazine, Amitrol-T and Fenac ranged between 35 and 39 per cent. Throughout the remainder of the experiment, Atrazine, Simazine, and Amitrol continued showing gradual decreases in rhizome yields, resulting in eventual declines of 88, 76, and 68 per cent, respectively, at the final sampling date. These three herbicides resulted in consistently lower survival of rhizomes than Fenac or Dalapon. While Fenac showed only minor changes from the initial decrease of 35 per cent throughout the remainder of the experiment, the effect of Dalapon was gradual and continuous throughout the growing season resulting in a 56 per cent loss of rhizomes by late autumn. However, its effect decreased during the winter and early spring, showing a reduction of only 31 per cent by May 10, 1960.

Since the herbicides generally caused simultaneous reductions of both rhizome yields and fructose content, the effects of chemical applications on the total carbohydrate yields were considerably accentuated, as shown in Table IV. Atrazine gave a very sharp and early decrease in fructose yield of 88 per cent by the first sampling date one month after application. This carbohydrate depletion increased slowly throughout the year to 97 per cent by autumn and 99 per cent by May 10, 1960. Simazine showed similar results although it reacted slower, with an initial reduction of 72 per cent, and a 94 per cent reduction by late summer. However, its effect decreased during the winter and early spring,

Table I Main Effects of Cultural Treatments on the Yield of Quackgrass Rhizomes at all Sampling Dates.

Sampling Date	Cultural Treatment Means (lbs./acre)			Significance (per cent)	Untreated Mean
June 15, 1959	Fallow	Plow	No cultivation		
	2000	2100	3340	N.S.	4760
Aug. 5, 1959	Fallow	Plow	No cultivation		
	1080	1900	2440	N.S.	4700
Sept. 10, 1959	Fallow	Plow	No cultivation		
	880	1440	1640	N.S.	3660
Nov. 10, 1959	Fallow	Plow	No cultivation	1	
	640	2040	2560	5	5960
May 10, 1960	Fallow	Plow	No cultivation	1	
	540	1600	2040	5	3000

Table II Main Effects of Cultural Treatments on the Yield of Fructose from Quackgrass Rhizomes at all Sampling Dates.

Sampling Date	Cultural Treatment Means (lbs./acre)			Significance (per cent)	Untreated Mean
June 15, 1959	Fallow	Plow	No cultivation	1	
	200	267	974	5	1873
Aug. 5, 1959	Fallow	Plow	No cultivation	1	
	126	276	759	5	1964
Sept. 10, 1959	Fallow	Plow	No cultivation	1	
	59	218	537	5	1540
Nov. 10, 1959	Fallow	Plow	No cultivation	1	
	54	488	851	5	2463
May 10, 1960	Fallow	Plow	No cultivation	1	597
	25	302	398	5	

Table III Main Effects of Herbicides on the Yield of Quackgrass Rhizomes at all Sampling Dates.

Sampling Date	Herbicide Treatment Means (lbs./acre)						Significance (per cent)	Untreated Mean
June 15, 1959	Atr.	Sim.	Ami.	Fen.	Dal.	No herb.	1	
	1760	2120	2220	2280	3020	3480	5	4760
Aug. 5, 1959	Sim.	Atr.	Ami.	Fen.	Dal.	No herb.	1	
	1060	1220	1680	1980	2060	2880	5	4700
Sept. 10, 1959	Sim.	Atr.	Ami.	Dal.	Fen.	No herb.	1	
	680	700	1220	1240	1640	2460	5	3660
Nov. 10, 1959	Atr.	Sim.	Ami.	Dal.	Fen.	No herb.	1	
	620	940	1280	1620	2360	3660	5	5960
May 10, 1960	Atr.	Sim.	Ami.	Fen.	Dal.	No herb.	1	
	340	680	880	1720	1920	2780	5	3000

Table IV Main Effects of Herbicides on the Yield of Fructose from Quackgrass Rhizomes at All Sampling Dates.

Sampling Date	Herbicide Treatment Means (lbs./acre)						Significance (per cent)	Untreated Mean
June 15, 1959	Atr.	Sim.	Ami.	Fen.	Dal.	No herb.	1	
	100	229	407	519	807	821	5	1873
Aug. 5, 1959	Atr.	Sim.	Ami.	Fen.	Dal.	No herb.	1	
	81	97	218	506	560	860	5	1964
Sept. 10, 1959	Atr.	Sim.	Ami.	Dal.	Fen.	No herb.	1	
	26	43	186	210	401	762	5	1540
Nov. 10, 1959	Atr.	Sim.	Ami.	Dal.	Fen.	No herb.	1	
	42	80	276	418	633	1337	5	2463
May 10, 1960	Atr.	Sim.	Ami.	Fen.	Dal.	No herb.	1	
	7	83	112	302	357	588	5	597

with an 86 per cent reduction by May 10, 1960. Amitrol-T induced an early food reserve yield reduction of 50 per cent which increased to about 80 per cent by fall and held constant till the following spring. Because of the reduction of rhizomes by Fenac, the fructose yield showed an initial decline of 37 per cent, which increased slowly to 53 per cent by late autumn, and then decreased to 49 per cent by the next spring. Dalapon showed no early effect on the fructose yields, but caused a fairly rapid decline during the summer to 72 per cent in total carbohydrates. The effect of Dalapon decreased during the fall and winter, resulting in a reduction of only 39 per cent by May 10, 1960.

Interaction between cultural and chemical treatments:

There was no significant interaction between the effects of cultural treatments and herbicidal applications on the survival of rhizomes until the last two sampling dates.

An explanation of the interaction may be given by comparing the effects of the different herbicides with each cultural treatment in the final sampling data given in Table V. The most striking comparison is where no cultivation was applied. The highest rhizome yield was not obtained on the untreated sod, but from plots treated with Dalapon or Fenac. Though the differences are not significant, they do indicate that these two herbicides had no lasting effects on the destruction of quackgrass rhizomes unless accompanied by tillage treatments, even though topgrowth was killed and regrowth suppressed by Dalapon. At the opposite extreme was Atrazine, which actually resulted in less rhizomes surviving when applied to uncultivated plots than when supplemented by plowing or fallow. Quackgrass sod treated with Atrazine and left undisturbed showed a 91 per cent reduction in the rhizome infestation by the following spring.

A comparison of the herbicides within the plow treatment indicates that all herbicides stimulated a highly significant reduction in the rhizome yield compared to spring plowing with no herbicide. This was in part due to a stimulating influence of plowing on the subsequent growth of quackgrass rhizomes when no herbicide was applied, showing an increase of about 50 per cent by May 10, 1960 over that of the uncultivated check plots. The results of continuous fallow tended to eliminate or mask the herbicidal effects by its rather uniform and complete destruction of quackgrass rhizomes. The data show that, by the following spring, the fallow treatments resulted in rhizome destruction ranging from 69 per cent when no herbicide was used to 87 per cent when Atrazine was applied, compared to the untreated check plots. There were no significant differences between any of the fallow treatments.

The interaction between cultural and chemical treatments on the total fructose yield was significant at all sampling dates. In general, any combinations of treatments that resulted in a change in the yield of quackgrass rhizomes simultaneously caused a change in the food reserve content of the rhizomes in the same direction. Consequently, the influence of the treatments on the total fructose yield was usually accentuated. Table VI gives a summary of the interaction data from the first, late fall, and final sampling dates.

All treatments with the exceptions of uncultivated plots treated with Dalapon or Fenac resulted in highly significant carbohydrate yield reductions by the first sampling date. The single plowing treatment caused the predominant

Table V Interaction Between Cultural and Herbicidal Treatments on the Yield of Quackgrass Rhizomes (sampled May 10, 1960)

Treatments Cultural	Herbicide	Significant at 1%	Mean (lbs/acre)	Significant at 5%	Per Cent Reduction
No cultivation	Atrazine		260		91
Fallow	Atrazine		380		87
Fallow	Simazine		380		87
Fallow	Fenac		380		87
Plow	Atrazine		400		87
Fallow	Amitrol		460		85
Fallow	Dalapon		680		77
Plow	Simazine		740		75
Fallow	No herbicide		920		69
No cultivation	Simazine		940		69
Plow	Amitrol		1020		66
No cultivation	Amitrol		1180		61
Plow	Dalapon		1360		55
Plow	Fenac		1680		44
No cultivation	No herbicide		3000		Per cent increase
No cultivation	Fenac		3120		4
No cultivation	Dalapon		3740		25
Plow	No herbicide		4440		48

Table VI Interactions Between Cultural and Herbicidal Treatments on the Yield of Fructose from Quackgrass Rhizomes at Three Sampling Dates.

Treatments Herbicide	 Cultural	June 15, 1959 Mean (lbs/acre)	Nov. 10, 1959 Mean (lbs/acre)	May 10, 1960 Mean (lbs/acre)
Atrazine	Fallow	57	49	11
Atrazine	Plow	154	75	9
Atrazine	No. cult.	90	3	3
Simazine	Fallow	150	14	9
Simazine	Plow	80	147	76
Simazine	No. cult.	457	81	164
Amitrol-T	Fallow	127	40	33
Amitrol-T	Plow	276	261	129
Amitrol-T	No cult.	819	527	174
Fenac	Fallow	141	45	8
Fenac	Plow	368	617	298
Fenac	No cult.	1049	1237	601
Dalapon	Fallow	413	48	33
Dalapon	Plow	449	409	189
Dalapon	No cult.	1560	797	848
No herb.	Fallow	314	129	57
No herb.	Plow	276	1420	1109
No herb.	No cult.	1873	2463	597
L.S.D. 1%		1010	1338	590
L.S.D. 5%		767	1018	450

plots showed smaller decreases with the exception of Atrazine, which gave an early decrease of 95 per cent with no cultivation. While the differences between the cultivated and uncultivated Atrazine treatments were never significant, the undisturbed sod treated with Atrazine consistently gave carbohydrate yields equal to or greater than when Atrazine was supplemented by tillage. The effect of Atrazine alone increased from a severe fructose yield reduction of 95 per cent by the first sampling date to virtually 100 per cent by late fall. This continued to the following spring, indicating that no live rhizomes remained.

Simazine, without cultivation, resulted in an early reduction of 76 per cent in the fructose yield, which increased to 97 per cent by late fall. By the following spring, however, the effect of Simazine decreased to a 73 per cent reduction in fructose yield. While spring plowing tended to slightly augment the effect of Simazine on the total food reserves throughout the experiment, it also decreased from a 99 per cent depletion in late summer to 87 per cent by the following spring, indicating that at least some live rhizomes survived.

Similar trends, but with less striking reductions, were generally observed for the other three herbicides. In all cases, Amitrol-T, Fenac and Dalapon on uncultivated plots induced a reduction in underground carbohydrates which increased to a high of 83 per cent, 50 per cent and 75 per cent, respectively, by fall. The effects of these herbicides ceased or diminished during the following winter and spring, however, showing a reduction of 71 per cent for Amitrol-T, but increases of 1 per cent for Fenac and 42 per cent for Dalapon. While the single spring plowing after application of Amitrol-T, Fenac or Dalapon was very effective in stimulating or prolonging the rhizome and carbohydrate yield reductions, their effects were, nevertheless, diminished between late fall and spring.

There was generally a close relationship between the appearance of the quackgrass rhizomes and the level of food reserves they contained. Vigorous white rhizomes with many fibrous roots were always relatively high in carbohydrates. As the prevalence of roots decreased, the rhizomes gradually appeared more discolored, and their carbohydrate level generally diminished accordingly. When no fibrous roots remained on the rhizome joints, the rhizomes appeared in various shades of brown corresponding to the degree of decomposition and carbohydrate depletion.

Summary and Conclusions

There was a general relationship between the effects of cultural and chemical treatments on the survival and regrowth of rhizomes and their effects on the carbohydrate content of rhizomes as presented in a previous paper (2).

Of the cultural treatments, spring plowing resulted in the most rapid decrease in yield of both rhizomes and carbohydrates. As soon as new topgrowth developed, however, carbohydrates were gradually restored and the growth of new rhizomes was stimulated.

Repeated cultivations during the growing season resulted in a continuous depletion of rhizomes and carbohydrates. Although more than 25 per cent of the total dry weight of rhizomes still remained in the fall and the following spring, they were greatly weakened due to a simultaneous reduction in food reserves.

Although reductions in the yield of rhizomes and carbohydrates resulted from all herbicides, the chemicals differed considerably in the rate, period and degree of the depletions. They also responded differently in the interaction with cultural treatments.

Dalapon, Amitrol-T and Atrazine all showed somewhat similar effects on quackgrass foliage. In all cases, the topgrowth ceased at the time of application, and gradually died back after about two weeks. Little or no regrowth occurred throughout the growing season on either the treated sod or plowed plots. On the underground organs and carbohydrates, however, Dalapon showed very little reduction during the first three months. Much of the reduction in yield of rhizomes and fructose that occurred by late fall was recovered by the following spring. Amitrol-T, while showing a more rapid and severe reduction in both rhizomes and carbohydrates, was similar to Dalapon in that it reached its peak effect by late fall, diminishing somewhat by spring. The effect of Atrazine was most rapid and complete, resulting in destruction of virtually all rhizomes and carbohydrates by late fall.

The effects of Simazine and Fenac on quackgrass foliage were quite similar, although much different from the other herbicides. Neither resulted in any appreciable effect on the sod plots during the first two months. The effect of Simazine on the rhizomes and their food reserves, however, was very pronounced and consistent throughout the growing season, while Fenac resulted in only minor reductions of rhizomes and carbohydrates.

All the herbicides applied did not respond equally or in the same way to cultural treatments. The herbicides, listed in the order of their dependency upon plowing for effective control, as measured by the reduction of rhizomes and food reserves, are as follows: Dalapon, Fenac, Amitrol-T, Simazine and Atrazine.

Dalapon and Fenac showed no tendency to cause direct death and decomposition of quackgrass rhizomes when not followed by tillage. A gradual and temporary reduction in food reserves and rhizome yield took place. However, this had been overcome by the following spring.

Amitrol-T resulted in greater reductions on unplowed plots than Dalapon or Fenac, but was still more efficient if followed by plowing. Simazine and Atrazine resulted in greater depletions of rhizomes and carbohydrates than the other herbicides either with or without tillage. Simazine was benefited slightly by plowing. Atrazine, however, showed no increase in effectiveness from either plowing or fallow since no live rhizomes remained by late fall.

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FURTHER EVALUATION OF HERBICIDES FOR WEED CONTROL IN NEW SEEDINGS OF ALFALFA

R. A. Peters and H. C. Yokum[1]

Many materials have been tried for selective weed control in alfalfa but to date none of the materials commercially available have given broad spectrum weed control as well as sufficient selectivity.

Since the practice of using grain companion crops for new seedings of forage legumes is now being questioned[2], there is an increasing need for a satisfactory herbicide for use on new seedings. Testing of some of the older materials as well as any promising new materials should be done on a continuing basis.

Procedure: The experimental area was on the Agronomy Research Farm, University of Connecticut, Storrs, Connecticut. The principal experiment discussed below was a summer seeding of DuPuits alfalfa seeded on July 28, 1961.

Pre-emergence applications were made on August 2, 1961. Approximately 25% of the alfalfa seedlings had emerged by the time of treatment. Post-emergence applications were made on August 15, 1961 when the second true leaf of the alfalfa was about to expand.

Plot size was 5 by 15 feet replicated three times. Estimates of stands were made on October 10 and yields were determined on October 11, 1961 by harvesting a strip 39 inches wide on each through the center of each plot.

The dominant weed species present in the experimental area was old witchgrass (Panicum capillare) with an admixture of large crabgrass (Digitaria sanguinalis). Only a trace of broadleaf weeds were present.

Sub-samples were taken for determination of dry matter and, when necessary, for hand separation to determine the percentage of alfalfa by weight in the plot.

In another experiment, not discussed in full in this paper, several herbicides were applied on a spring seeding (April 27, 1961) of alfalfa. Included was diphenamid at 4 pounds per acre and G34696 at 2 pounds per acre both applied as pre-emergence materials and dalapon plus 2,4-DB as a post-emergence material. Rainfall occurred within two hours of the time the pre-emergence materials were applied.

Results: In the spring seedings, the diphenamid gave outstanding results on alfalfa in terms of weed control with no indication of injury to the alfalfa.

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[1] Associate Professor and, formerly, Research Assistant, University of Connecticut, Storrs, Connecticut.

[2] Peters, R. A. Legume Establishment as Related to the Presence or Absence of an Oat Companion Crop. Agron. Jour. 53:195-198. 1961.

This material completely controlled both the grasses and the broadleaf weeds. Included were yellow foxtail (Setaria lutescens); large crabgrass (Digitaria sanguinalis), old witchgrass (Panicum capillare), and barnyard grass (Echinochloa crusgalli). Broadleaf weeds included black mustard (Brassica niger), common chickweed (Stellaria media), lambsquarter (Chenopodium album) and rough pigweed (Amaranthus retroflexus). There was little indication of re-invasion of weeds later in the growing season.

Table 1. Alfalfa Hay Yields Following Herbicide Treatment of a Summer Seeding

Chemical Treatment	Formulation	lbs./A Active Material	Time of Application	Ratings of Grassy Weed Stand	Yield lbs./A Dry Matter
Neburon	50% WP	3/4	Pre-emergence[1]	1.0	1550
Neburon	"	1 1/2	"	0.6	1390
Dacthal	50% WP	4	"	1.3	1550
Dacthal	"	8	"	1.0	1360
Diphenamid	80% WP	3	"	0	1360
Diphenamid	"	6	"	0.3	1090
Trifluralin	2 G	3	"	0.6	650
Trifluralin	2 G	6	"	0	215
G34696[3]	50% WP	1/2	"	2.3	1225
G34696	"	1	"	2.0	1180
Diuron	80% WP	1/2	"	0	510
Diuron	"	1	"	0	315
2,4-D	Amine	1/2	Post-emergence[2]	7.0	290
DNBP	3 lb a.f./G	1 1/2	"	3.3	1330
DNBP	"	3	"	3.6	1580
2,4-DB + dalapon		1 + 2	"	1.0	1160
2,4-DB + dalapon		2 + 2	"	1.6	1370
				L.S.D. 5% level	270
				L.S.D. 1% level	390

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[1] Pre-emergence treatments made 10 weeks prior to harvest, July 28, 1961.

[2] Post-emergence treatments made 8 weeks prior to harvest, August 15, 1961.

[3] G34696 is 2 chloro-4, ethyl amino-6-(3 methoxy propylamine)-S-triazine.

In the summer seeding, the highest yields of alfalfa were obtained from the low rates of neburon and dacthal with the dry matter production comparable for each chemical. While not significantly lower, somewhat lower yields were obtained from neburon, 1½ lb.; dacthal, 8 lb.; diphenamid, 3 lb.; DNBP, 1½ lb.; and 2,4-DB plus dalapon. Yields were significantly lower, however, when G34696 was used. Doubling the rate of diphenamid or DNBP resulted in a highly significant yield reduction of the alfalfa. Serious injury from both rates was obtained from trifluralin and diuron.

Control of the predominant weed, old witchgrass, is indicated by the estimate of stand given in Table 1. Complete grass control was obtained from both rates of diphenamid and diuron and from the high rate of trifluralin, with complete selectivity obtained only with the diphenamid. Alfalfa was seriously injured by diuron and trifluralin as stated previously. While not complete, good grass control was obtained from both rates of neburon, dacthal, the 2,4-DB and dalapon combinations, and the low rate of trifluralin. Only fair control was obtained from DNBP and G34696.

Discussion

Diphenamid was outstanding in its degree of selectivity on alfalfa in both spring and summer seedings, giving nearly complete weed control without injury to alfalfa at the 3 lb. per acre rate. This material merits further testing on alfalfa as a highly selective, wide spectrum pre-emergence herbicide.

In the summer seeding reported, neburon and dacthal were quite effective; however, these materials have not generally controlled as wide a range of weed species.

Two limitations of DNBP for weed control in alfalfa are shown in this experiment. The narrow range of alfalfa tolerance is shown by over a 50% reduction in alfalfa yield as the DNBP is doubled from 3/4 to 1½ lb. per acre. The weakness of DNBP in post-emergence control of grassy weeds is shown by the poor rating at either rate compared, e.g., with diphenamid.

G34696 merits further testing on alfalfa, at rates of 1 lb. per acre or less. While it did not give complete old witchgrass control in this experiment, in a separate trial at the Storrs Station this material controlled a fairly wide range of weed species. The dalapon plus 2,4-DB combination caused temporary injury to the alfalfa as evidenced by leaf curling and stunting. Injury has been more frequent at Storrs on summer seedings than on spring seedings. The injury noted was outgrown, however, by the time of harvest.

Trifluralin shows no promise for alfalfa weed control because of severe injury. The injury pattern is unique in that emergence occurs but development beyond the cotyledonary stage does not occur on most plants. If further development does eventually occur, multiple shoots form from the cotyledonary nodes resulting in multiple small stems.

Summary

Selective control of old witchgrass (Panicum capillare) in a summer seeding of alfalfa was obtained from pre-emergence applications of neburon, dacthal and diphenamid and from post-emergence applications of 2,4-DB and DNBP. Diphenamid in particular merits further consideration on alfalfa.

DNBP was selective only at the lower rate used (1½ lb.). G34696 caused some yield reduction but merits further testing by including lower rates. Diuron, trifluralin and 2,4-D show no promise for pre-emergence use on alfalfa.

The cooperation of the following companies in supplying chemicals is acknowledged: The Dow Chemical Co.; Amchem Products, Inc.; Eli Lilly and Co.; E. I. duPont de Nemours and Co., Inc.; Geigy Agricultural Chemicals; and Diamond Alkali Co.

EFFECT OF PHOSPHORUS ON THE UPTAKE OF TRICALCIUM ARSENATE BY BLUEGRASS AND CRABGRASS

C. Fred Everett[1] and Richard D. Ilnicki[2]

ABSTRACT

The phosphorus level in a soil is considered to be one of several factors which influence the phytotoxicity of arsenic.

An established Kentucky bluegrass sward was fertilized in the fall with three rates of phosphorus: 0,75 and 150 lb. P_2O_5/a. The soil was a Nixon sandy loam which was low in available phosphorus. Two pH levels, 5.0 and 6.0, were established by additions of sulfuric acid. "Low lime" tricalcium arsenate at 0, 3, 6 and 9 lb. of As per thousand square feet was applied the following March. Grass was harvested in June and August of the same year.

The arsenic and phosphorus concentrations in the grass were not affected by the additions of phosphorus to the sward. The higher pH slightly decreased the arsenic content of the grass. The application of higher rates of arsenate slightly increased the arsenic concentration. There was no visible sign of injury to the bluegrass.

In the greenhouse Merion bluegrass and crabgrass plants grown in a nutrient solution with 10 ppm of phosphorus were preconditioned for one week in nutrient solutions having 1, 10 and 100 ppm of phosphorus. "Low" lime" tricalcium arsenate and sodium arsenite treatments were applied and the plant tops harvested 24, 48 and 72 hours later.

High levels of phosphorus in the nutrient solution reduced the phytotoxicity of the arsenate treatments to practically nil, but they did not influence the phytotoxicity of the arsenite treatment. The phosphorus concentration in the bluegrass tops grown in the 100 ppm P nutrient solution was five fold greater than that in the bluegrass grown in the 1 ppm P nutrient solution. Bluegrass from the 1 and 100 ppm P nutrient solutions contained two to three times as much arsenic as bluegrass grown in the 10 ppm P nutrient solution. On the other hand, crabgrass had the most arsenic when grown in the 1 ppm P nutrient solution and by far the least when grown in the 100 ppm P nutrient solution.

"Low lime" tricalcium arsenate was synthesized in the laboratory and tagged with As^{76}. This was applied to nutrient solutions as above. The bluegrass and crabgrass tops were harvested 9, 18 and 36 hours later, digested and counted for As^{76}.

The results were similar to those obtained previously. There was more arsenic in the bluegrass grown in the 1 and 100 ppm P nutrient solutions than in that grown in the 10 ppm P nutrient solution. Likewise, crabgrass grown in the 1 ppm P nutrient solution had a much higher concentration of arsenic than crabgrass grown in the higher phosphorus nutrient solutions or than bluegrass grown in the 1 ppm P nutrient solution.

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FACTORS CONTRIBUTING TO THE LOSS OF AMIBEN PHYTOTOXICITY IN SOILS

W.E. Rauser [1] and C.M. Switzer [2]

Abstract [3]

This study was undertaken to determine the general persistence of Amiben (3-amino-2,5-dichlorobenzoic acid) in soil, and the effect of leaching, micro-organisms, and other factors on its activity.

Amiben was used as the triethylamine salt formulation containing two pounds acid equivalent per gallon. Application of herbicide was made to four soil types - muck, sand, clay and loam. Herbicidal activity in soil samples was determined by using a biological test based on the dry weight of oat seedlings.

Leaching studies were carried out in glass tubes, 9 in by 1 13/16 in. After leaching, the soil was pushed from the tubes and sliced into one inch segments which were then tested for amiben activity.

Amiben applied to muck (at 3, 6 or 9 lb/A) and leached with 2, 5 or 8 in of water was found to remain mainly in the upper one inch layer. The greatest movement downward was found with the highest rate of chemical. Leaching was independent of the initial moisture content of the soil or the volume of water applied.

As little as 2 inches of water was found to remove amiben almost completely from the sand soil whereas almost all of the applied chemical was found in the surface inch of clay, regardless of the applied water.

The direct dependence of the downward movement of herbicide on the application rate, but not on the applied water, suggests a mass action effect in which the herbicide was swept along allowing adsorption on colloid soil constituents. Soils high in colloids (muck) would be expected to retain much of the chemical near the surface whereas those containing few colloids (sand) would be unable to hold much. Such expectations were supported by the data obtained.

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2) Associate Professor, Department of Botany, Ontario Agriculture College, Guelph, Ontario.

3) Paper accepted for publication in Weeds; The Journal of the Weed Society of America.

In another experiment, loam soil was treated with amiben (at 0.25, 0.5, 1, 2, 4 or 6 lb/A) at 5 week intervals for a total of 7 applications. Oats were planted in the soil after each application. In general, the first herbicide application resulted in the greatest yield decrease relative to the check. Further amiben applications produced a lower constant yield depression at all rates. Therefore, it seemed that there was little build up of herbicide toxicity. Since leaching from the containers was impossible and volatilization was unlikely, the loss of herbicide (lack of accumulation) would seem to be due to either chemical or micro-organism breakdown. In experiments designed to separate these possibilities, it was found that loss of amiben toxicity from incubated soil was more rapid in muck than in clay. There was no detoxification in sandy soil during the 10 week period indicating that microbial breakdown of amiben is negligible in this type of soil.

When the two factors leaching and microbial detoxification are considered, it would appear that leaching is the major factor in amiben disappearance from sand. Loss of activity from muck and clay soils is dependent on both leaching and micro-organism activity, with the latter probably being more important in muck. Outdoor incubation of muck and clay soils showed that considerable breakdown could occur during the cropping season.

Nutgrass control studies in corn with atrazine and its residual effects on a forage seeding[1]

R. S. Bell and P. B. Gardner[2]

Atrazine has proven to be an efficient herbicide for the control of certain weeds in corn (1). Preliminary reports (3) indicated that early post-emergent applications of atrazine at 3 to 4 pounds per acre gave seasonal control of nutgrass. Donnalley and Rahn (2) reported that autoradiographs from foliage applications of amitrole and atrazine to nutgrass plants bearing tubers showed that atrazine did not accumulate in the nutlets but was readily translocated throughout the plant. Atrazine residues disappear slowly from the soil and may cause some damage to a forage seeding the following spring.

1960 Tests

Procedures

Penn. 602A corn was planted on May 25, 1960 in Bridgehampton silt loam soil fertilized with 1000 lb/A of an 8-12-12-2 grade. The subplots were 15' x 32' and there were 4 replicates of each treatment. One set of plots received 2.5 lb/A of atrazine 80W shortly after planting and 5 lb/A when the plants were 12 inches high on June 30. Other plots received atrazine at this later date at 5, 7.5, 10 and 12.5 lb/A, respectively. Fifty gallons per acre of spray was used. Four randomized plots received no herbicide.

The tests were not cultivated during the month of June so that the nutgrass stand on each plot could be estimated. Several randomized counts of one foot square plots indicated a range from 1000 to 2000 nutgrass plants per plot. After the post-emergent herbicides were applied the area was cultivated twice to loosen the soil. This incorporated the atrazine between the rows and dislodged much of the nutgrass.

The 1960 rainfall and weather in general favored the growth of corn. There were over 3 inches of rain during the 3-week period following the post-emergent applications of atrazine. The corn was harvested September 6.

Results

The yields and various nutgrass counts are shown in table 1. The corn yields ranged from 4.2 T/A of oven-dry material from the check plots to 4.8 T/A from the area which received 5 lb/A of atrazine. The check plots were heavily infested with yellow foxtail grass. Analysis of variance showed no significant difference in yields due to treatment. After harvest the nutgrass plants on each plot were counted. The average number per plot ranged from 21 on the check plots to only 1 where high rates of atrazine were used. The reduction of nutgrass in the control plots after cultivation is striking. This reduction is

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[1] Contribution No. 1046 Rhode Island Agricultural Experiment Station.

apparently due to severe competition from the growth of corn and yellow foxtail grass. Atrazine kept other weeds out of the corn and, combined with the corn competition, almost entirely inhibited the nutgrass.

Table 1. Tons per acre of Penn. 602A corn, nutgrass count, and forage survival in plots treated with atrazine. R.I. 1960-61

Atrazine lb/A	T/A Corn Dry wt.	Nutgrass plants/480 sq. ft. Estimate* 7/1/60	Total count 9/7/60	6/15/61**	Rye plants per foot 11/14/60	Red clover & timothy survival June '61
5	4.8	2112	4	641	12	30- 80%
7½	4.5	2496	1	777	10	0- 50%
10	4.3	2160	1	657	5	0- 5%
12½	4.4	2060	1	633	3	0- 1%
2½ pre-,5 post-	4.6	1056	2	557	12	25- 75%
no chemical	4.2	1584	21	620	17	95-100%
LSD at 0.05	0.4					

* estimated before cultivation by 4 random 1 foot square counts per plot.
**these counts represent plants from tubers dormant during 1960.
Scarcely any nutlets were produced by the small weak plants present on 9/7/60.

The nutlets which produce next year's crop of nutgrass lie dormant in the soil undamaged by atrazine residues which may be strong enough to destroy a crop of red clover and timothy. The winter rye on the areas treated with more than 5 pounds of atrazine per acre was destroyed by spring 1961. The count of rye seedlings per foot of row in mid-November 1960 ranged from 3 from the heaviest rate of atrazine to 17 on the checks. The area was plowed in April 1961 and seeded to red clover and timothy. The stand was uniform and vigorous for about 3 weeks, when the roots of the seedlings contacted the residual atrazine.

Estimates of forage survival in mid-June showed complete elimination of the forage crop where 10 to 12 lb/A of herbicide were applied the previous summer. Nutgrass, however, was growing vigorously in these plots, indicating a high tolerance to atrazine where no other competition was encountered. The numbers of nutgrass plants per plot ranged from 557 to 771 with no inhibition indicated from the previous herbicide treatment.

1961 Tests

Procedures

A nearby area heavily infested with nutgrass was selected for the 1961 tests. Both Penn. 602A and Penn. 602 dwarf silage corn were used. There were 3 randomized replicates of each chemical for each variety. Atrazine 80W in 40 gallons of water per acre was sprayed at rates of 2, 4 and 6 pounds, respectively, before the corn came up. Similar amounts were applied 3 weeks after emergence of the corn. These respective dates were June 6 and 29. Granular preparations were also used. These materials and the results are shown in table 2.

Results

July 1961 was considerably drier than the previous July, particularly the first 3 weeks after the post-emergent atrazine. Comparative accumulative rainfall for these seasons is shown in figure 1.

Nutgrass in four random one-foot square areas per plot was counted on June 19 indicating a range of 1000 to 6000 plants per plot. All plots were cultivated on June 20, 27 and July 3 to loosen soil and on the later date to incorporate the atrazine. After layby, a considerable infestation of crabgrasses occurred and most plots receiving atrazine at layby, as well as the checks, had heavy stands of redrooted pigweed. The pigweed grew as rapidly and as tall as the corn.

The corn was harvested on August 15 at the full pollen-shed stage in order to prevent further development of weeds. As soon as weed estimates were made, the area was plowed.

Because of the tangle of nutgrass and crabgrasses it did not seem feasible to try to count every nutgrass plant on each of the 72 plots. Weed estimates were made by cutting nutgrass, crabgrass and pigweed at ground level from an area 3 feet wide (1.5 feet on either side a corn row) and 7 feet long. These weeds were separated by genera and the grams of oven-dry weights per sample area are presented in table 2. Analysis of variance of the oven-dry weights showed that the 602A corn produced significantly more yield than the dwarf corn. The average yield for all treatments was 3.01 T/A of Penn. 602A and 2.72 T/A of Penn. 602 dwarf. The analysis showed there was no significant interaction between treatments and varieties as far as dry matter was concerned. Therefore only the average dry weight for the 2 varieties is shown in table 2. It can be seen that at the 5 percent level all plots receiving herbicides yielded significantly better than the check plots.

Two statistical analyses were made for the dry weight data. In one, all treatments were considered and the LSD at 5% are shown on the bottom line of table 2. For the second analysis the fallow and check plot yields were omitted to determine statistical differences between the various chemical treatments.

The average dry weight of nutgrass tops varied from 399 grams per plot from the no corn-atrazine plots to 10 grams per plot where 4 lb/A of granular atrazine was used at pre-emergence. Considerably less nutgrass was found in the plots which received no atrazine than in the fallow-atrazine ones due to the combined competition from corn and redrooted pigweed. Similarly, the no corn-atrazine plots averaged 513 grams of crabgrass while the control had 20 grams. Six lb/A of atrazine and competition from nutgrass and crabgrass did not eliminate all the redrooted pigweed but reduced it significantly below the 784 grams found on the control area.

In general, the pre-emergent applications were more efficient than the post-emergent for reducing the yield of crabgrass and redrooted pigweed under 1961 conditions. The average nutgrass weights were fairly similar for pre- and post- treatments with the exception of 4 pounds of granular atrazine per

Table 2. Average dry weight of corn (T/A) and nutgrass, crabgrass and redrooted pigweed (gm/21 sq. ft.) on plots treated with atrazine 80W spray or granular atrazine (20%). R.I. 1961.

Lb/A atrazine 80W or gran.	Dry wt. T/A Corn	Grams per 21 sq. ft.			
		Nutgrass	Crabgrass	Redroot	Weed totals
Pre-emergent					
2	3.07	217	20	--	237
4	2.96	83	20	--	103
4 gran.	3.05	10	3	--	13
6	2.88	104	11	2	117
Average	2.99	103	13	--	117
Post-emergent					
2	2.85	108	126	13	247
4	2.90	158	115	214	487
4 gran.	2.93	144	36	348	528
6	2.72	62	137		199
Average	2.85	118	103	195	365
Pre- and post-					
2 + 4	3.03	89	15	--	104
2 + 4 gran.	2.76	83	39	--	122
Average	2.89	86	27	--	113
LSD at 0.05		121	94	--	240
No chemical	2.37	120	20	784	924
Post- 6 lbs. No corn	--	399	513	187	1099
LSD at 0.05	0.32	147	265	282	339

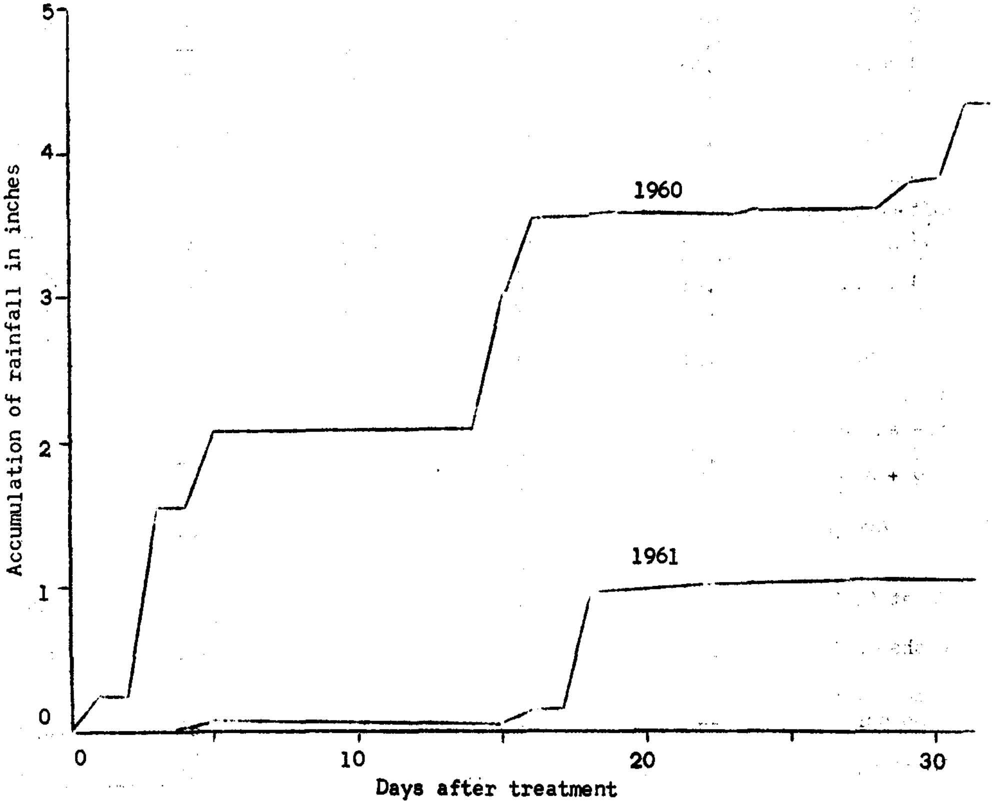

Figure 1. Accumulated inches of rainfall after the post-emergent applications of atrazine. 1960-61.

Summary and Conclusions

The most striking fact from the two-year test with atrazine and nutgrass is the ability of this weed to tolerate this herbicide. Nutgrass grew luxuriantly in areas which one year before received 12.5 lb/A of this material while red clover and timothy were completely eliminated. In a similar test in a nearby potato field, atrazine was used at 21 pounds per acre. A dense stand of nutgrass developed and looked like an untreated area except for no potatoes.

An ample supply of moisture seems necessary for the activation of atrazine. During 1961, with low rainfall in July, the post-emergent applications were not as effective as the pre-emergent ones in reducing crabgrass and redroot.

Competition from corn and weeds is a bigger factor in reducing nutgrass than is the use of atrazine. It is probable that when moisture conditions are ideal, atrazine complements the depressing effect of corn on nutgrass yield and therefore contributes to the control of this weed.

Use of 5 or more pounds of atrazine per acre may cause difficulty in the establishment of a forage seeding.

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WEED CONTROL IN FIELD CORN WITH ATRAZINE, EPTAM, AND TILLAM.

J. T. Kitchin, R. F. Lucey, and K. B. Kennedy[1]

INTRODUCTION

New Hampshire farmers have been unsuccessful in attempts to control nutgrass in field corn by cultivation. In observational trials, Eptam at 4 and 6 pounds active ingredient per acre satisfactorily controlled this weed in each of the three successive seasons (1958 - 1960) (2). No depression in yield had been apparent from visual observation, but yield data were not taken. Vengris (3) reported stunting to corn from 6 and 8 pounds Eptam per acre, but no reduction in yield accompanied the stunting. With both herbicides soil incorporated, Fertig (1) found 4 and 6 pounds of Eptam to be more effective in controlling nutgrass than 2, 4, 6, or 8 pounds of Atrazine. He found Atrazine to be more effective when applied post-emergence to the nutgrass.

At the outset this study was an attempt to evaluate the comparative effectiveness of Atrazine, Eptam, and Tillam in controlling nutgrass, and to measure their influence upon yield of corn. During the season, other weeds, including yellow rocket, wild mustard, red rooted pigweed, horsetail, etc., became so numerous in some plots that weed control ratings were made for over-all weed control including nutgrass, rather than just for nutgrass. In view of Fertig's findings, it was decided to use Atrazine pre-emergence and post-emergence, but not as a pre-plant treatment. Tillam is less toxic than Eptam to many plants and was included to see if corn yield would be higher with Tillam than with Eptam.

PROCEDURE

The plots, in a randomized block design with four replications, were located in a nutgrass infested field in North Haverhill, New Hampshire. The soil is a Hadley very fine sandy loam (highbottom phase). Each plot was 20 feet by 40 feet. Eptam and Tillam were incorporated into the previously plowed and harrowed soil on May 19 by roto-tilling in two directions with garden tractor roto-tillers. New England 420 field corn was planted on May 21. Pre-emergence treatments were applied May 25 and post-emergence treatments on June 12. For the period May 15 to June 15, rains in the amount stated occurred on the following dates: (May 20 - .13"), May 21 - .05", May 22 - 1", May 27 - .12", May 29 - .47", (June 2 - 1.53"), June 8 - .65", (June 10 - 1.02"), and (June 13 - 1.25"). Those enclosed within parentheses occurred as thunder storms. Harvest was made on September 9, 1961. Yield data were obtained from the center 20 feet of the two center rows of each plot. Treatment descriptions are given in Table 1.

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RESULTS AND DISCUSSION

On June 15, it was apparent that Eptam had given good control of nutgrass. Tillam at 4 or 6 pounds per acre had not given as good control as 4 pounds Eptam. At this early date, the pre-emergence Atrazine treatments did not appear as good as the Eptam treatment, and the post-emergence Atrazine treatments exhibited no herbicidal affects. On June 29, the Tillam plots had an abundance of nutgrass, mustard, horsetail, and other weeds. Eptam had controlled nutgrass, but mustard was starting. Atrazine at 4 pounds per acre gave good nutgrass and broadleaf weed control; some horsetail plants were alive, but the apical meristems were injured.

By July 19, it became evident that Tillam would not give adequate control of grasses or broadleaved weeds. Eptam at 4 pounds per acre controlled nutgrass adequately, but some broadleaved weeds were present. All Atrazine treatments had resulted in adequate broadleaf weed control although some horsetail, barngrass, foxtail, and crabgrass were present. Four pounds Atrazine per acre was effective against nutgrass, but 2 pounds per acre was not adequate. Table 1 gives weed control ratings on July 19 and two dates following harvest in September.

Table 1. Herbicide Treatments and Weed Control Ratings.

Herbicide	Lbs./A Active	Applied	Weed Control Rating*		
			July 19	Sept. 9**	Sept. 15**
Atrazine	4	post-emergence	1.5	1.3	1.7
Atrazine	2	pre-emergence			
plus Atrazine	2	post-emergence	1.0	1.0	1.1
Atrazine	2	pre-emergence	1.5	1.4	2.6
Atrazine	2	post-emergence	1.5	2.0	2.6
Atrazine	4	pre-emergence	1.0	2.0	1.7
Eptam	4	pre-plant	1.0	1.8	2.5
Tillam	4	pre-plant	4.0	4.0	4.0
Tillam	6	pre-plant	3.5	3.3	3.5
None	0		5.0	5.0	5.0

* 1 is excellent weed control, 5 is no weed control.

** Sept. 9 and Sept. 15 ratings each made independently by a different senior author.

Two pounds of Atrazine applied pre-emergence plus a repeat application of an additional 2 pounds post-emergence gave the best weed control. Four pounds of Atrazine applied pre-emergence gave better weed control early in the season than an equal amount applied post-emergence, but for the whole season there seemed to be no real advantage for either pre- or post-emergence application. It is doubtful that the added weed control effectiveness of two applications is sufficient to justify the added time and extra management involved in two applications. Four pounds Eptam controlled nutgrass more effectively than two pounds Atrazine, but it did not control broadleaved weeds as well.

The green weight of silage corn for each treatment, in tons per acre, are given in Table 2. Green weight yields of all treatments except Tillam, 4 pounds per acre, were significantly larger at the 1% level than from the no herbicide check treatment. The Eptam treatment and all Atrazine treatments resulted in significantly (1%) larger green weight yields than the Tillam treatments and the check.

A sample of corn from each plot was oven dried and the percent dry matter calculated. Dry matter in tons per acre are given in Table 2. Each of the Atrazine treatments and the Eptam treatment had significantly (1%) larger dry matter yields than the no herbicide treatment and each of the Tillam treatments.

At harvest, the number of plants in the harvested area of each plot were counted. The mean number of plants per acre for all treatments was 21,800. No herbicide treatment significantly reduced the plant population.

Table 2. Effect of Herbicide Treatment upon Green Weight and Dry Weight of Corn.

Herbicide	Lbs./A Active	Applied	Tons per Acre Green Wt.	Dry Wt.
Atrazine	4	post-emergence	25.82	4.95
Atrazine	2	pre-emergence		
plus Atrazine	2	post-emergence	26.82	5.04
Atrazine	2	pre-emergence	27.09	5.33
Atrazine	2	post-emergence	25.95	5.23
Atrazine	4	pre-emergence	24.68	4.83
Eptam	4	pre-plant	23.96	4.68
Tillam	4	pre-plant	18.06	3.58
Tillam	6	pre-plant	20.24	3.80
None	0		16.38	3.54
	LSD - 1%		2.40	0.47
	LSD - 5%		1.77	0.35

SUMMARY

Atrazine, Eptam, and Tillam were used for weed control in corn in a field heavily infested with nutgrass. Four pounds of Atrazine per acre applied pre-emergence or post-emergence gave good nutgrass control and excellent broadleaf weed control. Two pounds of Atrazine pre-emergence followed by an additional 2 pounds post-emergence 18 days later gave excellent nutgrass and broadleaved weed control. Two pounds of Atrazine per acre resulted in better broadleaf weed control but not as good nutgrass control as 4 pounds Eptam. Tillam at 4 and 6 pounds per acre did not give adequate nutgrass or broadleaf weed control.

Each of the Atrazine treatments and the Eptam treatment resulted in significantly larger green weight yield and yield of dry matter than the Tillam treatments and the no herbicide treatment. None of the herbicide treatments significantly reduced the corn plant population.

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NUTGRASS CONTROL IN FIELD CORN [1]

R. H. Cole, C. D. Kasler and F. B. Springer, Jr. [2]

The objective of these investigations was to determine the rate of application of Atrazine (2-chloro-4-ethylamino-6-isopropylamino-s-triazine) and EPTC (ethyl N, N-di-n-propylthiolcarbamate) needed to control yellow nutgrass (<u>Cyperus esculentus</u> L.) in field corn. Comparisons were made between pre-emergence and post-emergence applications of Atrazine and liquid and granular applications of both herbicides.

Nutgrass control results with Atrazine and EPTC have previously been reported by Vengris (2, 3). The effect of these herbicides on corn and nutgrass plants has been investigated by Donnalley and Rahn (1).

Procedure

Two nutgrass control tests were conducted in 1961 at the University Substation Farm, Georgetown, Delaware, on a deep, well drained Norfolk sandy loam. In Test I a heavy rye-vetch cover was plowed down two weeks prior to planting and in Test II a rye cover was plowed down one month prior to planting. Fertilizers were used as indicated by soil tests to approximate yields of 100 bushels per acre. The plot size in Test I was 12 feet by 60 feet and in Test II, 12 feet by 30 feet. Hybrids with known performance were planted on the dates indicated in Table I.

Applications of pre-emergence treatments followed planting. Post-emergence treatments of Atrazine were made approximately three weeks following planting. Wettable powders and emulsifiable concentrates were applied in water with a bicycle sprayer. Granulars were applied with a hand shaker. EPTC was incorporated with a hand rake directly following application. The rainfall

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2. Assistant Professor, Research Fellow and Assistant Agronomist, respectively, University of Delaware. Mr. Springer is presently Technical Advisor, Central Chemical Corporation, Hagerstown, Maryland.

pattern following applications of herbicides was remarkably similar in both tests. There was sufficient precipitation for activation of herbicides and for rapid germination of the corn and weeds. Table I lists the rates, application dates and forms of the herbicides studied.

All plots were cultivated once after the first nutgrass ratings were recorded. Ratings of nutgrass and other weeds present were also recorded at harvest. In Test I the only weed identified at the time of the first ratings was nutgrass. There was a very light infestation of common crabgrass (Digitaria sanguinalis) and horse nettle (Solamum carolinense) in some plots by harvest time. In Test II the predominating grasses were nutgrass, crabgrass and goosegrass (Eleusine indica); and the predominating broadleaves were ragweed (Ambrosia artemisiifolia), pigweed (Amaranthus retroflexus) and morning glory (Ipomoea purpurea).

Results and Discussion

Test I: All of the weeds except nutgrass were initially controlled by a pre-emergence application of three pounds of Atrazine. Three weeks after planting, none of the Atrazine treatments were providing nutgrass control. The Atrazine plus EPTC treatment was giving virtually 100 percent nutgrass control on the same date.

One week following the post-emergence applications of Atrazine, the nutgrass plants began to die where a total of six pounds or more Atrazine were applied. Dying occurred somewhat earlier in the pre- plus the post-emergence treatments than in those where the application was totally pre-emergence. This could have resulted from the small amount of absorption from the leaf surface.[1] Six pounds of Atrazine were giving effective control when the seven-week ratings were taken. While the Atrazine had not prevented the germination of tubers, plants were killed when the food reserves in the tubers were depleted. A total application of nine or twelve pounds of Atrazine gave complete nutgrass control.

The Atrazine plus EPTC treatment had lost its complete, initial nutgrass control by the time of the seven-week ratings. By this time it was ranked as giving no better control than six pounds of Atrazine alone. The work of Rahn [1] would suggest that the dormant tubers, inhibited by the EPTC during the early weeks, were now viable.

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[1] E. M. Rahn. Personal correspondence. November, 1961.

Table I. Weed Control Ratings of Two Nutgrass Control Tests Conducted at Georgetown, Delaware, in 1961. (10 = perfect control, 0 = no control). Averages of two replications.

Test I: Planted April 25. Chemicals applied pre-emergence April 26 and post-emergence May 15, 1961.

Herbicide	Rate in Pounds (a.i. / Acre)		Nutgrass Ratings		Other Weeds at Harvest
	Pre-emergence	Post-emergence	Seven Weeks After Planting	At Harvest	
Atrazine (w.p.)	3	9	10.0	10.0	10.0
	3	6	10.0	10.0	10.0
	3	3	8.5	9.0	9.0
	6		7.5	9.5	9.0
Atrazine + EPTC (e.c.)	3 + 4		7.8 (1)	8.0	8.5
Atrazine	3		0.0	0.0	9.0

Test II. Planted May 5. Chemicals applied pre-emergence May 5 and post-emergence May 25, 1961.

Herbicide	Form	Rate in Pounds (a.i. per acre)		Nutgrass Ratings		Other Weeds at Harvest
		Pre-emergence	Post-emergence	Six Weeks After Planting	At Harvest	
Atrazine	Liquid	3		8.0	9.0	9.5
			3	8.5	9.0	9.2
	Granular(20 G.)	3		7.0	8.0	8.5
EPTC	Liquid	4		10.0 (1)	9.8	4.5
	Granular(5 G.)	4		10.0 (1)	9.5	5.2
No chemical				0.0	0.0	0.0

(1) EPTC corn injury symptoms

Ratings at the time of harvest, although generally higher, showed little change in the relationship of treatments.

Test II: All the nutgrass weed control ratings of comparable treatments recorded in this experiment were higher than those found in Test I. This was partially attributed to the less severe and less uniform nutgrass infestation found in this field. The area in which Test II was conducted was lower in organic matter than that of Test I which would condition the results to be expected from both chemicals.

Three pounds of Atrazine, pre-emergence or post-emergence, were effective in controlling nutgrass in this test. Granular Atrazine, however, gave less consistent and slightly less effective control than liquid applications.

Four pounds of EPTC gave excellent early control and highly effective control throughout the season. The nutgrass growth, such as that observed later in the summer in Test I, could have been suppressed in Test II by the shading effect of the tall broadleaves growing in the EPTC plots. Granular and liquid EPTC applications were equally effective. EPTC corn injury symptoms, twisting of about 10 percent of the plants, were observed in all plots.

Summary

Nine pounds of Atrazine were required for complete control of nutgrass in field corn. Three pounds were sufficient for effective control in one test area; however, six pounds were needed in another test area. Four pounds of EPTC provided effective nutgrass control, but corn injury symptoms were recorded in both tests.

The time of application (pre- vs. post-emergence) of Atrazine was less important than the rate of application.

Granular Atrazine gave slightly less effective and less consistent control than its liquid counterpart. No important differences were observed between granular and liquid EPTC treatments.

Acknowledgement

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THE RESPONSE OF NUTGRASS TO HERBICIDES APPLIED AT VARYING STAGES OF GROWTH[1]

P. W. Santelmann and J. A. Meade[2]

In recent years Nutgrass (Cyperus esculentus L.) has become more prevalent in Maryland. There have been several reports published on nutgrass control and a regional bulletin is in press describing the life history and reproductive capabilities of this weed. This paper is an extension of this work in Maryland.

The promising chemicals currently available are adaptable only to nutgrass growing in corn and potatoes. Hence, the following work has been limited to pre-planting, pre-emergence and post-emergence applications in corn fields in the Piedmont area of Maryland.

MATERIALS AND METHODS

The materials were applied in all three years (1959, 1960 and 1961) with a bicycle sprayer delivering 30 gpa. In 1959 and 1960 the pre-planting materials were incorporated by cross-discing immediately at a depth of 3-4 inches. In 1961 a garden type roto-hoe was used. Rainfall data for the three years is listed in Table 1.

TABLE 1. Rainfall data (inches) for the years 1959, 1960 and 1961, at the location of the nutgrass control experiments.

May	1959	May	1960	June	1961
3	0.3	1	0.34	9	0.25
4	Pre-plant	8	1.50	10	1.58
11	Planting	9	1.03	14	0.96
12	0.41	12	0.50	15	0.13
13	0.85	18	0.25	20	All treatments except post-em
14	0.07	19	All treatments except post-em.	21	0.97
16	Pre-emergence	22	1.04	22	0.15
20	0.18	23	0.37	27	0.41
23	0.42	28	1.05		

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[1] Scientific Article No. A953 Contribution No. 3316, of the Maryland Agricultural Experiment Station, Department of Agronomy.

[2] Associate Professor and Assistant Professor, respectively. Department of Agronomy, Maryland Agricultural Experiment Station College Park, Maryland

Other information unique to one of the three years is listed below:

1959 - The pre-planting treatments of EPTC were applied on May 4. There were no plants visible at the time. The soil moisture was good. The corn was planted on May 11, and the pre-emergence treatments of EPTC and Atrazine were made on May 16.

Atrazine was applied again on June 4, to a different series of plots. At this time the corn was 8 inches tall and the nutgrass was 4-5 inches tall.

1960 - The pre-planting treatments of EPTC, R-1607 and R-2060, all materials of the Stauffer Chemical Company, were applied on May 19. The soil moisture was good. The corn (Conn. 870) was planted and Atrazine applied as a pre-emergence spray on the same day.

Post-emergence treatments of Atrazine were made on two dates in a separate experiment. The first treatment was made on June 9. The corn was 8 inches tall, nutgrass was 3-5 inches in height and in the 6 to 8 leaf stage.

On the second date of treatment, June 22, the corn was 15 inches tall and the nutgrass 8-10 inches with 9 leaves.

1961 - The pre-planting treatments of EPTC, Tillam, and R-1870 and the pre-emergence treatments of Atrazine and G - 34162 from The Geigy Chemical Company were applied on June 20. An extremely wet, cold spring was responsible for the late planting date.

Atrazine as a post-emergence treatment was applied on July 7. The corn was 8 inches tall. The nutgrass was 2 inches high with 3 leaves present. There were some old, established plants present which were 6 inches tall with 6 leaves.

RESULTS

The ratings of Nutgrass control and yield of corn are listed in Tables 2, 3, 4 and 5. The ratings on each date are the average of 4 replications. The yield figure was obtained by harvesting a single row and converting to bushels per acre of No. 2 shelled corn at 15.5% moisture.

1959 - The results as listed in Table 2, show that EPTC at 4 and 6 pounds per acre as a pre-plant treatment gave good early control but at harvest time there was considerable nutgrass present. The use of EPTC as a pre-emergence treatment did not satisfactorily control nutgrass.

As a pre-emergence treatment Atrazine at 2 pounds did not control the weed but at 4 and 8 pounds good control was obtained. The 4 and 8 pounds of Atrazine applied post-emergence performed well throughout the season. There were no significant differences in the yields obtained.

TABLE 2. Ratings of Nutgrass Control and yield of corn for 1959.

Treatment	Rate lbs/acre	Time	Date of Rating * 6/4	6/17	10/8	yield Bu/acre
EPTC	4	Pre-plant	9	8	0	110
EPTC	6	Pre-plant	9	10	2	92
.....						
EPTC	4	Pre-em	3	2	0	108
EPTC	6	Pre-em	3	1	0	102
.....						
Atrazine	2	Pre-em	3	5	2	110
Atrazine	4	Pre-em	4	8	7	103
Atrazine	8	Pre-em	5	9	8	112
.....						
Atrazine	4	Post-em	-	9	6	99
Atrazine	8	Post-em	-	10	10	104
Check	-	-	0	0	0	107

* Ratings on a scale of 0 = no control, 10 = complete kill

TABLE 3. Ratings of Nutgrass control and yield of corn for pre-planting and pre-emergence treatments in 1960.

Treatment	Rate lbs/acre	Time	Date of Rating * 6/22	8/4	10/6	yield bu/acre
EPTC	3	Pre-plant	7	5	4	116
EPTC	6	Pre-plant	6	3	3	110
.....						
R-1607	3	Pre-plant	7	7	5	102
R-1607	6	Pre-plant	4	2	4	113
.....						
R-2060	3	Pre-plant	2	0	1	94
R-2060	6	Pre-plant	5	4	5	111
.....						
Atrazine	3	Pre-em	6	6	5	106
Atrazine	6.5	Pre-em	7	8	9	104
Atrazine	9.5	Pre-em	9	9	9	119
Check	-	-	0	0	0	90

1960 - The EPTC applied pre-planting, as shown in Table 3, had about the same pattern of control as indicated for 1959. Good early season control was obtained but this control faded somewhat at the end of the season. Two analogs of EPTC, R-1607 and R-2060, were also included in the pre-planting applications. Of these the R-2060 was considerably less active than EPTC but the R-1607 was as effective or perhaps a little more so.

Atrazine as a pre-emergence treatment did not control the nutgrass adequately at 3 pounds. However, at 6.5 or 9.5 pounds season long control was obtained. There were no significant differences in yield between treatments in the pre-emergence experiment.

In a separate experiment Atrazine was used at 2, 4, and 6 pounds at two stages of nutgrass growth. The results as shown in Table 4 indicate that at stage 1, when nutgrass was 3 to 5 inches tall, 2 pounds of Atrazine did a fair job of control but was not entirely satisfactory. The 4 and 6 pound treatments were satisfactory the entire season. The application of 2 pounds of Atrazine at stage 2 did not control the nutgrass, and 4 pounds did not give season long control. The nutgrass at time of treatment of stage 2 was 8 to 10 inches tall. The 6 pound application on this mature nutgrass resulted in excellent control.

TABLE 4. Ratings of Nutgrass control and yield of corn for post-emergence treatments at two stages of growth in 1960.

Treatment	Rate lbs/acre	Date of Rating * 7/7	8/4	10/6	yield bu/acre
		Nutgrass 3 - 5 inches			
Atrazine	2	7	4	3	125.8
Atrazine	4	10	10	8	134.0
Atrazine	6	10	10	10	130.2
		Nutgrass 8 - 10 inches			
Atrazine	2	3	2	2	119.5
Atrazine	4	7	8	4	123.8
Atrazine	6	8	9	9	133.4
Check	-	0	0	0	97.2

LSD_{05} = 29.2

LSD_{01} = 39.3

* Ratings on a scale of 0 = no control, 10 = complete kill

All treatments produced significantly higher yields than the check except for 2 pounds of Atrazine at stage 2.

<u>1961</u> - As indicated in Table 5, this was an excellent year for Nutgrass control. The pre-planting treatments of EPTC, Tillam, and R-1870 all gave good control of nutgrass for the entire season. The EPTC at 6 pounds, however, significantly lowered the yield of corn. All other materials significantly increased the yield. On the basis of yield and weed control it would appear that R-1870 is the most promising chemical in this group.

TABLE 5. Ratings of Nutgrass Control and yield of corn for 1961.

Treatment	Rate lbs/acre	Time	Date of Ratings * 7/10	8/10	10/31	yield bu/acre
EPTC	3	Pre-plant	8	9	8	84.1
EPTC	6	Pre-plant	8	7	10	49.6
Tillam	3	Pre-plant	8	2	3	86.2
Tillam	6	Pre-plant	10	9	7	89.6
R-1870	3	Pre-plant	6	8	7	91.4
R-1870	6	Pre-plant	9	10	8	87.1
Atrazine	4	Pre-em	10	10	10	91.8
G-34162	4	Pre-em	10	7	10	80.7
Atrazine	3	Post-em	-	9	10	98.4
Atrazine	4	Post-em	-	10	10	100.0
Atrazine	5	Post-em	-	10	10	86.9
Check	-	-	0	0	0	69.0

LSD_{05} = 14.5

LSD_{01} = 19.6

* Ratings on a scale of 0 = no control, 10 = complete kill

The pre-emergence treatment of Atrazine at 4 pounds provided good control and resulted in a significantly higher yield than the check. Another Geigy material (G-34162) at 4 pounds per acre gave good nutgrass control but there was corn injury evident in the plots.

Atrazine applied as a post-emergence treatment when the nutgrass was 2 inches high with some old plants up to 6 inches resulted in excellent control at 3, 4 and 5 pounds per acre. The yields were significantly increased at all rates.

SUMMARY

The results of three years of work with nutgrass control chemicals indicates that the carbamate materials have promise. The use of EPTC at 6 pounds did result in decreased yields in 1961 but the R-1870 used in 1961 appears to be very promising. The advantage of these materials is that they do not have a residue problem in the suceeding crop.

As many investigators have shown, the use of Atrazine at rates exceeding 2 pounds precludes the growing of anything but corn the following year. In order to obtain satisfactory nutgrass control with Atrazine a rate of 4 pounds pre-emergence or post-emergence is necessary. If a nutgrass stand does appear in corn then 4 pounds as a post-emergence treatment will give excellent control.

WEED CONTROL IN CORN

S. M. Raleigh[1]

The pre- and post-emergence weed control corn plots were planted with a four row corn planter. The center two rows were treated. The plots were 6 x 20 feet each with 3 replications. The plots reported in Tables I and II were never cultivated.

Table I. Percent broadleaf control with pre-emergence herbicides
Planted--June 7; Sprayed--June 12 and 13

Chemical	Rate	Low rate	Medium rate	High rate
Atrazine 80W	1,2,3 (lb/A)	86	98	100
Atrazine 20g	1,2,3 (lb/A)	83	93	100
Atrazine 8g	1,2,3 (lb/A)	81	97	100
Simazine 80W	1,2,3 (lb/A)	83	96	100
Simazine 4g	1,2,3 (lb/A)	73	93	97
LV4 2,4-D	1,2,3 (lb/A)	60	83	93
20% 2,4-D granular	1,2,3 (lb/A)	53	78	91
Randox T	2,4,6 (qt/A)	20	75	83
Randox	2,4,6 (qt/A)	20	43	83
Upjohn U4513	2,4,6 (lb/A)	43*	27*	47*
Calcium formate	10,20,30 (lb/A)	0	0	0

* These weeds were all ragweed, other broadleaf weeds and grasses were killed.

The first seven treatments of Table I plus DuPont 326, Hercules 7531, Benvel D, Benvel T, Fenac, ACP 822 and 823 all at 1,2, and 3 pounds per acre were applied May 30 and 31. There were differences in weed control but all chemicals controlled weeds efficiently enough so cultivation eliminated them. At harvest nearly everything gave 100 percent control.

At low rates per acre the granular herbicides in the test gave poorer weed control than the same chemical applied as a liquid. At higher rates there were no differences.

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Table II. Percent control with post-emergence applications.

Chemical	Rate Lb/A	Low Broadleaf	Low Grass	Medium Broadleaf	Medium Grass	High Broadleaf	High Grass
Atrazine	1,2,3	93	77	98	93	100	65
Atrazine with wetting agent	1,2,3	95		99		100	
Geigy 34162	1,2,3	93	47	93	60	97	60
Geigy 32293	1,2,3	87	50	89	37	100	60
DuPont 326	1,2,3	95	40	99	95	100	73
LV-4 2,4-D	1/4, 1/2, 3/4	95	0	99	0	100	0

The percent weed control in Table II is from different tests. Neither field was cultivated. There were thick stands of annual broadleaf weeds where the broadleafs were sprayed and heavy stands of annual grasses in the other test.

All compounds killed the broadleaf weeds with the three different rates. DuPont 326 and Atrazine were best on the annual grasses. Atrazine is a little weak on crabgrass. The wetting agent added to Atrazine caused more rapid killing of the weeds. DuPont 326 must be applied as a directional spray.

EFFECTS OF WEEDS ON YIELD AND GROWTH CHARACTERISTICS OF FIELD CORN GROWN AT DIFFERENT NITROGEN LEVELS [1]

H. A. Collins and R. D. Ilnicki [2]

Abstract

That weeds compete with crop species as reflected by reductions in crop yield has been demonstrated by innumerable studies employing herbicides to control weeds; however, it is felt that additional basic information regarding the competitiveness of weeds is warranted if judicious use is to be made of our knowledge of herbicides.

Recognizing the need for additional fundamental information resulting from research if greater efficiency is to be obtained from herbicidal applications, a study was initiated in 1961 to determine the influence of varying densities of annual broadleaf and grass weeds at three nitrogen levels on the earliness of development of certain morphological characters and on the growth and yield of corn.

New Jersey #9 field corn was seeded to a sandy loam soil in hills 21 inches apart within rows spaced at 42 inch intervals. Individual plots were 4 rows in width and 12 hills in length, with yield data being taken from 8 hills of the center two rows. Subsequent to the emergence of seedlings, the plant population was adjusted to 17,000 plants per acre.

Crabgrass (Digitaria sanguinalis) and pigweed (Amaranthus retroflexus) were seeded by hand to specific plots within the experimental area and subsequently were thinned to the desired density within an 18-inch wide band over the corn row. Weed densities corresponding to treatments included: (1) weed-free (2) 4 grass (monocotyledonous) weeds per linear foot (3) 12 grass weeds per linear foot (4) 4 broadleaf (dicotyledonous) weeds per linear foot, and (5) 12 broadleaf weeds per linear foot.

Nitrogen applications were made at rates of 50 and 150 pounds of nitrogen equivalent per acre utilizing ammonium nitrate fertilizer. Prior to seeding, a broadcast application of 0-20-20 fertilizer at the rate of 300 pounds per acre was made to the area which was followed by disking into the soil.

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1. Acknowledgement is made to Cooperative Grange League Federation, Inc. for their support of this study.

2. Research Assistant in Farm Crops, Rutgers University, the State University of New Jersey, and Associate Research Specialist, Rutgers University, respectively.

The experimental area received no tillage throughout the growing season, the weeds in the center 24 inch strips between rows being controlled by a directed spray application of atrazine at 2 pounds active ingredient per acre utilizing a knapsack type sprayer. The atrazine application was made as a post-emergence treatment with respect to weed development. Weeds not killed by the spray were either removed by hand or by hand hoeing.

Periodic inspections of all plots were made to maintain the desired weed population and to remove undesirable weeds.

Data were collected during the season on the following: plant height, ear shoot emergence, silk emergence, ear height, tassel emergence, pollen maturity, and grain yield.

Corn Height:

The mean corn height (vertical distance from the soil surface to the tip of the highest extended leaf) was not significantly influenced by broadleaf or grass weeds during the season; however, there was a definite tendency for the broadleaf weeds to reduce the mean height of plants more so than grass weeds. Nitrogen significantly increased the mean height of corn. This was especially apparent during the latter part of the growing season.

Ear Emergence:

Broadleaf weeds significantly delayed ear shoot emergence, however, grass weeds apparently had no effect. Nitrogen was influential in inducing earliness of ear shoot development.

Silk Emergence:

Broadleaf weeds significantly delayed silk emergence, whereas grass weeds did not. Nitrogen stimulated the earliness of silk development to a significant extent over that of plots receiving no nitrogen.

Ear Height:

The mean ear height (vertical height from soil surface to ear attachment node) of corn plants was unaffected by weed type or density, however, the mean ear height within nitrogen plots was significantly greater than those of plots receiving no nitrogen.

Tassel Emergence:

Braodleaf and grass weeds apparently exerted no influence on the earliness of tassel emergence, however, nitrogen applications significantly stimulated the earliness of tassel emergence over plots receiving no nitrogen.

Pollen Maturity:

Broadleaf weeds tended to delay pollen maturity (pollen shedding) whereas grass weeds apparently had no effect. Nitrogen applications significantly stimulated the earliness of pollen maturity.

Yield:

The yield of corn in bushels per acre at 15.5% moisture was significantly reduced by broadleaf weeds at both levels of weed infestations over that of weed-free or grass infested plots which did not differ significantly from one another. Dry matter production of weeds per acre was closely associated with corn yield. The dry matter production of grass weeds per acre was significantly less than the production of broadleaf weeds. Corn yield was significantly increased by application of nitrogen.

VARIATION IN THE FLOW RATE OF GRANULAR APPLICATORS[1]

N. C. Glaze, J. A. Meade and P. W. Santelmann[2]

Granular herbicides are increasing in importance in the eastern United States, as is evidenced by increasing sales of this form of herbicides. However, there has been considerable question as to the efficiency of the machines used to apply the granular particles. This is one of the main problems confronting those who would rather use the granular forms of herbicides. The importance of the problem is becoming more acute as herbicide formulators make granular materials more concentrated, particularly where the rates applied per acre are very low. This experiment was set up to determine if there is variability in commercial granular applicators.

Materials and Methods

Four different granular applicators were compared. Two of these machines were row crop applicators and two were of the lawn spreader type. All were the most recent models of machines widely available on the market. They were as follows:

Applicator 1 - A row crop herbicide applicator, planter mounted, ground driven, 2 row type, the output regulated by a dial on the rear of the hopper which moved a plate on the bottom of the hopper and adjusted the hopper openings, with a flanged force feed rotor bar (agitator) inside the hopper at the base, the flanges traversing the full width of the hopper.

Applicator 2 - Similar to Applicator 1 except that the flanged agitator bar inside the hopper did not traverse the full hopper width. The flanges only covered the immediate area of the outlet holes.

Spreader 1 - A standard 2 wheel, oblong hopper lawn spreader, with the outlet holes covered on the outside of the hopper by a base plate. In operation the plate moves to the rear to open the holes. The output is regulated (by means of a calibrated plate on the hopper) by the distance the base plate is moved.

Spreader 2 - Similar to Spreader 1 except that the output is regulated by a dial at the upper end of the handle. This limits the degree to which the handle can be turned to open the holes in the base of the hopper. The base plate moves to the side to open the outlet holes, rather than to the rear.

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[1] Scientific Article No. A952 Contribution No. 3315, of the Maryland Agricultural Experiment Station, Department of Agronomy.

[2] Graduate Assistant, Assistant Professor and Associate Professor, respectively, Department of Agronomy, Maryland Agricultural Experiment Station, College Park, Maryland.

The applicators were tested under the conditions which would be encountered in normal practice. The row crop applicators were mounted on a planter and tested on level land that had been worked and leveled as for corn planting. The planter shoes were run in the soil. The lawn spreaders were tested on a bluegrass lawn.

The granules distributed by the row crop applicators, were collected by placing the delivery tubes into bottles and the material collected was weighed. The output of each delivery tube was collected and recorded separately so that it woulc be determined if there was a difference in the rate of delivery. A calibration box was designed to collect the herbicide delivered by the lawn spreaders. The settings on the applicators were not changed during the course of the experiment. The length of each run was 150 feet for the row crop applicators and 75 feet for the lawn spreaders.

The variables were:

(1) Three granule sizes - 30/60 granule size 10% 2,4-D; 24/48 granule size 10% DNBP; and 15/30 granule size 20% CIPC.

(2) Three speeds (2, 4 and 6 mph) for the row crop applicators or two speeds (2 and 3 mph) for the lawn spreaders.

(3) Three levels of material in the hopper (¼ full, ½ full or full) The materials used for the different granule sizes were commercial herbicides on attaclay.

For the field applicators the tachometer on the tractor was used as the standard and the tractor was run in the lowest gear which would attain the desired speed, so that each speed would be as constant as possible. A speedometer was mounted on the lawn spreaders so that the speed could be determined and maintained as a constant. Four repetitions were made with each variable, and the data statistically analyzed.

RESULTS AND DISCUSSION

The different applicators used varied in different ways and so each will be discussed separately.

Applicator 1

The weight of material delivered by the machine decreased as the speed was increased. This might be explained in that once the material is carried over the opening it becomes a matter of gravity feed and the faster the rotor bar is turning the less material will be able to pass through the opening before the next blade will sweep away what is left. The left delivery tube yielded significantly greater amounts than the right side.

The effect of particle size was highly significant with most of the difference being between the 15/30 size and the two smaller sizes. A sharp decrease in the amount of material delivered occurred between the 15/30 size particle and the 24/48, and then there was a slight increase to the 30/60 granule size.

Table 1. The effect of speed, particle size and degree of hopper fullness on the amount of granular material (in gms) delivered by Applicator 1*.

Particle Size	Degree of Hopper Fullness ¼ full	½ full	Full
		2 mph	
15/30	116.4 a	112.5 a	113.8 a
24/48	134.9 de	131.4 de	129.8 cd
30/60	133.1 de	126.0 bc	122.5 b
		4 mph	
15/30	70.8 b	66.0 a	69.3 ab
24/48	82.6 cd	83.6 cd	81.6 cd
30/60	85.5 d	82.6 cd	79.5 c
		6 mph	
15/30	53.6 b	46.5 a	49.4 a
24/48	58.1 c	58.9 c	56.9 bc
30/60	57.3 bc	58.5 c	55.6 bc

* numbers followed by the same letter within any one speed are not significantly different from each other.

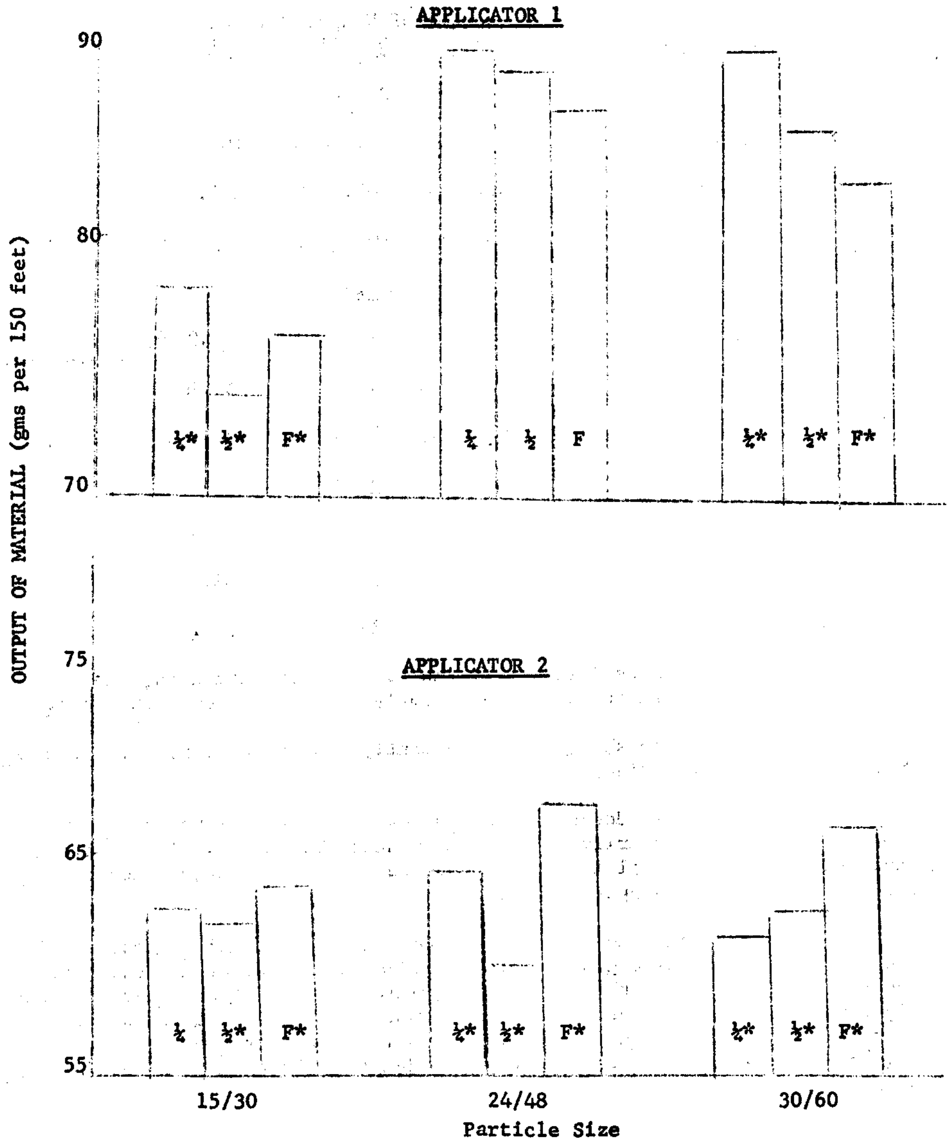
As shown in Figure 1, the degree to which the hopper was filled made a significant difference in the amount of granules delivered, with the amount delivered generally decreasing as the hopper varied from ¼-full to full. With the 15/30 material, the ½-full hopper had the least output.

Speed had a significant effect on the output of the different particle sizes (Table 1), usually the 24/48 particle size having the highest delivery rate while the 30/30 particle size fell between it and the 15/30 size. The 15/30 particle size output was significantly lower than the smaller sizes at all speeds.

Applicator 2.

Output variation due to particle size was not as great as in the previous instance and the yield of the 30/60 particle size fell almost midway between the 15/30 and the 24/48.

Figure 1. The effect of particle size and degree of hopper filling (¼ full, ½ full or Full) on the output of 2 granular applicators.



* indicates the columns are significantly different from each other

Table 2. The effect of speed, particle size and degree of hopper filling on the amount of granular material (in gms) delivered by Applicator 2*.

Particle size	Degree of Hopper Fullness ¼ full	½ full	Full
		2 mph	
15/30	103.3 b	101.8 ab	108.6 c
24/48	109.6 cd	101.1 ab	112.6 d
30/60	98.5 a	102.1 ab	108.8 c
		4 mph	
15/30	50.8 ab	50.0 ab	49.9 ab
24/48	51.6 abc	49.1 a	56.6 d
30/60	52.1 abc	53.5 bcd	55.0 cd
		6 mph	
15/30	36.1 a	35.5 a	36.0 a
24/48	34.5 a	34.6 a	37.8 a
30/60	37.0 a	36.3 a	38.1 a

* numbers followed by the same letter within any one speed are not significantly different from each other.

This applicator also showed a significantly higher delivery rate from the left side than from the right.

The output generally decreased as the level of material in the hopper decreased, but not necessarily in a linear manner (Figure 1). A significant granule size x hopper level interaction showed that the granule sizes did not react the same for all hopper levels.

Different particle sizes did not act the same way at all speeds. As is shown in Table 2 the 30/60 granule size yielded the lowest of all sizes at 2 mph (¼ full) but almost the highest at 4 mph. The effect was mainly linear. A significant speed x hopper level interaction showed that the output of the different hopper levels did not act in the same manner for the different speeds. The ¼ hopper level output consistently fell between the output of the full and ½ hopper levels.

Spreader 1

On this spreader only the main effects were significantly different and all were linear in effect. The output was inversely proportional to the speed, as seen with the previous applicators. As the particle size became smaller there was a consistant increase in the application rate of the spreader (Table 3). Also the amount delivered decreased as the level of material in the hopper was lessened (Figure 2). The lack of statistical significance between the columns in Figure 2 for the 15/30 granule size is due to the wide variation in the amount of material delivered in different runs with all variables constant.

Table 3. The effect of speed, particle size and degree of hopper filling on the amount of granular material (in gms) delivered by Spreader 1*.

	Degree of Hopper Fullness		
Particle Size	¼ full	½ full	Full
		2 mph	
15/30	441.8 a	516.3 b	538.8 b
24/48	553.3 b	545.0 b	610.8 c
30/60	642.5 c	609.3 c	613.0 c
		3 mph	
15/30	362.5 a	384.0 ab	417.8 bc
24/48	453.5 cd	444.3 cd	476.3 d
30/60	491.0 d	568.0 e	563.0 e

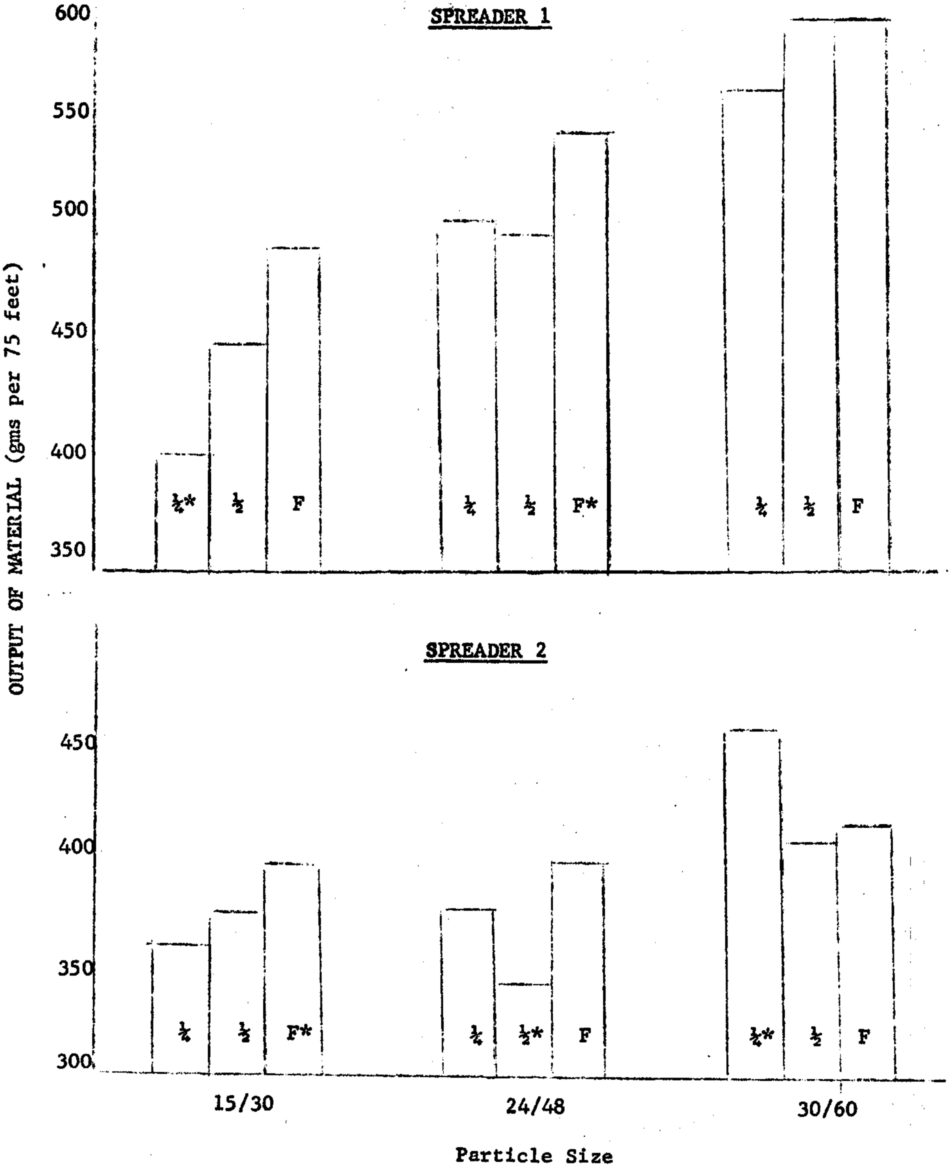
* numbers followed by the same letter at any one speed are not significantly different from each other.

Spreader 2

On this lawn spreader the three main effects were less linear in nature than with Spreader 1. There was again a decrease in the rate of application as the speed was increased. The amount delivered of each granule size showed a slight increase in going from the 15/30 to the 24/48 granule size and then a sharp increase when the 30/60 particle size was used. When the effect of hopper level was measured with the 24/48 particle size there was a sharp decrease in the amount metered by the spreader between the full and half hopper level, followed by a sharp increase to almost the full hopper rate at the quarter hopper level.

The interaction of granule size x hopper level showed that the granule sizes did not act in the same manner for all hopper levels, as shown in figure 2.

Figure 2. The effect of particle size and degree of hopper filling (¼ full, ½ full and Full) on the output of two lawn spreaders.



* Indicates this column is significantly different from the other two columns.

Table 4. The effect of speed, particle size and degree of hopper filling on the amount of granular material (in gms) delivered by Spreader 2*.

	Degree of Hopper Fullness		
Particle Size	¼ full	½ full	Full
		2 mph	
15/30	403.0 ab	394.5 ab	409.8 b
24/48	414.3 bc	369.0 a	450.3 cd
30/60	502.0 e	434.0 bc	484.0 de
		3 mph	
15/30	307.0 a	336.5 abc	357.5 bc
24/48	332.3 ab	309.3 a	342.3 abc
30/60	403.8 d	376.3 cd	340.3 abc

* numbers followed by the same letter at any one speed are not significantly different from each other.

The hopper levels again did not act in the same manner for the two speeds. The output of the full hopper was the highest at 2 mph but the middle value at 3 mph. The ½-hopper level output was the lowest throughout.

SUMMARY AND CONCLUSIONS

Four granular applicators were compared under conditions similar to those which would normally be encountered. The variation in the amount of granular material delivered by 2 field applicators and 2 lawn spreaders was measured; the variables being ground speed, particle size and amount of material in the hopper.

For all applicators tested, the output was inversely proportional to the speed of the machine. The various particle sizes reacted differently as the speed and hopper content changed. Also the variation within any one particle size was not consistant as speed and hopper content varied. The amount of material in the hopper had a significant, not necessarily linear, effect on the weight of granules delivered.

There was considerable variation between spreaders as to their reaction to a change in the speed, hopper content or particle size. In one applicator the output was inversely proportional to hopper content, in another it was directly proportional. There was also significant variation in the delivery rate of the left and right sides of the field applicators. For the lawn spreaders there was considerable variability in the amount of material delivered from one run to another at a constant speed, particle size and hopper content. This was true to a lesser degree with the field applicators.

THE EFFECT OF SEVERAL GRANULAR FORMULATIONS OF 2,4-D ON HERBICIDAL ACTIVITY

Thomas F. Tisdell and Richard D. Ilnicki [1]

Granular formulations of many herbicides have been available to research workers for several years. Some of these investigators report better weed control with the granular preparations (1) while others state that the liquid forms of certain herbicides are more satisfactory (3).

Previous work in New Jersey (2) indicated that a 10 per cent granular ester of 2,4-dichlorophenoxyacetic acid (2,4-D) gave better control than a 20 per cent ester. It was further observed and reported that a slow-breakdown particle resulted in a higher degree of control than fast disintegrating particles; however, more corn injury was also noted with the 10 per cent granular ester.

The present study was designed to further investigate these findings and to determine the effectiveness of several sizes of clay particles and two types of granule breakdown.

Methods and Materials

An experiment was conducted on a Sassafras sandy loam near Jamesburg, New Jersey. New Jersey No. 8 hybrid field corn was planted at the rate of four kernels per hill in 21-inch hills on May 17 and thinned to two plants per hill on June 19. The plots were four rows wide and 12 hills long. Herbicidal treatments listed in Table 1 were applied on May 18, using a bicycle sprayer for the liquid preparations and a hand applicator for the granular materials. The liquids were applied in 40 gpa using a pressure of 30 psi.

The experimental design was a factorial and with two formulations of 2,4-D (dimethylamine and iso-octyl ester), two types of attapulgite (Attaclay) carriers, two concentrations of the granulars, two rates of 2,4-D, and three mesh sizes of the granular carrier. Liquid preparations of the two formulations were included for comparison with the granular materials.

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[1] Formerly Research Assistant and Associate Research Specialist in Farm Crops, respectively, Rutgers the State University, New Brunswick, New Jersey.

Table 1: Herbicidal treatments used in the 2,4-D granular experiment.

Formulation	Granular concentration percentage	Breakdown type	Granular size, mesh	Rate lb/A
Amine	10	RVM (1)	30/60	1½
"	"	"	24/48	"
"	"	"	20/35	"
"	"	LVM (2)	30/60	"
"	"	"	24/48	"
"	"	"	20/35	"
"	20	RVM	30/60	"
"	"	"	24/48	"
"	"	"	20/35	"
"	"	LVM	30/60	"
"	"	"	24/48	"
"	"	"	20/35	"
Ester	10	RVM	30/60	"
"	"	"	24/48	"
"	"	"	20/35	"
"	"	LVM	30/60	"
"	"	"	24/48	"
"	"	"	20/35	"
"	20	RVM	30/60	"
"	"	"	24/48	"
"	"	"	20/35	"
"	"	LVM	30/60	"
"	"	"	24/48	"
"	"	"	20/35	"

1. Rapid disintegrating particles
2. Slow disintegrating particles

The treatments listed in Table 1 were also studied at three pounds per acre of 2,4-D. Cultivated and uncultivated check plots were included. There were three replications of all treatments. The cultivated check plots were hoed once during the season on June 19; however, due to inclement weather the treated plots were not cultivated at all.

Approximately five weeks after herbicidal applications were made, weed control and corn injury ratings were made by several independent observers using the scale 0 to 10, where 0 = no effect and 10 = complete control or kill. These data were transposed to square roots in order to permit more valid statistical analysis.

The corn was harvested from the two center rows on October 2 and 4. Yields were determined by obtaining ten butt samples and drying these to constant weight, then converting all field weights to 15.5 per cent moisture.

Results and Discussion

The principle weeds observed in the experimental area were barnyard grass (Echinochloa crusgalli) and lambsquarters (Chenopodium album).

The weed control data expressed as square roots for the three granular sizes for the two particle breakdown types and at the two rates of herbicidal application are presented in Figure 1. It can be seen that the material carried on the 30/60 size of the RVM type granular effected less weed control than that of the LVM granular type. The 24/48 size produced a higher level of control than the 30/60 size as RVM granulars, however, both sizes displayed comparable control with the LVM type.

When the various mesh sizes of the granular preparations were compared at the two rates, irrespective of granular breakdown or granular concentration, two interesting observations were made. Firstly, at the 1½ pound rate the 24/48 mesh size produced the highest level of control, the 20/35 mesh size produced the poorest control, and the 30/60 size was intermediate. Secondly, the inherent differences observed at the lower rate of 2,4-D were obliterated at the three pound rate.

The effects of particle breakdown and granular concentration on weed control, irrespective of formulation and particle size, are presented in Figure 2. It can be seen that the 10 per cent concentration granular showed better weed control than the 20 per cent material with the RVM type. However, these two concentrations gave similar results with the LVM granular.

There was a slight difference in weed control in favor of the 10 per cent concentration at the high rate of 2,4-D. When these two concentrations were compared at the 1½ pound rate, the control was similar.

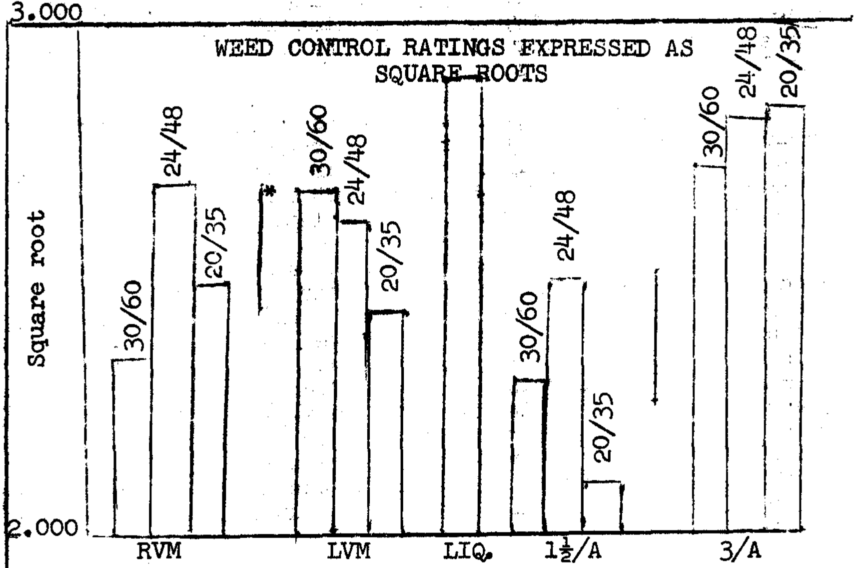

Fig. 1

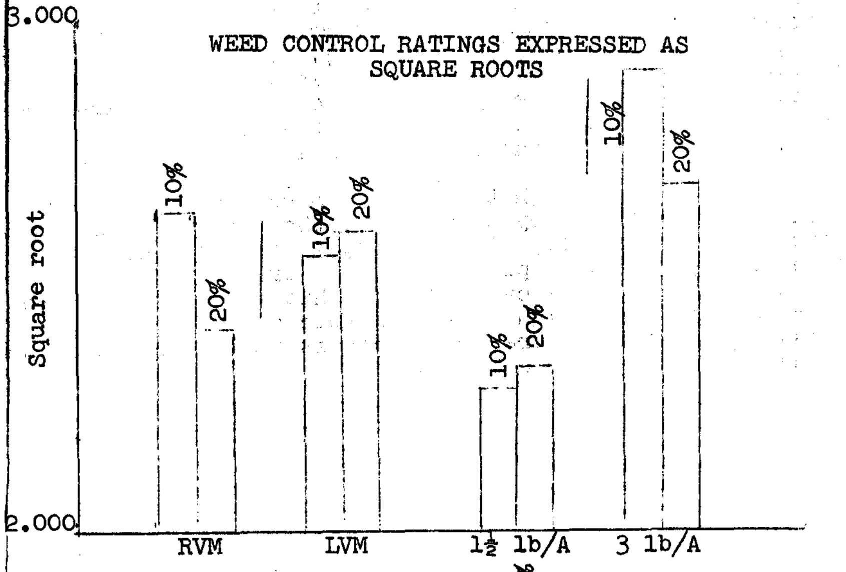

Fig. 2

* Distance required for significance at 5% level

The degree of corn injury obtained with the various particle sizes and breakdown types is graphically presented in Figure 3. The effect of granular size and rate of herbicidal application on the level of injury is also shown.

It is evident that there are no real differences among the various granular preparations with regard to size or breakdown. However, there is slight trend toward more corn injury with the higher rates of 2,4-D. Although not shown, the amine gave slightly more injury than the ester formulation.

In Figure 4 the effect of particle size, breakdown type, and rate of herbicidal application on the corn yields is illustrated. The yield presented for the liquid formulation is an average of the amine and ester and the two rates of 2,4-D. The differences among the various treatments were not statistically significant. Notwithstanding this lack of significance, there is an interesting trend toward higher yields with the 24/48 size granule at the 1½ pound rate. Although not represented in this figure, the ester formulation resulted in higher average yields than the amines. Generally the yields obtained with the liquids were higher than those with the granular treatments, but again the difference was not significant.

The poor weed control observed (in certain cases) with the 20/35 size may have been attributable to the smaller number of particles per unit area with this granule size. The same amount of herbicide was applied per unit area with all granular sizes; however, the 20/35 granular has approximately ¼ as many particles per given area as the 30/60 size (4). Thus with the larger size particle the herbicide distribution would be ¼ that of the 30/60 size. It could very well be that the 30/60 size particles would be subject to faster disintegration than the larger sizes. Therefore, accounting for the lower control with this size.

Notwithstanding that certain trends toward greater weed control and/or corn injury effected by the various granular carriers were not statistically significant, it is believed that with lower rates of herbicidal application these trends would be more clearly demonstrated. As was evidenced in this study, many expressions were masked at the high rate of herbicidal application. These expressions should be more pronounced at rates lower than the 1½ pound rate used in this study.

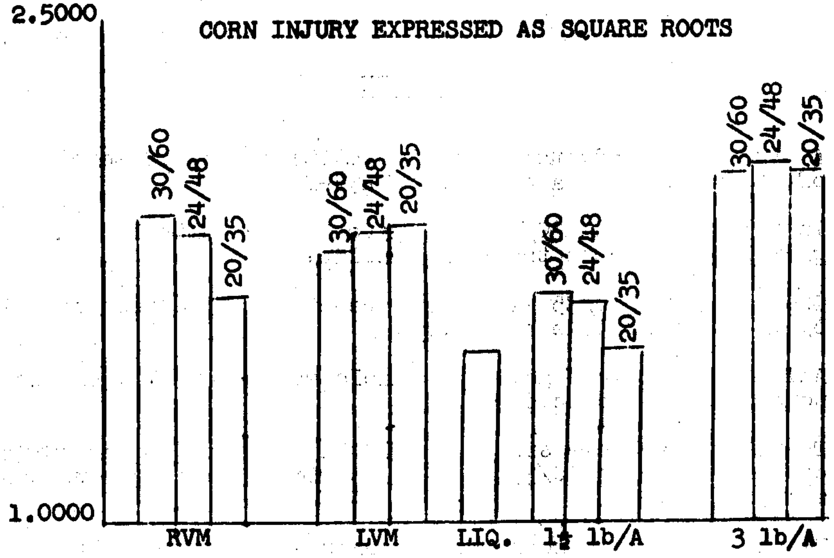
CORN INJURY EXPRESSED AS SQUARE ROOTS
2.5000
1.0000
30/60
24/48
20/35
30/60
24/48
20/35
30/60
24/48
20/35
30/60
24/48
20/35
RVM
LVM
LIQ. 1½ lb/A
3 lb/A

Fig. 3

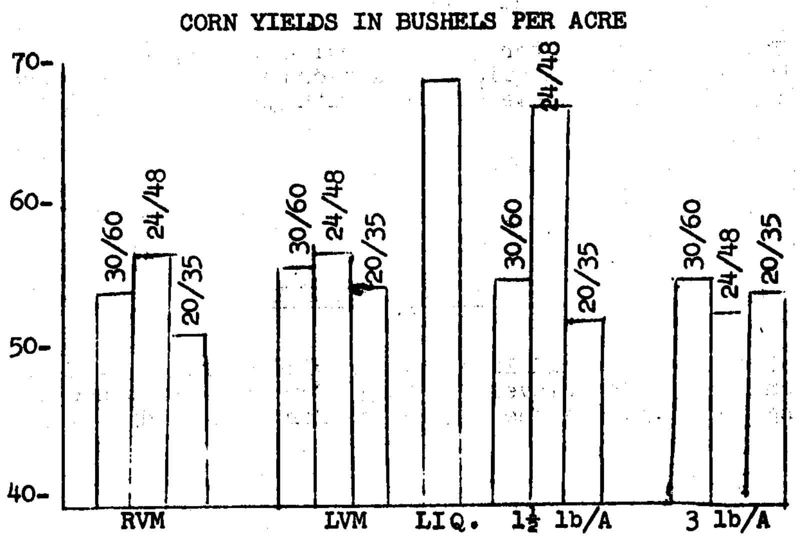
CORN YIELDS IN BUSHELS PER ACRE
70-
60-
50-
40-
30/60
24/48
20/35
30/60
24/48
20/35
30/60
24/48
20/35
30/60
24/48
20/35
RVM
LVM
LIQ. 1½ lb/A
3 lb/A

Fig. 4

SUMMARY

1. A study was conducted to evaluate the effect of several forms of attapulgite as a carrier of 2,4-D.
2. In this study the 30/60 size gave better control with the LVM granular than with the RVM granular.
3. The 24/48 and 20/35 sizes appeared to be affected very little by type of particle breakdown.
4. All granular sizes gave comparable weed control when the three pound rate was considered.
5. The 24/48 particle size resulted in a higher degree of weed control than the 20/35 size at the lower rate of herbicidal application.
6. The 10 per cent concentration granular produced better control than the 20 per cent concentration granular at the lower rate.
7. There was a slight trend towards higher yields with the 24/48 size at the $1\frac{1}{2}$ pound rate.
8. The somewhat greater weed control and lower corn injury obtained with the liquid formulations were not significantly different from those obtained with granular formulations.

ACKNOWLEDGEMENT

The authors would like to acknowledge Dr. R. J. Marrese of Diamond Alkali Co. Cleveland, Ohio, for his assistance in preparing and supplying the herbicides for this study.

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SELECTIVE WEED CONTROL IN CROPS WITH A NEW SUBSTITUTED UREA HERBICIDE[1]

G. D. Hill, A. W. Evans and R. W. Varner[2]

Introduction

Results from extensive laboratory and field studies have demonstrated that 3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea is a promising agricultural chemical for corn and soybean culture. This compound, coded as Herbicide 326, combines both post-emergence and pre-emergence herbicidal activity on annual weeds which permits marked departures from current weed control practices in crops. Such a versatile product provides the corn grower with a choice of two methods of weed control. For greatest economy, it may be desirable to use a rotary hoe and postpone the use of an herbicide until a weed problem develops in the corn field. Under such circumstances, Herbicide 326 as a directed post-emergence spray will eliminate most existing annual weeds and give residual control of weeds which germinate later. Where early protection is desired, application to the seed bed shortly after corn is planted will give pre-emergence control of germinating weeds.

Results from widespread tests on a range of soil types have demonstrated that Herbicide 326 will provide effective pre-emergence control of annual weeds with safety to soybeans. Good to excellent results have been obtained with pre-emergence and post-emergence applications of Herbicide 326 on carrots.

Herbicide 326 has a favorable pattern of disappearance from soil after the desired weed control period. Bioassays with oats have shown no detectable soil residues 3-4 months after treatment and fall-sown cover crops have grown normally.

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(1) Contribution from the Industrial and Biochemicals Department, E. I. du Pont de Nemours & Co., Inc., Wilmington, Delaware.

(2) The valuable assistance of L. E. Cowart, D. W. Finnerty, F. J. Otto, H. L. Ploeg, M. B. Weed and A. W. Welch of the du Pont Co., and commercial and institutional investigators is gratefully acknowledged.

3-(3,4-Dichlorophenyl)-1-methoxy-1-methylurea[3] under the trademark name of "Lorox" Weed Killer has received federal label registrations for pre- and post-emergence use in field corn grown for grain and pre-emergence use on soybeans grown for seed. "Lorox" Weed Killer, formulated as a 50% wettable powder, will be available for sale in limited quantities during 1962 for both crops.

Physical and Chemical Properties

Pure 3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea is a white crystalline solid (m.p. 93-94°C.) with a low vapor pressure. Its solubility in water is 75 ppm at 25°C. The compound is stable in water but decomposes slowly in acids and bases. It is subject to microbial decomposition under moist conditions in soil.

Toxicology and Residues

The approximate lethal dose (ALD) by oral administration to male white rats is 1500 mg./kg. body weight. While the chemical causes slight irritation to the skin and eyes, it is not a sensitizer. Long-term chronic studies are in the second year and the results indicate no toxicology problem. Analyses have demonstrated no residues in corn grain.

Pre- and Post-Emergence Weed Control in Corn

Summary data are now available from a total of 73 tests conducted over a two-year period in 21 states. Tests were conducted on different corn varieties and under representative conditions of soil type, weed growth, and weather conditions existing in the major corn-producing areas.

Results from pre-emergence tests show that soil type is the predominant factor in the selection of effective use rates. In the Corn Belt on silt loam and clay loam soils of moderate to high organic matter, effective control was obtained with rates of 2 to 3 pounds[4] per acre. No crop injury was obtained at twice

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(3) The du Pont Co. has proposed formally to the K-62 Committee of the American Standards Association that the term 'linuron' be established as the approved common (generic) name.

(4) All rates are expressed on an active ingredient basis.

these rates. On lighter soils, low in organic matter, which predominate outside the Corn Belt, rates of 3/4 to 1-1/4 pounds per acre gave effective weed control with an adequate safety margin.

Foliage sprays of Herbicide 326 are highly effective on growing annual plants. A selective effect is achieved by directing the spray nozzles to wet the growing portion of the weeds while avoiding the same on corn plants. This type of application has been most promising when the ~~corn was~~ at least 12 inches tall. When nozzles were mounted so that the spray struck only a few inches up the corn stalk, only superficial injury to the bottom leaves has been noted. Weeds up to 8 inches tall were controlled with 1-1/2 to 3 pounds per acre. These rates have provided adequate residual weed control on the various soil types prevalent in corn-growing areas. Established corn has shown a good margin of safety to directed post-emergence applications. In Corn Belt soils, where rates of 2 to 3 pounds per acre are recommended, rates up to 6 pounds have been non-injurious. In lighter soils, with recommended rates of 1-1/2 to 2 pounds per acre, 4 pounds has proven safe to corn. Spray volumes in the range of 30 gallons have performed well. Spray pressures of 40 p.s.i. or lower are recommended to prevent misting.

In most situations band treatments will be most economical. The weeds remaining in the middles can be removed by cultivating during the spray operation. The nozzles should be mounted ahead of the cultivator to eliminate weeds on the edge of the band. This procedure would reduce the amount of herbicide required by two-thirds.

The annual grasses and broadleaf weeds which have been controlled satisfactorily with recommended rates include foxtail (green, yellow and giant), crabgrass, barnyard grass or watergrass, smartweed, ragweed, purslane, lambs-quarters, pigweed, buttonweed and cocklebur.

Representative weed control results and yield data are contained in Tables 1 through 6.

Pre-Emergence Weed Control in Soybeans

Results from field tests during a two-year period at 30 locations in 12 states have demonstrated that Herbicide 326, applied at recommended rates, will provide effective pre-emergence weed control with adequate safety to soybeans. Tests were conducted under representative conditions of soil type, weed growth and weather existing in the major soybean-producing areas.

On silt loams and clay loams with moderate to high organic matter, commercial control was obtained with 1 to 2 pounds per acre with adequate safety margin. On lighter soils, low in organic matter, rates of 0.5 to 1 pound per acre were sufficient. Results from tests on lighter soils indicate that safety to soybeans increases when the depth of planting is increased from 1 inch to 2 inches. Representative weed control results and yield data are contained in Tables 7 through 9.

Pre- and Post-Emergence Weed Control in Carrots

Carrots have shown a high degree of tolerance to Herbicide 326. Satisfactory weed control has been obtained with 0.25 to 0.5 pound per acre for post-emergence treatments and from 0.5 to 3 pounds per acre pre-emergence depending on soil type.

Disappearance from Soil

The growth and evaluation of indicator crops is the most practical method for the determination of residual activity of herbicides in soils. This method was used to follow the rate of disappearance of Herbicide 326 under a wide variety of conditions on soil types ranging from sandy loams with low organic matter to heavy clay loams with a high organic matter content. Soil samples (0-4" and 4-8" depths) were taken from treated plots at 20 geographical locations in the United States. These areas encompassed the important corn and soybean-producing regions. These samples were compared with untreated samples from the same areas in oat assays in the greenhouse. Data were taken at 21-23 days after planting.

Results from these studies indicate that phytotoxic concentrations of Herbicide 326 disappear from the soil within 3 to 4 months after treatment, when used at rates of 1.5 pounds on sandy loams, 2 to 3 pounds on silt loam soils and 3 to 6 pounds per acre on heavy clay loams (medium to high organic matter). Thus, there should be no problem to the next crop.

Table 1. Weed Control Evaluations and Corn Yields Following Directed Post-Emergence Applications of Herbicide 326 - Midwest Corn Belt

Treatment	Rate Lb. Active Per Acre	Average Percent of Overall Weed Control and Mean Yields in Bushels Per Acre				
		Farm #1 6 Wks.	Farm #2 7 Wks.	Farm #3 3 Wks.	Farm #4 3 Wks.	Farm #5 3 Wks.
Herbicide 326[1/]	0.75	3 (92)[2/]	3 (35)	68 (95)	- -	60 (64)
"	1.5	37 (99)	65 (77)	87 (107)	72 (84)	75 (68)
"	3.0	83 (108)	92 (93)	90 (106)	78 (89)	83 (68)
"	6.0	93 (101)	97 (101)	95 (100)	87 (98)	95 (76)
Grower's Program[3/]	-	65 (105)	30 (87)	85 (85)	- (80)	75 (58)
Untreated Control	-	0 (79)	0 (13)	0 (65)	0 (56)	0 (40)

1/ Prairie soils: silt loam to silty clay loams. Three replications. None of the Herbicide 326 plots was cultivated. Broadcast treatments applied when corn was 12 to 22 inches tall and weeds were 2 to 9 inches tall. Weed species: watergrass, foxtail, butterprint, smartweed, cocklebur, crabgrass and annual morning glory.

2/ Yields in bushels per acre shown in parentheses.

3/ Grower's program generally consisted of 2 or 3 cultivations.

Table 2. Directed Post-Emergence Weed Control in Corn Du Pont Research Farm - Newark, Delaware

Material	Rate Lb./A (Active)	Percent Weed Control				Yield
		Grasses		Broadleaves		
		3 Wk.	9 Wk.	3 Wk.	9 Wk.	Bu./A
Herbicide 326	0.75	98	68	97	95	89
"	1.50	99	98	99	99	86
"	3.00	99	99	99	100	85
Hoed Control	-	98	95	98	45	81
Untreated Control	-	0	0	0	0	80

Keyport silt loam. Three replications. Corn 12" tall at time of treatment, weeds were 4" tall. No injury to corn. Weed species: crabgrass, Panicum, ragweed, smartweed, annual morning glory and horsenettle.

Table 3. Directed Post-Emergence Weed Control in Corn Du Pont Research Farm - Raleigh, N.C.

Material	Rate Lb./A (Active)	Percent Weed Control Weeks After Treatment		Crop Injury
		1	6	
Herbicide 326	0.75	80	63	No injury to corn.
"	1.50	97	99	
"	3.00	100	100	
Untreated Control	-	0	0	

Norfolk sandy loam. Three replications. Corn was knee-high and annual weeds were well established at time of treatment. Weed species: crabgrass, mustard, rape, millet and ryegrass.

Table 4. Pre-Emergence Weed Control in Corn
DeKalb, Illinois

Material	Rate Lb./A (Active)	Percent Weed Control 3 Wks.	5 Wks.	Yield Bu./A
Herbicide 326	1	81	56	87
"	2	90	84	94
"	4	99	90	111
Cultivated Control (3 cultivations)				101
Untreated Control	-	0	0	62

Clay loam. Three replications. Weed species: annual morning glory, smartweed, velvet leaf and Canada thistle.

Table 5. Pre-Emergence Weed Control in Corn
Du Pont Research Farm - Newark, Delaware

Material	Rate Lb./A (Active)	Percent Weed Control After 6 Weeks Grasses	Broadleaves	Yield Bu./A
Herbicide 326	0.75	96	100	90
"	1.50	99	100	89
"	3.00	100	100	84
Hoed Check	-	95	95	80
Untreated Control	-	0	0	42

Keyport silt loam. Three replications. Weed species: crabgrass, ragweed, smartweed, pigweed, Japanese millet and rape.

Table 6. Pre-Emergence Weed Control in Corn
Du Pont Research Farm - Raleigh, N.C.

Material	Rate Lb./A (Active)	Percent Weed Control After 4 Weeks	Yield Bu./A
Herbicide 326	0.5	92	61
"	1.0	98	59
"	2.0	99	59
"	3.0	100	59
Hoed Check	-		61
Untreated Control	-	0	47

Norfolk sandy loam. Three replications. Weed species: crabgrass, carpetweed, millet, mustard and rape. No significant

Table 7. Pre-Emergence Weed Control in Soybeans
Van Wert, Ohio

Material	Rate Lb./A (Active)	Percent Weed Control 4 Wks.	6 Wks.
Herbicide 326	1.0	66	73
"	2.0	97	96
"	4.0	99	97
Untreated Control	-	0	0

Brookston clay loam. Three replications. Weed species: foxtail, buttonweed, smartweed, barnyard grass, ragweed and pigweed. No injury to soybeans.

Table 8. Pre-Emergence Weed Control in Soybeans
Du Pont Research Farm - Newark, Delaware

Material	Rate Lb./A (Active)	Percent Weed Control After 4 Weeks Grasses	Broadleaves	Yield Bu./A
Herbicide 326	0.5	88	93	26
"	1.0	90	95	32
"	1.5	95	96	32
Hoed Check	-	98	98	28
Untreated Control	-	0	0	9

Keyport silt loam. Three replications. Weed species: crabgrass, Japanese millet, rape, pigweed, horsenettle and purslane.

Table 9. Pre-Emergence Weed Control in Soybeans
Du Pont Research Farm - Raleigh, N.C.

Material	Rate Lb./A (Active)	Percent Weed Control 3-1/2 Wks.	5-1/2 Wks.
Herbicide 326	0.5	92	47
"	1.0	98	88
"	1.5	99	97
"	3.0	100	99
Untreated Control	-	-	-

Norfolk sandy loam. Three replications. Soybeans planted 1-1/2 inches deep. Weed species: crabgrass, foxtail, pigweed, lambsquarters, ragweed and smartweed. No injury to soybeans.

TRIFLURALIN FOR PRE-EMERGENT WEED CONTROL IN AGRONOMIC CROPS[1]

S. J. Pieczarka, W. L. Wright, and E. F. Alder[2]

The herbicidal properties of trifluralin (2,6-dinitro-N,N-di-_n_-propyl-α,α,α-trifluoro-_p_-toluidine) have been investigated in the field and laboratory. Trifluralin appears promising as a selective pre-emergent annual grass and broadleaf herbicide for soybeans, lima beans, snapbeans, green peas, tobacco, peanuts and cotton. These crops have not shown injury from trifluralin applications as high as 8 pounds per acre, surface spray, or 4 pounds per acre, soil incorporated. Rates of 4-6 pounds per acre, surface spray, or 1-2 pounds per acre, soil incorporated, have given excellent annual grass and broadleaf weed control. Table 1 contains a list of weeds susceptible to trifluralin.

Table 1. Weed Species Susceptible to Trifluralin Surface Spray at 4-6 lb/A

Susceptible		Moderately Susceptible
Grass	Broadleaf	
Barnyardgrass	Carpetweed	Ragweed
Crabgrass	Chickweed, common	Smartweed
Foxtail	Lambsquarters	
Fall panicum	Pigweed	
Stinkgrass	Purslane	

Field Experiments

Surface Sprays -- A number of surface spray applications, both in-row and complete coverage, were conducted. A typical broad band

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1. Contribution of Eli Lilly and Co., Greenfield Laboratories, Greenfield, Indiana

2. Senior Plant Physiologist; Plant Physiologist; and Head, Plant Science Research; respectively

experiment is reported here. Trifluralin was applied to Clark and Harosoy soybeans with a Hahn Highboy sprayer. Plots were 5 by 25 feet, replicated 3 times. Trifluralin weed control results are given in Table 2. A rate of 1 pound per acre gave excellent grass weed control in this experiment but only fair broadleaf weed control. Four to 6 pounds per acre were necessary for good broadleaf weed control. Neither soybean variety was damaged by any of the treatments.

Table 2. Percent Weed Control in Soybeans with Trifluralin Surface Spray

Trifluralin	Percent Weed Control	
Lb/A	Grass[a]	Broadleaf[a]
1	93	56
2	96	84
4	99	88
6	99	96
0	0 (65.9)[b]	0 (2.5)[b]

[a] Grass weeds were crabgrass and foxtail; broadleaf weeds were pigweed and smartweed

[b] Number weeds per square foot

Soil Incorporation -- An experiment was conducted to determine if trifluralin activity is improved by soil incorporation. Trifluralin was sprayed on the soil surface with no incorporation, raked lightly into the soil, and pre-plant incorporated 2 inches deep. Herbicides were applied with a sulky rig to plots 3 by 15 feet, replicated 4 times. Soybeans, snapbeans, cotton, tomatoes, cabbage, and cucumbers were planted across the plots.

The results indicate that pre-plant soil incorporation of trifluralin increased herbicidal activity 4-6 times compared with the surface spray application (Table 3). One-half pound per acre of trifluralin pre-plant soil incorporated gave better weed control than 4 pounds per acre as a surface spray. Raked plots were intermediate in response. Cotton, soybeans, snapbeans and cabbage were tolerant to all treatments; tomatoes and cucumbers were not.

Table 3. The Effects of Different Soil Treatments on Preemergent Weed Control with Trifluralin

Trifluralin	Soil Treatment[a]	Percent Weed Control	
Lb/A		Grasses[b]	Broadleaves[b]
0.5	Surface Spray	29	4
1		66**	35
2		63**	52*
3		86**	61*
4		85**	44
0.5	Rake	63**	17
1		80**	4
2		78**	44*
3		95**	57*
4		89**	26
0.5	Pre-Plant	98**	70**
1		99**	57*
2		100**	87**
3		94**	87**
4		100**	65**
0	Control	0 (29.0) c/	0 (1.4) c/

a/ Soil Treatment: Surface spray=no incorporation; rake=soil incorporation by hand raking; pre-plant=soil incorporation with rotovator

b/ Grass weeds were crabgrass and foxtail; broadleaf weeds were pigweed and carpetweed

c/ Number weeds per square foot

With the demonstration of improved activity of trifluralin on soil incorporation, another experiment was conducted in which several common soil incorporation techniques were compared. Methods were: double disking once and twice; raking the soil surface; rotovation 2 and 4 inches deep; and rotovation 2 inches deep, delayed 6 hours after trifluralin application. Trifluralin surface spray was used for comparison. Plots were 5 by 15 feet, replicated 3 times. Crops planted across the plots included soybeans, snapbeans, peanuts, and cotton.

Results are given in Table 4. Rotovation was clearly the best method of soil incorporation. The order of activity was rotovation, raking, delayed rotovation, disking, surface spray. None of the crops were injured by any treatment.

Table 4. A Comparison of Soil Incorporation Methods with Trifluralin at 1 lb/A. Expressed as Percent Weed Control

Trifluralin 1 lb/A	Percent Weed Control	
Soil Treatment	Grasses	Pigweed
Surface	64*	26
Disk once	70*	63**
Disk twice	77**	52*
Rake	90**	86**
Rotovate-2"	97**	94**
Rotovate-4"	100**	96**
Rotovate-2", 6 hrs.	79**	83**
Control	0 (3.5)a/	0 (4.6)a/

* and ** significant at the 5 and 1 percent level, respectively, using the transormation $\sqrt{N+0.5}$

a/ Number of weeds per square foot

Laboratory Studies

Leaching studies were conducted with trifluralin to determine the rate of leaching from the soil surface and the depth of leaching in a soil column. Three soil types were used: Princeton fine sand, Brookston silty clay loam, and Houghton muck.

Leaching From Surface -- A measured quantity of soil was placed in number 2 cans provided with bottom drainage. The soil was flooded and allowed to drain 16 hours. The trifluralin was then applied at 2 pounds per acre to the soil surface and 1, 2, 4, 6, 8 or 10 inches of water was passed through the soil. Fresh weight of crabgrass plants grown from seed planted on the soil surface was used as a biological assay.

Table 5. The Leaching of Trifluralin at 2 lb/A from the Soil Surface, Expressed as Percent Reduction in Growth of Crabgrass

	Percent Reduction of Crabgrass Growth						
	Inches of Leach Water						
Soil Type	0	1	2	4	6	8	10
Princeton fine sand	99	97	96	97	96	84	90
Brookston silty clay loam	100	100	100	100	100	100	100
Houghton muck	91	90	85	79	80	74	74

The results are presented in Table 5. In the fine sand there was a slight reduction in the amount of herbicide present after the addition of 8 inches of water. Trifluralin did not leach from the surface of the silty clay loam. The 2 pounds per acre rate of trifluralin in Houghton muck was not sufficient to completely kill all the crabgrass, thus indicating adsorption of trifluralin on the soil. However, with added water, trifluralin did appear to leach slowly in muck.

Depth of Leaching -- To determine the depth to which trifluralin leaches in the soil profile, aluminum conduit was cut into segments. These were taped together to form an 18 inch column, filled with sand or loam, flooded with water, and drained. The herbicide was then applied and 10 inches of water was added to the soil column. After 24 hours the columns were separated and crabgrass was again used as a biological assay for trifluralin activity.

Table 6. The Depth to which Trifluralin Leached at 4 lb/A in Soil Columns with the Addition of Ten Inches of Water. Expressed as Percent Reduction in Growth of Crabgrass

	Percent Reduction of Crabgrass Growth							
	Depth of Soil Level (Inches)							
Soil Type	0	1	2	4	6	8	12	16
Princeton fine sand	100	100	83	34	31	29	4	7
Brookston silty clay loam	100	46	12	6	0	3	0	0

In Princeton fine sand, trifluralin leached to a depth of 8 inches, reducing subsequent crabgrass growth 29 percent at this depth (Table 6). In the silty clay loam, little activity was found below the 1 inch level. These results confirm the results from the previous experiment which indicated trifluralin did not leach from the surface in this soil.

Summary

Surface sprays of trifluralin gave excellent pre-emergent weed control at 4-6 pounds per acre with no damage to soybeans, snapbeans, lima beans, green peas, peanuts, and cotton. Soil incorporation increased activity 4-6 times over surface sprays. Rotovation proved superior to other incorporation methods. Trifluralin leached very slowly from the surface of sandy, silty clay loam, and muck soils. The compound leached to a greater depth in sand than in silty clay loam.

MODIFIED THIOLCARBAMATE HERBICIDES WITH BROADER UTILITY

R. D. Ilnicki, T. F. Tisdell, and R. W. Chase[1]

The thiolcarbamate herbicides are highly active especially when their volatility is reduced. Reductions in volatility have been obtained by incorporating them into the soil surface or by impregnating them on inert granular carriers which control their rate of release. The technique of incorporation or the use of inert carriers are not always desirable because of increased costs and the possible increased in crop injury. In this study several new formulations of two thiolcarbamate herbicides were evaluated for their activity. It was believed these formulations would permit spray applications without incorporation and give effective weed control with minimum crop injury.

Materials and Methods

High boiling hydrocarbon fractions were used as carriers for t-butyl di-n-propylthiolcarbamate (R-1856) and ethyl di-n-propylthiolcarbamate (EPTC). Two formulations of R-1856 (designated as EAP 4030 and 4031) and four formulations of EPTC (EAP 4000, 4001, 4002, and 4005) were prepared using select paraffinic hydrocarbon fractions having a carbon number above C_{18}. A lower boiling fraction was added to one EPTC blend (EAP 4005) to determine the effect of increased volatility in the base carrier. Two emulsifier systems were used. One was a fast-breaking one (EPTC - EAP 4000, 4002; R-1856 - EAP 4031), the other a slow-breaking one (EPTC - EAP 4001, 4005; R-1856 - EAP 4030). The hydrocarbon to herbicide ratio in one was 6:5 (EAP 4000), in the others the ratio was 4:5.

Details of the methods and the test crops used in evaluating these materials will be described below for each herbicide. All liquid preparations were applied in water with a bicycle sprayer delivering 40 gpa and the granular preparations were distributed with a hand applicator. Unless otherwise stated, all treatments were incorporated immediately after application. All rates were expressed in terms of the active ingredient per acre.

R-1856

This herbicide was evaluated for pre-emergence weed control in Thaxter baby lima beans and Clark soybeans at 4 and 6 pounds.

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[1] Associate Research Specialist in Weed Control; formerly

Included in the lima bean test were the standard formulations (R-1856 6E and 10G) and the experimental formulations EAP 4030 and EAP 4031. The design was a randomized block with three replications.

The soybean experiment was a split plot factorial with two replications. The main plot included rates of application and the subplots consisted of unincorporated and incorporated treatments of all formulations randomized completely.

EPTC

The experimental formulations were evaluated for weed control and crop tolerance in strawberries, corn, and soybeans.

The strawberry experiment included commercial EPTC (Eptam 6E and 5G) and the formulations EAP 4001 and EAP 4002. Rates of 3 and 6 pounds were used for the commercial EPTC but only the lower rate was used for the latter two materials. All treatments were applied in quadruplicate, in a randomized block design, 16 days after transplanting.

Included in the corn experiment were commercial EPTC (Eptam 6E and 5G) and experimental formulations EAP 4000 and EAP 4005 at rates of 3 and 5 pounds. The experimental design was a split plot factorial with three replications. The main plot included rate of application and the subplots consisted of unincorporated and incorporated treatments of all formulations randomized completely.

The soybean experiment was similar to the corn experiment in design. Rates of 4 and 6 pounds were applied in duplicate for the following formulations: Eptam 6E and 5G, EAP 4001 and EAP 4002.

Weed control and crop injury ratings were made periodically using the scale 0 to 10, where 0 = no effect, 10 = stand/vigor reduced 100% or complete kill. For the sake of brevity, details concerning planting, application, and observation dates have been omitted here. These may be found in the summary tables elsewhere.

Results and Discussion

In tables 1-5 are presented summaries of weed control and crop injury ratings for the experimental formulations of R-1856 and EPTC applied to the various test crops. For ease of discussion each thiolcarbamate herbicide will be discussed separately.

R-1856

In tables 1 and 2 summaries are presented for the baby lima data that EAP 4031 was 4-5 times more active than R-1856 6E or 10G on soybeans and lima beans. The formulation EAP 4030 was similarly more active than the emulsifiable concentrate on the granular preparation on lima beans but there was no difference on soybeans.

These active formulations, containing paraffinic hydrocarbon as carriers, were characterized as having greater residual activity and they retained their herbicidal potency for more than two months on soybeans. The same results would be anticipated on lima beans had additional weed control notes been made.

It is interesting to note that incorporation had no effect on any of the formulations and that unincorporated EAP 4031 was slightly superior to the incorporated treatment notwithstanding that this difference may not be statistically significant.

Injury to soybeans was higher with EAP 4031 than with any other formulation but this injury was later outgrown.

These data indicate that broader utility for R-1856 is possible and that its use may not be limited to grassy weed situations.

EPTC

The effects of the various formulations of EPTC on crop response and weed control are summarized for strawberries, corn, and soybeans in tables 3, 4, and 5, respectively.

Formulations EAP 4001 and EAP 4002, containing a paraffinic hydrocarbon as a carrier, effected greater initial weed control with decreased injury to strawberry transplants than commercial Eptam 6E. These two experimental preparations were comparable to the granular preparation but less injury was produced.

Initial activity of EAP 4001 and EAP 4002 was only slightly better than the commercial formulations on soybeans but their activity persisted longer. Crop injury was less on both corn and soybeans with the experimental formulations, including also EAP 4000 and EAP 4005, on both incorporated and unincorporated test plots.

Generally, incorporating the formulations effected greater weed control; however, with EAP 4001 on soybeans there was no advantage in incorporation.

Unincorporated EAP 4005 was not effective for weed control. An explanation for this is possible. There was increased volatility in the base carrier because of the type of hydrocarbon added to the system. When incorporated the activity of this formulation was greatly enhanced.

Table 1. The Effects of several formulations of t-butyl-di-n-propylthiolcarbamate (R-1856) on weed control and baby lima bean injury. Thaxter baby lima beans planted and formulations applied June 2. Weed control and crop injury ratings made July 7, 1961.*

Treatment	Rate, lb./A	Weed Control[1] Broadleaved weeds	Weed Control[1] Grasses	Crop Injury[2]
R-1856, E.C.	4	0.8	3.3	1.3
	6	1.3	5.3	2.0
R-1856, 10G	4	1.0	4.7	2.0
	6	1.7	5.7	5.7
EAP 4030[3]	4	10.0	9.6	7.3
	6	10.0	9.6	7.8
EAP 4031[4]	4	9.8	9.4	5.7
	6	9.9	9.4	7.0

* Average of three replications.

[1] Based on scale 0 to 10; 0 = no effect, 10 = stand/vigor reduced 100%.

[2] Based on scale 0 to 10; 0 = no effect, 10 = complete kill.

[3] R-1856 dissolved in a select hydrocarbon fraction above C_{18} and containing a slow-breaking emulsifier system.

[4] R-1856 dissolved in a select hydrocarbon fraction above C_{18} and containing a fast-breaking emulsifier system.

Table 2. The effects of several formulations of t-butyl di-n-propylthiolcarbamate (R-1856) at four pounds per acre on weed control and soybean injury. Clark soybeans planted and formulations applied June 5. Weed control and crop injury ratings made July 13 and August 20, 1961.*

Treatment		Weed Control[1]				Crop Injury[2]	
		Broadleaved weeds		Grasses			
		Days after Application					
		38	76	38	76	38	76
R-1856, E.C.	U[3]	3.0	0.0	4.0	0.0	0.0	0.0
	I[4]	2.0	0.0	2.0	0.0	5.0	0.0
R-1856, 10G	U	2.5	0.0	3.0	0.0	0.0	0.0
	I	2.0	0.0	2.0	0.0	2.0	0.0
EAP 4030[5]	U	4.0	0.0	3.0	0.0	0.0	0.0
	I	2.0	0.0	4.0	1.5	5.0	0.0
EAP 4031[6]	U	9.8	10.0	9.8	7.5	5.0	3.0
	I	9.2	10.0	8.3	5.0	6.0	1.0

* Average of two replications.

[1] Based on scale 0 to 10; 0 = no effect, 10 = stand/vigor reduced 100%.

[2] Based on scale 0 to 10; 0 = no effect, 10 = complete kill.

[3] U = treatment unincorporated.

[4] I = treatment incorporated into soil immediately after application.

[5] R-1856 dissolved in a select hydrocarbon fraction above C_{18} and containing a slow-breaking emulsifier system.

[6] R-1856 dissolved in a select hydrocarbon fraction above C_{18} and containing a fast-breaking emulsifier system.

Table 3. The effects of several formulations of EPTC on weed control and strawberry injury. Jerseybelle strawberries set April 12. Formulations applied April 28. Weed Ratings made June 9. Data on rooting of runners obtained July 7, 1961.*

Treatment	Rate, lb./A	Weed Control[1]		Crop Injury		Rooting of runners
		Broad-leaved weeds	Grassy weeds	Stand[2]	Vigor[3]	
EPTC, E.C.	3	6.5	8.7	0.0	2.9	Slight delay
	6	7.2	9.4	0.0	2.7	Slight delay
EPTC, 5G	3	8.2	9.8	0.0	2.1	Normal
	6	9.0	10.0	0.0	3.2	Slight delay
EAP 4001[4]	3	8.5	9.4	0.0	1.3	Normal
EAP 4002[5]	3	9.0	9.4	0.0	0.1	Normal

* Average of four replications.

[1] Based on scale 0 to 10; 0 = no effect, 10 = stand and/or vigor reduced 100%.

[2] Based on scale 0 to 10; 0 = no effect, 10 = stand reduced 100%.

[3] Based on scale 0 to 10; 0 = no effect, 10 = complete kill

[4] EPTC dissolved in a select hydrocarbon fraction above C_{18} and containing a slow-breaking emulsifier system.

[5] EPTC dissolved in a select hydrocarbon fraction above C_{18} and containing a fast-breaking emulsifier system.

Table 4. The effects of several formulations of EPTC at three pounds per acre on weed control and corn injury. New Jersey No. 8 corn planted May 22 and formulations applied May 23. Weed control and crop injury ratings made July 2 and September 8, 1961.*

Treatment		Weed Control[1]				Crop Injury[2]	
		Broadleaved weeds		Grasses			
		Days after Application					
		38	76	38	76	38	76
EPTC, E.C.	U[3]	3.0	6.3	2.0	4.0	0.0	0.0
	I[4]	8.0	3.7	9.0	6.0	2.0	0.0
EPTC, 5G	U	8.0	6.3	6.0	3.7	0.0	0.0
	I	8.0	5.0	7.5	5.0	4.0	0.0
EAP 4000[5]	U	5.0	5.5	5.0	4.0	0.0	0.7
	I	9.0	8.2	9.8	7.3	2.0	0.0
EAP 4005[6]	U	1.0	3.3	1.0	1.3	0.0	0.0
	I	9.3	9.0	9.3	6.8	0.5	0.0

* Average of three replications.

[1] Based on scale 0 to 10; 0 = no effect, 10 = stand/vigor reduced 100%.

[2] Based on scale 0 to 10; 0 = no effect, 10 = complete kill.

[3] U = treatment unincorporated.

[4] I = treatment incorporated into soil immediately after application.

[5] EPTC dissolved in a select hydrocarbon fraction above C_{18} and containing a fast-breaking emulsifier system.

[6] EPTC dissolved in a select hydrocarbon fraction above C_{18} and containing a slow-breaking emulsifier system.

Table 5. The effects of several formulations of EPTC at four pounds per acre on weed control and soybean injury. Clark soybeans planted and formulations applied June 5. Weed control and crop injury ratings made June 13 and August 20, 1961.*

Treatment		Weed Control[1]				Crop Injury[2]	
		Broadleaved weeds		Grasses			
		Days after Application					
		38	76	38	76	38	76
EPTC, E.C.	U[3]	9.0	0.0	8.5	0.0	0.5	0.5
	I[4]	9.0	2.0	9.5	4.0	5.0	1.0
EPTC, 5G	U	9.5	3.0	9.8	1.5	1.0	0.0
	I	9.5	1.5	9.8	9.8	4.5	1.0
EAP 4001[5]	U	9.3	8.0	9.3	2.0	0.5	0.0
	I	9.5	4.5	9.5	9.1	3.0	0.5
EAP 4002[6]	U	6.6	0.5	7.3	2.5	0.0	0.0
	I	8.8	5.0	9.2	7.5	4.0	1.5

*Average of two replications

[1] Based on scale 0 to 10; 0 = no effect, 10 = stand/vigor reduced 100%

[2] Based on scale 0 to 10; 0 = no effect, 10 = complete kill

[3] U = treatment unincorporated

[4] I = treatment incorporated into soil immediately after application

[5] EPTC dissolved in a select hydrocarbon fraction above C_{18} and containing a slow-breaking emulsifier system

[6] EPTC dissolved in a select hydrocarbon fraction above C_{18} and containing a fast-breaking emulsifier system

Summary

Experimental formulations of R-1856 and EPTC were evaluated for their herbicidal activity on several agronomic and horticultural crops. High boiling paraffinic hydrocarbon fractions, having carbon numbers above C_{18}, were used as carriers for these herbicides.

There were initial increases in weed control with the experimental formulations of both R-1856 and EPTC. Similarly, there was greater residual activity from these preparations than from the commercial formulations. These increases in activity were especially pronounced with R-1856. It was observed that with certain formulations it was not necessary to incorporate them into the soil surface for improved activity.

It may be concluded that the effectiveness of R-1856 can be extended to include broadleaved weed activity by formulating this herbicide in certain hydrocarbon carriers.

Acknowledgements

The authors wish to acknowledge Dr. Robert H. Salveson of Esso Research and Engineering Company, Linden, New Jersey for preparing and supplying the experimental formulations of the two thiolcarbamates. Credit is due him for his assistance in obtaining data in the field and for his aid in preparing this manuscript.

Credit is also due Stauffer Chemical Company for supplying R-1856 6E and 10G and Eptam 6E and 5G.

ENHANCING HERBICIDAL ACTIVITY OF SILVEX FOR THE CONTROL OF DOG FENNEL IN SMALL GRAINS

R. D. Ilnicki*

Dog fennel (Anthemus cotula) causes serious losses in small grain production and is also a pest in other crops and pastures in the Northeastern States. From previous work at this station it was found that of the phenoxyalkylcarboxylic acids evaluated for post-emergence control the alpha-phenoxypropionic acids were the most effective in controlling this species. Little or no significant injury to small grains results if these herbicides are used within a certain dosage range at tolerant stages of growth. 2-(2,4,5-trichlorophenoxy)-propionic acid (silvex) was the most active of this group (1,2).

Injury to small grains is imminent when applications are made at critical stages of growth. Since injury may occur from application rates necessary for dog fennel control an attempt was made to develop formulations which would be less phytotoxic to the grain but which would retain their specificity for dog fennel.

Materials and Methods

Formulations of silvex using high boiling paraffinic fractions as carriers were prepared as aqueous dispersions differing only in their emulsifier systems. The hydrocarbon fraction was a select material having carbon numbers above C_{18}. One formulation (EAP 4019) contained a slow-breaking emulsifier and the other (EAP 4020) contained a fast-breaking emulsifier system. Both preparations contained the same hydrocarbon to herbicide ratio. Commercially available silvex (propylene glycol butyl ether esters) was used as a standard for comparison with the two experimental systems.

Dog fennel infested areas of barley (var. Wong) and wheat (var. Pennoll) on the campus of the New Jersey Agricultural Experiment Station were selected to receive herbicidal applications of these materials. Rates of 1/8, 1/4, 1/2, and 1 lb. per acre were applied on April 21, 1961 in 40 gpa with an experimental sprayer of the type described by Shaw (3). The experimental design, for the two small grain areas was a split plot with three replications. Rates of application constitute the whole plots and formulations comprised the sub-plots. Several check plots were also included. Plots were 6 x 20 feet. At the time of application the small grains and dog fennel were at the following stages of growth:

barley - jointing
wheat - late tillering - early joint
dog fennel - 2-5" tall; 2-9" spread,
4-10 tillers.

Period observations were made throughout the course of the experiment and any unusual effects were recorded. Notwithstanding that tillering appeared complete at time of herbicidal application,

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tiller counts were made on June 22-23 per two feet of row on one drill band selected at random. Height measurements were made on June 29 and weed controls and crop injury ratings were made on July 5 and July 17 for barley and wheat, respectively. Plots were harvested on July 10 and July 17, respectively, for barley and wheat by selecting at random three drill bands for a distance of 12 feet. Prior to harvest ten heads from each plot were selected at random, hand-threshed, counted, weighed, and the data converted to weight per thousand kernels.

All data were analyzed as split plot and randomized block designs.

Results and Discussion

In tables 1 and 3 are found summaries of the weed control and crop injury ratings for barley and wheat, respectively. From these data it is evident that the two formulations which contained paraffinic fractions as carriers were much more effective in controlling dog fennel than the commercial formulations. Similarly, more injury was produced on barley with these formulations. Wheat was not affected by any formulation. These data were in agreement with earlier observations in which barley exhibited greater abnormal growth responses from the new formulations than from the commercial formulations of silvex. The formulation containing the slow-breaking emulsion effected greater abnormal growth responses on dog fennel and barley than the formulation containing the fast-breaking emulsion.

The effects of the formulations on tiller formation, plant heights, yield, and kernel weight are presented in tables 2 and 4 for barley and wheat, respectively.

Upon examination of the tiller data some interesting observations are evident. When compared to the untreated check no rate of any formulation effected decreases or increases in numbers of barley tillers. When formulations were compared more critically (split plot analysis) it was evident that there were greater decreases in tiller formation from the two formulations containing the paraffinic fractions than from the commercial formulation; moreover, the decrease was greater with the formulation containing the fast-breaking emulsion. The interaction of formulation x rate was significant. Generally, decreases in numbers of barley tillers resulted as rates increased from 1/8 to 1/4 pound. Tiller production increased with increasing rates above 1/2 pound. Increases were not as great with the formulation containing the fast-breaking emulsion. These data substantiate observations made in the field. Although tillering was almost completed at time of herbicidal application, the high rates of treatment retarded main culm development and tillering continued. This situation was not true for wheat.

Wheat was still in the tillering stage at the time of herbicidal application. From the presented tiller data it can be seen that all rates, of the three formulations, generally decreased tiller production. Furthermore, when formulations were compared more closely (split plot analysis) it was evident ~~that the~~

Heights of barley were significantly reduced by silvex containing the paraffinic carriers at rates of 1/2 and more. These formulations had no such effect on wheat.

That the two experimental formulations of silvex were more phytotoxic to barley than the commercial formulation is further evidenced by the yield data. Notwithstanding that commercial silvex reduced yields, the reductions were not as great as those from the two experimental formulations. Rates above 1/4 pound of all preparations significantly reduced barley yields. On the other hand, wheat yields were not reduced significantly below the check by any rate or formulation.

From the data on kernel weights it can be seen that this quantitative response was somewhat related to tiller formation. Greater decreases in kernel weight resulted from the formulations containing the paraffinic fractions than from the commercial formulation. This decrease was greatest with the formulation containing the fast-breaking emulsion. The same was true for tiller formation. The interaction of formulation x rate was also statistically significant for kernel weights. As with tiller production, increases in rate of all formulations effected corresponding increases in kernel weight. The reverse relationship of tillers to kernel weight might be suspected. The explanation is easily made. Since the high rates of herbicides tended to check the development of the main culms and often prevented the formation of heads, the ones that did form were larger in size and weight. It is known that checking the development of main culms results in the formation of more tillers. No such response or relationship was noted on wheat.

From the data and discussion it can be seen that herbicidal activity and general phytotoxicity of silvex was greatly enhanced by using paraffinic fractions, in aqueous dispersions, as carriers for this herbicide. Of the two experimental formulations, the one containing the slow-breaking emulsion was slightly more effective on dog fennel than the one containing the fast-breaking emulsion. The same generally was true with regard to their effects on certain yield components of small grains. There were instances when the reverse was noted. Additional work is needed to determine whether the latter is more apparent than real.

Summary

(1) Two formulations of silvex using high boiling paraffinic fractions as carriers were compared to a commercially available formulation of silvex for dog fennel control in barley and wheat.

(2) In addition to weed control, the effects of all herbicidal treatments on tiller production, plant heights, yield, and kernel weights were made.

(3) The two experimental formulations were more phytotoxic to dog fennel and on certain yield components of the small grains

Table 1. Injury to dog fennel and barley following treatment with several formulations of silvex.*

Treatment	Rate, lb/A	Injury Ratings			
		Dog Fennel		Barley	
		Stand[1]	Vigor[2]	Stand[1]	Vigor[2]
Silvex, propylene glycol butyl ether esters (commercial formulation)					
(1)	1/8	0.0	0.0	0.0	0.0
(2)	1/4	0.0	2.0	0.0	0.0
(3)	1/2	1.0	7.0	0.0	0.3
(4)	1	0.7	7.4	0.0	2.0
Av.		0.4	4.1		
Silvex, paraffinic carrier containing a slow-breaking emulsifier (EAP 4019)					
(5)	1/8	0.0	2.0	0.0	0.0
(6)	1/4	0.0	3.7	0.0	0.3
(7)	1/2	3.5	8.3	0.0	3.3
(8)	1	10.0	10.0	0.0	8.7
Av.		3.4	6.0		
Silvex, paraffinic carrier containing a fast-breaking emulsifier (EAP 4020)					
(9)	1/8	0.0	2.0	0.0	0.0
(10)	1/4	0.0	3.3	0.0	0.0
(11)	1/2	3.0	8.0	0.0	2.0
(12)	1	10.0	10.0	0.0	7.7
Av.		3.2	5.8		
Check					
(13)	--	--	--	--	--

*Average of three replications.

[1] Based on scale 0 to 10; 0 = no effect, 10 = 100% reduction of stand.

[2] Based on scale 0 to 10; 0 = no effect, 10 = complete kill.

Table 2. The effects of several formulations of silvex on tiller formation, plant heights, yields, and kernel weights of barley.*

Treatment	Rate, lb/A	Tillers, no./2'	Plant heights, inches	Yield bu/A	Kernel Wt. wt./1000, grams
Silvex, propylene glycol butyl ether esters (commercial formulation)					
(1)	1/8	57.7	37.3	44.4	35.75
(2)	1/4	51.7	36.0	30.9	40.62
(3)	1/2	43.7	34.0	17.2	40.46
(4)	1	68.7	35.7	14.8	40.58
Av.		55.4	35.8	26.8	39.35
Silvex, paraffinic carrier containing a slow-breaking emulsion (EAP 4019)					
(5)	1/8	46.3	37.7	36.8	39.24
(6)	1/4	42.3	35.7	29.0	35.36
(7)	1/2	53.3	33.0	13.8	39.06
(8)	1	64.7	33.0	7.3	40.03
Av.		51.6	34.8	21.7	38.42
Silvex, paraffinic carrier containing a fast-breaking emulsion (EAP 4020)					
(9)	1/8	44.0	37.3	35.9	39.33
(10)	1/4	44.7	35.7	29.0	40.24
(11)	1/2	47.3	32.0	17.0	32.07
(12)	1	51.7	33.3	5.3	38.27
Av.		46.9	34.6	21.8	37.48
Check					
(13)	---	48.0	35.7	44.5	34.61
L.S.D.'s					
Rate (split plot)					
	0.05	N.S.	2.9	5.6	N.S.
	0.01	N.S.	N.S.	8.4	N.S.
Formulation (split plot)					
	0.05	6.3	N.S.	3.1	1.15
	0.01	N.S.	N.S.	4.3	N.S.
Treatment (randomized block)					
	0.05	N.S.	N.S.	7.0	2.71
	0.01	N.S.	N.S.	9.5	3.94

*Average of three replications

Table 3. Injury to dog fennel and wheat following treatment with several formulations of silvex.*

Treatment	Rate, lb/A	Injury Ratings			
		Dog Fennel		Wheat	
		Stand^1	Vigor^2	Stand^1	Vigor^2
Silvex, propylene glycol butyl ether esters (commercial formulation)					
(1)	1/8	0.0	0.3	0.0	0.0
(2)	1/4	0.0	3.3	0.0	0.0
(3)	1/2	5.0	5.0	0.3	0.0
(4)	1	4.6	7.0	0.3	0.0
Av.		2.4	3.9		
Silvex, paraffinic carrier containing a slow-breaking emulsion (EAP 4019)					
(5)	1/8	0.0	3.0	0.0	0.0
(6)	1/4	2.3	4.6	0.0	0.0
(7)	1/2	9.3	8.5	0.0	0.0
(8)	1	10.0	10.0	0.0	0.0
Av.		5.4	6.5		
Silvex, paraffinic carrier containing a fast-breaking emulsion (EAP 4020)					
(9)	1/8	0.0	1.6	0.0	0.0
(10)	1/4	1.6	4.0	0.0	0.0
(11)	1/2	5.6	7.0	0.0	0.0
(12)	1	10.0	10.0	0.0	0.0
Av.		4.3	5.6		
Check					
(13)	--	--	--	--	--

*Average of three replications

[1] Based on scale 0 to 10; 0 = no effect, 10 = 100% reduction of stand.

[2] Based on scale 0 to 10; 0 = no effect, 10 = complete kill.

Table 4. The effects of several formulations of silvex on tiller formations, plant heights, yields, and kernel weights of wheat.*

Treatment	Rate, lb/A	Tillers, no./2'	Plant heights, inches	Yield bu/A	Kernel Wt. wt./1000 grams
Silvex, propylene glycol butyl ether esters (commercial formulation)					
(1)	1/8	39.7	45.3	22.2	45.4
(2)	1/4	34.7	44.0	21.8	47.42
(3)	1/2	30.0	43.7	23.3	48.07
(4)	1	30.0	44.0	22.5	47.92
Av.		33.6	44.2	22.4	47.20
Silvex, paraffinic carrier containing a slow-breaking emulsion (EAP 4019)					
(5)	1/8	32.7	45.3	22.4	46.12
(6)	1/4	33.0	44.0	25.9	46.12
(7)	1/2	30.7	47.0	27.5	46.82
(8)	1	32.7	46.3	25.6	47.25
Av.		32.2	45.6	25.4	46.58
Silvex, paraffinic carrier containing a fast-breaking emulsion (EAP 4020)					
(9)	1/8	33.0	45.0	25.8	46.94
(10)	1/4	33.0	45.0	29.7	45.59
(11)	1/2	46.0	46.0	27.9	47.59
(12)	1	41.0	45.7	24.6	48.37
Av.		38.2	45.4	27.0	47.12
Check					
(13)	--	47.3	47.3	27.4	46.97
L.S.D.'s					
Formulation (split plot)					
	0.05	5.1	N.S.	N.S.	N.S.
Treatment (randomized block)					
	0.01	5.3	N.S.	N.S.	N.S.

*Average of three replications.

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A PROGRESS REPORT ON COMMERCIAL APPLICATIONS OF MH-30 FOR GRASS INHIBITION UTILIZING A NEWLY DESIGNED HIGH SPEED HIGHWAY SPRAYER

Bohne, P. W. and Morgan, B. S.

In the spring of 1961 commercial type applications of MH-30 were made to highways in thirteen Eastern and Mid-Western states and Canada. These spray applications were started in mid-March in North Carolina and continued into the Northern States through June 1.

Four or six pounds of the active material in 50 gallons of water solution were used per acre as the basic mixture in these treatments. Sprays were made on (1) established grass after it obtained 3 - 4 inches of new spring growth; (2) established grass mowed to four inches prior to spraying, and (3) established grass which was sprayed and then cut to four inches 7 - 10 days later. Following all three methods of spraying proper turf management resulted in highly satisfactory growth control. MH-30 materially reduced or, in a few cases, eliminated mowing. This depended upon the particular management program in a given area. In some instances the use of MH-30 would show no reduction in numbers of mowings or of mowing costs. 2,4-D was added at the rate of 1 lb./A where broadleaf weeds were a problem.

Spray equipment had posed one of the major problems in commercial highway applications, especially in the hard to mow areas which were also hard to spray by conventional spray equipment. In cooperation with the F. E. Myers and Bros. Co., Ashland, Ohio, an experimental highway sprayer was designed and used for the application of MH-30. Off-center nozzles were used for covering areas up to 30 feet. Reaches up to 60 feet were sprayed with an air carry unit mounted on the rear of the truck. Plating studies and actual results showed uniform and effective grass inhibition out to 60 feet with this air carry spray unit. This truck unit proved to be fast and effective in making spray applications to varying types of highway terrain.

(Research and Development Department, Naugatuck Chemical Division, United States

CHEMICAL CONTROL OF VEGETATION ON THE PENNSYLVANIA RAILROAD

R. E. Kleist[1]

This paper will attempt to present the problems posed by vegetation on the Pennsylvania Railroad and the program which has been adopted as a guide to their solution.

Chemical control of vegetation on the Pennsylvania Railroad has been broken down into four areas:

1. Control of brush on right-of-way.
2. Control of weeds in yards.
3. Control of mixed vegetation on shoulder areas of main tracks.
4. Control of mixed vegetation on tracks and on shoulder areas of branch lines.

Brush Control

The problem here is to keep brush out of communication lines and to prevent the growth of large trees or dense thickets close to tracks. It is not our aim to kill every tree and bush on the right-of-way but rather to prevent their unrestricted development.

Where terrain prevents the use of mechanical brush cutters, which we have found to be most economical for controlling right-of-way brush, we recommend the following procedure:

1. Cut brush manually and stump treat with D&T in oil.
2. Spray right-of-way with D&T or Ammate in water or in an oil-fortified water mixture during the first or second growing season after brush has been cut.
3. Follow up at frequent intervals with D&T spray on a spot basis as necessary.

Following advantages are derived from this sequence for brush control:

1. Less material required to wet foliage when spraying first or second year growth.
2. Better penetration and, therefore, more uniform coverage with resulting better control obtained by spraying first or second year growth.
3. So called resistant species seem to be more readily killed or retarded before they become well established.

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[1] Assistant Engineer Tests - M. W., The Pennsylvania Railroad Company

4. Undesirable dead stems do not remain on right-of-way. Contrary to some popular opinion we find dead stems remain in lines for two to three years and may cause considerable trouble in communication lines, particularly in wet weather or if they are covered with vines.

We do not use dormant spray methods. Most of our railroad can be sprayed with D&T and where ornamentals or crops are present on adjacent properties they are treated with Ammate.

We do not make general use of granular brush control chemicals since we have found them to be not too effective at economical rates when applied by broadcast methods. Other methods do not seem to lend themselves to economical application on our railroad, except possibly for spot treatment.

Except for root suckling plants, such as sumac, there are not enough resistant species in our area to cause considerable concern when D&T or Ammate sprays are not effective. Fast growing root suckling species which develop into dense thickets are a problem however, and there is a need for a chemical which can be economically applied by spray methods and which will provide a root kill as well as a top kill for these plants.

Weed Control in Yards

Here the problem is one of obtaining more or less complete eradication of weeds in order to improve working conditions.

Because manual scalping is not economical and because soil sterilants will provide far better control with one application than weed burners are capable of in several passes through the season, sterilants have proven themselves the most practical means for controlling weeds in yard areas.

Soil sterilants in dry, granular form have been used in yard areas to a large extent on our railroad, although the use of spray applications of basic chemicals in water suspension has been investigated and has given promising results. These materials have been applied in mixtures of one pound of chemical per gallon of water at the rate of 25 gallons of mixture per acre with good results on an experimental basis. It appears that savings in material costs up to 50% per acre can be realized from use of this technique.

Differences in solubility of soil sterilants permit their use over a wide range of soil characteristics and rainfall. Variations in solubility also permit their application until late in May depending on conditions.

While soil sterilants have proven themselves effective, their high cost has prevented their utilization to the fullest extent. Many low traffic or marginal areas are not treated for this reason.

Chemical Control of Mixed Vegetation on Shoulder Areas of Main Tracks

Our purpose here is to kill or retard the growth of all vegetation in an area extending eight to ten feet from the ballast border. This treatment should be designed to improve the appearance of the railroad and maintain track drainage by preventing encroachment of vegetation into ballast.

Unfortunately we know of no single chemical which will effectively control the wide spectrum of vegetation found in shoulder areas. Various chemical mixtures have been used without success at reasonable cost. Most of these mixtures contain a contact killer to reduce vegetation to a pre-emergence state, a soil sterilant to control grasses and most annuals and a hormone material to get woody plants and broadleafs.

We have used contact killers on shoulder areas but satisfactory results require up to three applications per year in some areas and the total cost applied is comparable to that of a good combination treatment which will give season control with one application.

We have also tried systemic killers which are generally more effective than contact killers, but which do not give a 100% job, even with two applications per year.

Here again we are in need of something new. A chemical or mixture of chemicals which will provide complete control of shoulder vegetation at a cost of $20 per acre or less would be most desirable.

Weed Control on Track and Shoulder Areas of Branch Lines

Our purpose here is to retard growth or reduce population of weeds in the track structure and on shoulders over a total width of 16 to 20 feet. Systemic and contact killers which may be fortified with 2,4-D are generally suitable for this job. This treatment permits the track to be properly inspected and maintained without being restricted by excessive growth of vegetation. Systemic killers in particular will give us the partial control desired, but unfortunately the cost of such treatment is such that it is not generally used on a large scale basis.

Selection of Chemicals

The multitude of proprietary compounds available make selection of chemicals difficult for most railway maintenance engineers. For this reason we have been testing weed control chemicals since 1946. Our procedure is to apply materials on small scale plots at various application rates. Those materials which show promise on a small scale are then applied on larger areas under service conditions at various points on the system. Those which perform satisfactorily here are usually approved for general use.

Conclusion

Vegetation problems faced by railroads are generally well known to suppliers and manufacturers of weed control chemicals. The ever increasing number of weed control chemicals and compounds on the market are evidence of their interest in solving these problems. Use of improved application techniques and more economical selective use of available chemicals will help us to reduce our costs, but the ultimate in weed and brush control will not be achieved on the Pennsylvania Railroad until lower cost, more universally effective chemicals are available for use on a large scale.

VEGETATION CONTROL ON WESTERN MARYLAND RAILWAY

R. R. Gunderson[1]

I could discuss the history and the many virtues of the Western Maryland Railway Company at great length, because I am a member of a team that has tremendous pride in our property. However, I feel sure that each of you are familiar with what I might say along that line. I will therefore confine my comments to one of the problems that is of particular interest to this group - one that many of us share. Specifically, I will outline our problem of controlling weeds, grass and brush, on our properties, our objective in this regard, and what we are doing about the problem.

Our railroad originates, historically, in the tidewater area of the great seaport of Baltimore, Maryland. Physiographically, our line traverses the Piedmont area of central Maryland, crosses the Blue Ridge range of the Appalachian Mountains and down through the South Branch Valley, an extension of the Shenandoah Valley, westward thru Hagerstown, Maryland. We then follow the Potomac River to Cumberland, Maryland, and its North Branch to the headwaters, crossing the Allegany Mountains and then following the West slope of this range thru Elkins, West Virginia, into the extensive coal fields to Webster Springs and to Durbin, West Virginia. Our main line, westward, at Cumberland, passes thru one of the natural gaps thru the mountain range and climbs the East slope of the Allegany mountains for approximately twenty miles. Crossing this range, we slowly drop down the Western Slope of these mountains, following the Casselman and then the Youghiogheny Rivers, to Connellsville, Pennsylvania. We vary in elevations from plus 4 at Baltimore to 4,067, which, I believe, is the highest elevation reached by a Class I railroad east of the Mississippi River. I thus describe the areas on our lines merely to accentuate the variety encountered on our relatively small property. The weed, grass and brush problems are almost as varied as the physiographic areas.

Climatic conditions are very favorable to plant life - temperatures are moderate and rainfall is plentiful. Average annual temperature is in the mid-fifties, and annual rainfall varies from 35 to 43 inches. Snowfall is heavy in many areas, providing good protection to many dormant plants and seeds. We have abundant sunshine and right at the height of the growing season, the month of August, we also have our wettest month. These conditions produce excellent farm crops and fruit, but are not helpful in our efforts to control growth of vegetation.

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[1] Engineer Maintenance of Way, Western Maryland Railway Company

We probably have no specie of growth that is peculiar to our railroad, but we sure have variety. We have some spots of blue, bermuda, and crab grass that would be welcome in most home yards. We also have quack, witch, brome, wheat grasses, and foxtail. We haul large quantities of all commercial grains and leakage from cars adds to our problem, particularly in yards and the storage tracks at the elevators. Three species of weeds are a particular problem, namely, bouncing bet, milkweed, and horsetail. Many creeping varieties wait outside the control pattern and then come in as soon as other resistance has been knocked down. Sumac, sassafras, wild cherry, locust, are some of the more rapid growing species that become a hazard to our signal and communication wires and to vision at road crossings.

I have briefly outlined the physiographic and climatic conditions on our properties and some of the problem growth that we encounter. I do not wish to leave the impression that we accept all of this in resignation. On the contrary, we have, what we think to be, reasonably good control of weeds, grasses, and brush, on our railroad. I can say, with reasonable assurance, that we have close to 90% control of these problems. We do not have complete control - and it is entirely possible that we never will reach this stage.

Previous to 1951, we provided our men with hand scythes, brush hooks, and a couple of rather crude weed burning machines. At that time we were paying our trackmen a basic rate of $1.39 per hour. We could then spare men to cut down special problem areas and, after the other work was layed by, they could be used to clear right-of-way. I think, in all fairness, that we did a rather complete job - but it was always a case of handling an existing situation, and we accepted the fact that regrowth would occur the following year, or years. As wage rates crept, or leaped, upward, we soon looked sharply at our money available, and looked for more economical means of control. It is good that we started a decade ago, because today our basic rate of pay for trackmen has risen to $2.17, per hour, and, except for giving them tractor type weed mowers and powered saw type brush cutters, they could cover little more right-of-way today than they could ten years ago.

In 1951, we first contracted an application of chemicals in an effort to control brush. The active chemicals contained an average of two pounds acid equivalent to the low volatile ester of 2,4-D and two pounds acid equivalent of the low volatile ester of 2,4,5-T, per gallon. The effect of this application was dramatic, to say the least. Within a relatively short time after application of the chemicals, everything that it had hit was nice and brown, and it stayed that way. The following year showed an attempt to leaf out and then soon afterward there was a browning and defoliation. Branches and stalks became brittle and snows of the following winter broke down most of the standing material. These were our results ten years ago, and our results today are equally good. Sumac will sprout up from the old roots and establish their own root growth before the parent plant is completely killed and, in a matter of four or five years, this new growth demands attention. Other species are generally slower in their need for attention, particularly those that develop from seed. Brush has become a [illegible] problem on our property. We confine our brush control primarily to the pole line area and we do not pay much attention to brush elsewhere, until it restricts vision in the vicinity of signals or at road crossings, or unless it could constitute a hazard to structures or buildings. I will discuss how we handle these situations a bit later.

Shortly after we treated brush with chemicals we made our first efforts to control weeds and grasses with recommended chemicals. Our first treatment consisted of two basic chemicals. One was an average of four pounds of 78% 2,2-Dichloropropionic acid, sodium salt, to the gallon of concentrate solution. The other was on an average the equivalent of four pounds of Diachlorophenoxyacetic acid per gallon. These concentrate mixes were diluted in water at the rate of 1 to 20 and 1 to 100 respectively, and applied along the right-of-way and in yards.

The effect of this application was not as dramatic as the brush killer, in fact little immediate effect was apparent. There were some instances where heavy rains developed too soon after the application and, when this occurred, there was very little effect. The initial concentrate is for the control of grasses and the other for weeds. Both act by translocation, passing into the delicate living plant tissue and thence to the roots. Our initial results were fairly good but frankly did not come up to our hopes. Yards were especially disappointing, not necessarily because of the chemicals used, but more due to the inability to obtain clear tracks to work on. Some other solution to this particular problem was necessary.

Dry chemicals appeared to be a possible solution to our yard problems and we made an experimental application of a very small quantity. The initial field reports were bad - there was hardly any effect even two or three weeks after application - of course, we had no rainfall during that time. Rainfall did come, the chemicals penetrated the soil and within a reasonable time we had no plant life within the treated area. This method of control has been extended from that one small test area until we now have all of our yards treated. Switchmen in our yards used to complain of wet trouser legs and now complain about getting dust in their eyes. You can correctly conclude that we are pleased with the results obtained from dry chemicals in yard areas.

The principal active ingredient in the dry materials that we use is CMU, and I will not try to pronounce the chemical term. We use more than one trade name product, applying them at the prescribed rates. We have found that an initial application of approximately 35 lbs. per acre, of the basic chemical, will give us better than 90% control of vegetation. We reduced the rate by 50% during the second, and succeeding years, and we are holding the control. At the end of the third year we omitted treatment between the rails in one yard and regrowth became very evident. We thereby assume that the sterilent property should be continued each year in order to maintain control and, to date, we are following that practice. I do not want to imply that the material that we use is the only one that will produce results - I only report what we have obtained.

The good results that we obtained from use of dry chemicals in yards led to further applications. We distribute this material around signals, phone booths, relay boxes and power switch machines, buildings, fuel tanks, and beneath some bridge structures. We also have distributed material beneath pole lines that are not accessible from track. In this case a small handful of material placed in a pile at the base of larger growth will shortly remove that problem. You are aware that soil sterilent type materials are rather non-selective and that care must be exercised in their use so as not to damage growth adjoining your properties. However, we have hand applied materials without harming apple and peach trees that were less than fifty feet away. We have shared in paying claims after using liquid brush killers, but we have had no claims resulting from dry chemicals. I might mention one interesting complaint that has resulted from our use of dry chemicals and this was in the vicinity of our grain elevator in Baltimore. Weed growth was rather luxuriant in this area and rats found good harbor. The growth was eliminated, the rat population substantially decreased, and they moved further away for harbor, many of them off our property.

I have diverted from my first mention of weed and grass control within the berm section along our line of road. Our initial method of control was repeated the second year and our overall results were still spotty, generally good, but with discouraging effect upon several areas. The following year we added a third chemical to our previous mix, namely, Baron. I wanted to avoid use of any trade names, but the chemical terms for this product are too much. This was added at the rate of four pounds acid equivalent per gallon of concentrate and diluted at the rate of 7.5 gallons of water. This total combination produced much better results but the appropriation was not sufficient to cover the entire railroad and we lost some of our previous control in these untreated locations. The following year we reverted to our initial program but used an aromatic oil in some of our less troublesome areas. This oil was fortified with rather small quantities of pentachorophenol and of 2,4-D. We were able to hold the degree of control that we had developed but there was real room for improvement. Early in this year we had an interesting experience.

One of the manufacturers of basic chemicals knew of our attempt to maintain a planned control program. We were asked to set aside some areas of our most severe problems and cooperate with their research department in test application of various products. This was done, and we continue this relationship today. Some of the chemicals were available in very small amounts, often resulting from a laboratory pilot plant run. We noted from these test applications that the basic chemical, CMU, gave uniformly good results. This developed into a change in our control program the following year.

Our first use of CMU as our principal control chemical was done in conjunction with the same aromatic oil previously tried, except that it was further fortified with 2,4-D. The oil was applied at the rate of 20 gallons per acre, one gallon of 2,4-D per acre, and the CMU was varied in its rate of application. The dosage of CMU varied from 10, and 20 pounds per acre. This concentration was selected by observation of the test plots and with consideration of the density of growth. This treatment was applied early in June. The initial top kill of the oil was very good, as usual, and rainfall worked out very favorably in transmitting the sterilent into the soil. We experienced the best control that we ever had - weeds were effectively controlled, even to the difficult bouncing bet. Grasses were also controlled, except in one area that continues to be a problem to us, and to our research friends.

The treatment that I have outlined above is the one that we have used for the past few years, and was used this year. Our control has been observed by others outside our Company and is accepted as being good. We have very little bouncing bet within our spray pattern. Milkweed continues to grow but it is stunted and does not head up. However, we now have spots of horsetail although we are hopeful that the chemical will eventually get down to these roots too.

CMU does not keep several species of grasses out of the spray pattern in the problem area that I mentioned. Soil in this sixty mile area does not retain the sterilent chemicals near the surface a sufficient time to allow action on the roots of the grasses, although it does keep down the general weed problem within the spray pattern. This year we treated this problem area different than the rest of our lines, trying sodium trichloroacetate at six pounds per gallon, diluted in water. I have watched this area closely and I am still hopeful that we will find some answer that will be economically feasible. Several salesmen friends have already assured me that they have the right answer, and I feel confident that one does have. Our research friends came up with one product that is under test in this area and it is completely effective within the test plot. We hope we can get a further test of this material this coming year but, at the present time, it is not commercially available.

Our Company received some publicity in 1959 when we joined with the DuPont Company in a test application of dry chemicals from a helicopter. Dybar Fenuron, in pellet form, was deposited over a ten mile section of our railroad at a rate of 58 pounds per acre mile, and confined to about a 16 foot wide area beneath our pole line. This was applied in March of that year and we had below normal rainfall until about in June. Terminal growth and initial defoliation was evident late in July on sumac, wild cherry, and locust in the treated area. We also obtained considerable grass kill and good effect upon most weeds.

This experiment was conducted to give us a look at a new tool for application and it was our conclusion that accurate control of pattern and concentration was obtained. The tool is fast and is not hindered by traffic. The payload capacity is rather small and logistics become a problem. We have not furthered our use of this tool, but several other railroads have done so.

I have trouble pronouncing some of the names of chemicals that we deal with and my ability to positively identify a specie of plant is rather limited. This is a highly specialized field and the problem is only one of many that we have in our everyday work of maintaining a railroad property. But it is an important problem, and one that cannot be ignored.

I, for one, do not expect perfect control - complete elimination of all plant life within areas that we treat. I even question whether such an end development would be morally good - it might conceivably become another cold war weapon and potentially more dangerous than any presently known. I think most of us will accept a control that keeps down objectionable weeds and tall growing grasses. We need to keep growth out of the ballast section beneath our tracks so that drainage is not blocked. We want surface drainage to get out of the ballast section and into our drainage ditches. We want sufficient growth, preferably of the low growing type that has good roots, so that the slopes of our cuts and fills do not erode away. The modern highway sets a good example but we do not have their access to tax dollars to permit us to have our right of way look like a continuous park. We must have control at a price that we can afford to pay. I do not question that we could obtain the ideal results by using chemicals that are available today, but it would take so many different ones, and such quantities, that we cannot presently afford the ideal. We remain hopeful that there may be some all-purpose chemical in some laboratory that will permit our objectives and remain within our budgets.

So, in a very real sense, we are dependent upon research that is being carried forward. We want to cooperate with these people and we admire their high standards, both as individuals and as companies. I value my association with sales representatives in this field because they are knowledgeable gentlemen and keep us all informed of developments. I find them very patient with people like myself and I think they give me honest answers - it remains up to me to properly weigh their enthusiasm for their products. I value the advice, the concern for our problem, the cooperation and the follow-up service, that we receive from those, who apply our control program. I particularly appreciate being here today because I feel sure I will broaden my understanding of this problem, and take away far more than I have contributed. Thank you for your kind attention.

Three Year Summary of the Comparison of Certain Herbicides for Guide Rail Soil Sterilization in Connecticut

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This paper is a three year summary of data from a test first published (on a one year basis) in 1960. (1)

INTRODUCTION

In Connecticut there are more than 3,000 miles of state highways with an estimated 2,000 miles of cable guiderail. Vegetative growth under this railing causes a build-up of sand from winter maintenance operations, and thus impedes drainage from the pavement. Vegetative growth, if unchecked, is not only unattractive but can be a traffic and fire hazard. (2)

The two-foot strip under the guide rail is a difficult and hazardous location to maintain, and formerly involved much scarce manpower to hand cut the vegetative growth at a cost of about $50 per mile. Use of herbicides such as dalapon and 2, 4-D to eliminate existing vegetation, and chemical soil sterilants such as "karmex" diuron weed killer, Simazine, Urox, etc., to keep the area weed-free for several years after treatment, may cost as little as $10 per mile for materials. (3)

Vegetative growth is still effectively controlled under guide rail at some locations in Connecticut where monuron was applied at 40 pounds per acre in 1954. The same can be said of diuron applied at the same rate in 1955, and of diuron applied at 20 pounds per acre in 1957 and Simazine in 1958. It is important to note at this time that we expect a paradox of a good soil sterilant material -- we expect it to be effective enough to prevent vegetative regrowth on a treated area for several years, yet we do not want the material to be carried down-slope by surface water to damage desirable vegetation below the treated area. To reduce the down-slope movement of the chemicals and to prevent erosion, we place a bitumen cover (0.4 gallons per square yard) over the area that has been treated with a soil sterilant immediately after application of the sterilant. (3)

Damage to down-slope vegetation has been observed occasionally even though bitumen has been used.

OBJECTIVE

In 1958 an experiment was designed to evaluate the weed killing efficiency of two soil sterilants, diuron and simazine, and to determine the relative extent of surface washing after application. No bitumen cover was used on plots.

MATERIALS AND METHODS

Diuron and simazine were each compared at 10, 16, 32 and 64 pounds active material per acre in 10 square-foot plots established on sloping areas. Four replications of each rate were made, with two replicates at one location and the other two each at different locations. The treatments were applied on September 30, 1958.

The plots were evaluated for vegetative control and down-slope damage outside the plot one year after application (October 8, 1959). Vegetative control was rated as zero for no effective control to 10 for complete weed control. Down-slope damage was recorded as the number of feet below plots showing kill of weeds. Ratings were made in October 1959, July 1960 and August 1961.

Table I: Amount of Diuron and Simazine Applied Per Acre on Roadside Slopes in Central Connecticut (September 30, 1958)

Treatment No.	Lbs. Active	Lbs. Commercial Product	Treatment No.	Lbs. Active	Lbs. Commercial Product
D10	10	12.5	S10	10	20.0
D16	16	20.0	S16	16	32.0
D32	32	40.0	S32	32	64.0
D64	64	80.0	S64	64	128.0

*As "Karmex" diuron weed killer (80 per cent diuron wettable powder).
**As "Simazine" 50-W (50 per cent simazine wettable powder).

Ten square-foot plots, four replications of each treatment. Replications at three locations accentuated degree of slope and type of watershed for the plots.

REPLICATES I & II - Glastonbury Route 17. Plots 2x5 feet across the slope. Top of plots eight feet below guide rail cables of fill slope. Manchester gravelly loamy sand, 35 per cent slope. Growth at time of application was a sparse cover of sandbur, red fescues, equisetum, tall fescues, some brambles, and broadleaf

REPLICATE III - Portland Route 6A, near intersection of Route 17. Plots, 2x5 feet, across an excavated slope, about 10 feet from the pavement shoulder. Growth at time of application was a dense cover of chiefly red fescues, some bluegrass, some milkweed and equisetum, and a few small brambles. Manchester gravel under the plots; Manchester gravelly loamy sand above the plots. Slope under plots about 25 per cent and above plots about 40 per cent, length of slope above plots about 50 feet.

REPLICATE IV - Columbia, intersection of Route 6 and 6A. Plots (about 3.2x3.2 feet) about 10 feet from edge of pavement shoulder on a gentle slope (5 to 10 per cent). No curb at edge of road so pavement watershed could run across the plots. Hinckley sandy loam, well drained under the plots. Growth on location a lawn-like texture, composed of bluegrass and fescues, with some bents.

FIELD DATA
1959 - 1960 - 1961

Table II: Weed Control Ratings in Plots One Year After Treatment (October 8, 1959)

Treatment No.		Replicates I	II	III	IV
D10	Grasses	9.5	8.5	9.0	5.5
	Broadleaves	6.0	5.0	7.0	10.0
S10	Grasses	3.0	7.0	6.5	5.5
	Broadleaves	4.0	7.0	5.0	10.0
D16	Grasses	10.0	10.0	10.0	9.0
	Broadleaves	8.0	8.0	6.5	10.0
S16	Grasses	4.0	7.5	10.0	9.0
	Broadleaves	7.5	8.0	9.0	9.0

Variation due to material rates significant at 0.1 per cent level. Variation due to material source not significant. Variation due to replication not significant for grasses, but significant at five per cent level for broadleaves.

Applications of 32 and 64 pounds active for both products showed complete sterilization (10) of both grasses and broadleaves in all plots. Note: Nonsignificance is herein meant as below the 20 per cent level.

Table III: One Year Measurement of Damaged Area Below Plots as the Number of Feet of Killed Vegetation (October 8, 1959)

Replicates	Treatments Above Damaged Area							
	D10	S10	D16	S16	D32	S32	D64	S64
I	2.0	0.5	3.0	0.5	3.5	1.5	7.0	1.5
II	1.5	1.0	2.5	1.0	4.5	1.0	7.0	1.0
III	0.5	0.5	1.0	0.5	2.5	2.0	3.0	2.0
IV	0.5	0.5	1.0	7.0	9.0	6.0	10.0	8.0

Variation due to material source not significant; due to replication significant at five per cent level; and due to material rates significant at 0.1 per cent level.

Table IV: One Year Sterilization Ratings for Grass in Damaged Area Below Plots as Designated in Table III

Replicates	Treatments Above Damaged Area							
	D10	S10	D16	S16	D32	S32	D64	S64
I	8.5	4.0	6.5	1.0	9.5	10.0	8.0	8.5
II	8.5	7.0	10.0	7.0	9.0	10.0	9.5	10.0
III	10.0	6.0	10.0	10.0	9.5	7.0	10.0	9.0
IV	5.5	9.0	9.5	4.0	6.7	4.5	7.0	5.5

Variation due to material source not significant; due to replication significant at five per cent level; and due to material rates not significant.

Table V: One Year Sterilization Ratings for Broadleaf Weeds in Damaged Area Below Plots as Designated in Table III

Replicates	Treatments Above Damaged Area							
	D10	S10	D16	S16	D32	S32	D64	S64
I	5.0	4.0	4.0	1.0	5.0	10.0	8.0	8.5
II	5.0	7.0	8.0	7.0	7.0	10.0	6.0	10.0
III	7.0	6.0	6.5	7.0	9.5	7.0	10.0	9.0
IV	10.0	9.0	9.5	4.0	6.7	4.5	7.0	5.5

Variation due to replication and material source and material rates not significant.

Table VI: Second Year Sterilization Ratings for Vegetation in Plots (July 1960)

Replicates	Treatments							
	D10	S10	D16	S16	D32	S32	D64	S64
I	5	6	7	6	9	9	9.5	9.5
II	6	6	8	7	8	8	10	10
III	5	5.5	8	7	7	9	9.9	9.9

Variation due to replication and material source not significant; variation due to material rates very highly significant at the 0.1 per cent level.

Table VII: Second Year Measurement of Damaged Area Below Plots as the Number of Feet of Bare Soil (July 1960)

	Treatments Above Damaged Area							
Replicates	D10	S10	D16	S16	D32	S32	D64	S64
I	0	0	1	1	2.5	2	6	4
II	0	0	1	1	1.5	1.5	3	3
III	0	0	0	0	0	0	0.5	0.5
IV	0	0	0	0	2	1	6.5	6

Variation due to replication significant at the 5 per cent level; due to material source not significant; due to material rates very highly significant at the 0.1 per cent level.

Table VIII: Third Year Sterilization Ratings for Vegetation In Plots (August 1961)

	Treatments							
Replicates	D10	S10	D16	S16	D32	S32	D64	S64
I	0	1	2	3	6	8	8	8
II	1	0	0	1	2	3	8	7
III	0	0	8	6	6	6	8	9
IV	3	3.5	6	5	9	8	1	0

Variation due to replication and material source not significant; variation due to material rates significant at the 5 per cent level.

Table IX: Third Year Measurement of Damaged Area Below Plots as the Number of Feet of Bare Soil (August 1961)

	Treatment Above Damaged Area							
Replicates	D10	S10	D16	S16	D32	S32	D64	S64
I	0	0	0	0	1	0.5	3	1.5
II	0	0	0	0	1	1	1.5	1
III	0	0	0	0	0	0	0	0
IV	0	0	0	0	1	1	0	0

Variation due to replication, material source and material rates not significant.

DISCUSSION

One Year After Application (1959):

Observations one year after treatment showed a high degree of weed control but some weeds, broadleaves in particular, were present in many of the plots. There was regrowth of some grasses such as sandbur and crabgrass (shallow roots), and of broadleaf species such a Linaria, Stellaris, Lepidium and Chenopodium within the plots at the lower two rates. Living plants of equisetum were found in both the diuron and simazine plots, except at the two higher rates.

Eliminating the two higher rates in which weed control was so complete as to show no differences, the data shows diuron to be appreciably more effective than simazine on grasses, and equal to or slightly more effective than simazine against broadleaf weeds (Table II). In fact, on grasses, 10 pounds of diuron usually performed as well as 16 pounds of simazine (Tables II and IV). Thus, these tests indicate that the first year diuron gives more effective weed control than simazine on an equal active ingredient basis. As the rate of application increases above the minimum required for complete kill, differences in the materials are not evident.

This difference in efficiency between the two compounds must be taken into account in evaluating the data on surface washing on slopes. As can be seen from the data, the effect of down-slope washing was not appreciably different between the two compounds at equal lower rates. (Table III) Both materials tended to wash, as would be expected. At equal higher rates, the effect of diuron was more pronounced, but whether this was due to a greater tendency to wash, or to its greater herbicidal efficiency, is not clear from these data.

Second Year After Application (1960):

Observations the second year after application (Table VI) showed 50 to 60 per cent vegetation control in the plots at the 10 pounds per acre rate of both materials; 60 to 80 per cent control at the 16 pounds per acre rates; but 80 to 100 per cent control at the 32 and 64 pounds per acre rates. Effective vegetation control dropped rapidly for the two lower rates, regardless of material source.

The degree of sterilization (injury) below plots due to herbicidal transport down-slope (Table VII) was no longer evident at the 10 pounds per acre rate. Below plot injury was only slightly evident at the 16 and 32 pounds per acre rates, and 50 per cent of the damaged area below the 64 pounds per acre plots recovered from the herbicidal effects by the date of these observations.

Third Year After Application (1961):

Observation of the plots the third year after application (Table VIII) indicated only 10 to 30 per cent vegetation control at the 10 pounds per acre rate; 10 to 60 per cent control at the 16 pounds per acre rate; 20 to 90 per cent control at the 32 pounds per acre rate; and 10 to 80 per cent control at the 64 pounds per acre rate.

In general, most of the area which showed some degree of below-plot injury to vegetation due to herbicidal transport the first and second years was recovered from the harmful effects by the third year. (Table IX)

Most of the areas which recovered from the effects of the herbicides are now filled in with the species of grasses adjacent to the area.

SUMMARY

In general there are a few main conclusions that can be offered:

1) There was no long term significant difference due to source of material under the conditions of this study; however, the rate of active herbicide used was significant up to the third year after application. It is doubtful that any visible control will be evident by the fourth year after application, even at the highest rates.

2) It would appear that the optimum vegetation control per dollar of expenditure would be obtained at the 16 pounds per acre active herbicide rate.

3) Type of soil (sandy soils used in this study) might presumably have some bearing upon the rate of vegetation recovery, and upon the extent of down-slope transport of the herbicide.

4) Prevention of concentrated water running over treated areas would materially help to reduce down-slope transport of herbicides. (There is no substitute of good construction and sound run-off control.)

5) Departmental experience with 6 to 8 year vegetation control under guide rail fences after soil sterilization with herbicides is presumably the result of an adequate bitumen cover applied immediately over the sterilized area, rather than to the rate or kind of herbicidal soil sterilant which was used. The bitumen cover prevents re-entry of viable seed to the treated soil, and materially helps to prevent down-slope transport of the chemical itself.

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HERBICIDE: AN INDIRECT FACTOR IN THE PRODUCTION OF A TASTE PROBLEM IN POTABLE WATER

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INTRODUCTION

Fayson Lake Community, Inc., a water company located in a residential area in New Jersey, obtains their water supply entirely from well sources, although they maintain three lakes for recreational purposes.

Two lakes and two wells are significant in terms of this paper namely, West Lake (65 acres), South Lake (30 acres) and the South and West wells located immediately offshore of South Lake.

The two lakes are interconnected, in series, with the West Lake flowing into the South Lake. The South well is located in the proximity of the dam over which South Lake flows into a stream. (See Figure A).

In the summer of 1960 undesirable growths were prevalent in the two lakes, and the lakes were treated with a commercial herbicide (Kuron).

Kuron is a propylene glycol ($C_3H_6O_2C_9H_{10}O_3$) containing butyl ether esters of 2-(2, 4, 5-Trichlorophenoxy) propionic acid.

The treatment consisted of applying a 2 ppm dosage of the herbicide in the West lake and 1 ppm in the South lake. This was completed in August 1960.

In September 1960, immediately following Hurricane Donna, a strong medicinal taste was prevalent in the well water emanating from the South well. No significant taste was apparent in the West well.

This persisted until the period between November 15, 1960 and December 1, 1960 when the taste diminished and finally disappeared.

However, in December 1960 the taste returned as strong as had been experienced in the past. This reoccurrence coincided with the laying of an underwater cable in the lake by I. T. and T.

These two incidents appeared to lend weight to the consideration that a distrubance of the lake bed was at least partially responsible for the production of the undesirable taste.

LABORATORY INVESTIGATIONAL STUDIES

With this history as a starting point and the taste still persisting in January 1961, samples were drawn from the South Lake (bottom sample), the South well and a point in the distribution system which embraced a combination of the South and West well waters. These were analyzed, the results of which are tabulated in Table I.

The comparative analyses of the South Lake water and the South well revealed sufficient differences to establish that they were not the same water. This, of course, did not rule out the possibility that a portion of the lake water was present in the well water.

Since Kuron is a phenolic compound, phenol determinations were performed on all samples with negative results being obtained. This coincided with previous findings by others.

Since the medicinal taste was pin-pointed as being iodoform, iodine determinations were performed and revealed an interesting picture. The South Lake water, as obtained from the bottom, contained 0.65 ppm of iodine; the South well water and the combination well water contained 0.15 and 0.20 ppm of iodine; the West well alone contained only a trace of iodine which was not sufficient to produce the disagreeable taste found in the South well.

In order to establish whether these concentrations could be classified as significant, it was necessary to first establish a "threshold" concentration of iodine.

This was accomplished by applying increasingly larger dosages of iodine to distilled water and observing the taste qualities of each. Concentrations under approximately 0.1 ppm did not materially affect the taste of the water, but concentrations greater than this resulted in a rapid increase of the intensity of the iodoform taste.

Since the tastes resulting from these studies coincided closely with the offending taste of the water in question, it was apparent that the agent producing the disagreeable taste had been found.

However, in order to substantiate these findings, chlorine, in increasing dosages, was applied to the water since this is an established method for the removal of iodine tastes from water.

Table II tabulates the data obtained from these studies. A dosage of 2 ppm of chlorine alleviated the taste considerably but did not completely abolish it. A 3 ppm dosage completely removed the iodoform taste and did not reveal any other disagreeable taste such as chlorinous tastes.

FIELD PROCEDURES

Although the West well water did not reveal significant concentrations of iodine, as an extra precautionary measure both the South and West well chlorine feeds were increased to 3 ppm. This resulted in immediately abolishing the iodoform tastes from the combined waters from the wells.

The West well chlorine feed was then reduced to its normal feed with no ill-effects in terms of tastes.

The South well chlorine feed was maintained at 3 ppm for the next two months after which it was decreased in small increments to ascertain whether the disagreeable taste would return. It was found that the chlorine feed was eventually returned to normal without resultant ill effects.

For the next eight months there was no further evidence of a taste problem. However, in September 1961 it reappeared, immediately following Hurricane Esther. The chlorine dosage was increased, and the taste immediately disappeared.

At present, the chlorine feed has been returned to normal, and there is no evidence of a taste problem.

A recent analyses obtained on November 2, 1961 revealed an iodine content in the South well to be 0.05 ppm (insufficient to produce a disagreeable taste). A bottom sample of South Lake revealed a concentration of 0.28 ppm iodine. This is considerably less than the concentration found in this lake on January 11, 1961 (0.65 ppm) but indicates that the effects have not yet been fully dissipated.

CONCLUSIONS

The taste problem that occurred on three separate occasions prior disturbance of the lake bed. The offending well was, in each case, the well located immediately adjacent to the overflow dam of South Lake (South well). The well located at the far end of this same lake did not exhibit any taste problems (West well).

In addition, the concentration of iodine was considerably greater at the lake bottom as compared to the concentration found in the well water.

These considerations resulted in the theory that the iodine was present at the bottom of the lake and, following disturbance of the bottom, significant amounts of iodine found its way into the South well supply.

The reason for the contamination of the South well supply and not the West well supply can be attributed to the fact that the flow pattern in South Lake is away from the West well and toward the South well. Further, it appeared possible that the iodine was concentrated in the immediate area of the overflow dam (and South well).

The source of the iodine, of course, remained a mystery. It did not appear feasible that the disturbance of the lake bed alone was significant in itself since other disturbances had certainly been encountered prior to this past year without the production of disagreeable tastes. Neither could the herbicide itself be termed the direct responsible agent since its chemical makeup does not include any form of iodine.

The only remaining source, then, appeared to be the undesirable plant growths that were effectively destroyed by the herbicide. Possibly these fresh-water plant growths, upon being destroyed, resulted in the release of iodine which eventually settled to the lake bottom.

Seaweed (or kelp) is known to be a significant source of iodine, although these are of salt-water origin.

In the light of these data it appears desirable to give consideration to the derivation of a classification of fresh water growths in terms of their iodine content in order that effects similar to those experienced herein can be avoided in the future. Further, it may be possible to harness these effects by controlled feeding and thereby derive more beneficial results from these effects.

It is the sincere hope of the author that this paper will result in stimulating minds more familiar with this problem to ascertain the possible far-reaching significance of these findings.

ACKNOWLEDGMENT

Grateful acknowledgment is given to Fayson Lake Community, Inc. and, in particular, Mr. John Stoveken, for their allowing the presentation of this material and their sincere aid and advice in its completion.

FIGURE A

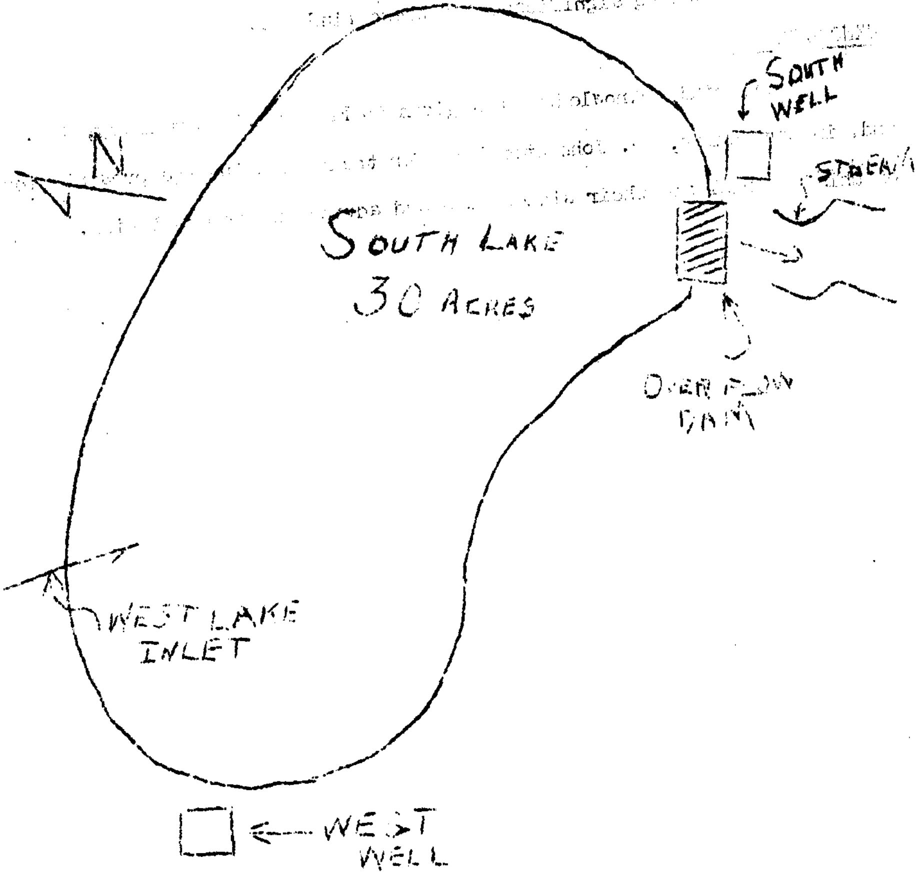
N
SOUTH WELL
STREAM
SOUTH LAKE
30 ACRES
OVER FLOW DAM
WEST LAKE INLET
WEST WELL

TABLE I

SAMPLE CHARACTERISTICS

DRAWN: Wednesday; 1/11/61 ANALYZED: Wednesday; 1/11/61

CHARACTERISTIC	SOUTH LAKE: BOTTOM	SOUTH WELL WATER	COMBINATION SOUTH & WEST WELL WATERS
pH	6.70	7.22	7.28
Specific Conductance, u mhos	120	201	201
Phenol, ppm	N.F.	N.F.	N.F.
Iron, ppm	0.35	0.08	0.08
Iodine, ppm	0.65	0.15	0.20
Chlorides, ppm as Cl^-	12.8	9.1	8.5
Taste	-	Fairly strong medicinal; iodoform	Strong medicinal; iodoform

Note: N.F. = None Found

TABLE II

CHLORINE TREATMENT OF WELL WATER

CHLORINE DOSAGE APPLIED, ppm	REMARKS
0.0	Strong medicinal (iodoform) taste
1.0	Strong medicinal (iodoform) taste
2.0	Weak medicinal (iodoform) taste
3.0	No disagreeable taste

SUMMARY OF SEVERAL AQUATHOL TREATMENTS IN NEW JERSEY WATER

by

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This discussion deals with a summary of some results of commercial applications on several different lakes within potable watershed areas in Northern New Jersey. The following are the results, observations:

I. COZY LAKE -

Conditions: The total lake area is 30 acres with a maximum depth of 9½ feet and an average of 4 feet, with a total of 100 acre feet. The major weed species was Najas minor, with minor species Ceratophyllum sp., Potamogeton crispus, Nuphar sp., Elodea canadensis, green filamentous algae.

Application: An application was made on May 22, 1961, by Roy Younger, Consulting Biologists Inc., Philadelphia, Pennsylvania, on Cozy Lake. The lake was drawn down 6 inches. One application was made of 227 gallons of AQUATHOL for a total concentration of 2 ppm.

Results: Excellent control of all species except Elodea and algae. In mid-September Najas minor had commenced to regrow in small patches. Elodea canadensis had started to take over one end of the lake. Other species were not present. An algae control treatment of 0.25 ppm $CuSO_4$ was made to control algae bloom.

II. DARLINGTON COUNTRY CLUB -

Conditions: The total lake area is 18 acres with a maximum depth of 10 feet and an average depth of 7.5 feet. The major weed species was Potamogeton crispus, with scattered Myriophyllum sp. and Elodea sp..

Application: Two treatments were applied as follows: One on June 13, 1961, to the north side of the lake and the other on June 23, 1961, to the south side of the lake by W. C. Hall, Chemtree Corporation, Harriman, New York. The lake was drawn down 12 inches, and a total of 225 gallons was applied in a split application of 112 gallons for a 1.5 ppm treatment (in treated area), with one-half of the lake being treated each time.

Results: Effective weed control was obtained for the season. Observations and comments on water quality were made by Richard E. Roby, Passaic Valley Water Commission, Little Falls, New Jersey, as follows:

> "An effective weed kill was obtained without apparent increase in lake water odor due to the use of AQUATHOL. The increase in odor when it did occur was due primarily to decaying vegetation.
>
> "Further indications were that microscopic organisms were killed initially by the use of AQUATHOL, and this in turn followed by an enormous increase in the water bacteria; however, complete balance appeared to have been regained in about 10 days to 2 weeks after treatment."

III. WHITE MEADOW -

Conditions: Total lake area is 140 acres with an 896 acre foot volume, with an average depth of 6.4 feet. The major weed species was Potamogeton crispus, with algae patches present throughout the lake prior to treatment.

Application: A single application was made on July 10, 1961, by Roy Younger, Consulting Biologists Inc., Philadelphia, Pennsylvania, applying 345 gallons of AQUATHOL to 31.5 acres at a concentration of 3 ppm in the treated area.

Results: The control achieved was 90% with a limited amount of regrowth by mid-September. The entire lake was treated with 0.5 ppm $CuSO_4$ to control algae bloom.

IV. MISCELLANEOUS -

Various other lakes in New Jersey outside of watershed areas were treated with very good results when applications were made against the weeds specified on the label and at recommended rates. This coincides very well with the results obtained in the rest of the United States and Canada.

HERBICIDE TESTS WITH SHOULDER-MOUNTED MIST BLOWERS [1]

Shoulder-mounted mist blowers have been used to apply high concentration, low-volume applications of herbicide to control hardwoods in mixed stands since 1958. They have been employed also to regulate vegetation on power and pipe-line rights of way, to keep the shore-lines of reservoirs clear of brush, to control Japanese honeysuckle and kudzu on problem areas in the South and to apply insecticides to young pine stands subject to attack by the white pine weevil.

Various spray solutions of 2, 4, 5-T, "Kuron", and Ammate have been tried in water, oil-water emulsions, fuel oil, and non-phytotoxic oil such as mineral seal oil with fair to good effectiveness. Results to date indicate better hardwood control with some oil in the spray solution. Oil is probably a better carrier than water for herbicide, because (1) it has low surface tension and excellent wetting ability, (2) most oil molecules have a structure which permits easy penetration of the leaf cuticle, and (3) oil has a slow-acting toxicity of its own. Damage to conifers from oil in the spray mixture has usually been of an acceptable level if spraying is done after the conifers have hardened off in the late summer. In Massachusetts the entire month of August and, in most years, the last week of July and the first week of September are suitable times to spray to control hardwoods without undue damage to conifers.

The pattern of hardwood control with mist blowers is different from that of aerial sprays using the same spray mixture. Much of the spray from mist blowers strikes the underside of the leaves while that from aircraft hits the upper side. The upper side of the leaf with its cuticle is probably more resistant to penetration of spray material than the lower side. On the other hand, the pattern of kill and damage is not as consistent on mist-sprayed areas, because spray application by mist blower is not as uniform as aerial application. Aerial application is, of course, superior for killing an overstory of hardwoods to release conifers which are protected from the spray when it comes from above. Ground application of herbicide is superior for controlling understory hardwoods. The most serious limitation of shoulder-mounted machines is their inability to kill large trees.

In tests made during the last three weeks of August in 1959 and 1960, 188 acres were sprayed in Massachusetts and New Hampshire in an attempt to evaluate various spray mixtures for the control of hardwoods in mixed stands without excessive damage to conifers. In most cases the tested material was matched against a standard mixture of 2, 4, 5-T in No. 1 fuel oil at a ratio of 1:9 applied at the same rate as the tested material, on the same day, employing the same techniques. Results indicate that the materials used react in a fairly uniform way under differing weather conditions, in various stands.

SPRAY MIXTURES TESTED

Five spray mixtures were tested in concentrations ranging from 1 to 2 pounds acid equivalent of 2, 4, 5-T per acre. One mixture was applied at two different rates per acre and another at three rates to give a total of eight tests. The herbicides used were 2, 4, 5-T and invert emulsion of 2, 4, 5-T. All spray mixtures were made at the ratio of 1:9, one part herbicide at four pounds acid equivalent per gallon, to nine parts of carrier. Different rates of application were achieved by applying differing amounts of the same mixture to an acre. Table 1 shows six pairs of matching herbicide spray mixture tests.

In the invert emulsion water droplets are dispersed through a continuous system of oil giving an invert or water-in-oil emulsion in contrast to a conventional emulsion which is oil-in-water. Conventional oil-in-water emulsions have about the same viscosity as water. Invert emulsions may be thick like heavy engine oil or even mayonnaise. The increased viscosity results in increased droplet size, a reduction in drift hazard, and increased deposits of spray on treated plants. Viscosity is controlled by the amount of oil in the mixture. If it is too thick, addition of a small amount of oil will thin it out. To flow properly through a shoulder-mounted mist blower, the invert emulsion should resemble Number 30 engine oil.

Table 1 . <u>Formulations of Herbicide Used in Six Pairs of Matching Tests</u>

Test No.	Herbicide	Application Rate per acre (gallons)	Acid Equivalent per Acre (pounds)	Carrier No. 1 Fuel Oil	Carrier Diesel Oil (gallons)	Carrier Water
1	2,4,5-T	5.0	2	4.5		
2	2,4,5-T	5.0	2			4.5
3	2,4,5-T	5.0	2		4.5	
4	2,4,5-T[1]	5.0	2	1.0	+	3.5
5	2,4,5-T	5.0	2	4.5		
6	2,4,5-T	2.5	1	2.25		
7	2,4,5-T	2.5	1	2.25		
8	Invert 2,4,5-T[2]	2.5	1	.5	+	1.75
9	2,4,5-T	3.75	1.5	3.37		
10	Invert 2,4,5-T	3.75	1.5	.75	+	2.63
11	2,4,5-T	3.75	1.5	3.37		
12	Invert 2,4,5-T	3.75	1.5	.75	+	2.63

[1] The 2, 4, 5-T used in the oil-in-water emulsion contained an oil stable emulsifier which improved oil-water emulsions of the herbicide.

[2] The invert 2, 4, 5-T used was an experimental invert emulsion formula of the herbicide at 4 pounds acid equivalent per gallon. This product is now on the market at 2 pounds acid equivalent per gallon and the oil has been added as part of the formula.

All the mixtures except the invert emulsion were easy to make and did not tend to settle out. The invert 2, 4, 5-T readily formed a white, thick creamy emulsion, but the water tended to separate out if not frequently agitated. A machine with motor-powered agitation makes invert emulsions easier to make and use. The ingredients need only be added to the tank in proper order while the motor is running and the consistent agitation prevents the water from seperating out of the mixture while spraying is in progress. Oil mixtures may safely be made up any time; emulsions of oil and water should be made up fresh on the job. Good mixing instructions appear on the labels of all herbicides and should be carefully followed.

EQUIPMENT USED

Two shoulder-mounted mist blowers were used. One of Dutch manufacture has a 1.5-horsepower 2-cycle gasoline motor and weighs 25 pounds empty. The spray solution is carried in a seperate 2.5 gallon tank which is suspended from the shoulder straps supporting the machine and hangs in front of the operator. The second machine is of German manufacture, weighs 27 pounds empty, and has a 2-cycle 3-horsepower gasoline motor. The spray solution tank of 2.5 gallon capacity is an integral part of this machine. This tank is of plastic composition permitting the use of corrosive materials like Ammate without damage to the machine. The spray tank has mechanical agitation, an important feature for spray mixtures which tend to separate. Manufacturers of both machines claim 30 feet of spread, and the machines are both capable of this. They deliver mist to a height of 20 feet in still air. By letting the air stream build up, 30 feet of height is achieved. In normal operating situations 2½ gallons of spray material are delivered in 20 to 30 minutes. With the two machines working in tandem, 10 to 20 acres can be sprayed in a day. In these tests 188 acres were sprayed in 14 working days. The smallest acreage completed in a day was 10 acres, the largest was 20, and the average for the period was 13.4.

METHOD OF APPLICATION

In these tests two mist blowers were usually operated in tandem by a three-man team. Two men operated the blowers, the third man replenished the supply of herbicide and spelled the operators when they tired. Parallel strips were run at 20-foot intervals through the forest, and strands of toilet paper were put out by the outside man at intervals to orient the inside man on the next strip. In this manner a forty-foot swath was sprayed by the two machines operating together. Some spraying was done by one man working alone and by two men operating both machines without help. Different crew organizations had little effect on the cost or efficiency of the operation.

All the tests were made in Massachusetts or New Hampshire during the last three weeks of August in 1959 and 1960.

RESULTS

Treatment effect was determined by measuring 123 concentric circular plots early in September the year after spraying. Low brush was measured on .001-acre plots (radius 3.72 feet), high brush on .005 acre plots (radius 8.33 feet), and trees on .05-acre plots (radius 26.3 feet). The plots were mechanically located by compass and pacing.

The first two matching tests were made in Massachusetts in a white pine-hardwood stand less than forty feet tall. The major hardwood species present were gray birch and red maple with some oak and shrubs like blueberry and huckleberry. The hardwoods were for the most part taller and more vigorous than the pine.

Two pounds 2, 4, 5-T in 4.5 gallons of No. 1 fuel oil per acre was matched against two pounds 2, 4, 5-T in 4.5 gallons of water. As shown in Table 2, the water mixture proved to be less effective than the matching oil mixture and was less effective than any other herbicide mixture tested. Twenty-eight per cent of the low brush on Test 1 showed no damage (Table 2). This undamaged vegetation was huckleberry and blueberry. The undamaged low brush in Test 6 was maleberry and laurel. Huckleberry, blueberry, maleberry, and laurel (all ericaceous shrubs) proved resistant in every test where they occurred. In all tests control of hardwoods in the tree class (2" DBH and up) was not as good as control of the lesser vegetation. Many of these trees were beyond the effective height range of the machines used. In dense stands the lower branches of trees were killed, but the tops were left intact, because spread of the mist was checked on hitting the bottom of the tree crowns. A second spraying would do more damage or probably kill the tree if it were less than thirty feet tall.

The second set of matching tests was conducted in New Hampshire so that the sensitivity of red spruce and balsam fir to the herbicides could be judged. Tests were conducted in stands with pine, hemlock, red spruce, and balsam fir mixed with hardwoods which were generally overtopping the softwoods. Most of the trees were less than forty feet tall.

Test 3, two pounds 2, 4, 5-T in 4.5 gallons of No. 2 diesel oil was matched against Test 4, two pounds 2, 4, 5-T in one gallon of No. 1 fuel oil and 3.5 gallons of water per acre. Here again the mixture with straight oil as a carrier was substantially superior to that containing part water (Table 2). On the other hand, the mixture with the oil-water carrier, Test 4, gave better control than the mixture with straight water as the carrier, Test 2. It is probably safe to say the more oil there is in the mixture, the better is the hardwood control.

Some damage to conifers was observed on all the test areas. Most damage to conifers was observed on Test 3, the area treated with the diesel oil mixture. Six small suppressed pine were found dead on the plots taken in this area. This damage probably occurred, because diesel oil, being less volatile than No. 1 fuel oil, stays on the tree longer and has a more lasting toxic effect. It should be mentioned that damage to conifers occurred on all plots. The only other dead conifer was recorded on a plot on Test 2 where water only was used as a carrier. Spruce, fir, and hemlock were more sensitive to all herbicides than pine, but damage to these species did not exceed an acceptable level. An occasional leader or side branch was killed, but most of the trees showed no evidence of damage.

The diesel oil mixture did not appear to spread as well or to hang in the air as long as the lighter fuel oil. There were more gores of undamaged trees between the strips, an indication that the material did not drift well. Height penetration did not equal that of the other mixtures. Diesel oil should not be used in portable mist sprayers, because the operator will end the day drenched with oil. If No. 1 fuel oil or kerosene is used, it will evaporate from the operator readily, and he will end the day dry and comfortable. Number 1 fuel oil is superior to diesel oil because it gives hardwood control equal to or better than diesel oil, gives better height penetration, and it does less damage to conifers.

The third set of matching tests compared oil mixtures at the rates of one and two pounds per acre. The stands treated were natural and planted white pine interspersed with hardwood trees and shrubs. Most of the trees were less than thirty feet in height. Aspen was the predominant hardwood species. Test 5, two pounds 2, 4, 5-T in 4.5 gallons of fuel oil per acre, was matched against Test 6, 1 pound 2, 4, 5-T in 2.25 gallons of fuel oil per acre. Both treatments gave good control of hardwoods with little pine damage. Treatment at the two-pound level was somewhat better than the one-pound treatment, but the one-pound treatment compared favorably with other oil treatments conducted in other tests (Table 2). Most of the low brush which showed no damage in these tests was maleberry, huckleberry, and laurel, species which were resistant to all the herbicides tested, as noted earlier. Two white oaks over 12" in diameter and more than forty feet tall were killed on this area. Control of aspen was very good except when the trees were above the effective range of the equipment or the canopy was so dense that only the lower branches were hit by the mist.

Resprouting occurred abundantly only on smaller aspen and red maple. Sprouts were much more abundant the second year after spraying. Some of the head high aspen stands which had excellent hardwood control the first year with only 12% of the stems sprouting were severely competing with the pine at the end of the second growing season. This experience coupled with observations on other areas treated with mist blowers since 1957 points up the fact that control and not complete kill is achieved with mist spray. Two or more treatments may be necessary to bring a slowly responding stand of softwoods up through the competing hardwoods which are rendered less competitive by the treatment or killed. Hardwood damage is often progressive, and control may be better the second or third growing season after spraying than it was the first year; whereas damaged conifers, on the other hand, quickly recover.

Three sets of tests were made matching the standard oil mixture of 2, 4, 5-T against and invert emulsion of 2, 4, 5-T. One set of tests was made with an acid equivalent of one pound per acre, and two sets were made at one and one-half pounds per acre. The areas treated were abandoned fields invaded by hardwoods which had been planted to conifers. Most of the vegetation was less than thirty feet tall.

Test 7, one pound 2, 4, 5-T in 2.25 gallons of fuel oil per acre, was matched against Test 8, one pound invert 2, 4, 5-T in .50 gallons fuel oil and 1.75 gallons of water. In two different situations on different days (Tests 9 and 11) the oil mixture applied at one and one-half pounds per acre was matched against the invert solution applied at the same rate per acre (Tests 10 and 12).

Good hardwood control was achieved on all six areas treated, and the invert emulsion gave control which compared favorably with the standard oil mixtures (Table 2). There appears to be little difference in susceptibility among the species when treated with the two mixtures (Table 3). There was less drift with the invert emulsion which reduced the effective range of the blowers. Treated strips should be less than twenty feet in width if satisfactory coverage is to be attained with invert emulsions. These tests would indicate that this material can be more safely used than regular 2, 4, 5-T where danger of damage to agricultural crops or other nearby vegetation is a factor.

It was hoped that greater height penetration would be achieved with the invert emulsions than with regular 2, 4, 5-T, because the droplets are of larger size. This result was not evident, however, on any of the three tests.

An examination of the effects of the various herbicides tested on species groups (Table 3) does not indicate that one mixture is effective on one group of species and not effective on another. The herbicides which proved most effective were equally effective on all species of hardwood and about equal in their damage to conifers.

COST

Costs are based on 188 acres sprayed in fourteen working days in 1959 and 1960. Costs range from $6.17 to $10.73 per acre (Table 4). Materials, labor, and machine costs increase with the application of more material per acre. The use of oil in the mixtures increases the cost modestly but improves hardwood control greatly. Increasing the volume of herbicide applied may somewhat improve hardwood control at a substantial increase in cost for the small gain attained. However, costs for even the most expensive application are still very reasonable at $10.73 per acre for a single treatment. If some additional spraying is necessary to achieve the results desired, costs will be increased accordingly. Two light sprayings at one pound per acre will probably give better control for the money spent than one spray at the two-pound per acre level.

Table 2. Effectiveness of Various Formulations of 2,4,5-T and Invert Emulsions of 2,4,5-T Applied with Shoulder-Mounted Mist Blowers

Herbicide	Carrier	Lbs. per Acre	Low Brush (0.6 ft. to 0.5"DBH)								Tall Brush (0.6" to 1.9"DBH)								Trees (2.0" DBH and up)							
			Dead[5]		Severe[6]		Light[7]		None[8]		Dead		Severe		Light		None		Dead		Severe		Light		None	
			S/A[4]	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%
245-T	Oil	2	2538	57	461	10	231	5	1230	28	862	73	139	12	154	13	31	2	53	21	64	35	59	32	21	12
245-T	Water	2	1364	50	91	3	909	34	364	13	254	44	199	34	54	9	73	13	220	6	47	15	124	38	131	41
245-T	D O[2]	2	7666	69	778	18	333	8	222	5	644	63	222	22	89	9	67	6	66	20	84	25	163	50	15	5
245-T	O+W[1]	2	1279	40	557	18	334	11	1001	31	443	51	177	20	189	21	67	7	53	28	43	19	98	40	52	19
245-T	Oil	2	6307	75	1461	18	538	6	77	1	1186	69	262	15	200	12	62	4	118	34	69	20	156	45	3	1
245-T	Oil	1	7075	54	2307	18	923	7	1615	21	893	72	231	18	108	9	15	1	16	25	6	9	37	48	12	18
245-T	Oil	1	1375	100	—		—		—		1250	83	250	17	—		—		142	47	32	11	122	40	7	2
Invert[3]	O+W	1	1111	100	—		—		—		1887	88	244	10	22	1	22	1	44	29	102	38	141	27	9	6
245-T	Oil	1½	333	40	500	60	—		—		1598	71	466	20	200	9	—		155	44	59	17	99	28	40	11
Invert	O+W	1½	225	25	555	63	111	12			1516	94	89	5	—		22	1	70	24	48	16	130	44	35	16
245-T	Oil	1½	1125	70	125	15	125	15	—		1750	83	300	17	—		—		92	31	65	22	105	35	35	12
Invert[3]	O+W	1½	8335	100	—		—		—		1665	94	100	6	—		—		112	31	168	47	79	22	—	
		Ave.	3242	72	570	13	292	7	376	8	1155	78	221	14	85	6	28	2	78	28	66	23	109	39	28	10

+W - Oil and water
0 - Diesel oil
nvert - 2,4,5-T

4 S/A - Stems per acre
5 Dead - 80% or more defoliated
6 Severe - 50% to 80% defoliated

7 Light - 20% to 50% defoliated
8 None - Less than 20% defoliated

Table 3. Effectiveness on Species of Various Formulations of Herbicides

Species	Low Brush--0.6 ft. to 0.5"DBH								Tall Brush--0.6" to 1.9" DBH								Trees--2.0" DBH and up							
	Dead		Severe		Light		None		Dead		Severe		Light		None		Dead		Severe		Light		None	
Groups	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%	S/A	%
2,4,5-T in water at 2 lbs. per acre Test 2																								
Birches					273	100			146	62	36	15			55	23	9	7	9	7	45	38	58	48
Maples	273	60			91	20	91	20	36	40	36	40	18	20			7	6	22	21	38	35	41	38
Oaks									36	67	18	33					4	9	11	24	13	28	18	39
Aspen																					5	56	4	44
Other									18	100									5	18	11	41	11	41
Shrubs	1091	54	91	2	545	27	273	14	18	10	109	60	36	20	18	10					12	100		
TOTAL	1364	50	91	3	909	34	364	13	254	44	199	34	54	9	73	13	20	6	47	15	124	38	131	41
2,4,5-T Oil and Water at 2 lbs. per acre Test 4																								
Birches	111	10	56	5	278	27	612	58	33	12	44	17	122	46	67	25	2	6	2	4	21	44	22	46
Maples	1001	76	167	12			167	12	344	67	100	20	67	13			34	26	29	22	52	39	18	13
Oaks																					1	100		
Aspen																	2	9	3	14	9	41	8	36
Other	111								22	50	22	50					10	28	9	26	14	40	2	6
Shrubs	56	8	334	50	56	8	222	34	44	80	11	20					4	57			1	14	2	29
TOTAL	1279	40	557	18	334	11	1001	31	443	51	177	20	189	21	67	7	53	22	63	19	98	40	52	19
Invert Emulsion 2,4,5-T in oil and water at 1 and 1½ lbs. per acre Tests 8,10,12 Combined																								
Birches	1083	100							275	100							14	43	9	27	10	30		
Maples									192	85	25	11	8	4			21	30	22	39	17	24	5	7
Oaks									8	100							4	80			1	20		
Aspen	917	100							150	72	58	28					9	13	21	29	32	45	9	13
Other	292	100							183	76	41	17					4	14	7	24	10	34	8	28
Shrubs	333	62	208	38					909	97	25	3					17	43	18	45	2	5	3	7
TOTAL	2625	93	208	7					1717	91	149	8	8				69	28	82	33	72	29	25	10
2,4,5-T in oil at 1 to 2 lbs. per acre Tests 1,3,5,6,7,9,11 (Combined)																								
Birches	543	91	44	7	14	2			406	81	63	12	34	7			38	39	30	31	23	24	6	6
Maples	486	70	100	14	71	10	43	6	163	63	60	23	26	10	11	4	6	15	12	30	16	40	6	15
Oaks	300	55	186	34	43	8	14	3	146	82	29	17			3	1	19	66	4	14	6	20		
Aspen	1100	65	428	26	142	8	14	1	194	73	46	17	26	10			9	19	9	19	28	58	2	4
Other	357	96					14	4	143	62	24	23	23	10	11	2	12	54	1	5	6	27	3	14
Shrubs	815	55	129	9	43	3	486	33	60	80	9	12	6	8										
TOTAL	3601	67	887	16	313	6	572	11	1112	73	261	17	115	8	25	2	84	36	56	24	79	33	17	7

SUMMARY AND CONCLUSIONS

Herbicides were applied with mist blowers at costs comparable with aerial applications. Good hardwood control was achieved with a variety of spray mixtures with little damage to conifers, though some respraying may be necessary to hold the hardwoods back until the slower responding conifers gain dominance. The machines used have an effective range of thirty feet in quiet air. To get this amount of height penetration it is necessary to hold the nozzle still in one position to let the air stream build up. Oaks were most susceptible to the herbicide. In the tests some oaks 12" DBH and over forty feet tall were killed. Aspen and red maple were the most resistant tree species. They responded fairly well to the herbicide, but sprouted more readily than other species. Huckleberry, maleberry, blueberry, and laurel were the most resistant shrubs.

Oil solutions of 2, 4, 5-T mixed at 1:9 and applied at rates of 1, 1½, and 2 pounds per acre were about equally effective in the control of hardwoods. When diesel oil was used in place of No. 1 fuel oil as the carrier, hardwood control was similar to that attained by the fuel oil mixtures, but there was more damage to conifers, and height penetration was reduced. Diesel oil, unlike the fuel oil, drenched the machine operators, and they ended the day soaked with oil. For these reasons diesel oil or heavy fuel oils are not recommended for use in shoulder-operated mist blowers.

The mixture with water as the carrier gave the poorest kill; the oil-water mixtures were better but less satisfactory than mixtures with oil alone. It can be said that the more water there is in the carrier, the poorer will be the kill. Invert emulsions of 2, 4, 5-T gave hardwood control which was equal to that of the oil mixtures. There was no difference in effectiveness between applications of one-pound and 1.5-pound per acre of invert emulsion. Drift was less with the invert emulsions and the diesel oil mixture.

It is easier to mix invert emulsions and oil-water emulsions in a machine with mechanical agitation. The materials need only be added to the tank in proper order while the machine is running. Oil mixtures are easier to mix, stay in mixture without agitation, and are lighter to carry than water mixtures. Oil mixtures may be made up in advance; oil-water or invert mixtures should be made up fresh on the job.

Ground application of herbicide with mist blowers should be more extensively employed. Good results may be achieved on small areas at moderate cost. Problems of drift are not serious. Ground machines should extend the use of foliar applications of herbicides at a reasonable cost, where aerial spraying is not possible or desirable.

Table 4. Per Acre Cost of Shoulder-Mounted Mist Blower Applications of Herbicide

	2,4,5-T in Oil		2,4,5-T in Water	245T in Oil+Water	Invert Emulsion
	1 lb.	2 lbs.	2 lbs.	2 lbs.	1½ lb
Item	Cost	Cost	Cost	Cost	Cost
2,4,5-T Cost	$2.25	$4.50	$4.50	$4.50	$3.92
Oil Cost	.45	.90		.20	.15
Labor Cost	3.00	4.61	4.61	4.61	4.61
Machine Cost	.47	.72	.72	.72	.72
Total Cost	$6.17	10.73	$9.83	$10.03	$9.40

FENURON, A PROMISING NEW TOOL FOR FOREST RENOVATION IN THE NORTHEAST

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The Northeast has an increasing trend toward permanent forest holdings by urban people, who use the houses for summer retreats, week-end recreation or retirement. They do most of the work on this land themselves as a spare-time occupation, because hired labor is expensive even when it's available. These holdings are mostly less than 1,000 acres, and each tract is generally less than 100 acres.

Typically, these are mixed stands of valuable hardwoods and conifers in which various weed trees shortly predominate. Some of the more serious weed species are aspen, gray birch, swamp maple, wild cherry, and elm. Cutting these weed trees is not satisfactory because re-sprouts from the stumps and roots become an even more severe problem.

The answer to this problem seems to be an inexpensive and simple method of selective chemical weeding, involving little investment in mechanical equipment. Blanket chemical applications either from the air or ground are inadvisable because of possible damage to desirable forest trees or nearby crops and ornamentals.

In three years' experimentation at Blackhawk Farms, fenuron, which is commercially available only in 25 per cent pellets at the present time, appears to be a promising tool for forest weeding.

The Site

Blackhawk Farms consists of about 1,000 acres of typical northeastern woodland, in six tracts around Gilmanton, N. H., a few miles southeast of Laconia. All six tracts were at one time parts of cultivated farms or pastures, but they have now reverted to forests and brush.

The over-all forestry aim is to develop this total acreage into an economic sustained-yield tree farm unit. The present program started in 1949. Until 1956, the main activity was planting conifers in abandoned fields. Cutting was the only method used for removing weed trees.

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Early Chemical Treatment

Chemical control of weed trees began in 1957, mostly with a one per cent solution of 2,4,5-T in oil, applied by hand as a basal spray. Although this was effective, it was laborious. Promising 1958 trials with dry fenuron in a sawdust carrier, and later with the 25 per cent fenuron pelleted formulation, led to an extensive experiment in 1959.

An 18-acre piece of mixed forest (the 2-Durgin field) was chosen for this experiment. Applications were made in May 1959. The fenuron pellets were applied in a heel depression at the base of each weed tree or clump. The rate was one-quarter ounce per tree or clump (a slightly heaping domestic teaspoon or 1.9 grams of the basic chemical). A few weed trees were chopped down, rather than treated, where they seemed too close to desirable trees for safe chemical use.

Although the summer was very dry, widespread defoliation was observed after the fall rains began, just before frost. During the winter and early spring of 1960, neighboring conifers showed some browning of the needle tips. However, they recovered during 1960, and grew with increased vigor. Seedlings more than doubled their top growth. Most of the weed trees showed additional defoliation and finally died. Many of those which did not die continued defoliating in 1961. A number of the weed trees that survived into 1961 were multi-stemmed birch or stump sprouts of swamp maples. The explanation for the birch survival seems to be either that more chemical should have been used per clump, or it should have been spread over more area. With the swamp maple stumps, apparently the feeder roots were too far from the point where the chemical was applied.

A group of professional foresters who inspected this tract on July 25, 1961, considered it an adequate job of forest weeding.

The 1960 Experiments

Beginning in July 1960, further chemical weeding was undertaken on about 35 acres of a 50-acre piece (the 1-Proctor lot). On this land there were many valuable hardwoods intermixed with small pines. Since the selectivity of the 1959 fenuron applications had not been completely established, the program started mainly with 2,4,5-T applied in frills. To reduce transportation and labor, jellied sodium arsenite was shortly used for the weed trees close to desirable ones.

As continued observation of the 1959 fenuron applications indicated its safety to nearby untreated trees, more and more fenuron was applied during the summer of 1960, at the same rate and by the same method. Most of the fenuron was applied in September, October and November.

Repeated inspections of this area in 1961 indicate that the 2,4,5-T treatment was effective without noticeable re-sprouting. Trees treated with sodium arsenite re-sprouted severely, even where the stems were killed; but many of the larger trees did not die at all.

Observations during 1961 of the trees treated with fenuron in the fall of 1960 indicate that about 80 per cent of them have been surely killed. The same problems of inadequate dosage or poor distribution for multi-stemmed and large trees appeared again in the 1960 fenuron program. However, no valuable trees were damaged with fenuron, except one large wolf oak. Fenuron from four nearby treated trees apparently was taken up by its perimeter roots on one side and the whole tree defoliated late in 1961.

Two general conclusions were made from the 1960 program. First, fenuron could have been used more widely in place of the 2,4,5-T and sodium arsenite, with consequent reduction in labor and in re-sprouting. Results with fenuron would have been better on larger and multi-stemmed trees with higher dosage and wider scattering over the root zone.

The 1961 Experiments

On the basis of 1960 success, fenuron was used in 1961 for weeding 10 different forest areas, ranging in size from slightly under an acre up to 25 acres. The total was 61 acres, requiring 318 pounds of fenuron pellets or only about five pounds per acre. The first application was made in March, on snow, and the work continued through September 20. During the summer a few modifications in application were adopted. Fenuron was applied in the conventional manner on the ground, and, for close work, in various homemade jellies or pastes in hatchet cuts. Dosage for soil application was differentiated for various size trees, up to a full ounce of pellets for a 30-inch swamp maple. The spoon was abandoned for hand application. Except for close work, the pellets were slightly scattered at tree bases, instead of being concentrated in a heel print. In most areas, the duff was scuffed away so the pellets were put on bare soil, and then a duff covering was kicked over them. (A tabulation of these 10 "commercial-scale" treatments is available from the author.)

In the first nine, and a first part of the tenth, of the fields injury symptoms from "Dybar" fenuron weed and brush killer were quite evident before the seasonal changes of foliage by the middle of October. In each case all the smaller weed trees (up to six inches d.b.h.) with few exceptions, were defoliated.

On the majority of these weed trees, a second crop of leaves had started, as occurs in the spring when a late frost freezes early leaves. In most cases, the second crop of leaves also showed chlorosis. That is, the chemical, either remaining in the ground, or, what is more likely, remaining in the tree systems, was interfering with the production of the second crop of leaves. The inner wood of the trees was still clear, white, and seemed alive.

Although definite results will not be evident until 1962, the preliminary showing was excellent.

Mode of Action

There are a number of reasons for understanding the mode of action of fenuron in tree-killing and for recognizing its effects at various stages.

Since trees treated with fenuron die slowly, or may recover from what appear to be noticeable effects, it is important to recognize the various symptoms and to be able to predict whether an affected tree will die or recover.

The clearest case is that of the healthy swamp maple leaf during the height of the tree feeding and high photosynthesis season. Lighter-shaded spots first appear in the tissue of the leaves between the veins. These may be detected by looking through the leaf toward the sun. The colors of these spots change backward on the light spectrum scale, green-yellow-orange-red-brown, until they seem to be dead material. In the meantime, the edges of the leaves die and by then the living leaf is reduced to a stem with veins only. Then the total leaf dies and separates from the tree. A new leaf appears, unfolds, and generally is dying at the tip before it reaches half-size.

Leaves of other species react somewhat differently. Elm and wild cherry seem to become chlorotic first of all at the extreme edges and aspen at the tip. The elm and cherry ~~are~~ lighter green at first on the edges and then yellow. Fully chlorotic elm leaves eventually look almost as veiny as fine lace.

White and red pine first become white at the tips of the needles, and this often spreads with eventual browning of the whole needle. If all of the needles brown all over, the tree almost never recovers. Most of the affected pine on Blackhawk, other than those killed intentionally, have recovered and begun rapid growth within a year.

The recognition of these chlorotic conditions is basic to the use of the chemical as a forestry tool. Five cases have been studied during 1961 in which persons persuaded to experiment with fenuron have complained that it was ineffective. Inspection, however, showed the treated trees were clearly well advanced in inability to make chlorophyl. In one case two foresters gave up and applied other chemicals to the already-dying trees. It was decided finally not to induce others to use fenuron unless its detailed mode of action could be explained.

Further understanding of the properties of fenuron and how it works in trees is highly desirable, from practical standpoints as well as to satisfy scientific curiosity. This understanding is needed to establish methods for its proper use, to determine its residual period in forest soils, and to give assurance of its safety to humans, animals, birds, and desirable insects.

Some observations are being planned in the 1962 program of Blackhawk Tree Farms, with the help of translocatable dyes.

Meanwhile, the following observations may suggest lines for further study.

Water is essential to carry fenuron into the soil where it is taken up by the roots and thence into the trees and leaves. Even though fenuron is applied in the early spring when the ground is wet from melting snow, a dry summer may mean that there will ~~be no~~ visible results until the fall rains. In fact, if the chemical does not get sufficient water to carry it into tree roots, within a few months after application, most of its effect is lost. If the summer is moderately dry, treated trees may not defoliate completely that season. In a wet summer, however, trees may defoliate at least twice.

A period of active growth and transpiration is necessary for effective kill. When fenuron is applied to the soil, it moves into the roots somewhat according to the rapidity of growth. Successful usage has been made at Blackhawk from March through November, but most rapid results were from June through August. As leaves grow, they transpire, moving the chemical to the leaves where it affects photosynthesis. Photosynthesis is naturally most affected under the best growing conditions. Since fenuron seems to inhibit photosynthesis directly, the leaves seem starved for sugar, and chlorophyll is not manufactured. The lack of chlorophyll further reduces the total photosynthetic activity of the affected plants. Then the plant appears to draw on reserves of sugars and starches in the roots until these are depleted, and the plant finally starves to death.

Applications in the late and wet fall of 1960 did not show material results until after the highly active growth period in midsummer 1961. Early spring applications in 1961 did not show any effects until late in the summer. But applications made between May 24 and July 5 showed gross visible results in two months, before any of the earlier 1961 applications. By October 15, 1961, all applications made between September 1, 1960, and August 1, 1961, had reached about the same stage of effect even though there were eleven months between the first application and the last.

The quickest reaction from a fenuron application was on a swamp maple in a wet area, treated with pellets. It showed chlorotic effects from the fenuron nine days after application. This was probably due to rapid absorption and translocation of the chemical resulting from the abundance of soil moisture. The slowest reaction so far was observed in a large aspen, which finally defoliated completely two years after application.

Exposure of Trees to Sun: If a forest has a clearly exposed east side so that it gets heavy sunshine the first three-quarters of the day, it will react to the chemical before the western side, and long before the interior and shaded trees. If the west side is exposed and the east side is not, the west will show chlorotic conditions before the interior or eastern unexposed side. However, an exposed west side will not react as quickly as an eastern exposed edge.

The exposed side of the forest is warmer and has more transpiration of water to move the chemical to the leaves. The warmer temperature seems to increase the action of the fenuron in preventing photosynthesis once it reaches the leaves. Also, the exposed side has higher rates of photosynthesis and growth, which contribute to differences in the speed of reaction to fenuron.

Nature of Partial Kills: Unless sufficient chemical gets into the trees to kill them -- probably through repeated defoliations -- the tree ordinarily recovers and is harmed only temporarily as if by a severe drought. Pines slightly affected by the chemical, (showing the effects some months after treatment of their neighboring weed trees), seem to recover and to put on vigorous growth within a year or so. Hardwoods (black cherry in particular) treated with mild doses of the chemical in 1957 and 1958 showed very evident chlorotic signs the first year but recovered their vigor completely by 1958 and 1959. Repeated treatment with a full dose in 1961 (Home-Third field) apparently killed them.

The partial killing of a single-stemmed tree is unusual and seems to be only in certain affected branches. That is, its roots which carried the chemical from far away to the trees, seem still alive. A wolf oak in the roadside border of field 1-A Durgin and a large apple located elsewhere received a minor dose from some distance in the spring of 1960. Small limbs on the treated side of each died. These are wide-rooted trees. In 1961 the oak received two more doses in the same root area and defoliated entirely. The roots appeared not dead in this location after the 1960 treatment. On the other hand, the apple, which received no more, is as healthy as ever. However, oaks as a species may be more susceptible than apples to fenuron.

In cutover land, there are numerous multi-stemmed trees, particularly gray birch and swamp maple. With these, a few or a half of the stems often have been killed entirely without killing the rest. There seems to be some direct relation between the basal diameter of a tree, or a group thereof, and the amount of the chemical it takes to kill. Control may be improved by greater dispersion of the chemical in the soil so that it will be taken up by more roots. One method used was to put a half of the chemical on one side and a half on the other.

Another exception to partial killing of trees is that of the multi-stemmed gray birch. In 1959, some multi-stemmed birch received very small dosages. This killed part of the stems, the upper and lower parts -- leaving the center like an umbrella. Since then these partial defoliated stems have been dying. However, pines -- red and white -- do not seem to have localized effects or partial kill. Possibly due to their circulatory systems, or their photosynthesis methods, they seem affected all over and recover all over or die totally. That is, the treatment does not leave dismembered or ill-shaped pines in the forest.

Apparently the killing of a tree with this chemical is largely a problem of getting sufficient chemical into the tree. At forest application rates, the longevity of the chemical in the ground appears not very great -- one season at the most, but one application may still bring about partial defoliation in broadleaf trees the third season after application -- possibly even later.

Thus as a forest tool it is even valuable for these continued partial defoliations, as the forest is opened more and more to increased penetration of the sunlight. Furthermore, the tree seems affected as a total organism. What kills the tree, also seems to kill the incipient sprouting, as the second foliations seem to be "nipped in the bud."

Injected Fenuron

While the pellet applications of fenuron on the soil appear to be a great improvement over anything tried previously, there is still need for a safer method of tree-killing close to desirable trees. On pure speculation, in the face of doubts from some advisers, an injection method was first tried with fenuron in September, 1960. A watery mixture was made up from fenuron pellets and poured into hatchet gashes in a number of weed trees.

Since then, about a dozen homemade forms of fenuron liquids, pastes, jellies, and salves have been made and used during the year 1961. Several additives have been used. These have been injected beneath the cambium layers of several thousand trees of all sizes and types. The aim of the project is to develop a one-incision, one-injection quick method of eliminating weed trees in situations where applications on the ground could endanger valuable trees.

So far, the results of these experiments have been highly satisfactory. The influence of the chemical fenuron seems to be the same, no matter whether it is introduced into the tree through the roots or injected almost anywhere beneath the cambium layer of the trunk. However, further time is needed to confirm these results.

Conclusions

Great advantages of fenuron pellets are minimal equipment cost (a pail or pouch), light weight, slow kill and selective treatment. Five to ten pounds are all that one person can apply in a day in doing a careful job after the forest dries in the morning and before the late afternoon showers which are common on New England summer days. Further, fenuron is of a low order of toxicity to warm-blooded animals.

This dry chemical can be the mainstay of a forest weeding program.

Less than a fraction of one per cent of the desirable trees have been affected in tracts where fenuron has been used for tree weeding. Of these, most were only slightly touched, and experience indicates that they will recover. In other words, with due precautions, the non-selective nature of fenuron is not an important danger in its use as a forest weeder. Most of the valuable trees affected were in tracts which were treated when there was snow on the ground. Apparently the snow water puddled the chemical away from the point of application.

It is believed that this study shows clearly that fenuron pellets, applied to the ground, constitute a usable and valuable instrument for the necessary weeding of forests. It also suggests evidence for further study of injection treatment. The ordinary forest owner can now become a silvicide expert if he learns to use this chemical. He needs no other equipment except a pail and a paint marker.

This chemical is not a "treatment" but a "tool" for forest use. Each tree, each plot, each acre, can be approached according to its needs, and toward an over-all design for a valuable sustained yield forest.

PLANT RESPONSE TO TRIZONE SOIL FUMIGANT

E. G. Terrell, Jr.[1]

Weed control in forest tree nurseries continues to be a high labor cost operation despite the general use since 1948 of petroleum distillate or oil sprays. (2,5). In the Northeast, weed control is complicated by the great variety of species grown for reforestation. Some are tolerant while others are sensitive or intolerant. Seedlings of Scotch pine and larch, while ordinarily not killed by moderate amounts of oil spray applied during the first year, are often damaged so that plantable-size seedlings are not produced in 2 years. Hardwood seedlings, which are intolerant to oil spray must be hand-weeded or cultivated.

Weed control in seedbeds is most important during the first year when the small, relatively slow-growing seedlings are least able to stand the competition of fast-growing weeds. Hand-weeding is costly, and may do considerable damage if weeds are allowed to get large. The use of soil surface herbicides, such as Neburon, before or soon after tree seed germination causes high seedling mortality in some species.

Weed control need not be considered separately from the control of other nursery pests if one treatment will provide effective control of both. Soil fumigants, which erradicate or greatly reduce the numbers of living weed seeds and weed vegetative parts, as well as nematodes, fungi, and insects, are useful nursery tools. They can help the nurseryman get the seedlings past the first critical year with a minimum of damage by pests. Soil fumigation is not new; in fact, it has been in use since World War I left large stocks of Chloropicrin (4). Fumigation with methyl bromide under hand-sealed plastic tarps has become standard practice in some Southern nurseries, but adoption of the practice in the Northeast has been slow. Labor costs, soil temperatures, sowing times, and the severity of the damage by weeds and pests in the Northeast are quite different from those in the South.

The development of a tractor-mounted combination injector-tarp layer by the Dow Chemical Co. led to our resumption of fumigant testing in 1959 (1,6). Results obtained from an application of one of the test materials, Trizone, is reported here.

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Material

Trizone is a mixed fumigant with the following composition by weight (1):

Methyl bromide	61.0%
Chloropicrin	30.0%
3-Bromopropyne (proparg yl bromide)	6.8%
Brominated C_3 hydrocarbons	2.2%
	100.0%

It is a liquid at 68°F. at pressures above 29 lb. per sq. in. and is supplied in 175 lb. cylinders. Recommended dosages are from 140-200 lb. per acre depending upon the severity and the nature of the pest problem.

Pre-Treatment of Fumigation Area

Since the fumigant is injected with shanks, it is essential that the soil is free of trash which can catch on the shanks, cause excess furrowing, and even clog the shanks so badly that the treatment can't be applied. Trash reduction can be accomplished by chopping crops before plowing, and plowing well in advance of the time of treatment. Winter fallow may be necessary for early Spring treatments.

Soil disturbance after fumigation is kept to a minimum by forming standard 4-foot wide seedbeds in advance.

Fumigation methods are most effective when organisms are active rather than dormant, so the soil is kept moist, by irrigation if necessary, for at least a week prior to treatment. Soil temperature during this conditioning period should reach 60°F. - 80°F. for best results.

Application

Trizone is injected into the well prepared formed seed bed by six narrow shanks to a depth of about 6 inches. The injected area is immediately covered with a 2 mil by 5 ft. clear polyethylene tarp which is edge-sealed with soil thrown up by discs. Pressure to force the fumigant from the cylinder and through metering orfices to the shanks is supplied by a cylinder of nitrogen equipped with a pressure regulator. Application rate is controlled by orifice plates, pressure, and speed of the tractor. Tractor speed in our soil is 3 m.p.h.

Since standard nursery seedbeds are formed with a six-foot center-to-center distance between paths, the 5 foot tarp does not extend to the center of the path. This allows treatment of adjacent beds without removal of tarps. However, the usual method is to treat alternate beds on one day and the remaining alternate beds about 2 days later. This avoids the danger of a tear from a tractor tire before the treatment has had a chance to diffuse through the soil.

Tarps are left in place at least 48 hours, at temperatures above 60°F., but may be left until two or three days before sowing to avoid contamination. At this time, tarps are removed and the beds are given a light raking with a tractor-mounted seedbed rake to smooth and areate the soil. It is unnecessary to use test plants to be sure fumigant is out of the soil because the least volatile constituent, chloropicrin, is readily detectable by its' odor.

The plot reported here was treated as described with Trizone at 175 lb. per acre on September 26, 1960, in preparation for Fall sowing of white spruce.

Sowing

The plot was sown in the usual way with a Gandy broadcast seeder at the rate of 8.3 oz. per 100 ft of bed length. The seed was covered with a light coating of dune sand which is essentially free of weed seed as mined, but is usually contaminated with weed seed in handling from the storage piles to the sander. A Brillion seeder which does not use sand for seed covering is now used to avoid this source of contamination.

Untreated rows were sown adjacent to fumigated rows in the same way.

Observations

Weeds

In the untreated rows weed growth was abundant, while in the treated rows there were few or none except in a low spot subjected to flooding during the Spring run-off. This weed growth was obviously due to post-fumigation contamination by water borne weed seeds from untreated paths and headlands. Annual weeds, primarily crab grass and purslane, were predominant. On June 19, 1961 it became obvious that the weeds in the untreated rows and those in the contaminated spot would be a serious and costly problem if allowed to grow unchecked until the hand-weeding crew could get to them. Therefore, both treated and untreated areas were sprayed with our regular oil spray, Sovasol #5.

Trees

On November 16, 1961, at the end of the first growing season, 100 trees each from a treated and untreated row were randomly selected for comparison of height, diameter, root length, and top-root ratio. Stocking was also measured with a standard inventory frame measuring .5 sq. ft. across the bed. The means of these observations are recorded in Table I.

Table I The effect of Trizone soil treatment on stocking and size of 1 yr. white spruce seedlings.

Treatment	Stocking per sq ft.	Height inches	Diam. inches	Root length longest root	Top-root Ratio Oven-dry wt. basis
Trizone 175 lb per acre	90	2.6	.053	7.4	2.6 - 1
None	57	1.2	.026	5.5	1.9 - 1

Stocking is increased a significant 58%, thereby permitting a proportional reduction in the sowing rate (3). Height and diameter are roughly doubled by the treatment. Mycorrhizal roots were present on both treated and untreated areas.

Cost

Trizone fumigation at present rates, costs $526.00 per acre at 140 lb. per acre rate. This is composed of the following costs:

Chemical	140 lb @ $1.90 per lb.	$ 366.00
Tarp	44 M sq. ft @ 3.26 per M sq ft	144.00
Labor	1 MD @ $16.00	16.00
		$ 526.00

At a stocking of 32 trees per sq. ft., the treatment costs $.48 per M seedlings. In some species, such as larch, the cost about equals hand weeding costs, in others part of the cost will have to be justified by savings of seed and by increased growth. There is reason to believe that Trizone fumigation coupled with good soil fertility may reduce by a year the time required to grow a plantable seedling.

Summary and Conclusions

A Fall application of Trizone at the rate of 175 lbs per acre was made to nursery seedbeds with an injector-tarp layer machine. Broadcast beds of white spruce were sown in the usual manner about one month later. Observations in the Summer of the first year indicate good weed control in areas not contaminated with weed seed after fumigation. Modifications of sowing methods have been made to reduce this type of contamination. A substantial increase in stocking, height, and diameter was apparent at the end of the first growing season.

Trizone, a relatively new soil fumigant, has performed well in the Saratoga production trials. Use of this material seems justified where 1) weed control by other means is more costly, more difficult, or more damaging, 2) plant stimulation effects can be utilized to reduce the time required to grow a plantable seedling.

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CHEMI-THINNING WITH AMINES IN THE DORMANT SEASON

Robert R. Morrow[1]

Hardwoods

Considerable early work in chemi-thinning hardwoods was reported in 1959 (3). At that time the importance of a complete frill for dormant season deadening of most Northeastern United States species was stressed. Top-kill was caused by adding chemical to the frill to make a zone of dead wood. Successful chemi-girdles were made with 2,4,5-T in kerosene, 2,4-D in kerosene, and kerosene alone. The former chemical caused a wider girdle and appeared to hasten top-kill by as much as two years in comparison with 2,4-D and oil alone. Wiant and Walker (4) have recently confirmed that oil alone is sufficient to cause top-kill when added to frills.

In recent years there has been considerable interest in the performance of amines of 2,4-D and 2,4,5-T in comparison with esters. Such interest is spurred by reports that top-kill, especially of oaks in the growing season, has resulted from amines in partial cuts (some literature reviewed in reference 3). Comparative tests of amines, esters, and oil were made in 1957 and 1958 on a variety of species in woodlots in southern New York. All chemicals were applied in a complete frill at a rate of 2-3 ml. per inch of diameter. Most treatments were made in October and November; a few were made in February. Table 1 gives the approximate time required for 90 percent of the chemi-girdled trees to be 90 percent top-killed.

In most trees that required two to four years for top-kill, there was little kill the first year. Occasional trees cling to life for many years, even though completely girdled, presumably through root grafts. In general there was little difference between treatments in the time required for top-kill. A few cases of live wood bridging girdles were found in the 100# ahg 2,4-D amine treatment. These occurred on large vigorous trees, mainly red maple. This may have resulted from poor spreading and translocation of amine in water at near freezing temperatures. On the other hand, kerosene spreads and soaks into woody tissue rapidly at low temperatures.

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[1] Assoc. Prof. of Forestry, Department of Conservation, Cornell University. The author wishes to acknowledge the extensive cooperative tests carried out in western New York by the New York State Conservation Department under the supervision of District Forester E. J. Whalen.

Table 1. Years required for top-kill

Treatment	Species	No. trees	D.b.h. range	Years
400# ahg 2,4-D amine (undiluted)	beech	13	4-14"	2-3
	red maple	5	6-12"	3-4
	sugar maple	5	5-10"	3
	white ash	5	5- 9"	3-4
	basswood	3	6- 8"	2
100# ahg 2,4-D amine in water	beech	19	5-15"	3
	red maple	24	6-15"	3-4
	sugar maple	30	5-12"	3+
	white ash	7	7-14"	3-4
	basswood	13	7-11"	3+
	black birch	2	7 "	2
20# ahg 2,4,5-T ester in kerosene	beech	9	4-11"	2
	red maple	4	5- 9"	3-4
	sugar maple	4	4- 7"	2-3
	black birch	2	5- 6"	2
Kerosene	beech	9	5-14"	2-4
	red maple	2	7- 8"	3-4
	sugar maple	4	6- 9"	3
	white ash	1	5 "	3-4
	basswood	2	7 "	3-4
100# ahg 2,4-D amine in water (in a second woodlot)	sugar maple	100	4-12"	3+
100# ahg 2,4-D amine in water (in a third woodlot)	basswood	21	5-12"	3
	hickory	13	6-10"	1-2
	American elm	8	5-12"	1-2
	black cherry	6	6-11"	1-2
	white oak	8	6-10"	1
400# ahg 2,4-D amine (placed in partial cuts, not complete frill)	white oak	6	5- 9"	no kill
400# ahg 2,4-D amine (frilling incomplete[2])	many hardwoods			partial or no kill

[2] These results were obtained from extensive field application where workmen sometimes did not make a complete frill.

These tests show once again the need for complete frills in dormant season chemi-thinning in Northeastern United States. They also demonstrate no advantage for amines over esters or oil alone in dormant season work.

Conifers

In 1957, a preliminary report (2) was made concerning dormant season application of undiluted 2,4-D amine in partial cuts for chemi-thinning pine plantations. Briefly this report stated:

1. In red and Scotch pine plantations, trees 3-5" d.b.h. received 2 or 3 cuts per tree. Each cut received 3-4 ml. of chemical.
2. For red pine treated in November and March, the terminal leader and uppermost whorl of lateral branches died back the following June; the whole tree was top-killed by the end of summer.
3. For Scotch pine, death of trees was slower; edge trees with large crowns sometimes recovered.
4. Presence of a few dead red pine trees adjacent to treated trees suggested caution in recommending the new treatment.

Subsequent red pine growth studies have established the probable reason for death of untreated trees in the plantation as a combination of drought and shallow soil which predisposed the weaker trees to successful bark beetle attack. Similar bark beetle damage has been found on numerous red pines on poor sites in recent years.

In the past five years, application of undiluted 2,4-D amine in partial cuts has been made in several plantations of moderate size to test the general utility of this method of chemi-thinning. These treatments are described in Table 2.

Nearly all trees in these stands were top-killed by the end of the growing season following treatment. Exceptions were hemlock, which was not killed, and summer treatments of Scotch and red pine, which resulted in slow kill over most of two growing seasons. Slow kill was observed occasionally in trees with large crowns and in trees with fewer than one cut per two inches of diameter.

Table 2. Description of tree stands and chemical treatments

Species	Age	Acres	No. trees treated	Treatment date	D.b.h.	Cuts/tree	Ml./cut	Remarks
Scotch pine	25	.5	60	11/56	5-8"	4-5	2	
Scotch pine	25	.2	30	7/57	5-8"	4	2-3	Slow kill
Red pine	30	2	500	11/57	2-10"	1-6	3	
Red pine	25	.2	30	5/58	4-7"	2-4	2-3	
Red pine	30	5	1200	10/58	2-10"	1-6	2	
Red pine	20	1.6	400	11/58	4-7"	2-3	2-	
Red pine	20	1	150	6/61	4-8"	3-5	2-3	Slow kill
White pine	45	1.5	300	11/58	5-14"	3-7	2-	
White pine	40	2	400	11/59	4-12"	2-7	2-3	
European larch	10	.5	90	5/61	3-4"	2	2-3	
Hemlock	30-40	.1	10	11/56	5-9"	3-6	2	No kill

This chemical treatment is closely associated with bark beetle damage to trees. Ips pini, the principal bark beetle involved, normally is "pitched out" of healthy trees, but weak or dying trees are susceptable. Thus chemically treated trees that are slowly dying are prime targets, and beetle populations may build up following treatment of extensive areas. This population build-up poses two questions: (a) What roles do beetles play in killing treated trees? (b) Will the build-up cause successful beetle attack on neighboring healthy trees?

Most of the chemical appears to be translocated upward in narrow bands above the point of application, leaving sizable streaks of live wood between dead wood. This is indicated by discoloration of sap wood following treatment. Very little downward translocation is indicated. This has been verified by treating one stem of twin red pines; usually only the treated stem dies. Since the tree dies from the top down, a tree with a small crown is soon killed. Trees with large crowns and large areas of live wood between dead tissue may live longer or even recover. For such trees to die, they must either be overtopped and shaded out by competing trees or be girdled through progressive dying of live tissue along the stem. Beetle attack may influence the latter process, but its significance is not known. In most of the treatments, beetle activity was abundant and trees often died quickly. In at least two of the areas, there was little or no beetles activity; good top-kill was still attained.

Whether or not bark beetle population build-up might become sufficient to endanger healthy trees is not known. In most of these treatments beetle activity was sufficiently heavy to cause the base of treated trees to be ringed with frass droppings; even so, no untreated trees were damaged. This fact appears to be especially significant in respect to the white pine stands which had never been thinned and contained many non-vigorous trees supposedly susceptable to beetle damage.

The use of undiluted 2,4-D amine is cheap. The chemical cost of most thinnings is about $2.00 per acre. The labor time required by an experienced man using hatchet and plastic squeeze bottle with chemical varies from 1.5 to 4 hours per acre depending mainly on ability to move through the plantation. One cut for every two inches of diameter is often sufficient. For particularly fast kills to reduce bark beetle build-up, for trees with large crowns, and for speeding kill following summer treatment, more cuts are needed and the cost will be somewhat greater.

In summary, 2,4-D amine in partial cuts is an easy, cheap, non-hazardous, and effective method of chemi-thinning many conifers in the dormant season. It is particularly applicable to plantations because "flashback" is unlikely and cuts, rather than complete frills, are far easier to make where many low branches obstruct work. Leonard and Harvey (1) have reported the method successful for killing digger pine in California; thus there may be widespread application.

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A Comparative Study of the Application of Three Weedicides, Kurosal G, Kurosal SL and a 2, 4-D Ester to Three Areas in Long Pond, Dutchess County, New York.

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The purpose of this study was to compare the results of the application of three weedicides upon three separate plots. The weedicides were Kurosal G, Kurosal SL, and a 2, 4-D Ester. All were applied at the same concentration of active ingredients, 2.2 ppm. In the early summer, frequent observations were made and records kept not only of the effect upon the pondweeds, but also upon nekton, plankton, and benthic organisms. The duration of this study was from May 31 - October 4, 1961.

I wish to thank Mr. Warren McKeon, and Mr. Kenneth Wich of the Poughkeepsie office of the New York State Conservation Department for their help in the field. Mr. Otto Johnson again gave the use of his boats for the season. Dow Chemical Company supplied the products which were being studied; and Vassar College provided a small grant for covering student assistance and transportation expenses.

Conditions in Long Pond have been carefully described in detail in previous papers. (Pierce 1958, 1959, 1960, 1961)* Three experimental areas were staked out. Two of these were located within the shallow littoral zone (1-3ft.) of the west shore, which is choked with floating and submerged vegetation close to shore, but which becomes less dense toward the center of the pond. Area I was one acre, located 300 feet along the shore and 140 feet wide. Area II was one half acre, also 300 feet along the shore, but only 70 feet wide. Area III a full acre (300-140) crossed from the east shore to the west shore. It therefore included typical shallow shore lines as well as the deeper (6 feet) channel area. All three plots were essentially the same in the littoral zone. The bottom consists of a very deep layer of soft mud and decomposing plants. The dominant floating plant is Nymphaea odorata, but Brasenia sp. and Nuphar advena are common. The most abundant submerged weeds are Utricularia purpurea, the moss Drepanocladus sp and of course,

* Pierce, 1958. 12 Ann. Meet. Northeast. Weed Control Conf. 338-343
1959. 13 Ann. Meet. Northeast. Weed Control Conf. 310-314
1960. 14 Ann. Meet. Northeast. Weed Control Conf. 472-475 and 483-487
1961. 15 Ann. Meet. Northeast. Weed Control Conf.

several species of Potamogeton (P. amplifolius, P. crispus, P. pusillus, and P. natans). Other submerged weeds are present but in limited areas.

The control area selected was the original one which has served as such since the summer of 1958. It is located south of all experimental areas.

Between the dates May 31 - June 7, and preceding the application of the weedicides, preliminary observations and samplings were made. After the applications on June 13, routine observations and samplings were repeated at intervals on the following dates: June 14-16, June 20-23, July 5-7, July 22-24, September 19, October 4.

In each area the temperature of water near the bottom was recorded, since, if any variation occurred it was more likely to be here. Surface temperature was uniform over the pond. Both water samples and hauls of the dredge were taken well within the limits of the area, rather than near the periphery. Two water samples were taken from each plot, and four hauls were made with an Eckman dredge. A plankton haul was also made and standardized as well as possible by rowing three lengths of the section. The organisms from the dredges were sieved, identified and counted in the field. The plankton was removed to the laboratory where it was identified under a binocular dissecting microscope or the low power of a compound microscope within a few hours. The water samples were treated in the field (Winkler Method), carried immediately to the laboratory where determinations of pH and O_2 in ppm were made at once by use of the Hellige Testing Apparatus. On June 13, the experimental areas were treated. The pellets were scattered by hand from the boat. Some fell upon the lily pads where they remained for a day or two. Others sank slowly to the bottom where a few remained undissolved and visible through the tenth day after treatment. The liquid form was applied with a hand sprayer.

The three areas were treated as follows: Area I, one acre, received 74 lbs. of pellets of Kurosal G, which has 20% of active ingredient. Area II, one half acre, received 53 lbs. of pellets of 2, 4-D Ester which has 10% active ingredient. Area III, one acre, received 2½ gallons of Kurosal SL which has 60% active ingredient. All areas received the same concentration of active ingredient, namely 2.2 ppm. The concentration of 2.2 ppm was chosen for all plots because it was the recommended dose for Kurosal G, of 25 lbs. per surface acre.

Three weeks later, on July 5, the northern half of area I received a second application of 37 lbs. of pellets of Kurosal G, at the same concentration as before, 2.2 ppm.

The immediate results were similar for all three areas. Not only were they similar but they were typical. After one petioles, now elongated, formed miniature arches above the water; the pads overturned and the entire plot presented a reddish cast compared to the surrounding untreated green area. By the end of the first week, the surface supported a tangled mass of stems, leaves, and blossoms, which soon began to decompose. From this point on, decomposition proceeded slowly, more slowly than in previous years. Whereas the surface of treated areas usually had been free of pads by late July, they were not free of pads until August or early September in 1961.

In caves or little bays of area III, where the water was quiet, the lily pads disappeared more quickly, as well as more completely. In the region of the channel, exposed to winds, and probably a small current, the treatment was not as effective, and even in September considerable numbers of lily pads dotted the surface. Submerged weeds (*Utricularia*) responded in much the same way. They were reduced or nearly eliminated in quiet waters, but not in the deeper and more exposed channel area.

Areas I and II can be commented upon together. Except for a narrow band close to shore, these areas responded successfully to treatment. By early September the surface was well cleared of lily pads, and the submerged weeds (mostly *Utricularia*) had been either eliminated or much reduced. Along the west shore, a moss, hornwort, and some water lilies form an exceedingly dense border of 8 feet in width. These plants were not eliminated or substantially reduced. As for the *Potamogetons*, it is very difficult to judge. In sparsely populated areas, it seems to disappear with treatment, but in densely populated areas, there appears to be no reduction in number of plants.

One half of area I received a second application of Kurosal G on July 5, three weeks after the first application. This treatment was made in order to test the vigor of a large patch of *Nuphar advena* which had not been affected by the first application. By the end of two weeks, the plants were dying, and by early September they were decimated, but not completely eliminated.

It may be concluded that, in general, *Nymphaea*, *Brasenia*, and *Utricularia* responded successfully to all three weedicides when applied at a concentration of 2 ppm. No one of the three weedicides proved more effective than the other two.

The summer of 1961 in Dutchess County was hot and humid with air temperatures often in high 80's and low 90's. From May 31 - September 20, bottom temperatures of the pond varied with the usual seasonal trend. On May 31, the temperature was a cool 60°F, which rose sharply during a hot period in early June to 78°F. During the latter half of June and early July, the pond cooled to a constant 74°F, but rose again by mid-July to 80°F. Although no samples were taken in August, it is reasonable to assume the pond remained near the 80°F level for several weeks. By September 20, bottom temperatures had fallen to 68°F.

The dissolved oxygen reflected in general the seasonal trend of temperature. As in previous summers, the dissolved oxygen content of the control area was consistently the lowest. On May 31, it was 9.5 ppm. Then occurred a steady decrease to a low of 4.5 ppm in late July, followed by a reading of 5.8 ppm on September 20. Experimental areas showed the same trend. In areas I and II on May 31, the dissolved oxygen content was 10 ppm, dipping to 7.4 ppm, and remaining around 7.4-7.8 ppm as late as September 20. The dissolved oxygen content of Area III showed closer correlation with temperature. On May 31 it was 10 ppm, decreasing during July to 5.5 ppm, and returning by September 20 to 7.2 ppm. There appeared to be no correlation of oxygen content with the application of the weedicide.

The pH readings in all areas showed the same trend. They were highest in May and June, decreased to a lower point by late July, and remained at this level even as late as September. The variations occurred between 8.3 - 7.2. The pH of the control area was consistently lower than all others, 7.8 - 7.2. Experimental areas were similar to each other and showed variations between 8.3 - 7.4. No correlation of pH with the application of the weedicide can be deduced.

The plankton identified can be grouped as in previous years: Myxophyceae; Chlorophyceae; Protozoa; Rotifera; Annelida; Crustacea (Copepoda, Cladocera, Ostracoda, and Amphipoda); Insecta (larvae or nymphs of Mayflies, Damselflies, and Diptera) Gastropoda; and Arachnida (mites). There were 50 commonly occurring species large enough to be identified either by a dissecting microscope or the low power of a compound microscope. This year there was no indication, directly after treatment, of the loss of any age group, of loss in vigor, or of any advense effect upon the organisms. The experimental areas showed qualitative variation within the plankton, but these paralleled the pattern of the control. The study of these micro-organisms revealed a fascinating picture of the change occurring within the plankton population as the season progressed. No accurate quantitative studies were attempted. No correlation could be made between plankton forms and the treatment of experimented areas.

In both experimental and control areas, large aquatic vertebrates, fish, frogs, and turtles were present in abundance and lively in behavior. Many adult fish and large schools of small young fish were constantly observed.

Benthic organisms dredged and identified in 1961 were members of the same large groups as in previous years: Annelida (oligochaete worms and leeches); Gastropoda (Amnicola, Helisoma, Menetus, Physa and Valvata; Pelecypoda (Sphaerium); Amphipoda (the scud); Isopoda (Asellus); Insecta (larvae or nymphs of Mayfly, Damsel fly, Dragonfly, and Midge). The seasonal trend of population was reflected in both experimental and control areas, and like the plankton, presented a fascinating picture of the changes proceeding within the pond. The following examples, each an average from 14 dredges, give a slight indication of these seasonal changes:

Forms	Individuals/ dredge (6 x 6 inches)	
	June	Sept.
Mayflies	25	5
Damselflies	0	5
Sphaerium	10	2
Amnicola	3	25
Valvata	1	9

Summary

1. Three experimental areas were chosen along the shore of Long Pond. Two of these were one acre, one was but a half acre.

2. Observations on these areas were made from May 31 - October 4, 1961.

3. Preliminary study of the following conditions and organisms was carried out from May 31 - June 7: bottom temperatures, pH, dissolved oxygen content, plankton population, benthic population, large aquatic vertebrates, and pondweeds. After treatment, this procedure was repeated June 14-16, June 20-23, July 5-7, July 22-24, and September 19-26.

4. The three areas were treated on June 13 with the same concentration of weedicide, namely 2.2 ppm. Area I received Kurosal G, Area II a 2, 4-D Ester, and Area III Kurosal SL.

5. Within a narrow marginal border of extremely dense growth, surface and submerged weeds did not respond to treatment.

6. Within more open portions, although still of dense weed growth, weeds did respond.

7. Nymphaea odorata and Brasenia sp. were successfully eliminated in most areas.

8. Utricularia purpurea was eliminated in many areas, and greatly reduced in most areas.

9. Nuphar advena was decimated, but not entirely cleared, even after a second application.

10. The three weedicides used appear equally effective. No one appeared to be superior.

11. The temperature of the bottom water showed seasonal variations within 60° - 80°F.

12. The range of pH was between 7.4-8.0, and followed the pattern of the control.

13. The fluctuations of dissolved oxygen content were between 4.5 - 9.5 ppm, and paralleled those of the control.

14. The plankton was represented constantly by the same groups as in previous years. The rise and fall in abundance of individual plankters reflected seasonal trends, and were obvious in both experimental and control areas. No period of decreased numbers or activity was observed after the

15. The benthic population was constantly represented by the same forms as in previous summers. Any significant increase in number of a single species was exhibited by experimental and control areas, and therefore interpreted as seasonal.

16. Fish of all ages, frogs, and turtles, were present and lively in treated and control areas throughout the summer.

OBSERVATIONS ON DISTRIBUTION AND CONTROL OF EURASIAN WATERMILFOIL IN CHESAPEAKE BAY, 1961

John H. Steenis,[1] Vernon D. Stotts,[2] and Charles R. Gillette[2]

The rapid spread of Eurasian watermilfoil, Myriophyllum spicatum, in the United States is alarming because the plant completely dominates the waters in which it grows. This spread has been described by Patten (1954), Springer and Stewart (1959), Springer (1959), Beaven (1960), Stotts (1961), Springer et al. (1961), and Haven (1961). Eurasian watermilfoil seriously hampers fishing, boating, and swimming; chokes out valuable waterfowl food plants; provides conditions for mosquito breeding[3]; and lowers real estate values.

The invasion of the upper Chesapeake Bay region by Eurasian watermilfoil did not become apparent until the plant was discovered in the Gunpowder River at the head of the Bay in 1954, although a specimen was collected in the river in 1902 and the plant had been established in the Potomac River at least since 1933[4]. By late 1959, fragments of the plant were found drifting over much of the Bay, and new beds had become established wherever environmental conditions were satisfactory. Since floating fragments can survive in salinities of 20 ppt[5] (Beaven, 1960), tidal currents could carry living plants into the fresher portions of most estuaries of Chesapeake Bay.

Eurasian watermilfoil closely resembles a native watermilfoil (Myriophyllum exalbescens, which is found principally in glaciated areas. The differences in appearance between these two species are for the most part relative. Leaflet segments on the upper portions of the stem usually number more than 12 in Eurasian watermilfoil and fewer than 10 in the native species. Inter-leaflet spaces in Eurasian watermilfoil usually are smaller than those in the native species. In addition, leaflets of Eurasian watermilfoil often are more curved. These two characteristics give the leaf of

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[1] Patuxent Wildlife Research Center, U. S. Fish and Wildlife Service, Laurel, Maryland.

[2] Maryland Game and Inland Fish Commission, Pittman-Robertson Project W-30-R, Annapolis, Maryland.

[3] Information supplied by Gordon E. Smith, Tennessee Valley Authority.

[4] Francis M. Uhler, unpublished reports.

[5] ppt = parts per thousand.

Eurasian watermilfoil a wet-feather appearance. Winter buds and seeds of the native species generally are twice as large as those of Eurasian watermilfoil. Both species grow best in alkaline water habitats. Eurasian watermilfoil, however, is the only species of Myriophyllum known to grow in coastal waters of appreciable salinity. It produces vigorous growth in waters of salinity up to 10 ppt and can grow at higher salinities (Beaven, 1960).

Objectives

The objectives of these continuing studies are to determine the extent of spread of Eurasian watermilfoil in the Chesapeake Bay region and to find methods for its control. During 1961, further efforts were made to refine techniques for control, particularly with 2,4-D, and to explore possibilities of using other phenoxy compounds. Our investigations were conducted in conjunction with studies of possible adverse effects of 2,4-D on aquatic organisms. These other studies are discussed in a companion report, "Field observations upon estuarine animals exposed to 2,4-D," by G. Francis Beaven, Charles K. Rawls, and Gordon F. Beckett.

Acknowledgments

Because of the seriousness of the infestation of Eurasian watermilfoil in the Chesapeake Bay region, joint field studies are being conducted by the Natural Resources Institute of the University of Maryland, the Virginia Institute of Marine Science, the Maryland Game and Inland Fish Commission, and the U. S. Fish and Wildlife Service. Various personnel within these agencies provided assistance in these investigations.

Local people in the Chesapeake Bay region are very much interested in controlling Eurasian watermilfoil and have been very cooperative in certain phases of the work. Chemical companies--particularly Amchem Products, Inc.; Chemical Insecticide Corporation; Diamond Alkali Company; Dow Chemical Company; Pennsalt Chemicals Corporation; and Reasor-Hill Corporation--furnished technical assistance and some of the materials. The U. S. Army Chemical Center, Aberdeen Proving Ground, Maryland Department of Tidewater Fisheries, and others have contributed information on distribution of this plant in Chesapeake Bay. We also are indebted to Gene Barrett, Fish and Wildlife Service, and Robert Wakefield, University of Maryland Natural Resources Institute, for part-time assistance in the field work.

Methods of Study

Surveys of the status of Eurasian watermilfoil in 1961 were made by boat. The area covered extended from Talbot County on the central Eastern Shore of Chesapeake Bay to the head of the Bay and down the Western Shore to the James River. Surveys included the principal tributaries of the Bay; those in the Potomac River extended to Washington, D. C. Records of watermilfoil were obtained by direct observations or drags of the bottom. Notes also were taken on the species and abundance of native plants. The Virginia Institute of Marine Science cooperated on the survey in Virginia; the Maryland Natural Resources Institute helped survey the area from Below Washington, D. C., along the Maryland side of the Potomac River, and along the Western Shore to the head of Chesapeake Bay; and the Maryland Game and Inland Fish Commission assisted in the survey of most of the Eastern Shore down to Talbot County.

Since previous studies (Steenis and Stotts, 1961) had indicated that phenoxy compounds, particularly 2,4-D impregnated in attaclay granules, were the most effective chemicals for control of Eurasian watermilfoil in tidal areas, the emphasis in 1961 was on refinement of techniques of treatment and on trials to determine whether other granular phenoxy compounds besides 2,4-D would give successful results. About 5,000 pounds of granular phenoxy formulations were applied on 250 plots ranging in size from 1/10 to 1 acre. Compounds used in the tests were:

Common Name	Chemical Name
2,4-D	butoxyethanol ester of 2,4-dichlorophenoxyacetic acid
"	iso-octyl ester of 2,4-dichlorophenoxyacetic acid
"	propylene glycol to butyl ether esters of 2,4-dichlorophenoxyacetic acid
"	dimethylamine salt of dichlorophenoxyacetic acid
2,4,5-T	iso-octyl ester of 2,4,5-trichlorophenoxyacetic acid
2,4-D + 2,4,5-T	iso-octyl ester of 2,4-dichlorophenoxyacetic acid and of 2,4,5-trichlorophenoxyacetic acid
2,4-D + 2,4,5-T	dimethylamine salt of 2,4-dichlorophenoxyacetic acid and of 2,4,5-trichlorophenoxyacetic acid
Silvex	iso-octyl ester of 2-(2,4,5-trichlorophenoxy) propionic acid
2-(2,4-DP)	butoxyethanol ester of 2-(2,4-dichlorophenoxy) propionic acid
2-(MCPP)	butoxyethanol ester of 2-(2-methyl-4-chlorophenoxy) propionic acid
Endothal	disodium salt of 3,6-endoxohexahydropthalic acid

Emphasis was on testing non-volatile esters of 2,4-D impregnated in granules. Series of randomized, replicated treatments, with checks, were made on 1/5-acre and 1-acre plots in fresh and brackish water habitats during times of slack low water. The dosage rates were 10, 20, and 30 pounds a.e.[1] per acre. Chemicals were applied during the latter part of May and early June after watermilfoil was high enough to reach the water surface at ebb tide; most of the treatments were made when the temperature of the water was above 18°C. Other phenoxy formulations were applied at dosages of 5, 10, and 20 pounds a.e. per acre on 1/10-acre plots in both fresh and tidal water areas; replications were made at the 10 pound a.e. per acre rate. Testing was continued until after initial flowering.

Additional tests of both esters and amine salts of 2,4-D were made at high tide, when dispersal of herbicides by currents would be greatest; these tests were made on 1/2-acre and 1-acre plots. Endothal, which is a highly soluble and readily dispersed formulation, was tested at 40 pounds a.e. per acre on a 2 1/2-acre plot in a small bay at dead-low tide to see whether it would be effective under such favorable conditions.

Herbicides were applied from a 14-foot boat, which was propelled by a 5 horsepower air-thrust motor. Granular herbicides were applied with a knapsack power sprayer (Solo Model 60) strapped to a seat in the center of the boat. A hopper of the type used for farm tractors was cradled in a wooden frame on the gunnels of the boat and attached to the knapsack power unit with a rubber hose. The granules were fed by gravity into the rotor of the air-thrust unit and dispersed through a 4-inch rubber hose and head device in a 10-foot swath. The flow of granules was regulated with a pointed stick that fitted the opening of the funnel. Liquid formulations were applied with conventional power spray equipment from a boat propelled by an air-thrust motor.

Results

Distribution Studies. The results of the survey in the Chesapeake Bay and Potomac River region in 1961 indicated that the area of infestation of Eurasian watermilfoil totaled about 100,000 acres and that new establishments were occurring at a rapid rate. This is in contrast to its known range of 50,000 acres in 1960 (Stotts, 1961).

The rapidity of invasion is illustrated by the records of annual October surveys of the Susquehanna Flats, an area of major importance for waterfowl. Previous sampling of stations showed the following frequencies of occurrence at vegetated stations in successive years: none, 1957; 1 percent, 1958; 47 percent, 1959; and 84 percent, 1960 (Springer et al., 1961)[2] The survey in 1961 revealed that Eurasian watermilfoil was present at 88 percent of the stations. In July 1961, a similar survey showed that 71 percent of the stations had Eurasian watermilfoil.

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[1] a.e. = acid equivalent.

[2] Also, P. F. Springer, V. D. Stotts, and C. K. Rawls, Jr., unpublished field notes, 1961.

Another illustration of explosive growth is the very rapid increase in creeks at the mouth of the Chester River, which is another very important waterfowl area. No Eurasian watermilfoil was noted in surveys made during the summer and fall of 1958 and 1959, but it was common and conspicuous by 1960. By October 1961, the creeks were completely matted over with this plant, and native plants, including highly desirable duckfood species, were virtually absent.

Growth of Eurasian watermilfoil is generally absent along shorelines in shallow water exposed to severe wave and tidal action, but oyster dredges have picked up rooted specimens at depths of 14 to 16 feet offshore from some of these areas. The plant grows best on soft, mucky bottoms, but also rapidly invades hard sand in protected areas.

Although Eurasian watermilfoil is spreading very rapidly in the upper part of Chesapeake Bay, it seems to have reached its maximum range in much of the Potomac River. In fact, in recent years it has decreased somewhat in certain areas, and density of growth has been observed to fluctuate. The factors causing these reductions in growth are unknown, although salinity, turbidity, tidal currents, carp infestation, and possibly midge larvae infestations may be involved.

Control Experiments. Granules impregnated with 2,4-D continued to give better control than the other phenoxy compounds. This is significant since 2,4-D also is the cheapest phenoxy compound on the market. Accordingly, tests were made primarily with formulations of 2,4-D.

The three esters of 2,4-D (butoxyethanol, iso-octyl, and propylene glycol to butyl ether) gave almost complete control at a dosage rate of 20 pounds a.e. per acre. Under ideal situations of limited water movement, the amine salt of 2,4-D applied at a rate of 10 pounds a.e. per acre gave similar results. Environmental conditions usually did not permit maximum control with amine salts at low dosages, however. Under varying conditions of tidal movement and wave action, esters of 2,4-D gave more consistent control than did the amines. This may have been because the non-soluble esters have more residual effects than the soluble amine salts of 2,4-D.

Good control at high tide resulted from applications of esters of 2,4-D on 1-acre plots. On smaller plots and fringe areas, however, better control was obtained at low tide when the vegetation helped to contain the herbicide.

Most herbicide granules used in this study were of 8 to 15 inch mesh hard-baked attaclay. Smaller sizes were difficult to use. Soft granules gave a faster dispersal of the ester and a slightly faster herbicidal reaction than the baked granules. The soft pellets, however, usually crumbled more readily and, for this reason, were more difficult to use.

Investigations during this season, coupled with those made during the last 2 years, clearly indicate that Eurasian watermilfoil is susceptible to treatment with 2,4-D during the period when the plant is growing vigorously and when the temperature of the water is above 18°C. In the Chesapeake Bay region this vulnerable period lasts until initial flowering occurs. After this time, control is erratic and, for the most part, not successful even in those locations where there is no flowering or where flowering is delayed (as in more saline situations). However, the vulnerable period often is extended a few days where flowering is delayed. It appears that the vulnerable period for treating Eurasian watermilfoil in the Chesapeake Bay region lasts about 3 weeks, from about the middle of May to the first week of June. It may be possible to make large-scale treatments earlier with the more residual, granular formulations of 2,4-D esters. More study is necessary on this phase of the work. In September there is often a resurgence of growth during which herbicidal treatments may be effective. This possibility also needs to be explored further.

The other phenoxy compounds tested were less effective than 2,4-D. Silvex, 2-(2,4-DP), and 2-(MCPP) did provide some degree of control at 20 pounds a.e. per acre, but were inferior to 2,4-D at the same rate. 2,4,5-T produced very little, if any, herbicidal reaction. Also, 2,4,5-T showed no increased herbicidal effect when used in mixture with 2,4-D.

Endothal, a contact killer, applied at 40 pounds a.e. per acre on a 2 1/2-acre plot at dead-low tide, did kill watermilfoil above the test plot where the herbicide was carried by the tide and concentrated within a small embayment. There was a set-back of top growth over an area about 10 times as large as the original plot where the herbicide was carried back out by the tide.

Summary

The rapid spread of Eurasian watermilfoil, Myriophyllum spicatum, in the Chesapeake Bay region from approximately 50,000 acres in 1960 to 100,000 acres in 1961 is seriously hampering fishing, boating, and swimming; choking out waterfowl food plants; providing mosquito breeding habitat; and lowering real estate values.

Eurasian watermilfoil is an adaptable, vigorously growing aquatic plant that often dominates areas in which it is established. It grows in fresh water and in saline water up to 10 ppt. Since floating parts containing leaves and stems can survive salinities up to 20 ppt, new invasions from these propagules occur when tidal currents lodge these fragments in fresher parts of estuaries.

Granular 2,4-D continues to be the most effective herbicide for controlling Eurasian watermilfoil. Esters of 2,4-D gave successful control on larger plots when applied at 20 pounds a.e. per acre at both high and low tide periods. When water movement was minimal near low tide, amine salts of 2,4-D at 10 pounds a.e. per acre also provided successful control. However, under less favorable conditions, treatments with esters of 2,4-D gave more consistent control than the amine salt of 2,4-D because of greater residual effect. Eurasian watermilfoil was controlled by 2,4-D during a specific vulnerable period, beginning in mid-May when the plant starts to grow vigorously and when the temperature is above 15°C. In the Chesapeake Bay region this period lasts until initial flowering.

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FIELD OBSERVATIONS UPON ESTUARINE ANIMALS EXPOSED TO 2,4-D[1]

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ABSTRACT

Oysters, crabs, clams and fish were held near the center and outside of one-acre tidewater plots of *Myriophyllum spicatum* L. during and after treatment with the butoxy-ethanol-ester of 2,4-D at several specified rates. Mortality of the caged animals in treated plots and in controls was observed for five weeks. Examination of native bottom organisms in the plots was made by hydraulic dredge and by grabs with a Petersen dredge. Results indicate that applications at rates as high as 120 lbs. acid equivalent per acre are not directly lethal to the caged animals. In one instance an anaerobic condition developed that was lethal to both caged and native animals. When normal aerobic conditions are maintained treatments of 30 lbs. AE/A resulted in no mortality to the native macro-fauna observed and did not kill the valuable native plants. Groups of animals exposed to the above treatment are being analyzed for herbicide residues.

INTRODUCTION

The Chesapeake Biological Laboratory of the University of Maryland Natural Resources Institute, in cooperation with the Patuxent Wildlife Research Center, the Maryland Department of Game and Inland Fish, and the Virginia Institute of Marine Science, is engaged in a joint research program upon the varied aspects of invasion of the Chesapeake area by Eurasian watermilfoil (*Myriophyllum spicatum* L.). This paper deals with preliminary observations of the effects upon certain native aquatic organisms that result from milfoil control by 2,4-D in tidal estuaries.

Acknowledgment and sincere appreciation is expressed for the help given to this phase of the study by personnel of the above agencies, by the Taft Sanitary Engineering Laboratory, by the many cooperating shore owners and marina operators in the areas where the experiments were conducted, and by Mr. Robert Wakefield, a student of Antioch College who shared in the field work during the spring and early summer.

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OBJECTIVES

A major aim of the toxicological studies conducted by the Institute during 1961 has been to determine whether or not the field application to milfoil of attaclay pellets impregnated with the butoxy-ethanol-ester of 2,4-D causes lethal effects upon species of commercial importance that occur in the Chesapeake area. A second objective was to determine if herbicide residues are present in tissues of food species held in experimental plots during and after treatment. An additional objective has been the accumulation of data concerning the effect of treatment on other aquatic animals and plants native to the treated areas.

This particular formulation of 2,4-D was selected for the study because earlier research (Beaven, 1960; Steenis and Stotts, 1961) had demonstrated its effectiveness and apparent safety when used for milfoil control in local tidal areas.

LOCATION OF EXPERIMENTAL PLOTS

Important commercial fisheries for the eastern oyster (Crassostrea virginica), the blue crab (Callinectes sapidus) and the softshell clam (Mya arenaria) occur in the saltier waters invaded by milfoil. For this reason, the primary area selected for study was the lower Potomac River where these three species occur. Field trips were made in early spring to select milfoil infested creeks or coves where one-acre plots could be laid out. It was essential that these be well sheltered and subjected to a minimum of water dispersal from tide and wind movement. The three most suitable Potomac tributaries meeting these specifications were St. Patrick Creek and White Neck Creek on the Maryland shore and Lower Machodoc Creek on the Virginia side. In each of these, oysters are planted, commercial crabbing and fishing are practiced and beds of native softshell clams are present although not exploited commercially. An additional area, Dundee Creek near the head of the Chesapeake, was chosen for observations in fresh to barely brackish tidal water.

In the Potomac experiments three replications of treatments were made during late spring at 30 lbs. acid equivalent of 2,4-D per acre, 60 lbs. AE/A and of untreated control plots. A single plot treated at the rate of 120 lbs. AE/A and a fourth control plot were also located in this area. These provided observations of applications, made during the most favorable period for herbicide effectiveness, at double and quadruple the quantity shown by prior experiments (30 lbs. AE/A) to be sufficient for good control. Subsequent observations this year (Steenis et al 1962) have shown that over large plots, 20 lbs. AE/A can suppress milfoil under proper conditions of application.

Each one-acre plot was roughly square in shape and contained dense beds of milfoil. Plots were measured with floating polyethylene rope and corners marked by stakes set firmly in the bottom and projecting eight or more feet above the surface. Each plot was designated by a number. Average depth was approximately 3 feet with tidal fluctuations of a little more than 2 feet. Exceptional tides several feet beyond the normal range occasionally occur.

No single creek in the lower Potomac had sufficiently extensive milfoil beds to accommodate all of the replicated plots and provide adequate buffer zones between them. The three creeks selected were as nearly alike as possible but had slight differences in salinity and in other characteristics of minor importance. Since it was more desirable to replicate measurements of the differences in mortality between groups of animals exposed to zero, 30 and 60 lbs. AE/A of 2,4-D than to replicate identical treatments, a complete series of the three treatments was placed in each creek. Hence, plot numbers for one each of the three treatments were chosen separately and at random for the individual creeks. The site of the 120 lbs. AE/A treatment and of a control were drawn from plots near the mouth of White Neck Creek. Plots for each type of treatment in the low salinity habitat of Dundee Creek also were chosen at random.

WATER TEMPERATURE AND SALINITY

Collection of certain environmental data began in early spring when the plot sites were selected. During the period of test-animal exposure, the salinity of the Maryland Potomac tributaries usually varied between 7 and 9 parts per thousand, while that of plots in the upper portion of the Lower Machodoc was approximately two parts lower. Salinity in Dundee Creek remained well under 1 ppt or essentially fresh. The Potomac values were about two ppt below the seasonal normal for that area.

Water temperatures rose irregularly during the study period and generally were below seasonal normal. At the time of herbicide application in the Maryland Potomac tributaries (May 29-June 1), water temperatures ranged between 18.5° and 21.5° C. During the preceding week, they ran from one to two degrees higher. When the Machodoc plots were treated on June 7, water temperatures were unrecorded at the time of application but were ranging in the low to mid-twenties as determined from parallel data. During the subsequent period of observation, water temperatures ranging up to 27.5° were recorded in the Potomac plots.

In Dundee Creek the water temperature was 16.5° C when herbicide was applied on May 20 at 5:30 A.M. Higher temperatures had occurred at this location a few days earlier and on May 21 the temperature was 18.5°. No further temperature readings were taken in the toxicological study plots at this location.

HOLDING OF EXPERIMENTAL ANIMALS

In each treatment plot, cages of experimental animals were placed near the center, about 10 ft. outside the plot boundary and at a point about 200 ft. outside the plot. On control plots, animals were held near the center. Limitations of time and personnel did not permit replication of cages at each holding site.

The cages used were two-foot cubes constructed of half-inch mesh galvanized hardware cloth fastened by hog rings. A horizontal partition about 8 in. above the bottom divided the cage into two compartments. Ropes and buoys marked the position of each cage in the water.

One or two days before herbicide application each cage in the Potomac tests had 25 oysters and 5 blue crabs placed in the bottom compartment and 5 small fish in the upper section. In Dundee Creek 10 fish (pumpkinseed, _Lepomis gibbosus_) were used. The Potomac fish were a mixture of pumpkinseeds, white perch (_Roccus americanus_) and yellow perch (_Perca flavescens_).

In addition, 25 softshell clams were placed in bread tins 6 inches in depth and filled with bottom soil. Corners of each tin were fastened to ropes leading to a buoy line. These groups of clams were placed beside each cage in the Maryland Potomac tributaries. Special cages and trays containing large groups of each animal were placed at the center of one of the salt water plots treated at 30 lbs. AE/A to provide animals for residue tests.

ANIMAL MORTALITY OBSERVATIONS

All caged animals in the Maryland Potomac tributaries were examined daily for the first seven days after herbicide application. During the second week they were examined twice. Examinations then were made at approximate ten-day intervals up to the time when cages were removed at the end of five weeks. In the Machodoc, on the Virginia side, two examinations were made during the first week, one the second, one the third and the cages removed at the end of the fifth.

An anaerobic condition developed in one of the 60 lb. treatment plots and is described separately. With the above exception, no important differences were observed in mortalities of test animals among the three creeks in the Potomac area. Statistical analysis of data from the similar plots is not warranted and these plots are grouped together in the summary that follows.

OYSTERS. No dead oysters were found in any of the cages, excepting in the anaerobic plot, during the first two weeks. A few scattered deaths occurred during the following three weeks that approximate expected mortality among similar oysters in this area. This took place both in controls and in treatment plots. A condensed tabulation of the number of oyster deaths is shown in Table 1.

TABLE 1. Response of oysters to different concentrations of 2,4-D.

		Total animals in 4 plots	Total animals in 3 plots of 30 lb. AE/A			Total animals in 2 plots of 60 lb. AE/A			Total animals in 1 plot of 120 lb. AE/A		
Days Exposed		Control	Center	edge	200'	Center	edge	200'	Center	edge	200'
14	Live	100	75	75	75	50	50	50	25	25	25
	Dead	0	0	0	0	0	0	0	0	0	0
24	Live	98	75	75	75	48	50	50	25	23	25
	Dead	2	0	0	0	2	0	0	0	2	0
35	Live	98	74	73	75	47	49	50	25	23	25
	Dead	2	1	2	0	3	1	0	0	2	0

CLAMS. No clams in the containers died during the first week except in one of the controls where nine were dead on the sixth day. Crabs were feeding upon these and attacking the remaining live clams. During the second week dead clams with crabs feeding upon them were found in all of the remaining plots. At the end of the second week none of the experimental clams were left.

Crabs have been observed elsewhere to attack and consume live soft clams that are exposed above the bottom. It is theorized that in our plots crabs were attracted as scavengers soon after the first death occurred in each container of clams. Since the living clams were thinly covered by soil they were easily uncovered and attacked by the scavengers. Crabs continued to be attracted until all clams were destroyed.

CRABS. The normal mortality rate among captive crabs is high, especially after the first few days of confinement. Furthermore, dead crabs, together with any that become injured or that molt, are rapidly consumed by other crabs and predators such as eels that can enter the cages. The large number missing from our cages exceeded expectations and rendered the number of dead recorded, two from the controls and two from the outer cages, of no significance. If it can be assumed that most of the missing had died, a doubtful possibility, then the number of survivors gives some indication of the extent of mortality. For this reason, the survivors are summarized in Table 2. Initial numbers are listed since a few crabs were lost before herbicide application.

TABLE 2. Survival of caged crabs.

	Total number in 4 plots	Total number in 3 plots of 30 lb. AE/A			Total number in 2 plots of 60 lb. AE/A			Total number in 1 plot of 120 lb. AE/A		
Days Exposed	Control	Center	edge	200'	Center	edge	200'	Center	edge	200'
0 days	24	14	14	14	9	9	9	5	5	5
1 day	22	13	12	11	9	9	8	5	5	5
7 days	20	13	10	9	8	6	8	4	4	5
35 days	3	2	5	3	4	4	1	2	3	5
Final %	15.8	14.3	35.7	21.4	44.4	44.4	11.1	40.0	60.0	100.0

FISH. The only large mortality of fish occurred in one of the control cages. Many of those found dead appeared to have become gilled in small openings or to have been caught by crabs nipping them through the horizontal partition of the cage. During the first week and at two later periods, holes were found in the top of several cages that permitted the fish to escape, thus accounting for most of those missing. Table 3 shows the observed fish mortality in the Potomac plots for the most significant intervals.

TABLE 3. Response of fish (3 species) to different concentrations of 2,4-D

		Total number in 4 plots	Total number in 3 plots of 30 lb. AE/A			Total number in 2 plots of 60 lb. AE/A			Total number in 1 plot of 120 lb. AE/A		
Days Exposed		Control	Center	edge	200'	Center	edge	200'	Center	edge	200'
1	Live	34	25	24	25	20	20	20	10	10	10
	Dead	0	0	0	0	0	0	0	0	0	0
7	Live	26	20	14	21	19	19	18	10	9	9
	Dead	8	0	1	4	1	1	2	0	1	1
35	Live	17	0	2	12	9	16	0	10	9	9
	Dead	17	0	1	5	6	4	11	0	1	1

In the Dundee Creek series, one of the fish died before herbicide application and is excluded. On the first day after application, all were alive. This series remained unchecked until 19 days after application when again all fish present were alive though several had escaped. Local fishermen occasionally examined the cages throughout the period and reported no dead fish in them up to the time they were removed in late summer. They also reported that fishing was good in the plots from which the herbicide had cleared the milfoil. The fish caught appeared to be normal and were of excellent flavor.

ANAEROBIC DEVELOPMENT. The plot where anaerobic conditions developed was in a cove containing very dense *Myriophyllum* growth. The bottom was a soft muck with water depth of 4 to 7 feet, depending upon tidal stage. Rate of 2,4-D application was 60 lbs. AE/A. Effects of the herbicide were well contained within the plot and, as the mass of weeds died, it sank to the bottom and was not displaced by currents. On the first day after application, all animals were alive. Tabulation of the oysters is shown in Table 4.

TABLE 4. CUMULATIVE NUMBER OF OYSTERS DEAD AT PLOT 10

Days Exposed	Number of oysters		
	Center	10' out	200' out
1	0	0	0
5	4	0	0
9	8	0	0
16	16	2	0
34	25	2	removed

The 5 fish and 4 crabs present in the center cage at the time of application were alive after one day. By the 5th day, 1 fish and 3 crabs were dead. On the 9th day, 3 fish and all 4 crabs had died. One fish was alive on the 16th day and none at the end of observations. No predation occurred in the center cage but did occur in the other two. Two fish survived to the 34th day in the cage outside the edge and 2 crabs to the 16th day.

NATURAL FAUNA AND FLORA. Numbers of fish, mostly menhaden (*Brevoortia tyrannis*) were observed swimming in the Potomac area plots both before and after treatment. Bottom samples were taken by Petersen dredge in early May and again in mid-June from the treatment plots in the Machodoc. These have been analyzed by Dr. Marvin Wass of the Virginia Institute of Marine Science. He concluded that, for these samples, the detection of changes due to the experiment is negated by natural seasonal changes during the long time interval that resulted from postponement of the scheduled treatment.

On August 23rd the Laboratory's research vessel, equipped with a fine-meshed hydraulic dredge, made transects of the Machodoc plots. This device effectively washes out from the bottom and brings up all material that can be retained on the three-eighths-inch-mesh belt. The sampling depth extends to 18 inches below the bottom-water interface (Manning, 1959). Except in the anaerobic plot, numerous species of living clams, worms, and other animals appeared to be equally abundant both within and outside the treated plots. Of interest in evaluating effectiveness of the herbicide against milfoil was the evidence of extensive killing of milfoil roots in the treated plots, although such roots were so abundant outside as to render operation of the dredge very difficult. In the anaerobic plot all clams were dead and the upper six inches of bottom material contained none of the invertebrates that were abundantly present a short distance outside of the plot boundary.

In a number of the plots, other species of aquatic plants, including sago pond weed (*Potamogeton pectinatus* L.), redhead grass (*P. perfoliatus* L.), widgeon-grass (*Ruppia maritima* L.), wild celery (*Vallisneria americana* Michx.), water-stargrass (*Heteranthera dubia* [Jacq.] MacM.), coontail (*Ceratophyllum demersum* L.) and waterweed (*Elodea* spp.), occurred sparsely and appeared to show little or no effect from applications of 2,4-D up to 60 lb. AE/A. These species became increasingly visible and continued to grow during the period of observation after treatment. At the site of the 120 lb. plot, all vegetation was killed for several hundred feet beyond the plot boundary and the bottom remained as a bare area of sand for the remainder of the 1961 season.

RESIDUE STUDY

A gallon of freshly shucked local oysters, a gallon of shucked clams and a quantity of fish and crabs caught in the area were frozen prior to the herbicide treatments and sent to the Taft Sanitary Engineering Laboratory for bioassay, together with a sample of the herbicide to be used. Similar samples of animals that had been held at the center of a one-acre plot during treatment with 30 lb. AE/A, and retained in the plot for three days after herbicide application, were shipped to the Laboratory.

Chemical methods for detecting residues that are satisfactory for other meats were tried but proved unsatisfactory when applied to these seafoods. The Taft Laboratory is continuing to check the samples by different methods and has not yet completed its analyses for the presence or absence of 2,4-D residues in these samples.

DISCUSSION

Herbicide application was made jointly with personnel of the Patuxent Wildlife Research Center and the method is described in the companion paper (Steenis et al, 1962).

Both laboratory and field tests of the toxicity of 2,4-D to fish and to some invertebrates in fresh water have been reported upon by other workers. Springer (1961) cites a number of references and gives values as low as 1 ppm for damage to bluegills by the butyl ester. Other esters were less toxic and the sodium salt was tolerated by rainbow trout at concentrations up to 112 ppm. It is thought that in some cases additives and impurities may account for much of the observed fish mortalities.

No references have been found that give toxicity of 2,4-D to the eastern oyster, the blue crab, the softshell clam or common species of estuarine fish. The presence of inorganic salts in seawater may possibly alter the toxicity of 2,4-D compounds to a species of fish in salt water as compared to the same species in fresh water. A series of experiments is underway at Solomons to determine the toxicity of the butoxy-ethanol-ester used in our field tests upon the economically important estuarine animals in both fresh and saltwater aquaria.

A preliminary series of observations on caged animals was made in the Machodoc during July and August of 1960 (Beaven, 1960). In that series, no lethal effects were detected upon oysters, crabs or fish at the centers of three plots each receiving a different formulation of 2,4-D at 40 lb. AE/A. A fourth formulation at 20 lbs. AE/A, however, killed all animals in the cage. These tests all were made during higher water temperatures than in 1961 and with plants more mature. Milfoil control was poor. In the plot where the animals died, the treatment produced little noticeable kill of milfoil and anaerobic conditions were not a factor. It was postulated that toxic impurities in the formulation caused the observed animal losses.

In late June of 1961 an additional one-acre treatment of 30 lbs. AE/A and a control were placed in the Lower Machodoc. Data from these are not included in the preceding tables since they were not directly comparable to the others due to the later application. Fifty days after treatment, all oysters in both plots were alive, 2 crabs survived in the treatment compared with 0 in the control, and 8 fish survived the treatment compared with 9 in the control.

Although data for crabs are weak, the results of the studies to date indicate that the formulation of 2,4-D used, when applied in a similar manner at concentrations of 30 lbs. AE/A or less, does not directly cause a significant mortality among the economic forms exposed, nor among the observed native bottom fauna.

A serious threat, however, to oysters, clams and other bottom organisms is evident in treated areas when large mats of decomposing milfoil remain upon the bottom. Parallel kills of native fish or crabs may not occur in a small plot, even though those caged in the anaerobic plot did die. As free swimmers, these animals can move out of locally unfavorable areas and it is noteworthy that, though living abundantly in surrounding water, no native fish or crabs were found as dead specimens in the plot. However, if dense milfoil beds over an entire creek are killed, with subsequent anaerobic development, it is possible that a heavy mortality of fish and crabs in it may follow.

The anaerobic condition observed probably was largely confined to the layer of water and mud immediately beneath the decaying vegetable mat. It permitted generation of hydrogen sulphide by sulphur bacteria. This was evidenced by odor and by heavy blackening of the shells of both oysters and crabs at the bottom of the cage. It is possible that the toxic effect of hydrogen sulphide, rather than oxygen deficiency, was the direct cause of death in the case of the caged animals.

It is suggested that formation of destructive anaerobic conditions might be prevented by one of the following methods; (a) application of herbicides earlier in the spring before massive growth of the plant has developed; (b) cutting off and either removing or permitting dense growths to drift from the area before applying herbicides; (c) extension of the operation to the edge of channels or open water in such manner that water currents can flush out and dissipate the dead weeds; (d) removal after treatment of killed weeds before serious anaerobic conditions develop; and (e) repeated light herbicide applications designed to produce a gradual kill.

Further field observations of caged and unconfined native organisms in 2,4-D treated plots are planned for next season. These will include herbicide applications designed to minimize the accumulation of large masses of decomposing vegetation.

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OBSERVATIONS ON THE OCCURRENCE AND PERSISTENCE OF 2,4-D AND 2,4-DICHLOROPHENOL IN LAKE WATER[1]

by Samuel D. Faust[2], Roy R. Younger[3], Robert J. Tucker[4]
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Various organic esters of 2,4-dichlorophenoxyacetic acid (2,4-D) are used extensively and effectively for control of some species of aquatic vegetation in lakes, ponds, and reservoirs. There are, however, the questions of the effect of this aquatic herbicide on the general chemical quality of these potable water supplies and of the occurrence and persistence of 2,4-dichlorophenol (2,4-DCP) since 2,4-D is a phenoxy derivative. Chlorinated phenols, in general, are known to impart disagreeable tastes and odors to potable water supplies.

A granular formulation of an iso-octyl ester of 2,4-D was added to Rockaway Park Lake, Rockaway, N.J. for the control of water milfoil, species Myriophyllum spicatum. Effective control of this species of aquatic vegetation was observed within 28 days. The secondary species, Anacharis canadensis (water weed), was not controlled. This report examines the immediate and prolonged effects of 2,4-D on the chemical water quality for a period of 132 days after treatment. Emphasis is placed on the occurrence and persistence of 2,4-D and 2,4-DCP. Attention was given also to the possible secondary effects of decaying vegetation on chemical water quality.

Methods of Sampling

Rockaway Park lake covers a surface area of 10 acres, has an average depth of 5.5 feet, and contains approximately 17.88 million gallons of water. Samples were taken at two sites at the edge and at two sites in the center of the lake. No water escaped from the lake spillway during the sampling period.

Analytical Methods

Most of the chemical analyses were made in accordance with the Standard Methods manual (1). The 2,4-DCP and phenol were

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determined by a modification of the 4-aminoantipyrine colorimetric method (2). Analyses for phenol were made in order to ascertain the background level of these naturally occurring compounds from decaying vegetation and to correct the 2,4-DCP data. The 2,4-D was determined by a modified chromotropic acid colorimetric method (3).

Materials

The granular formulation contained 20 per cent by weight acid equivalent of the iso-octyl ester of 2,4-dichlorophenoxyacetic acid. This material was added at the rate of 20 pounds of the acid equivalent per acre or at the concentration of 1.34 mg/l. This formulation was found also to contain 0.65 mg/gram of 2,4-DCP or a concentration of 4.36 ug/l in the lake.

Table I shows the chemical quality of the lake water just before addition of the 2,4-D. The high pH value of 9.4 was attributed to a tributary carrying drainage from a limestone quarry. The bicarbonate (total) alkalinity and the total hardness were of low to medium concentrations. The color value of 20 is fairly low for surface waters. Organic matter was measured indirectly through the chlorine demand and B.O.D. analyses. The values of 0.4 mg/l and 3.5 mg/l, respectively, indicate small amounts of organic matter. The natural or background threshold odor number of 2 was quite low and was qualitatively identified as "earthy" or "musty". Small, insignificant amounts of interfering substances were reported as 2,4-D and phenol. No 2,4-DCP was detected prior to herbicide treatment.

Results

No significant effects on the chemical characteristics of pH, total hardness, and total alkalinity (Table I) by the 2,4-D were observed throughout a sampling period of 70 days. Likewise, there were no significant deviations from the original values for color, chlorine demand, B.O.D. and dissolved oxygen. These latter analyses were made primarily to observe any secondary effects on water quality by decaying vegetation. Apparently the release of organic matter was too slow to register an appreciable effect. The threshold odor number remained at the value of 2 throughout the sampling period. The significance of this observation is discussed later in the paper.

Table II shows the occurrence and persistence of 2,4-D, 2,4-DCP, and phenol at various time intervals up to 132 days. The maximum concentration of 2,4-D, 49.5 ug/l, was observed 13 days after treatment whereupon there was a gradual decrease to 13.0 ug/l after 132 days. These data show that very little 2,4-D was detected in the "free-flowing" portion of the lake despite the fact that the herbicide was applied at the concentration of 1.34 mg/l.

TABLE I

Chemical Water Quality of Rockaway Park Lake[(a)]

Analyses	Result[(b)]
pH	9.4
Total Alkalinity	42.5 mg/l as $CaCO_3$
Total Hardness	54.5 mg/l as $CaCO_3$
Color	20 color units
Chlorine Demand[(c)]	0.40 mg/l as Cl_2
Biochemical Oxygen Demand[(d)]	3.5 mg/l as O_2
Temperature °F	73
Dissolved Oxygen	119.5 % saturation
Threshold Odor Number	2
2,4-DCP	0.0
Phenol	9.0 ug/l as phenol
2,4-D	8.0 ug/l as 2,4-D

(a) sample taken 6/27/61 and analyzed 6/28/61
(b) average of four samples
(c) contact time = 15 min., chlorine residual (OT)= 0.1 mg/l
(d) 5-day, 20°C, B.O.D.

The 2,4-DCP exhibited the same pattern of occurrence and persistence as 2,4-D in Table II, but at lesser concentrations. There appeared to be a slight increase of 2,4-DCP to the 10-11 ug/l range after 70 days. A spot check for 2,4-DCP was made at 132 days where the concentration was observed to be 13 ug/l. A very low level, 5.0-15.0 ug/l, of "background" phenols were observed.

Discussion

The use of 2,4-D as an aquatic herbicide releases 2,4-dichlorophenol as an impurity from the commercial formulation. A calculated concentration of 4.36 ug/l 2,4-DCP in the lake would have resulted from the granules of 2,4-D used in this study. The possibility also exists that this chlorinated phenol would be released as an intermediate biological degradation product of 2,4-D. There is some evidence to support this statement from a preliminary report on the effect of some aquatic herbicides on water quality (6) and from a study of 2,4-D degradation by soil microorganisms (5).

TABLE II

Occurrence and Persistence of 2,4-D, 2,4-Dichlorophenol, and Phenol

	Determination-Average of Four Sampling Areas		
Time	2,4-D ug/l	2,4-DCP ug/l	Phenol ug/l
Before[(a)]	8.0	0.0	9.0
1 hour	38.5	1.0	5.0
2 days	45.0	3.0	11.0
13 "	49.5	2.0	15.0
22 "	30.8	.5	7.8
27 "	25.8	2.0	7.8
48 "	25.8	0.0	9.0
55 "	20.0	11.3	7.5
70 "	24.5	10.5	9.3
132 "(b)	13.0	13.0	0.0

(a) June 27, 1961
(b) November 16, 1961

The levels of 2,4-DCP shown in Table II can be compared with threshold taste and odor concentrations reported by Burttschell et al (4). These investigators found that the major chlorination products of phenol (C_6H_5OH) were 2-chlorophenol, 4-chlorophenol, 2,6-dichlorophenol, 2,4-dichlorophenol and 2,4,6-trichlorophenol. Of these five compounds, the 2-CP, 2,4-DCP, and 2,6-DCP were found to be the major taste and odor producers. Threshold taste and odor concentrations of these five chlorinated phenols are given in Table III.

The odor level of Rockaway Park lake water was not affected by the observed concentrations of 2,4-DCP in Table II since the threshold value of 2 remained constant through 70 days of examination. A spot check was made for the typical medicinal taste and odor of chlorinated phenols at 132 days since a concentration of 13.0 ug/l of 2,4-DCP was found. No medicinal taste or odor was observed. These data are in general agreement with Burttschell since the concentrations of 2,4-DCP did not significantly exceed those required to impart a taste or to raise the threshold odor level.

Addendum to Table II - Figures of 18.7 and 37.5 ug/l of 2,4-DCP were observed between 70 and 132 days. These data were not verified by subsequent analysis and, therefore, were not considered valid.

TABLE III

Threshold Taste and Odor Concentration of Various Phenolic Compounds(a)

Component	Geometric Mean Threshold-ug/l	
	Taste	Odor
Phenol	>1000	>1000
2-CP	4	2
4-CP	>1000	250
2,4-DCP	8	2
2,6-DCP	2	3
2,4,6-TCP	>1000	>1000

(a) after Burttschell et al (4)

The data also indicate that any 2,4-DCP present in a lake treated with 2,4-D would be there primarily as an impurity from the formulation. There is no evidence from this study to suggest that an appreciable concentration of 2,4-DCP would arise from the biological degradation of 2,4-D. If 2,4-DCP is an intermediate degradation product, then apparently it decomposes at about the same rate as 2,4-D.

The data also show that 2,4-D does not persist for any appreciable length of time. This compound apparently reaches its peak concentration soon after application whereupon it decreases to levels that reach the sensitivity of the analytical method. In addition, very small amounts of 2,4-D, 13-50 ug/l, were detected in the "free flowing" portion of the lake that came from the initial 1.34 mg/l dosage. This may be an empirical reason why, in this particular study, the degradation of small amounts of 2,4-D is not a significant source of 2,4-DCP.

This study, perhaps, presents a more realistic picture of the occurrence and persistence of 2,4-DCP in a 2,4-D- treated lake than the carboy study reported here last year (6). At that time, there was evidence that 2,4-DCP occurred and persisted at levels high enough to produce tastes and odors according to the data of Burttschell. Since this investigation was limited to one lake and one type of formulation, however, additional field studies are needed to show the effect of various concentrations of 2,4-D and of other types of formulations on taste and odor water quality. The previous carboy study showed that the concentration of 2,4-DCP impurity varied considerably with type and concentration of formulation (6). The possibility also exists that decaying aquatic vegetation may release 2,4-DCP as a metabolite of 2,4-D. This would involve, first, a study on the fate of 2,4-D in the metabolic system of aquatic vegetation.

Conclusions

The effect of a 2,4-D granular formulation on the chemical water quality of a Northern New Jersey lake was studied for a period of 132 days. The following conclusions are made:

1. There were no effects on the chemical characteristics of pH, total hardness, and total alkalinity of the lake water.

2. There were no significant effects on the chemical characteristics of dissolved oxygen, biochemical oxygen demand, chlorine demand and color up to 70 days of observation. These characteristics would have indicated any secondary effect of decaying vegetation.

3. A very low level of 2,4-D, up to 49.5 ug/l, was released to the water from the original dosage of 1.34 mg/l.

4. No effect on the "natural" threshold odor level was produced by the observed concentrations of 0.5 to 13.0 ug/l 2,4-DCP.

5. No 2,4-dichlorophenol appeared to accumulate as the result of biological degradation of 2,4-D.

Acknowledgment

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Seed and seedling tolerance of lawngrasses to certain crabgrass herbicides[1]

E. J. Rice and C. R. Skogley[2]

Several herbicides will selectively control crabgrass when applied to stands of established turfgrass prior to the germination of the crabgrass seed. The degree of injury to established grasses has been quite well determined under many conditions. Very little knowledge is available regarding the action of most crabgrass herbicides when applied to the soil prior to seeding turfgrasses or when applied to immature grasses.

There are many instances when it would be desirable to treat soils before seeding, at the time of seeding or shortly after seeding. This study was undertaken in an effort to determine, under one set of conditions, how long residues, toxic to certain perennial grasses, remained in the soil. A second purpose was to ascertain the length of time necessary between seeding and treating with certain herbicides at various rates.

Materials and Methods

The test plots were located on a soil that is classed as Bridgehampton silt loam. A productive, well-drained soil, it had been fallowed for two seasons prior to 1961. Fifty pounds of ground limestone and 25 pounds of an 8-6-2 grade fertilizer per 1000 square feet were added to the soil during the seedbed preparation on June 21, 1961.

Nine chemicals, most of them at two or more rates of application, were included in the test. An untreated check was maintained for comparison purposes. The chemicals, formulations, and rates at which they were applied can be found in table I.

All chemicals were applied to each of three grasses - Merion Kentucky bluegrass (Poa pratensis), Astoria colonial bent (Agrostis tenuis) and Chewing's fescue (Festuca rubra). The bluegrass was seeded at the rate of two pounds per 1000 square feet, the fescue at 5 pounds and the bentgrass at one pound.

Each block or replication consisted of one 28-foot strip, 66 feet long, for each of the three grasses. Each 28-foot strip of grass was divided into 7 4-foot widths through the entire 66 foot length. These 4-foot plots were treated or seeded, the full length, at each treatment interval. The 66-foot length was divided into 22 3-foot widths, each of which received different chemical treatments. Thus, each individual plot size was 3- by-4 feet, and there were 462 plots in each of the 3 blocks.

Chemicals were applied according to the following plan:

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[2] Graduate Assistant and Associate Professor of Agronomy, respectively.

Code
A - seeded June 29 treated 2 weeks later 7/12/61
B - seeded June 29 treated 4 weeks later 7/28/61
C - seeded June 29 treated 9 weeks later 8/30/61
D - soil treated June 29 seeded - same day 6/29/61
E - soil treated June 29 seeded 2 weeks later 7/12/61
F - soil treated June 29 seeded 4 weeks later 7/28/61
G - soil treated June 29 seeded 9 weeks later 8/30/61

The test area was irrigated frequently throughout the season to assure adequate moisture for germination and growth of the grasses. The grasses were cut at a height of 1 1/2 inches as needed following establishment. Clippings were removed when they were excessive.

Those plots seeded 2, 4 or 9 weeks after the soil was treated were hoed and raked lightly prior to each seeding date. This most certainly caused some mixing of the chemical with the soil. It was necessary, however, to remove annual weeds and to loosen the soil surface to prepare a satisfactory seed bed. In all cases seed was spread with a mechanical spreader. Chemicals were weighed or measured in amounts required to treat individual 3-by-4 foot plots with the exception of treatments 20 and 21. These chemicals were applied with a mechanical spreader. Dry formulations were mixed with one pint of dry sand and applied by hand. The liquids were added to one pint of water (450 gals/A) and applied with a hand sprayer at 30 pounds pressure.

Grass response to chemical treatment or treatment interval was determined by comparing the growth of grass on the treated plots with that on the checks. Assuming that, in most cases, the stand and vigor of the grass on the untreated plots to be 100 percent the grass on the treated was scored from 0 to 100 percent. The scoring was done from 2 to 4 weeks following treatment. This depended on the length of time required for the slowest grass to attain sufficient growth to be properly scored.

Two or three subsequent readings were taken during the season to determine whether the initial injury was of a temporary or permanent nature.

Results and Discussion

Table I presents the average turf scores, based on density and vigor, of the three grasses when seeding was done at various intervals following the application of the herbicides to the soil. The average turf scores on the three grasses receiving treatment at various intervals after seeding are given in table II. These scores are for the first readings taken on each plot.

The scores for each grass at each interval were subjected to analysis of variance and the least significant difference at the 5 percent level was obtained. This information is also given in tables I and II.

With only a few exceptions chemical treatment resulted in some reduction in stand or vigor of the grasses. There are a few general observations that can be stated regarding the results obtained in this study.

First, soil treatment within a few weeks prior to seeding grasses was more risky than application to young, established grasses. Injury was greater when treating the soils and seeding two months later than when seeding and treating two weeks later.

Second, four-week old turf was more tolerant of chemical treatment, in general, than was two-week old turf. This trend did not continue through the 9th week. For some reason the resultant injury was greater, in general, on the turf treated 9 weeks after seeding than on younger turf. One possible explanation would be the weather conditions on or following the treatment date. The growing conditions on August 30th were considerably less favorable than on July 12 or 28. The fescue and, to a lesser extent, the bentgrass were not growing as rapidly, or exhibiting as healthy an appearance in late August as they did during July. It would appear that growing conditions at the time of treatment, as well as age of the young plant, are important considerations in timing herbicide applications.

Third, although chemical treatment often thinned or delayed the initial stand of grass, enough plants often remained in healthy condition to eventually give satisfactory stands of turf. Tables III and IV contain the turf ratings taken at the end of the trial in mid-October. Comparisons of the turf scores between tables I and III and II and IV will clearly bear this out.

The treatments that did not significantly lower the turf score are shown in tables I and II. When the soil was treated at, or prior to, seeding only 41 treatments out of a total of 240 failed to significantly reduce the turf score. Twenty-one of these 41 treatments were associated with the use of calcium propyl arsonate and the combination of calcium propyl and calcium methyl arsonates. Diphenatrile and the light rate of Bandane plus Chlordane accounted for over half of the other treatments that did not significantly lower the turf score.

In table II there are 91 out of a total of 189 treatments that did not show a significant reduction in turf score. This would indicate that there is less injury associated with foliar applications of the chemicals used than with soil treatments at or before seeding. Only trifluralin was unsafe to all grasses at all rates and dates of application. As is shown on the table, certain rates of all other materials appeared safe to one or more grasses at one or more time intervals. Diphenatrile, Bandane, Bandane plus Chlordane, Dacthal G1.5 SY, and the combination of calcium propyl and calcium methyl arsonates appeared to be relatively safe to use at certain rates or times.

Two trends which appeared during the test are of interest. First, the grasses with the largest seed were injured the least from soil treatment with chemicals. Injury was greatest to bentgrass, bluegrass was intermediate and fescue was injured the least.

Second, when treating grasses after seeding, the time interval required for safety depends somewhat on the rate of establishment. Bluegrass is slow to establish and was injured more frequently when treated two weeks after seeding than was the bent or fescue. At later treatment dates the blue was the most tolerant of the herbicides, bent was intermediate and fescue was the most susceptible to injury.

Summary and Conclusions

The following chemicals at the acre rates indicated were applied to the soil at seeding, 2, 4, and 9 weeks prior to seeding, and 2, 4, and 9 weeks after seeding three different turfgrasses: trifluralin (N,N-di-n-propyl-2,6-dinitro-4-trifluoromethylaniline) at 2 and 4 lbs., Dipropalin (N,N-di-n-propyl-2,6-dinitro-4-methylaniline) at 2, 4 and 8 lbs., Diphenatrile (diphenylacetonitrile) at 30 lbs., Bandane (polychlorodicyclopentadiene isomer) at 20 and 40 lbs., 75% Bandane plus 25% Chlordane at 20, 30 and 40 lbs., Dacthal (dimethyl ester of tetra chloroterephthalic acid) at 10 and 20 lbs., Dacthal SY (experimental compound) at 10 lbs., calcium propyl arsonate at 40 lbs. and a combination of calcium propyl and calcium methyl arsonates at 50 lbs.

Merion Kentucky bluegrass, Astoria colonial bentgrass and Chewing's fescue were the grasses used. The first treatments and seedings were made on June 29 and the last ones on August 30. Turf scores based on density and vigor of stand were taken during the season. The average scores on all treatments are given for two complete readings.

Based on the results obtained under the conditions of this study the following conclusions are made:

1. Calcium propyl arsonate and combinations of calcium propyl and calcium methyl arsonates, when applied to the soil at or prior to seeding certain lawngrasses, do not appreciably interfere with germination and growth of those grasses.

2. Nine weeks after soil treatment with Diphenatrile it is safe to seed Merion Kentucky bluegrass, Astoria Colonial bentgrass and Chewing's fescue.

3. In general, soil treatments with herbicides prior to seeding turfgrasses are more apt to result in injury than are the same treatments made after seed germination.

4. Dipropalin, Diphenatrile, Bandane, Bandane-Chlordane combinations, Dacthal SY and combinations of calcium propyl and calcium methyl arsonates, at certain rates, may be safely applied to 4-week old stands of turfgrass.

5. Bandane, the arsonates and Diphenatrile appeared to be the least phytotoxic to the turfgrasses.

Acknowledgment

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I. Average turf scores[1] of three grasses seeded at intervals after the application of herbicides to the seedbed: first observations.

Chemical	% act.	Lbs. active Per acre	Same time Bent	Same time Blue	Same time Fes.[2]	2 wks. later Bent	2 wks. later Blue	2 wks. later Fes.	4 wks. later Bent	4 wks. later Blue	4 wks. later Fes.	9 wks. later Bent	9 wks. later Blue	9 wks. later Fes.
Trifluralin	2.0	2	0	3	10	3	7	40	3	7	17	17	20	43
Trifluralin	2.0	4	0	0	3	0	0	17	0	0	10	7	10	20
Dipropalin	2.0	2	17	27	50	20	30	70	20	30	73	53	60	77*
Dipropalin	2.0	4	17	23	43	20	13	63	13	7	53	30	20	73*
Dipropalin	2.0	8	3	7	23	3	27	60	0	3	17	7	20	40
Diphenatrile	11.5	30	20	30	63	57	43	83*	57	87*	97*	83*	90*	93*
Bandane (E.C.)	4#/gal.	20	7	13	27	50	50	73	43	50	77*	77	63	90*
Bandane (E.C.)	4#/gal.	40	3	3	23	30	30	60	10	23	27	20	23	67
Bandane (Verm.)	7.5	20	37	50	57	33	40	73	30	43	63	73	70	80*
Bandane (Verm.)	7.5	40	20	10	37	27	23	57	17	17	33	27	27	57
Bandane (Clay)	7.5	20	63	57	60	63	63	77	40	60	83	67	70	73*
Bandane (Clay	7.5	40	40	27	47	37	40	63	20	17	23	3	33	53
Bandane & Chlordane	10.0	20	63	67	77*	57	70	83*	77*	53	90*	77	93*	80*
Bandane & Chlordane	10.0	30	47	33	57	37	47	73	40	43	60	57	70	67
Bandane & Chlordane	10.0	40	33	23	53	27	33	60	17	23	37	33	47	63
Dacthal	2.3	10	3	20	43	10	33	67	0	20	43	30	47	73*
Dacthal	2.3	20	3	3	33	3	13	43	0	0	7	3	10	30
Dacthal	1.5	10	17	10	27	0	3	50	0	7	10	7	13	40
Calcium methyl arsonate +	6.0													
Calcium propyl arsonate	18.0	50	80	77*	87*	93*	90*	93*	100*	97*	93*	83*	97*	83*
Calcium propyl arsonate	12.5	40	73	90*	83*	97*	97*	90*	83*	93*	83*	77	97*	97*
Check	-	-	100	100	93	97	90	100	90	97	100	100	97	90
LSD/5%			17	24	20	16	26	19	16	17	23	20	23	21

score = visual observation of turf density with 0 being bare ground to 100 being optimum density.

= Astoria colonial bentgrass, Blue = Merion Kentucky bluegrass, Fes. = Chewing's fescue.

cates those treatments that did not significantly reduce the turf score.

II. Average turf scores[1] of three grasses treated with herbicides at intervals after seeding: first observations.

			Treated			Treated			Treated		
		Lbs. active	2 wks. later			4 wks. later			9 wks. later		
Chemical	% act.	Per acre	Bent	Blue	Fes.[2]	Bent	Blue	Fes.	Bent	Blue	Fes.
Trifluralin	2.0	2	20	20	27	43	40	40	23	60	20
Trifluralin	2.0	4	3	7	17	23	30	30	17	53	10
Dipropalin	2.0	2	63	47	80	63	80*	80*	67*	97*	63
Dipropalin	2.0	4	67	50	73	63	70	70	47	90*	57
Dipropalin	2.0	8	23	27	50	50	73	60	47	80	37
Diphenatrile	11.5	30	67	53	87*	87*	97*	93*	53	100*	50
Bandane (E.C.)	4#/gal.	20	47	37	50	77*	80*	57	93*	97*	70*
Bandane (E.C.)	4#/gal.	40	33	23	27	70	63	53	53	90*	40
Bandane (Verm.)	7.5	20	83*	67*	90*	97*	93*	97*	93*	100*	77*
Bandane (Verm.)	7.5	40	77	63	80	93*	97*	83*	80*	93*	57
Bandane (Clay)	7.5	20	90*	80*	97*	97*	100*	87*	93*	100*	80*
Bandane (Clay)	7.5	40	70	63	83	77*	93*	70	87*	100*	57
Bandane & Chlordane	10.0	20	90*	60	87*	93*	100*	83*	90*	93*	70*
Bandane & Chlordane	10.0	30	80*	57	90*	97*	97*	93*	90*	100*	90*
Bandane & Chlordane	10.0	40	80*	50	87*	97*	93*	90*	93*	90*	63
Dacthal	2.3	10	47	53	60	63	93*	73	67*	90*	50
Dacthal	2.3	20	37	37	53	70	90*	83*	53	90*	60
Dacthal	1.5	10	37	57	50	73	93*	67	70*	93*	60
Dacthal G-1.5 SY	1.5	10	57	67*	78	77*	90*	87*	70*	100*	73*
Calcium methyl arsonate + Calcium propyl arsonate	6.0 18.0	50	97*	73*	97*	93*	73	80*	87*	87*	47
Calcium propyl arsonate	12.5	40	87*	57	80	83*	70	57	40	53	7
Check	-	-	100	100	100	97	97	93	83	100	97
LSD/5%			22	36	15	22	18	18	22	14	28

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score = visual observation of turf density with 0 being bare ground to 100 being optimum density.

= Astoria colonial bentgrass, Blue = Merion Kentucky bluegrass, Fes. = Chewing's fescue.

ates those treatments that did not significantly reduce the turf score.

III. Average turf scores[1] of three grasses seeded at intervals after the application of herbicides to the seedbed: final observations.

		Lbs. active	Same time			2 wks. later			4 wks. later			9 wks. later		
Chemical	% act.	Per acre	Bent	Blue	Fes.[2]	Bent	Blue	Fes.	Bent	Blue	Fes.	Bent	Blue	Fes.
Trifluralin	2.0	2	27	27	33	3	7	13	10	20	37	17	20	63
Trifluralin	2.0	4	20	7	10	0	0	7	7	3	17	7	7	20
Dipropalin	2.0	2	83	80	83	67	80	83	70	63	90	50	77	93
Dipropalin	2.0	4	63	70	80	37	37	57	40	23	87	27	20	87
Dipropalin	2.0	8	43	67	63	7	13	33	3	13	33	10	13	57
Diphenatrile	11.5	30	80	87	73	77	83	90	97	100	83	90	10	90
Bandane (E.C.)	4#/gal.	20	70	70	47	73	87	77	90	90	80	77	60	90
Bandane (E.C.)	4#/gal.	40	40	37	30	33	37	37	50	53	60	33	33	77
Bandane (Verm.)	7.5	20	87	100	90	73	93	80	90	90	77	73	70	87
Bandane (Verm.)	7.5	40	93	83	80	67	60	67	63	53	50	30	30	70
Bandane (Clay)	7.5	20	90	97	90	87	97	90	93	90	87	73	80	80
Bandane (Clay)	7.5	40	87	90	73	73	67	47	57	50	40	33	50	73
Bandane & Chlordane	10.0	20	100	97	60	100	93	93	100	97	87	83	87	77
Bandane & Chlordane	10.0	30	93	100	87	80	93	87	97	83	70	67	70	90
Bandane & Chlordane	10.0	40	97	93	87	63	80	67	57	60	47	40	57	70
Dacthal	2.3	10	50	80	80	33	77	73	17	53	67	37	47	87
Dacthal	2.3	20	40	63	30	10	67	40	3	13	27	7	17	27
Dacthal	1.5	10	40	50	33	10	40	40	3	23	47	7	17	47
Calcium methyl arsonate +	6.0													
Calcium propyl arsonate	18.0	50	97	100	93	100	100	87	100	100	93	93	93	93
Calcium propyl arsonate	12.5	40	100	97	90	100	100	83	93	97	90	83	90	97
Check	-	-	90	100	90	93	97	93	100	100	97	93	100	93

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score = visual observation of turf density with 0 being bare ground to 100 being optimum density.

= Astoria colonial bentgrass, Blue = Merion Kentucky bluegrass, Fes. = Chewing's fescue.

e IV. Average turf scores[1] of three grasses treated with herbicides at intervals after seeding: final observations.

			Treated 2 wks. later			Treated 4 wks. later			Treated 9 wks. later		
Chemical	% act.	Lbs. active Per acre	Bent	Blue	Fes.[2]	Bent	Blue	Fes.	Bent	Blue	Fes.
Trifluralin	2.0	2	57	83	57	43	60	0	50	47	13
Trifluralin	2.0	4	10	53	13	17	40	0	23	50	0
Dipropalin	2.0	2	93	93	93	83	100	77	97	100	83
Dipropalin	2.0	4	87	97	80	63	90	43	63	87	67
Dipropalin	2.0	8	70	97	80	53	77	13	77	73	30
Diphenatrile	11.5	30	83	100	70	77	97	70	83	100	87
Bandane (E.C.)	4#/gal.	20	87	93	63	100	93	53	100	97	87
Bandane (E.C.)	4#/gal.	40	70	80	20	83	77	50	63	87	50
Bandane (Verm.)	7.5	20	83	100	83	90	93	53	100	100	80
Bandane (Verm.)	7.5	40	97	93	67	83	87	20	93	97	60
Bandane (Clay)	7.5	20	100	100	83	93	100	50	97	100	83
Bandane (Clay)	7.5	40	100	97	67	90	87	17	93	100	63
Bandane & Chlordane	10.0	20	93	100	80	97	100	67	93	100	87
Bandane & Chlordane	10.0	30	90	100	90	97	100	53	100	100	83
Bandane & Chlordane	10.0	40	100	100	77	97	97	21	100	100	77
Dacthal	2.3	10	73	100	37	83	100	21	83	97	70
Dacthal	2.3	20	63	90	13	83	90	7	80	100	53
Dacthal	1.5	10	57	93	17	67	90	13	77	97	60
Dacthal Gl.5 SY	1.5	20	80	93	33	77	93	17	93	100	83
Calcium methyl arsonate +	6.0										
Calcium propyl arsonate	18.0	50	100	100	90	100	100	73	100	100	47
Calcium propyl arsonate	12.5	40	93	97	60	100	93	43	67	87	10
Check	-	-	93	100	93	97	100	97	87	97	100

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f score = visual observation of turf density with 0 being bare ground to 100 being optimum density.

t = Astoria colonial bentgrass, Blue = Merion Kentucky bluegrass, Fes. = Chewing's fescue.

PHYTOTOXIC EFFECTS OF CERTAIN PRE-EMERGENCE CRABGRASS CONTROL TREATMENTS ON SEEDLING TURF GRASSES

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Four turfgrasses that are generally grown in Virginia were chosen for this study. They were Merion bluegrass, creeping red fescue, common bermuda, and seaside bent. The main object was to find out if seedling plants of these species were susceptible to certain chemicals that had shown promise of controlling crabgrass when applied as pre-emergence applications.

In one series of experiments, the chemical was applied in the spring and seeding was done at intervals after the applications were made. In another series of experiments, the grasses were seeded in May and the chemical treatments applied at intervals after seeding. Before and after seeding treatments were made in the case of bent and bluegrass but not for fescue and bermuda. Only the before seeding treatments were applied on bermuda and only the after seeding treatments were made in the fescue experiments.

All treatments and seeding dates were replicated three times in a randomized block design. Prior to application of the chemicals and seeding, the entire area was furmigated with SMDC at a rate of 1 pint per 100 sq. ft. and covered with plastic for 48 hours. The cover was removed 10 days before the beginning of the experiment. All plots were kept moist by means of an overhead irrigation system. The bluegrass, fescue and bermuda grass were kept mowed at a height of 1½ inches and the bentgrass at ½ inch.

Treatments and Results

Except for bermuda grass, the same treatments were applied to all species before and/or after seeding. Final density ratings were made on October 25, 1961. The ratings taken on this date are given for each experiment. The treatments used and results obtained are given in the following tabulation.

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[1] Professor of Plant Physiology and Assistant Professor of Agronomy, Respectively.

BENT GRASS - TREAT AND SEED

Treatment	A.	Lilly L-36352	2%	4#/A
	B.	" "	2%	8#/A
	C.	" L-35455	2%	4#/A
	D.	" "	2%	8#/A
	E.	Amchem No Crab	20%	43#/A
	F.	Chlordane	60%	60#/A
	G.	Bandane	7.5%	20#/A
	H.	"	7.5%	40#/A
	I.	"	3#/gal.	20#/A
	J.	"		40#/A
	K.	Zytron	8%	13#/A
	L.	Dacthal	2.5%	10#/A
	M.	Diphenyl acetonitrile	11.5%	4#/A
	N.	Check		

Treated - May 1, 1961
Seeded - 1.- 5/7/61
2 - 6/14/61
3 - 7/5/61
4 - 7/19/61
5 - 8/2/61

Chemical Treatment - Density

1=All dead
10=Vigorous plants

B	I	A	K	H	D	N	G	F	L	M	I	C	E
5.20	5.47	5.53	5.67	6.27	6.80	7.00	7.27	7.40	7.40	7.40	7.47	7.73	7.73
				—	—	—	—	—	—	—	—	—	—*
			—	—	—	—	—						
	—	—	—	—	—	—							
—	—	—	—	—	—								

Time of seeding - Density

1=All dead
10=Vigorous plants

7/19	8/2	5/17	7/5	6/14
5.98	6.21	6.62	6.86	8.02
				—
		—	—	
—	—			

BENT GRASS - SEED AND TREAT

Seeded - May 24, 1961
Treated- 1 - 6/12/61
2 - 7/4/61
3 - 7/18/61
4 - 8/1/61

Chemical Treatment - Density

1=All dead
10=Vigorous plants

B	A	K	G	J	D	N	F	M	C	E	H	I	L
6.25	7.88	7.88	8.63	8.163	8.75	8.75	8.88	8.88	9/00	9.00	9.00	9.00	9.00
			—	—	—	—	—	—	—	—	—	—	—*
	—	—											
—													

* Figues underscored by a continuous line are not significantly different.

MERION BLUEGRASS - TREAT AND SEED

Treated - May 1, 1961
Seeded - 1 - 5/20/61
2 - 6/17/61
3 - 7/10/61
4 - 7/24/61

Time of seeding averages - not significant

Chemical Treatments

Not significantly different.

Seeding dates

1=Dead bluegrass
10=Vigorous bluegrass

6/17	5/20	7/10	7/24
3.76	4.83	5.26	6.14

BENT GRASS - SEED AND TREAT

Seeded - May 24, 1961
Treated - 1 - 6/22/61
7/15/61
7/27/61
8/8/61

Chemical Treatment - Density

B	A	K	D	T	C	E	H	I	L	G	F	N	M
1.75	4.63	5.88	6.38	7.25	7.38	7.50	7.50	7.63	7.63	8.00	8.13	8.13	8.25

Seeding Dates - Density - Not significant

FESCUE - SEED AND TREAT

Seeded - May 24, 1961
Treated - 1 - 6/26/61
7/17/61
7/31/61
8/14/61

Chemical Treatment - Density - 10/25/61

10=100%
1=Dead plants

B	A	K	D	L	M	J	F	E	C	N	I	G	H
2.67	4.00	5.75	6.00	6.42	6.42	6.67	6.83	6.92	7.08	7.42	7.50	7.58	7.92

Treatment Dates - Density

1=dead plants
10=100%

7/31	8/14	6/26	7/17
5.90	5.90	6.83	6.83

BERMUDA - TREAT AND SEED

Treated - June 30, 1961
Seeded - 1 - 7/15/61
2 - 7/29/61
3 - 8/10/61
4 - 8/24/61

Treatment	A. Zytron	8.0%	15#/A
	B. Dacthal	2.5%	10#/A
	C. Cal. Prep. Ars.	20.0%	43#/A
	D. Bandane	7.5%	20#/A
	E. Diphenyl acetonitrile	11.5%	4#/A
	F. Lilly L-35455	2.0%	4#/A
	G. Check		

Treatment - Density

1=Dead grass
10=100%

F	A	D	E	B	G	C
2.75	3.67	4.67	4.75	9.83	6.00	6.75

Seeding date - density

1=dead grass
10=100%

8/24	7/15	8/10	7/29
3.62	4.76	5.48	5.81

In general, the treatments applied before seeding resulted in more injury to the grasses than did those which were seeded first and then treated. This could be expected since most germinating seed are usually killed easily in the presence of most herbicides. Poor stands of grass in the treat and seed plots can be partially attributed to weather conditions at the time of seeding. A better technique would have been to treat at different dates and seed all plots at one time.

Under the conditions prevailing in these experiments, the dipropalin caused considerable injury to bent, fescue, and bluegrass seedlings. This was true in the pre-seeding and post-seeding applications. As indicated by the data, there was little effect of the other treatments on grass stands.

From these studies it appears that seeding grasses are not adversley affected by the more commonly used pre-emergence Crabgrass control treatments if they are three weeks old or more. On the other hand, seeding soon after application may not be advisable.

THE EFFECT OF CERTAIN PREEMERGENCE CHEMICALS ON GRASS GERMINATION AND SEEDLING GRASSES

J. M. Duich, B. R. Fleming, A. E. Dudeck and G. J. Shoop[1]

The objectives of this study were to determine the effect of several preemergence chemicals on seedlings of three major turfgrass species when applied at varying intervals following seeding, and their effect on the germination of these grasses when seeded at varying intervals following application.

Materials and Methods

This study was conducted at University Park, Pennsylvania on Hagerstown silt loam soil with a pH of 6.3 and medium levels of available phosphorous and potash. Initiation of the study was delayed until late spring due to inclement weather. The area was treated with hot methyl bromide at 1.2 pounds per 100 square feet in late May 1961, following root zone tillage, to eliminate any undesired plants during the growing season. Prior to final seedbed preparation, 45 lbs. of 10-5-5 (70% ureaform and 30% activated sludge nitrogen) per M was applied.

Turf was maintained at 1¼" height of cut throughout the season with all clippings removed. Irrigation was applied for establishment and maintenance, however, the turf was allowed to show moisture stress prior to maintenance watering to allow any possible treatment effects to be expressed.

Post-emergence Test. On June 20, 1961 common Kentucky bluegrass, creeping red fescue and Astoria bent were seeded in individual 3 x 63 foot adjacent strips at 2, 4 and 1 pound per M, respectively. Three foot sod strips were placed parallel to each series of seeded strips to facilitate mulch removal, irrigation, etc. The experimental design was a triple replicated randomized block with treatment dates, grass species and chemical treatments the respective factors.

Chemical treatments were applied in 3 x 9 foot strips perpendicular to the grass strips resulting in 3 x 3 foot treatments on each grass species. Treatments were made at 6, 38, 69 and 100 days following seeding.

Preemergence Test. The above chemical treatments were applied at similar rates and plot sizes to a prepared seedbed on June 26. All plots were mulched with first-cut forage at approximately 100 pounds per M to assimilate a turf cover condition and to prevent material movement and exposure to light. The three grass species were seeded at 0, 32, 63 and 93

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days following the chemical treatment. Except for the first seeding date which was made with the chemical treatment, each subsequent seeding date was handled in the following manner: mulch was removed, seed applied, covered with sterilized soil, rolled to firm, re-covered with mulch and watered. Mulch was finally removed on the basis of control plot germination.

Treatments. Six chemicals were involved in both the pre- and post-emergence study at rates listed in Tables 1 and 2. Bandane (polychlorodicyclopentadiene isomers with 60-62% chlordane) as emulsion concentration and on attapulgite ; No-Crab (calcium propyl arsonate); Dacthal WP (dimethyl ester of tetrachloroterephthalic acid); U-4513 W (N, N-dimethyl-γ, α-diphenyl acetamide); Zytron emulsion (O-(Z, 4-dichlorophenyl) O-methyl isopropylphosphoramidothioate); and Diphenatrile (diphenylacetonitrile).

Liquid formulations were applied with a plot sprayer at 35 psi and 90 gpa. Dry materials were diluted with two quarts of dry screened soil and spread by hand.

Discussion and Results

Preemergence and post-emergence effects on the three grass species are shown in Tables 1 and 2, respectively.

Bandane. The emulsion formulation had a more immediate effect on both germination and seedlings than did the dry formulation, but the toxicity appeared to dissipate rapidly beginning with the second treatment date. Only a slight difference in results was noted between the 20 and 40 lb. rates. The greatest species difference occurred for the 0 date on fescue germination and at 6 days after seeding on bluegrass, which could still be considered partial preemergence.

No-Crab resulted in the least reduction in germination and reduction in stand on seedling turf of all treatments in the experiment. Except for an 18 percent reduction in bent germination at 0 date, all other treatments resulted in less than 10 percent reduction. There was a slightly greater effect on fescue stand for the 6 and 38 treatments. No reduction occurred after 38 days.

Dacthal toxicity to germination and seedling stand was high for the initial date with somewhat less effect on fescue germination. Stand reduction decreased progressively especially on bluegrass. Germination increased for subsequent treatment dates, but progressively less for fescue and especially bent where a maximum of 15 percent occurred at 93 days.

U-4513 treatment resulted in no germination and complete seedling loss for the first treatment date. Slight germination occurred beginning with the 32 day treatment and increased to a maximum of 87 for bent at 93 days. Bluegrass showed same level of fair tolerance beginning with the 38 day treatment, whereas fescue and bent tolerance was not increased substantially until after 69 days. The 100 day treatment reduced stand of all species by 20-30 percent with continued discoloration 50 days after application.

Zytron showed the longest residual effect on grass germination from complete inhibition at the 0 day treatment to a maximum of 30 percent on bluegrass after 93 days. Bent germination was completely inhibited for 0, 32, and 63 day treatments and only 8 percent showed following 93 day treatment. Seedling stand reduction was complete for all species at 6 days, 60-90 percent reduction at 38 days and 20-40 percent reduction following 69 and 100 day treatments. The latter treatment continued to show discoloration 50 days after application.

Diphenatrile showed the greatest species differential effect for both germination and stand. At 0 date bluegrass and bent were greatly inhibited, followed by a sharp increase at 32, 63 and 93 day treatments which ranged from 67 to 98 percent. Fescue emerged at 80 percent at 0 day treatment and ranged from 87 to 98 percent for following three treatment dates. Bluegrass, bent and fescue stands were reduced 88, 58 and 40 percent, respectively, at 6 day treatment, 2-15 percent at 38 days and showed no stand reduction for the following two treatment dates.

Under moisture stress, no treatments were observed to show possible root reduction except for severely injured plots where all plant parts appeared to be affected, even at optimum moisture.

Conclusions

The effects of preemergence crabgrass chemicals on the germination and seedling stand of bluegrass, fescue and bent were studied. Differential species effect was found with certain materials on both inhibition of germination and seedling turf. In all instances injury was correlated with age of seedlings, but with varying effect. Provided that acceptable levels of crabgrass control can be achieved, certain materials appear to show promise for situations requiring use on seedling turf and at periods following seeding.

Table 1. Percent Germination* of Bluegrass, Fescue and Bent Seeded at 0, 32, 63 and 93 Days Following Chemical Application. Data Recorded 30 Days After Seeding

Material	Rate	0	32	63	93	0	32	63	93	0	32	63	93
Bandane EC	20 a.i./A	7	90	95	100	38	92	92	100	2	83	95	100
Bandane EC	40 a.i./A	0	82	82	95	22	80	83	72	0	72	80	88
Bandane Attap.	20 a.i./A	52	78	87	93	70	82	87	95	52	78	78	95
Bandane Attap.	40 a.i./A	24	57	72	83	48	55	68	85	8	57	72	87
No-Crab	5/M	94	96	93	100	91	93	96	100	82	95	97	100
Dacthal-W	10 a.i./A	6	52	87	77	24	43	70	63	0	12	4	15
U-4513 W	2.5 a.i./A	0	8	48	65	0	3	37	67	0	13	77	87
Zytron EC	15 a.i./A	0	0	5	30	0	3	13	15	0	0	0	8
Diphenatrile	30 a.i./A	7	78	88	95	80	87	88	98	2	67	85	98

* Based on control plot germination.

Table 2. Percent Reduction in Stand* of Bluegrass, Fescue and Bent Treated at 6, 38, 69, and 100 Days After Seeding. Data Recorded 30 Days Following Chemical Treatment.

		Kentucky Bluegrass No. of Days				Cr. Red Fescue No. of Days				Astoria Bent No. of Days			
Material	**Rate**	6	38	69	100	6	38	69	100	6	38	69	100
Bandane EC	20 a.i./A	88	27	2	0	38	18	4	0	80	22	6	0
Bandane EC	40 a.i./A	96	35	11	2	85	37	13	0	99	13	6	0
Bandane Attap.	20 a.i./A	38	13	0	0	17	25	0	0	13	33	0	0
Bandane Attap.	40 a.i./A	60	13	0	0	35	27	0	0	67	23	0	0
No-Crab	5/M	7	10	0	0	12	22	0	0	7	10	0	0
Dacthal W	10 a.i./A	83	27	3	0	92	57	13	2	92	80	12	3
U-4513 W	2.5 a.i./A	100	25	15	20**	100	75	15	20**	100	65	15	30**
Zytron EC	15 a.i./A	100	60	20	20**	100	87	40	35**	100	90	25	20**
Diphentrile	30 a.i./A	88	10	0	0	40	15	0	0	58	2	0	0

* Based on control plot stand.

** Showing variable degrees of discoloration after 50 days.

PRE-EMERGENCE CONTROL OF CRABGRASS WITH CHEMICALS[1]

J. Troll, J. Zak and D. Waddington[2]

Several chemicals were applied to turf areas in order to determine their effectiveness for pre-emergence crabgrass control. One series of plots was laid out in 1960 and a second series in 1961.

Trials initiated in 1960

Procedure in 1960:

Seven pre-emergence crabgrass control chemicals were tested in 1960 with the following objectives: (1) Pre-emergence control of crabgrass *per se*; (2) Their effectiveness under natural precipitation and irrigation; and (3) Their effectiveness at different fertility levels.

Plots were established on fairway turf which contained a heavy infestation of crabgrass in 1959 at the Amherst, Massachusetts, Golf Course. The permanent grasses consisted mainly of bluegrass (Poa pratense), intermixed with a small amount of bent (Agrostis palustris) and fescue (Festuca rubra).

The efficacy of the herbicides were compared in five blocks. Each block consisted of 24, 4'x10' plots. Treatments were replicated three times within each block.

The pH of the test areas was 6.0. Four blocks received 50 pounds of a 10-10-10 fertilizer per 1,000 sq.ft. The fifth block received no lime or fertilizer in either 1960 or 1961.

All chemicals were applied on April 14 in both years at rates recommended by the respective manufacturers. All dry ingredients were mixed with clean, coarse sand for ease of spreading. Liquid treatments were applied with a knapsack sprayer.

Those herbicides which showed promising control of crabgrass in 1960 were again applied to two of the five blocks in 1961.

Results in 1960:

Because of the insignificant differences between the fertilized versus the non-fertilized plots and between the natural precipitation versus irrigation plots, results obtained from the 5 blocks have been combined and are shown in Table I.

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[1] Contribution No. 1334 of the University of Massachusetts, College of Agriculture, Experiment Station, Amherst, Massachusetts.

[2] Assistant Professors and Instructor, Department of Agronomy, University of Massachusetts, Amherst, Massachusetts.

TABLE I. Pre-emergence Control of Crabgrass with Chemicals
Amherst, Mass. 1960

Herbicide	Rate of Application	*Estimate % Control Aug. 1960
Dacthal	25 lbs/2500 sq.ft.	99
Zytron, Dry	6 lbs/1000 sq.ft.	98
Arsenical complex	20 lbs/1000 sq.ft.	63
PMA	7 pints/acre	27
Calcium arsenate	12 lbs/1000 sq.ft.	73
Zytron, Emulsion	10 gal/acre	99
Chlordane	80 lbs actual/acre	89
Check	water	0

* Percent control based on average estimated by 3 individuals.

Procedure 1961:

In 1961 two of the five blocks were re-treated with 4 chemicals which were most effective in controlling crabgrass in 1960.

To determine the residual effect of the four chemicals, 2 of the 5 blocks were left untreated. The fifth block was seeded with viable crabgrass seed and not re-treated with chemicals. This was done to obtain a truer picture of residual effects.

All chemicals were applied at the same rates as in 1960. Results are shown in tables 2, 3, and 4.

Results in 1961:

TABLE II. Crabgrass Control in Plots Retreated in 1961

Herbicide	Rate of Application	Estimate % Control
Dacthal	25 lbs/2500 sq.ft.	95
Zytron(granular)	6 lbs/1000 sq.ft.	99
Calcium arsenate	12 lbs/1000 sq.ft.	99
Chlordane	80 lbs. actual/acre	97
Check	water	0

TABLE III. Residual Effects in Plots Not Retreated in 1961

Herbicide	Estimate % Control
Dacthal	16
Zytron (granular)	2
Arsenical complex	15
PMA	1
Calcium arsenate	53
Zytron Emulsion	41

TABLE IV. Residual Effect on Crabgrass Seeded Plots Not Retreated in 1961

Herbicide	Estimate % Control
Dacthal	17
Zytron (granular)	46
Arsenical complex	18
Calcium arsenate	39
PMA	11
Zytron Emulsion	69
Chlordane	63

Trials initiated in 1961

Procedure:

Several new introductions as well as those chemicals which had controlled crabgrass satisfactorily in the 1960 trials were used. A series of plots 4'x10' were set up with three replications. The established turf consisted of Kentucky bluegrass (Poa trivialis), bentgrass (Agrostis palustris), and some ryegrass (Lolium spp.). The area was heavily infested with crabgrass. The soil was a sandy loam. Fertilizer was applied to the area in the fall of 1960 and again in the spring of 1961. The chemicals were applied at the manufacturer-recommended rates on April 14, 1961.

Results:

TABLE V. Effectiveness of Pre-emergence Crabgrass Control Chemicals
Amherst, Mass. 1961

Herbicides*	Lbs. Active Ingredient/Acre	Estimated Percent Control
Dacthal (Swift)	10	95
Zytron, Dry (Dow)	15	100
Calcium arsenate (Linck)	413	81
Calcium arsenate (Linck)	826	91
Calcium arsenate (Linck)	1239	99
Chlordane	80	99
Diphenylacetonitril (Corenco)	28.4	98
Diphenylacetonitril (Agrico)	25.4	91
Calcium propyl arsonate (AmChem)	43.5	8
U 4513 (Upjohn)	2.0	0
Zytron Emulsion M2025 (Dow)	17 in 1000 gal. H_2O	100
Zytron Emulsion M2025	17 in 3000 gal. H_2O	100

* Supplied by designated companies

Summary and Conclusions

Lime and fertilizer applications showed little effect on the effectiveness of various herbicides.

Excellent crabgrass control was obtained with Dacthal and granular Zytron in 1960 and also in 1961.

Chlordane, at 80 lbs/acre rate, gave good control in 1960 and excellent control in 1961.

Calcium arsenate gave fair control in both 1960 and 1961. An area treated in 1960 and re-treated in 1961 indicated excellent control in 1961. Good and excellent control were obtained by doubling and tripling the recommended rate of application for this chemical.

PMA, which is not recommended for pre-emergence control, was ineffective.

The arsenical complex gave poor control.

Zytron emulsion gave excellent control in 1960, but it also severely injured the desirable grasses. Zytron M2025 which was used in 1961 gave excellent control of crabgrass and did not injure the desirable grasses.

Diphenylacetonitril gave excellent control at the higher rate of application (28.4 lbs. per acre). Calcium propyl arsonate and Upjohn product U4513 were ineffective as pre-emergence crabgrass killers. Grass in plots treated with U4513 appeared stunted two weeks after treatment. Five weeks after the date of application, the turf in these plots was severely injured and did not recover.

Areas treated with either Calcium arsenate, Zytron emulsion, or Chlordane in 1960 and not re-treated in 1961 had the lowest re-infestation of crabgrass. The apparent residual control of these chemicals could have come about by control of new seed which may have come into these areas or possibly by a greater kill of the existing seed in 1960. The fact that some degree of control was found on the plots which were hand seeded with crabgrass indicates the possibility of some carry over of these chemicals from the 1960 to the 1961 season.

Toxicity of Pre-Emergence Crabgrass Killers to Some Basic Grasses[1]

J. Troll, J. Zak, and D. Waddington[2]

Several pre-emergence crabgrass killers were applied to pure stands of nine well established grass species. The soil type was Sudbury fine, sandy loam having a pH of 5.5. The chemicals were applied at the rates recommended by the manufacturer, and in two cases, at additional rates. Applications were made on April 27, 1961. The plots were then inspected periodically to note any discoloration or other signs of injury. Herbicides, rates of application, and results are listed in table 1.

U4513 injured all species tested. At first the effects of this chemical stunted growth, but color was normal. After fifteen days, the stunted plants started to die with very little recovery. In this, as well as in another experiment, this chemical was ineffective in controlling crabgrass.

Chlordane and diphenylacetonitril did not cause observable damage to any of the grasses treated.

Injuries and discoloration caused by chemicals other than U4513 were not lasting.

Table 1. Effect of Pre-Emergence Crabgrass Control Chemicals on Established Turf Grasses at Amherst, Massachusetts, 1961

Herbicide*	Application Rate Active Ingredient Lbs/Acre	Chewing's fescue	Kentucky blue	Merion	Colonial bent	Velvet bent	Creeping bent	Redtop	Tall fescue	Perennial rye
Rid (Dacthal) - Swift	10.0	M					S	S		
Zytron - Dow	15.0	M			S		S	S		
Dimet P.C.C.+ - Linck	413.0	S								
Dimet P.C.C.+ - Linck	826.0	S				S				
Dimet P.C.C.+ - Linck	1,239.0	H	S		S	H	S	S	S	S
Chlordane	80.0									
Diphenylacetonitril - Corenco	28.4									
Diphenylacetonitril - Agrico	25.4									
Calcium propyl arsonate - AmChem	43.5	S								
U 4513	2.0	H	H	H	H	H	H	H	H	H
U 4513	4.0	H	H	H	H	H	H	H	H	H

Extent of injury is indicated by S (slight), M (medium), and H (heavy)
*Supplied by designated companies

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Pre-emergence Crabgrass Control

R. G. Mower and J. F. Cornman[1]

A number of chemicals are now available for the pre-emergence control of crabgrass (Digitaria ischaemum, D. sanguinalis). This paper reports the results of our 1961 trials in which commercial formulations of seven different chemicals were observed for their effectiveness in the pre-emergence control of crabgrass.

MATERIALS AND METHODS

The experimental plots were located at the Cornell Turfgrass Research Plots, Nassau County Park, East Hempstead, Long Island.

Two separate areas were selected for these trials. One area, designated "poor turf," consisted of a thin stand of native bentgrass and red fescue and was selected because of its reliability of crabgrass infestation. The experimental design was a complete randomized block with seven treatments in quadruplicate on 7 x 7' plots. Four plots served as checks. The area was fertilized following application of the chemicals except for plots treated with the arsenical-fertilizer formulation (Pax). All the chemicals were watered in.

The second area, designated "established turf," consisted of a uniform and dense stand of Kentucky bluegrass, red fescue, and bentgrass. Little crabgrass was present in this area in 1960 even though a heavy infestation (70% crabgrass) had occurred in 1959. In order to provide conditions more favorable for the development of crabgrass within this area, it was subject to a rather severe renovation treatment prior to the application of the chemicals. The area was clipped at a height of approximately ½ inch. Several passes were made over the area with a Henderson Thin-Cut set so the blades cut into the soil approximately ¼ inch. The pre-emergence crabgrass control materials were then applied and watered in. The experimental design was a complete randomized block with eleven treatments in triplicate on 7 x 7' plots. Seven plots served as checks. The turf was maintained at approximately 1 inch, well fertilized and adequately irrigated.

The materials were applied on March 29, 1961. All of the chemicals were in granular formulations and were broadcast by hand without diluent.

RESULTS AND DISCUSSION

The materials used, rates of application, percentage crabgrass control and turf injury ratings are found in Table 1.

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[1] Assistant Professor and Professor of Ornamental Horticulture, respectively, Cornell University, Ithaca, New York.

Table 1. Results of 1961 pre-emergence crabgrass control trials. Cornell-Nassau County Park Turfgrass

Application: March 29, 1961 Injury ratings: May 31, 1961 Control ratings: July 25, 1961

Plots: 7 x 7' Established turf: 3 replications Poor turf: 4 replications

			Established turf		Poor tu
Proprietary material	Active ingredient	Pounds of Formulation/M	% Control[1]	Injury Ratings[2]	% Control
1. Chip-Cal granular	calcium arsenate	15	99	1.0	96
2. Halts	chlordane + related compounds	6	91	0.0	61
3. Pax	arsenical compounds	20	95	1.0	71
4. No-Crab	calcium	5	2	0.0	25
	propyl arsonate	10	21	0.0	--
5. Agrico Crab-grass Control	diphenatrile	10	40	0.0	69
		20	87	0.3	--
6. Rid	dacthal	10	100	0.0	98
		20	100	1.7	--
7. Dow Crabgrass Killer	zytron	8	96	0.7	99
		16	100	2.0	--
Percent crabgrass in check					90

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1. Percent crabgrass control calculated on the basis of average number of plants per square foot in chec at the time of estimating; average of 9 samples, 3 one square foot samples per replicate.

2. Turf injury ratings: 0-none; 1-slight; 2-moderate; 3-severe; 4-complete kill.

3. Percent control based on estimates of percent crabgrass in checks at time of estimating.

Crabgrass Control and Turf Injury - Established Turf

Zytron (Dow Crabgrass Killer) and dacthal (Rid) gave 96% and 100% control, respectively. When double the recommended rate was used, 100% control was obtained with both materials. However, slight to moderate turf injury occurred when these rates were used (zytron caused some thinning of the turf at the normal rate of application). Turf injury, in this case, was expressed by the failure of the red fescue and bentgrass populations to fully recover following the pre-application thinning and mowing treatments.

Kentucky bluegrass was not injured and continued to develop until later in the season (late July), the plots regained their original densities. It was interesting to note that in August, the bluegrass in the plots treated with zytron and dacthal became severely infected with the fungus that causes Sclerotinia Dollar Spot. This was not observed in plots treated with other chemicals and appeared to be related to the increased population of bluegrass plants that had developed.

Among the arsenical compounds, calcium arsenate (Chip-Cal) gave excellent crabgrass control (99%). The arsenical-fertilizer formulation (Pax) also gave good control of crabgrass (91%). There appeared to be some injury to the turf with each of these materials as was evidenced by a slight yellowing and browning of all the grasses within the plot areas.

Chlordane (Halts) gave good crabgrass control (91%) with no evidence of any injury to the desirable grasses. Chlordane has been rather inconsistent in our experimental work with variation in control from mediocre to good having been observed in previous trials (1, 2, 3).

Calcium propyl arsonate and diphenatrile are two new chemicals that became commercially available this year. Diphenatrile (Agrico Crabgrass Control) failed to give satisfactory control (40%) at the recommended rate. However, when twice the recommended rate was used, the control of crabgrass increased proportionately. This indicated that satisfactory control of crabgrass might be obtained if higher rates of active ingredient are employed. There was little or no turf injury noted with this material. Calcium propyl arsonate (No-Crab) gave only negligible crabgrass control. Although the amount of crabgrass was somewhat reduced when the rate of application was doubled, the degree of control was still much lower than that observed for the other materials used in these trials.

Crabgrass Control in Poor Turf

The same materials used in experimental trials on established turf were also used in the pre-emergence crabgrass control trials on poor turf. The results were similar to that which occurred on established turf, although in some cases, the reduction in crabgrass populations was not as great. The most notable examples of this were with chlordane (Halts) and with the arsenical-fertilizer formulation (Pax). Crabgrass control with chlordane was reduced from 91% in established turf to 61% in the poor turf areas, with a similar decrease (95% to 71%) observed for the arsenical-fertilizer formulation (Pax). Calcium propyl arsonate (No-Crab) and diphenatrile (Agrico crabgrass control) gave a greater crabgrass control, than that found in corresponding plots on established turf, but were still not as effective as the other materials included in these trials.

Another point that is felt to be of sufficient merit to be reported here is that when the annual grasses began to develop in the poor turf area, it was observed that approximately 10% of the grasses were that of corn-grass, Panicum dichotomiflorum. This is an annual species of grass that, although not common, is apparently found as a lawn weed in some areas on Long Island. This was first brought to our attention several years ago during post-emergence crabgrass control trials at our research plots (3). Zytron and dacthal gave excellent control of this annual grass (99%). Calcium arsenate, however, did not appear to be effective and the Panicum continued to develop within these plots even though crabgrass control was excellent. It appears, therefore, that calcium arsenate is more selective in its toxicity to the various species of annual grasses than either zytron or dacthal. This may be an important consideration in areas where Panicum species are a problem. It should be emphasized that these are only one years observations.

No turf injury ratings could be made for any of the chemicals within this area because of the lack of sufficient stands of the desirable grasses to make accurate ratings.

SUMMARY

Under the conditions of these trials, a number of the pre-emergence crabgrass control chemicals gave good control of crabgrass. Zytron and dacthal continued to give excellent crabgrass control (96 to 100%) although slight to moderate turf injury was noted. Turf injury by these materials was confined to red fescue and bentgrass with no apparent injury to Kentucky bluegrass. Calcium arsenate was also effective in controlling crabgrass (96 to 99%). Chlordane and the arsenical-fertilizer formulation gave good control of crabgrass on established turf although the degree of control was reduced in trials on poor turf where larger populations of crabgrass developed. Diphenatrile gave only an intermediate level of control at the recommended rate although the degree of control increased proportionately as the rate of application was increased. Calcium propyl arsonate gave only negligible crabgrass control.

Panicum dichotomiflorum was effectively controlled by dacthal and zytron but was not controlled in plots treated with calcium arsenate.

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COMPARISON OF CHEMICALS FOR PRE-EMERGENCE CRABGRASS CONTROL IN TURF[1]

John R. Havis[2]

The area used for this test had been seeded to a fairway mixture about fifteen years previously. The grasses present were mostly bluegrass and fescues. Miscellaneous weeds were present, including dandelion and plantain, but very little natural crabgrass.

During the first two weeks of April, 1962, the grass was mowed to 1 1/2 inches, fertilized with 10-6-4, and a light top dressing of soil was applied. The area was then seeded with 5 pounds of weed seeds having a high percentage of crabgrass. The area, 32 x 60 feet, was divided into 24 plots 8 x 10 feet in size. This provided plots for 8 treatments, including a check, replicated three times. The area had a slight pitch to the east but not sufficient to cause excessive washing.

Seven granular pre-emergence herbicides were applied April 14 at rates recommended by the manufacturers, as follows:

	Per 1,000 Sq. Ft. (Pounds)
PAX - "new" formulation (more arsenicals, Less N)	20
Bandane 7.5%	6.1
Tricalcium Arsenate 48% (1961 formulation)	16
Dacthal 2.3%	10
Zytron 4.4%	8
Calcium Propyl Arsonate 20%	5
Diphenatrile 11.5%	6

Irrigation was not available. The spring weather was cool and moist, rainfall during May measuring 4.67 inches. Crabgrass in the test plots germinated about June 15. The first week of July the turf area was given a second application of fertilizer and sprayed with 2,4-D to kill broad-leaved weeds. The grass was mowed weekly at 1 1/2 inches.

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[1] Contribution Number 1331, Massachusetts Agricultural Experiment Station.

[2] Department of Horticulture, University of Massachusetts, Amherst.

Results and Discussion

Estimated crabgrass control on August 11, 1961
(Average of three replications):

Zytron	99%
Calcium Arsenate	85%
Bandane	85%
Dacthal	83%
Diphenatrile	53%
PAX	42%
Calcium propyl arsonate	23%

The turf and the methods used in this trial were similar to the test conducted in 1960 (1). The main difference was in the time interval between application of chemicals and germination of crabgrass. The interval in 1960 was about three weeks; in 1961 the interval was about nine weeks.

Zytron gave excellent control in 1961, as was true also in 1960.

Dacthal did not give as good control in 1961 as in 1960.

Calcium arsenate gave better control in 1961 than in 1960. The improvement could have been either from earlier application, or from the change in formulation, or both.

PAX gave poor control both years.

Of the three newer materials tested in 1961, Bandane gave better control than Diphenatrile and calcium propyl arsonate.

None of the chemicals appeared to injure the turf.

This test was financially supported by the Massachusetts Turf and Lawn Grass Association.

LITERATURE CITED

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1961 PREEMERGENCE CRABGRASS RESULTS

J. M. Duich, B. R. Fleming, A. E. Dudeck, G. J. Shoop and J. Boyd[1]

The object of this study was to determine the effect of various commercial and experimental preemergence crabgrass chemicals under practical conditions in southeastern Pennsylvania where crabgrass is a paramount problem and permanent turf difficult to produce.

Materials and Methods

The test was conducted at The Springhaven Club (golf) in Wallingford, Pennsylvania on two areas. Test area No. 1 was the practice fairway (irrigated) with a history of heavy crabgrass infestation, annually, and a large population of Poa annua which predominated spring and fall and usually faded during the summer period. Bluegrass, bent and fescue accounted for less than 20 percent of the permanent turf population.

Test area No. 2 (non-irrigated) was located on a fairway saturated with seepage water from underground springs, primarily in the spring and fall. Turf was predominantly creeping bent, Poa trivialis, and traces of bluegrass.

Single applications of each treatment were made on April 3, 1961 two weeks prior to earliest anticipated crabgrass germination for the area. The region was characterized by unusually cold, wet weather which delayed the initial germination of crabgrass for four weeks on Area 1 and six weeks on Area 2. Poa annua growth was also unusually heavy due to protection from heavy winter snows and moist conditions for most of its growing season. Poa annua faded quickly starting in mid-July. A further indication of climatic conditions was the first mowing date of April 27, which is late for the area.

Individual plots were 6 x 12 feet with three replications on Area 1 and two replications on Area 2 with four controls per replication. Liquid materials were applied with an experimental boom sprayer at 35 psi and 90 gpa. Dry materials were diluted with four quarts of soil and applied by hand. There was over one inch of rainfall over a three day period beginning the day following application.

Plots were rated periodically throughout the season for discoloration and injury. Final crabgrass cover determination was made on October 2 on the basis of estimated percent cover since partial control often resulted in more vigorous crabgrass growth due to lack of turf competition.

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[1] Assistant Professor, Instructor, Graduate Assistant, Graduate Assistant, Agronomy Department, Pennsylvania State University and Superintendent, Springhaven Club, respectively.

Discussion and Results

Materials, rates and percent crabgrass control for both test areas are shown in Table 1. A higher level of control was obtained on Area 2 with the exception of 7 of 28 treatments, 4 of which gave the best control in the study (95 percent or better). A higher level of control on Area 2 due to permanent turf competition to crabgrass germination would probably have resulted if the colder, wet soil conditions had not further delayed germination on this area. Delayed germination and loss of effective toxicity over time could be interpreted as the explanation for lower levels of control in general for some of the materials.

U-4513 was found to be toxic to Poa annua and resulted in almost complete elimination of this species on Area 1 by June 1. Consequently, with little turf competition the U-4513 plots had a higher level of crabgrass infestation than the control plots. This material obviously had little preemergence value under the conditions of this experiment.

Highest levels of permanent turf and Poa annua injury were experienced with Calcium Arsenate, Pax and U-4513. This was especially true on Area 1 with the arsenicals where the soil phosphorous level was obviously low. Their respective control levels of 98 and 74 percent were nullified on the practical basis by almost complete elimination of turf cover. Addition of P_2O_5 to a second Calcium arsenate treatment reduced control from 98 to -1 and 72 to 52 percent on the two test areas. Calcium arsenate was more toxic to Poa trivialis and had only a moderate effect on the bent on Area 2.

Other than temporary discoloration with higher rates of Bandane emulsion, no other injury to turf was observed.

Formulation effects on control were quite apparent with several materials. Bandane on attapulgite was found to be more effective than the vermiculite or emulsion formulation especially at the highest rate. Granular chlordane was also superior to the emulsion formulation and the commercial Halts applied at the manufacturers suggested rate. No significant differences were observed between four Diphenatrile formulations.

The most satisfactory levels of control, considering turf injury, were achieved with Zytron M-1937 at 15 pounds, Chlordane granular at 90 pounds and Bandane on attapulgite at 30 pounds.

Conclusions

1. Delayed crabgrass due to unfavorable weather conditions was considered to be a factor on relatively low levels of control in this study.

2. High level of crabgrass control without an adequate turf cover or resulting in turf injury loses significance.

Table 1. Percent Crabgrass Control From Single Application of Preemergence Materials on April 3, 1961 Springhaven Club, Wallingford, Pennsylvania

Material	Rate	% Crabgrass Control* Area 1	Area 2
Zytron M-1937	15 a.i./A	99	92
Zytron M-1329	10 a.i./A	53	84
Chlordane G	90 a.i./A	95	92
Chlordane EC	90 a.i./A	50	68
Chlordane - Halts	6/M	35	79
Bandane - Verm.	10 a.i./A	4	19
Bandane - Verm.	20 a.i./A	45	36
Bandane - Verm.	30 a.i./A	65	52
Bandane - Attap.	10 a.i./A	26	3
Bandane - Attap.	20 a.i./A	56	19
Bandane - Attap.	30 a.i./A	97	84
Bandane EC	10 a.i./A	10	- 9
Bandane EC	20 a.i./A	18	20
Bandane EC	30 a.i./A	48	68
Dacthal - Rid	10/M	68	84
Diphenatrile - Agrico	10/M	33	47
Diphenatrile - Lilly	30 a.i./A	31	38
Diphenatrile - LV 2-21-61	6/M	34	76
Diphenatrile - LC 2-21-61	6/M	34	56
35455 - Lilly	6 a.i./A	48	68
Ca. Arsenate G-48	18/M	98	72
Ca. Arsenate + P_2O_5	18 + 2/M	- 1	52
Pax	20/M	74	84
Ca. Prop. Arson. - No Crab	5/M	14	19
U-4513 50 W	1 a.i./A	- 4	- 2
U-4513 50 W	4 a.i./A	- 4	-13
U-4513 G	1 a.i./A	- 4	11
U-4513 G	4 a.i./A	- 1	3
	Average	40	46

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* Based on control.

PRE-EMERGENCE CRABGRASS CONTROL TRIALS — 1961

J. E. Gallagher[1] and R. J. Otten[1]

The 1961 pre-emergence crabgrass control trials compared the effectiveness of a number of commercial formulations, experimental materials from other companies, and a number of our own experimental materials.

Similar rates and dates of application were used in tests at three principal sites: AMCHEM Research Farm, Ambler, Pa.; Oak Terrace Country Club, Ambler, Pa.; Pine Valley Golf Club, Clementon, N. J. Sites were chosen because they all had a past history of severe crabgrass infestations. The turf at each site was rather thin, open and closely cut. The natural turf at each site was a mixture of bluegrass and fescue with some bentgrass.

Method

All materials were applied as a dry formulation, usually on vermiculite or an organic carrier. All materials were weighed out in advance according to the rate and plot size. Applications were made with a mechanical spreader or dusted on by hand, depending on the plot size.

Plots at Oak Terrace CC were 5' x 20' or 100 sq.ft.
Plots at Pine Valley GC were 5' x 10' or 50 sq.ft.
Plots at AMCHEM Research Farm were 18" x 16.6' or 25 sq.ft.

A total of about 750 individual plots were applied at these three locations during the 1961 season.

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1) Agricultural Research Department, Amchem Products, Inc., Ambler, Pennsylvania

Materials

(1)	Calcium propyl arsonate	(Amchem)	20% on vermiculite carrier
(2)	Zytron	(Dow)	4.4% on organic carrier
(3)	Dacthal	(Swift)	2.3% on organic carrier
(4)	Dacthal	(Swift)	2.53% on organic/fertilizer carrier
(5)	Chlordane	(Scotts)	23% on vermiculite carrier
(6)	Dipropalin	(Lilly)	2% on vermiculite carrier
(7)	Trifluralin	(Lilly)	2% on vermiculite carrier
(8)	Diphenatrile	(Lilly)	11.5% on vermiculite carrier
(9)	Diphenatrile	(Agrico)	5.85% on fertilizer carrier
(10)	Tricalcium arsenate	(Chipman)	48% on vermiculite carrier
(11)	Lead arsenate/arsenous oxide complex	(Kelly-Western)	8.5/25.1% on inorganic carrier
(12)	Calcium propyl/calcium methyl arsonate mix	(Vineland)	17.7/5.1% on vermiculite carrier

Dates of Application as Related to Crabgrass Growth

AMCHEM Research Farm	March 18	pre-emergence
	April 18	pre-emergence
	May 18	at emergence
	June 5	early post-emergence
	July 17	late post-emergence
Oak Terrace CC	April 13	pre-emergence
	May 17	early post-emergence
	June 5	early post-emergence
	July 17	late post-emergence
Pine Valley GC	April 18	pre-emergence
	May 4	pre-emergence
	June 10	early post-emergence

Evaluations

Visual estimates of the proportion of each plot infested with crabgrass were made at intervals throughout the season. These were compared to the untreated check plots to obtain the Per Cent Control figures reported in the following tables.

By the middle of August the crabgrass infestation in all untreated plots was so complete that little or no turfgrass was showing.

Dates of evaluations were as follows:

AMCHEM Research Farm:	June 20, July 24, August 24 September 29
Oak Terrace CC:	June 20, July 27, August 24 September 29
Pine Valley CC:	June 27, July 22, October 11

Discussion

The spring of 1961 was very cold and wet in the Philadelphia area, as it was in many other parts of the Northeast. Crabgrass emergence was two weeks to a month later than usual, and growth after emergence was very slow until around the middle of June. Much of the emerged crabgrass was still in the 2 to 4 leaf stage on June 1st.

Rainfall was constant throughout the summer and temperatures were high enough to favor continuous and maximum emergence of crabgrass. There were no distinct periods of crabgrass emergence and growth as is usual in our area.

While no numerical counts of the actual stand of crabgrass per unit area were taken to compare the stand to previous seasons, visual evaluations indicated that the natural crabgrass infestation was much more uniform and severe than in previous years. Thus, it is possible that in the past seasons an effective chemical producing 95 to 98 per cent control may have left 10 to 15 crabgrass plants in a 50 to 100 square foot area. In 1961, on the other hand, 95 to 98 per cent control of a much larger number of sprouting crabgrass seeds may have allowed 50 to 75 plants to develop in the same plot area.

When transformed into the visual estimates used in our evaluations, the larger number of plants present would greatly reduce apparent control. Thus, a chemical may have controlled 50 per cent of the crabgrass plants actually emerging, but those surviving plants would be enough to completely infest the plots and we would evaluate this as no apparent control.

This probably accounts for the reduced effectiveness of materials such as dacthal, zytron and tricalcium arsenate, which have been consistently effective in our tests in previous years. The only materials providing more than 80 per cent control through the season were trifluralin at 4, 6 and 8 lb/A and dipropalin at 8 lb/A.

In 1960, calcium propyl arsonate showed excellent tolerance to established turf and new turf planted before or after application, good post-emergence activity on crabgrass, and satisfactory seasonal pre-emergence crabgrass control.

Based on the 1961 trials reported here, calcium propyl arsonate shows definite post-emergence activity on crabgrass up to the 4 to 5 leaf stage. The best treatments with this compound were applied in May, about two weeks after crabgrass emergence. Rates of 1¼ and 1½ lb/1000 sq.ft. gave control comparable to pre-emergence treatments at 15 lb/A of zytron and far superior to pre-emergence treatments with recommended rates of dacthal, chlordane, diphenatrile, tricalcium arsenate and lead arsenate complex.

The combination of calcium methyl arsonate and calcium propyl aronate may have slightly increased initial post-emergence activity, but did not increase pre-emergence residual activity in comparison to calcium propyl arsonate alone.

Turf Tolerance

The only compounds causing obvious turf injury in these test plots were trifluralin and tricalcium arsenate. Trifluralin thinned the turf slowly over a period of several months. Tricalcium arsenate caused a general foliage burn within a week after application, and much of the grass never recovered during the remainder of the season.

Conclusion

Because of a combination of weather conditions in 1961 — cold, wet spring, delayed crabgrass germination, warm, wet summer — all the principal selective crabgrass control chemicals presently available produced unsatisfactory crabgrass control. While no definite reason for this can be presented at this time, possible explanations for these failures are excessive crabgrass emergence, leaching and biological breakdown.

Calcium propyl arsonate, applied as an early post-emergence treatment rather than a standard pre-emergence treatment, produced seasonal crabgrass control equivalent to the best of the long residual pre-emergence crabgrass killers included in our 1961 tests.

TABLE I: Comparison of several commercial and experimental pre-emergence crabgrass control chemicals applied at Oak Terrace Country Club, Pine Valley Golf Club and AMCHEM Research Farm.

Material	Rate Per Acre	Applied	Location *	Percent Crabgrass Control During Season *** June	July	Aug.	Sept/Oct.
Zytron	15	April	OT	96	85	74	65
	15	April	PV	94	92	**	71
Dacthal	10	April	OT	94	71	34	18
	10	April	OT	92	85	49	32
	10	April	PV	97	94	**	68
Diphenatrile	20	April	PV	89	65	**	22
	26	April	OT	45	37	32	10
	26	April	ACP	50	17	**	13
	30	April	PV	85	73	**	8
Trifluralin	4	April	PV	100	100	**	96
	6	April	PV	100	100	**	98
	6	March	ACP	68	91	**	37
	8	April	PV	100	100	**	99
Dipropalin	4	April	PV	91	79	**	31
	6	April	PV	97	90	**	54
	6	May	ACP	100	93	**	50
	8	April	PV	100	98	**	85
Lead arsenate complex	870 (form.)	April	OT	69	53	20	0
Tricalcium Arsenate	780 (form.)	April	OT	83	71	53	28
Chlordane	60	April	OT	20	13	18	0
	60	May	OT	56	0	12	0
	90	April	OT	50	42	20	8
	120	April	OT	30	8	14	2
	120	May	OT	59	13	4	0

* Location:
OT - Oak Terrace Country Club
PV - Pine Valley Golf Club
ACP - AMCHEM Research Farm

** No ratings of these plots made on these dates.

*** Average of 3 replications. Control based on comparison to untreated

TABLE 2: Crabgrass control with Calcium Propyl Arsonate using various rates and dates of application.

Calcium Propyl Arsonate Pounds per 1000 sq. ft.	Location*	Applied	Percent Crabgrass Control During Season ***			
			June	July	August	Sept.
1/2	OT	April	0	0	0	0
	OT	May	94	84	47	26
3/4	ACP	March	34	0	0	0
	ACP	April	95	70	31	37
	OT	April	30	5	0	0
	ACP	May	100	96	84	57
	OT	May	94	69	35	15
	ACP	June	82	97	72	24
	ACP	July	**	**	51	30
	OT	July	**	**	25	16
1	ACP	March	18	25	0	0
	ACP	April	50	29	6	2
	OT	April	82	64	35	40
	ACP	May	100	99	82	47
	OT	May	96	95	79	43
	ACP	June	100	98	78	33
	OT	June	96	90	69	32
	ACP	July	**	**	66	27
	OT	July	**	**	18	8
1 1/4	OT	April	69	40	18	3
	OT	May	96	92	85	68
	OT	July	**	**	37	13
1 1/2	ACP	March	67	25	0	0
	ACP	April	91	88	55	40
	OT	April	69	40	4	0
	OT	May	100	100	94	58
	OT	July	**	**	43	16

* Location: OT - Oak Terrace Country Club; ACP - AMCHEM Research Farm

TABLE 3: Pre-emergence and post-emergence crabgrass control with a combination of calcium propyl arsonate and calcium methyl arsonate.

Pounds per 1000 sq. ft.				Per Cent Crabgrass Control During Season ***			
Ca.Prop.As.	Ca.Meth.As.	Applied	Location*	June	July	Aug.	Sept/Oct.
.44	.14	May	OT	94	48	24	3
		July	ACP	**	**	51	30
.66	.21	May	OT	96	82	55	10
		June	PV	72	79	**	28
		July	OT	**	**	41	2
		July	ACP	**	**	29	7
.88	.28	May	OT	94	84	79	45
		June	ACP	100	98	80	37
		June	PV	97	88	**	48
		July	ACP	**	**	59	10
		July	OT	**	**	51	16
1.11	.35	May	OT	96	90	80	43
		July	OT	**	**	39	7
1.32	.44	May	OT	100	95	75	52
		July	OT	**	**	53	15
-	1.0	June	OT	100	47	0	2
1.0	-	May	OT	95	95	79	43
1.0	-	June	OT	96	90	69	32
-	2.0	June	OT	100	63	26	10
-	3.0	June	OT	100	63	35	7

Notes:

* Location - OT - Oak Terrace Country Club
PV - Pine Valley Golf Club
ACP - AMCHEM

** No ratings of these plots made on these dates.

*** Average of 3 replications. Control based on comparison to untreated check plots.

DIPHENATRILE, DIPROPALIN, AND TRIFLURALIN AS PRE-EMERGENT TURF HERBICIDES[1]

E. F. Alder and R. B. Bevington[2]

Diphenatrile (diphenylacetonitrile), dipropalin (N,N-di(n-propyl)-2,6-dinitro-p-toluidine) and trifluralin (2,6-dinitro-N,N-di-n-propyl-α,α,α-trifluoro-p-toluidine) have been extensively tested as pre-emergent herbicides for turf at the Greenfield Laboratories of Eli Lilly and Company. Sixty turf experiments, consisting of over 3,500 plots, were conducted. Emphasis in these investigations has been placed on the determination of effectiveness, appropriate application rates, duration of activity, safety to turfgrasses and ornamentals, effects of early post-emergent applications on weed grasses, and length of delay before reseeding.

Diphenatrile

The herbicidal properties of diphenatrile have been previously reported in detail (1). At 30 pounds per acre the compound has controlled seedling weed grasses (barnyardgrass, goosegrass, foxtails, and crabgrasses) in turf. Diphenatrile is completely safe to established turfs, trees, shrubs, and annual flowering plants. Since diphenatrile is highly selective against seedling grasses and has almost no activity on broadleaf plants, it can be safely used for pre-emergent grass weed control in flower beds.

Recent investigations have established that: 1) Diphenatrile controls crabgrass through the two-leaf stage. 2) New seedlings of bentgrass, bluegrass, fescue, and ryegrass are not damaged by diphenatrile applied 5 weeks after seeding. 3) Successful reseedings of turfgrasses can be made as early as thirty days after diphenatrile application (see Table 1). The larger seeded grasses, ryegrass and fescue, can be reseeded even sooner. 4) Diphenatrile is compatible with fertilizer and performs well on this carrier.

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1. Contribution of Eli Lilly and Company, Greenfield Laboratories, Greenfield, Indiana

2. Head, Plant Science Research and Associate Plant Physiologist, respectively

Table 1. Reseeding Results after Application of 30 lb/A Diphenatrile. Expressed as Injury to Turfgrasses

Days After Treatment	Turfgrass Injury Rating[a]			
	Bentgrass	Bluegrass	Fescue	Ryegrass
1	5	5	5	2
10	5	5	3	1
17	4	4	3	1
24	3	3	2	1
37	1	1	1	1

a/ 1=no injury, 2=slight, 3=moderate, 4=severe, 5=complete kill

Dipropalin and Trifluralin

Last year the selective herbicidal properties of dialkyl substituted dinitroanilines were first reported (1). From this series have come the compounds dipropalin and trifluralin, orange dyes of low mammalian toxicity. At 27° C. dipropalin has a water solubility of 304 parts per million; trifluralin, 24 parts per million. Both compounds are readily soluble in many organic solvents, thus permitting emulsifiable concentrate as well as dry, spreadable formulations.

Dipropalin and trifluralin are pre-emergent herbicides for seedling grasses and a number of annual broadleaf weeds; trifluralin is roughly 4-6 times as active as dipropalin. Dipropalin shows some foliar contact activity; trifluralin has practically none. Both are active in the soil by root absorption or absorption by young germinating seedlings. Soil incorporation in field crop tests has markedly improved weed control activity of both compounds. Leaching of dipropalin and trifluralin occurs only slowly in all soil types tested.

Effectiveness -- Dipropalin and trifluralin were run in a variety of tests and at several application rates. In tests on crabgrass control, plots were placed in areas known to be infested with crabgrass the previous year. Plots were 4 by 6 feet, 3 by 8 feet, or 6 by 16 feet. Buffer areas were left around the plots. Treatments were replicated 3 or 4 times. Granular and vermiculite formulations were applied with a lawn spreader; spray applications with a small plot spray unit. Maintenance of the turf usually followed normal procedure for the area, except for special studies on maintenance effects.

Table 2 presents a summary of crabgrass control results obtained with dipropalin and trifluralin. With 6-8 pounds per acre of dipropalin or 1.5 pounds per acre of trifluralin, very good crabgrass control was obtained.

Table 2. Summary of Crabgrass Control Results

Treatment		Percent Crabgrass Control[a]
Compound	Rate (Lb/A)	
Dipropalin	4	88
	6	93
	8	97
	10	98
Trifluralin	0.5	85
	1.0	94
	1.5	99
	2.0	99

[a] Based on crabgrass counts made 128-131 days after treatment

Recommended Rates -- In a dry formulation, dipropalin is recommended for further testing at 6-8 pounds per acre. In the New England area 4-6 pounds per acre is suggested. Trifluralin in a dry formulation is recommended and approved for turf at 1.5 pounds per acre. In the New England area or for later season application elsewhere, one pound per acre is suggested. Slightly higher rates (8-10 pounds per acre for dipropalin, 2 pounds per acre for trifluralin) are recommended for spray applications. Best results with sprays are obtained when gallonage rates are high enough to wash the herbicides from the turf foliage on to the soil surface.

Duration of Activity -- A study was set up in Kentucky bluegrass turf to ascertain how long dipropalin and trifluralin remain effective in controlling crabgrass (Table 3). The area selected had been heavily infested with smooth crabgrass the previous year. Plots, four by six feet, replicated three times, were used. A total of ten applications were made. The first six treatments were made at fourteen day intervals starting February 16. The last four treatments were made weekly starting May 10. Final observations, given here, were made on September 21. Percent crabgrass control was calculated by estimating the percent reduction of crabgrass cover in the treated plots as compared with the untreated control. A single application of dipropalin or trifluralin at recommended rates gave full-season crabgrass control. Excellent control was obtained from mid-March treatments which were subjected to over 30 inches rainfall and irrigation water. Substantial control was obtained as long as 216 days after chemical application.

Table 3. Duration of Crabgrass Control with Dipropalin and Trifluralin

Appl'n	Days	Percent Control of Crabgrass[a]		
		Dipropalin	Trifluralin	
Date	Elapsed	8 Lb/A	1 Lb/A	2 Lb/A
Feb. 16	216	81	69	79
Mar. 3	201	69	69	85
Mar. 16	188	86	71	94
Mar. 29[b]	175	--	--	--
Apr. 13	160	86	47	91
Apr. 27	146	83	74	91
May 10[c]	133	87	68	90
May 17	126	97	87	96
May 24	119	93	83	94
June 2	110	92	79	84

a/ Calculated by estimating percent reduction in crabgrass cover (Sept. 21) in treated plots as compared with untreated control

b/ Poor application due to high winds

c/ Crabgrass germination started May 3

Safety to Plants -- Dipropalin and trifluralin were observed for safety to turfgrasses in 31 experiments. Observations were made on bentgrasses, bluegrasses, fescues, ryegrass, Bermudagrass, and Zoysia. Applications of dipropalin through 10 pounds per acre gave no turf grass damage in any test. Trifluralin was safe on all turfs at 2-3 times the recommended rate. Damage occurred at 6 pounds per acre in bentgrass, bluegrass, and fescue turfs; some damage was observed at 4 pounds per acre. Zoysia and Bermudagrass were not damaged by 10 pounds per acre.

A large number of woody ornamentals, shrubs, vines, and established annual and perennial flowers have proved tolerant to trifluralin, even at very high application rates. Of 18 trees, 38 shrubs, 2 broadleaf ground covers, 3 perennial species, and 6 rose varieties tested, none showed damage to trifluralin at 10 pounds per acre. Thirty of 40 young established annual flower species were undamaged by trifluralin at this rate. Dipropalin has been less widely tested, but shows similar safety to ornamentals.

Early Post-emergent Activity -- Several experiments show essentially the same results already given in Table 3. In this experiment crabgrass first became visible in untreated areas on May 3. At the May 10 application date it was in the 1-leaf stage; on May 17, the 2-leaf stage; on May 24, the 2 and 3-leaf stage; and on June 2, the 3 and 4-leaf stage. Excellent control was obtained with both dipropalin and trifluralin through the May 24 treatment. Activity was reduced in the last application at the 3 to 4-leaf stage. Dipropalin and trifluralin at recommended rates control crabgrass through the 2-leaf stage.

Reseeding Studies -- Dipropalin and trifluralin were applied and desirable turfgrasses were seeded at the time of chemical application, and three and six weeks following treatment (Table 4). Injury ratings were made six to seven weeks after each seeding. No injury was observed with either chemical six weeks after treatment. Current recommendations are to wait 45 days after treatment before reseeding.

Table 4. Reseeding Injury of Turf Grasses after Dipropalin and Trifluralin Treatment[a/]

Treatment	Turf Grasses	0 Wks.	3 Wks.	6 Wks.
Dipropalin 8 Lb/A	Bentgrass	4	3	1
	Bluegrass	5	4	1
	Fescue	5	3	1
	Ryegrass	3	1	1
Trifluralin 2 Lb/A	Bentgrass	4	3	1
	Bluegrass	5	3	1
	Fescue	5	3	1
	Ryegrass	4	2	1

a/ 1=no injury, 3=moderate injury, 5=complete kill

Summary

Diphenatrile at 30 pounds per acre, dipropalin at 6-8 pounds per acre, and trifluralin at 1.5 pounds per acre have given excellent full-season control of weed grasses in turf. Spray formulations of dipropalin and trifluralin are easily prepared; slightly higher rates are required. All three compounds are safe for use on turfgrasses, trees, shrubs, roses, perennial and most young annual flowering plants. All three materials kill crabgrass in turf through the 2-leaf stage. Reseedings can be made 30 days after diphenatrile and 45 days after dipropalin or trifluralin treatment.

Literature Cited

1. E. F. Alder, W. L. Wright, and Q. F. Soper. Control of seedling grasses in turf with diphenylacetonitrile and a substituted dinitroaniline. Proc. NEWCC 15:298-302. 1961.

Pre-emergence Control of Crabgrass in Turf with Fall and Spring Treatments

J. F. Ahrens, R. J. Lukens and A. R. Olson[1]

Pre-emergence herbicides are rapidly becoming popular for the control of crabgrass in lawns. Further evaluation of materials for this use is needed. Studies covered in this report are (1) comparisons of fall and spring applications, (2) mowing heights and effectiveness of herbicides and (3) residual effects of herbicides on crabgrass and turf.

Materials and Methods

Replicated experiments were set up on established turf in Windsor, Mt. Carmel and New Haven, Connecticut. Plots were 2 or 4 feet wide and 12 to 20 feet long in all tests. To obtain a precise estimate of crabgrass control, untreated plots were alternated with treated plots. Crabgrass control was then based on paired comparisons between treated and adjacent untreated plots.

Most of the materials tested were available commercially, a few were considered experimental. The following granular materials were used in these tests:

a) Calcium propyl arsonate 20% G ("No Crab")
b) Chlordane 20 or 23 % G ("Halts")
c) Dacthal, 2,3,5,6 tetrachloroteraphthallic acid 2.3% G ("Rid")
d) Diphenatrile, diphenylacetonitrile 11.5% G
e) Dipropalin, N,N-di-n-propyl-2,6-dinitro-4-methyl aniline 2% G
f) Lead arsenate, arsenous oxide ammonium sulfate and heptochlor ("Pax")
"Pax" has 8% N, new "Pax" has 4% N
g) Polychlorodicyclopentadiene isomers 7.5% G ("Bandane")
h) Tri-calcium arsenate 48% G ("Chip-Cal")
i) Trifluralin, N,N-di-n-propyl-2,6-dinitro-4 trifluoromethylaniline 11.5% G
j) U4513 2% G (Upjohn Co.)
k) Zytron, O-2,4-dichlorophenyl O-methyl isopropylphosphoro amidothioate
4.4% G ("Dow Crabgrass Killer")

These granular materials were applied with a 2-foot lawn spreader calibrated for each material. All of the turf areas were adequately fertilized, and irrigation was supplied as needed. Mowing heights were kept at 1½ inches in most experiments.

The 1961 season in Connecticut was characterized by lower than normal temperatures and higher than normal rainfall in April and May, followed by normal temperatures and lower than normal rainfall in June and July.

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[1] Associate Plant Physiologist, Associate Plant Pathologist and Assistant Forester, The Connecticut Agricultural Experiment Station, Windsor and New Haven.

Results and Discussion

Fall vs. spring treatments The objective of this experiment was to determine the relative effectiveness of fall and spring treatments for the control of crabgrass in turf. The test was conducted in Mt. Carmel, Connecticut, on turf seeded in the spring of 1960 with a mixture of Kentucky bluegrass, Astoria Colonial bentgrass and chewings fescue. Fall treatments were applied on October 10, 1960 and spring treatments were applied on April 27, 1961.

Crabgrass emergence started about May 10 but was delayed because of cool temperatures. Stands of crabgrass in this test were excellent, averaging 40 plants/sq.ft. in the control plots. Digitaria ischaemum was the principal species.

As shown in Table 1, the spring applications of every herbicide controlled crabgrass better than fall applications, although the difference was small at the low rates of zytron, chlordane, and calcium arsenate. The interaction of season of application with chemicals was statistically significant at $p = .05$. "Pax" and dacthal were most affected by season of application. The results suggest that higher rates of herbicide are required for fall applications than spring applications, indicating that part of the herbicide may be lost during the fall and winter.

At the low or "normal" rate, "Pax" provided only 30 to 40 per cent control of crabgrass. Control with the other materials was much better, ranging from 85 to 98 per cent. In this test the lower rate of dacthal (7.5 lbs./A) was about 4 lbs./A less than the suggested commercial rate.

High rates of spring-applied treatments caused more injury to turf than similar rates applied in the fall. Applied in April, dacthal at 15 lbs./A, zytron at 30 lbs./A and calcium arsenate at 740 lbs./A all caused thinning of turf in July. However, this thinning was hardly evident in September. At normal rates of application, spring applications of the materials tested do not appear to constitute a greater hazard to turf than fall applications.

Spring treatments on rough turf Several commercially available and experimental pre-emergence herbicides were evaluated on a stand of rough turf in Windsor, Connecticut. The turf consisted of a mixture of bluegrass, red fescue, alta fescue, Colonial bentgrass and miscellaneous weeds. The soil was a sandy loam of generally low fertility.

Lime and fertilizer were applied in early April and additional fertilizer was applied in June and July. To insure a stand of crabgrass, the area was overseeded on May 3.

Commerically available materials The herbicides were applied on May 4, on 4' x 20' plots replicated three times. Crabgrass emergence started between May 10 and 20 and populations were quite low, averaging 3.8 plants/sq.ft. in the untreated plots.

Table 1. Effect of Season of Application on Crabgrass Control and Turf Injury

Herbicide	Rate a.i. lbs./A	Time of Application	Percentage control of crabgrass[1] Sept. 14	Percentage thinning of turf[1] July 13	Sept. 14
Calcium arsenate	370	Oct.	85.3	0	0
		April	90.7	0	0
	740	Oct.	98.0	0	0
		April	99.3	8	0
Chlordane	70	Oct.	85.7	0	0
		April	87.7	0	0
	140	Oct.	89.0	4	0
		April	95.3	2	0
Dacthal	7.5	Oct.	86.7	0	0
		April	96.0	5	0
	15	Oct.	97.3	2	0
		April	98.3	30	5
"Pax" (8%N)	880	Oct.	31.7	0	0
		April	46.0	0	0
	1760	Oct.	64.3	5	0
		April	86.0	2	0
Zytron	15	Oct.	87.7	0	0
		April	92.3	0	0
	30	Oct.	93.0	0	0
		April	96.0	12	0
L.S.D.	.05		9.6		
	.01		12.8		

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[1] Average ratings of two persons over three replicates.

At the lower rates of application, zytron, diphenatrile, and chlordane provided 90 per cent or better control of crabgrass; whereas calcium propyl arsonate and calcium arsenate provided about 85 per cent control of crabgrass (Table 2). "Pax" at 880 lbs./A and dacthal at 7.5 lbs./A did not control crabgrass satisfactorily. These rates of "Pax" and dacthal apparently are too low for consistent control of crabgrass.

In general, crabgrass control with zytron, dacthal, and "Pax" in 1961 was similar to that obtained in 1960. Calcium arsenate was less effective in 1961 than in 1960 and chlordane at 70 lbs./A in 1961 was somewhat more effective than at 60 lbs./A in 1960.

In addition to crabgrass, zytron also appeared to control <u>Oxallis</u> spp. in this test, and both calcium arsenate and "Pax" appeared to control sheep sorrel (<u>Rumex</u> <u>acetosella</u>).

Table 2. Crabgrass Control in Rough Turf with Spring Treatments of Commercially Available Materials

		Crabgrass Control		Percentage thinning[1]	
Herbicide	Rate a.i. lbs./A	Percentage control[1] August 21	No. Plants per sq.ft.[2] Sept. 2	July 17	August 21
Untreated plots		0	3.77	0	0
Calcium arsenate	370	86	1.39	16	8[3]
	740	95	.67	3	0
Calcium propyl arsonate	44	85	1.25	8	7
	88	80	-	16	10
Chlordane	70	91	1.28	1	0
	140	98	.28	0	3
Dacthal	7.5	66	1.83	3	3
	15	93	.89	5	3
Diphenatrile	30	99	.39	6	6[3]
	60	99	.50	13	15[3]
"Pax"(4%N)	880	31	2.39	2	0
	1760	89	1.17	3	3
Zytron	15	98	.17	0	0
	30	99	.11	0	0

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[1] Average ratings of two persons over three replicates.

[2] Average of six sq. foot samples in each of three replicates.

[3] Colonial bent appeared to be thinned.

The higher rates of chlordane, dacthal, "Pax", and zytron did not injure the turf in this test. Zytron actually stimulated growth of the grasses and clover. Diphenatrile at 60 lbs./A, calcium arsenate at 370 lbs./A and calcium propyl arsonate at 44 or 88 lbs./A all caused thinning of the turf. Calcium arsenate and diphenatrile appeared to be thinning the colonial bentgrass whereas calcium propyl arsonate appeared to be thinning the fescue grasses.

Experimental materials The materials given in Table 3 were applied on May 8, 1960, in twice-replicated plots. Granular zytron, included in this test as a standard, provided excellent control of crabgrass with no injury to the turf. Zytron also controlled spotted spurge (Euphorbia nutans) and knotweed (Polygonum aviculare).

Table 3. Crabgrass Control in Rough Turf with Experimental Materials

Herbicide	Rate a.i. lbs./A	Percentage control of crabgrass August 21	Percentage thinning July 18	August 21
"Bandane"	20	70.0	0	0
	40	97.0	0	0
Dipropalin	5	99.0	5	0
	10	99.0	8	15
Trifluralin	3	99.0	13	15
	6	99.0	39	35
U4513	4	77.0	36	26
	8	94.5	75	95
Zytron	15	99.0	0	0

U4513 controlled crabgrass well but killed most of the grass at the 8 lbs./A rate, leaving only broadleafed weeds. Trifluralin also was very injurious to the turf. Dipropalin at 5 lbs./A provided good control of crabgrass and was not injurious to the turf. At 10 lbs./A, however, dipropalin caused considerable thinning. "Bandane" at 40 lbs./A provided excellent control of crabgrass and no turf injury. Of the new materials, both dipropalin and "Bandane" warrant further testing.

Effects of mowing height on herbicide effectiveness In the spring of 1960, stands of turf grasses were established in unreplicated blocks. The fourteen individual grasses and mixtures of grasses consisted of the following:

a) pure stands of fescue grasses: alta, Kentucky 31, Illahee creeping red, Pennlawn red, chewings, and meadow
b) pure stands of Kentucky bluegrass and merion bluegrass
c) pure stands of bentgrasses: Astoria Colonial bent, Seaside creeping bent and C1-C19
d) mixtures of: 1) Kentucky bluegrass and chewings fescue
  2) Astoria Colonial bengrass, Kentucky bluegrass and chewings fescue

On April 29, 1961, zytron and dacthal were applied in strips within each block, at rates suggested on the herbicide bag. Untreated strips were left in each block. Mowing heights of 1 and 2 inches were then superimposed on each block.

No thinning or injury was observed in any of the fourteen grass plots treated with zytron and dacthal. However, the zytron plots were greener and looked better than the dacthal or untreated plots.

The effects of the mowing and chemical treatments on the crabgrass are given in Table 4. Raising the height of cut from 1 to 2 inches in the untreated plots reduced stands of crabgrass from an average of 33 plants/sq.ft. to 12 plants/ sq. ft. Raising the mowing height also increased the effectiveness of both zytron and dacthal. The best control of crabgrass was obtained with zytron at the 2-inch cutting height. This test reemphasizes the need for proper turf management in crabgrass control, with or without a herbicide.

Table 4. Effects of Mowing Heights and Herbicide Treatments on Crabgrass Control in a turf Nursery

Treatment	Mowing height (in.)	Visual estimates: Percentage area covered by crabgrass[1]	Visual estimates: Percentage control[2]	Crabgrass counts: No. plants per sq.ft.[3]	Crabgrass counts: Percentage control[2]
Untreated	1	69	0	32.7	0
	2	25	64	12.4	62
Zytron 15 lbs./A	1	4.3	94	0.9	97
	2	0.2	99.7	0.3	99
Dacthal 11.25 lbs./A	1	11	84	3.8	88
	2	1.9	97	1.0	97
L.S.D. .05				1.5	

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[1] Averages over eleven turf grasses grown alone or in combination.

[2] Percentage control based on comparison with untreated plots at 1" cutting height.

[3] Averages of four random sq.ft. samples in each of eleven turf grasses or mixtures.

Although the interaction between chemicals and mowing height was not statistically significant because of small amounts of crabgrass in some grass blocks, it appears that zytron was less affected by cutting height than dacthal. At the 1-inch cutting height, control of crabgrass was unsatisfactory in some of the dacthal plots. It is clear that a low cut subjects these herbicides to a more severe test than a high cut. Further work should reveal how other materials are affected by mowing height.

Residual effects of herbicides on crabgrass and turf. Plots in New Haven treated with pre-emergence herbicides in April 1960[1] were partially retreated on April 29, 1961. The only changes were slight increases in the rates of chlordane and "Pax" in 1961. The results are shown in Table 5.

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[1] Ahrens, J. F. and A. R. Olson. Comparisons of Pre-emergence Herbicides for Control of Crabgrass. Proc. NEWCC 15:276-279 (1960).

Table 5. Residual Effects of Pre-emergence Herbicides

Treatments		Crabgrass control Sept. 14, 1961		
1960	1961	No. plants per sq.ft.	Percentage control[1]	Percentage thinning[1]
Untreated	untreated	52	0	0
Calcium arsenate 370 lbs./A	retreated	0	100	10
Calcium arsenate 555 lbs./A	-	0	100	20
Chlordane 60 lbs./A	retreated 70 lbs./A	4.9	86	0
Chlordane 60 lbs./A	-	42	27	0
Chlordane 120 lbs./A	-	2.5	70	0
Dacthal 7.5 lbs./A	retreated	0.3	98	0
Dacthal 7.5 lbs./A	-	22	10	0
Dacthal 10 lbs./A	retreated	0.1	99.9	0
Dacthal 10 lbs./A	-	3.2	71	0
"Pax" 784 lbs./A	retreated 880 lbs./A	4.5	90	30
"Pax" 784 lbs./A	-	79	0	0
Zytron 10 lbs./A	retreated	1	94	0
Zytron 10 lbs./A	-	17	15	0
Zytron 20 lbs./A	retreated	0.4	99.9	0
Zytron 20 lbs./A	-	1.6	80	0

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[1] Visual estimates by three persons.

The treatments that provided 98 per cent or better control of crabgrass in 1960 also provided a large measure of control in 1961. These included calcium arsenate at 555 lbs./A, dacthal at 10 lbs./A, and zytron at 20 lbs./A. Treatments applied in 1960 that did not control crabgrass in 1961 included chlordane at 60 lbs./A, "Pax" at 784 lbs./A, zytron at 10 lbs./A, and dacthal at 7.5 lbs./A.

The 555 lbs./A rate of calcium arsenate in 1960 was still thinning the turf in 1961. In repeat treatments, calcium arsenate at 370 lbs./A and "Pax" thinned the fescue-bluegrass turf but zytron, dacthal, and chlordane did not.

The 1960 application of chlordane at 120 lbs./A, applied post-emergence did not control crabgrass that season. In 1961, however, about 70 per cent control was obtained on this plot without further treatment. Control here was a result of residual chlordane in the soil. Because of its long life in the soil, the residual control of crabgrass obtained with calcium arsenate also can be attributed to residual chemical activity. Although tests are in progress, it is not yet known whether the residual effects of zytron and dacthal on crabgrass the year following treatment are due to residual chemical activity or the prevention of seed production in the year of treatment. Studies on residual effects of herbicides on crabgrass and turf are being continued.

Summary and Conclusions

Comparisons were made of several pre-emergence herbicides for the control of crabgrass in established turf. To evaluate the performances of various chemicals, effects of season of application, residual activity, and heights of cut were studied.

Spring applications of calcium arsenate, chlordane, dacthal, "Pax", and zytron controlled crabgrass better than fall applications. Although fall applications may be slightly less injurious to turf, spring applications appear to be more practical. Several things may happen to lawns between October and May that could reduce the effectiveness of fall applications, i.e., raking of leaves and grass, flooding, etc.

Raising the height of cut from 1 to 2 inches greatly reduced crabgrass populations and increased the effectiveness of zytron and dacthal. A practical implication is that good crabgrass control may be achieved even with relatively ineffective herbicides if the turf is mowed high. It also can be expected that good control of crabgrass in closely cut turf, such as putting greens, will require high rates of application or highly effective materials.

At normal rates of application in April or early May, all of the labelled materials tested except "Pax" controlled crabgrass satisfactorily. Two experimental materials, "Bandane" and dipropalin, also provided good control.

Calcium arsenate has injured Colonial bentgrass and fescue-bluegrass turf in some tests, whereas "Pax" has caused little or no turf injury. Repeated applications may be hazardous with both materials. Calcium propyl arsonate has injured fescue-bluegrass turf in two different areas.

Even at high rates of application, chlordane has not injured turf in any test. For consistent control of crabgrass, however, rates higher than the current suggested commercial rate of 60 lbs./A are needed.

Diphenatrile, tested here for the first time in 1961, has injured Colonial bentgrass.

At suggested commercial rates, dacthal and zytron have consistently provided good control of crabgrass without serious injury to most of the common turf grasses.

Residual control of crabgrass a second season has been obtained with single applications of zytron at 20 lbs./A, dacthal at 10 lbs./A, calcium arsenate at 555 lbs./A, and chlordane at 120 lbs./A. It is not known in all cases whether this residual control of crabgrass is due to prevention of seed production or to residual chemical activity.

OBSERVATIONS ON CHEMICAL CONTROL OF CRABGRASS IN TURF (1961)

R. A. Peters, H. C. Yokum, and K. C. Stevens[1]

Presently a large number of herbicides are available which show promise for selective control of crabgrass in turf. Further evaluation is needed of available materials used under a range of conditions and at various stages of crabgrass growth.

Procedure: The experimental areas were laid out on the lawn of the University of Connecticut at Storrs. The areas were subjected to the same fertilization and mowing management as was the rest of the campus lawn. Individual plot size was 4 by 25 feet with each treatment replicated three times for the pre-emergence and emergence experiment. On one post-emergence area (Area A) each plot was 4 by 10 feet and was replicated four times. On the other post-emergence area (Area B) each plot was 10 by 25 feet and was replicated twice.

All of the materials used were granular except for the dacthal and M-2025 which were applied as sprays at the rate of 40 gallons per acre. The crabgrass present was small crabgrass (Digitaria ischaemum). The predominant perennial grass species was Kentucky bluegrass with an admixture of colonial bent on the post-emergence sites.

The pre-emergence applications were made on March 31 at which time the bluegrass was just beginning to green up. The emergence applications were made on May 15 when less than 25 percent by estimate of the crabgrass seedlings were visible. The date of crabgrass emergence was delayed, due to a cold spring. Crabgrass development, however, was unusually vigorous for the season as a whole.

The post-emergence applications were made on June 13, 1961 on Area A when the crabgrass seedlings were in the two leaf stage and averaged about one-half inch in height. While the stand of crabgrass was quite dense, the vigor of the stand was poor. Post-emergent applications were made on Area B on June 26, 1961 when the crabgrass was one-half to one inch in height and had two to four leaves.

The control of crabgrass obtained was evaluated by making estimates of ground cover on the plot with 0 indicating no cover and 10 indicating a complete cover of crabgrass. Independent ratings were made of each plot by two observers with an average of the two observations being reported. Arbitrary ranges were set up as follows: 0-1, very good control; 1-2, good control; 2-4, fair control; 4-5, poor control; and 5 or over, no control.

Results and Discussion: The control ratings following pre-emergence and emergence applications are given in Table 2.

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[1] Associate Professor, formerly Research Assistant, and Graduate Student,

Table 1. Chemicals Used for Crabgrass Control

Common Name	Chemical Name	Formulation Used
Zytron	0-2,4-dichloro-phenyl-0-methyl isopropyl phosphoroamidothioate	4.4 G and emulsion, 3 lb. a.i. per G
Dacthal	dimethyl 2,3,4,6-tetrachloro tetraphthlate	50% wettable powder
Tri-calcium arsenate	tri-calcium arsenate	48 G
Diphenatrile	diphenylacetonitrile	3.44 G and 11.5 G
Diphenamid	N,N-dimethyl α, α diphenyl acetamide	2 G
CPA	calcium propyl arsenate	20 G
Dipropalin	N,N-di-n-propyl-2,6-dinitro-4-methylaniline	2 G
Trifluralin	N,N-di-n-propyl-2,6-dinitro-4-trifluoro-methylaniline	2 G
DMA	di-sodium monomethylarsenate	3 G
NIA-6370		5 G

The cooperation of the following companies in supplying chemicals is acknowledged: The Dow Chemical Co.; Eli Lilly and Co.; UpJohn Co.; Eastern States Farmers' Exchange; Amchem Products, Inc.; Food Machinery and Chemical Corp.; Chipman Chemical Co.; Diamond Alkali Co.; and Geigy Agricultural Chemicals.

Table 2. Pre-emergence and Emergence Control of Crabgrass in Turf as Evaluated by Stand Estimates

Chemical	Pounds Active Material per Acre	Crabgrass Control Rating (0 = no cover; 10 = complete cover)	
		Pre-emergence	Emergence
Check	——	5.7	4.4
Zytron granular	8.8	1.0	2.2
Zytron granular	13.0	0.3	0.3
Dacthal	6.5	0.5	0.8
Dacthal	13.0	0.3	1.0
Tricalcium arsenate	305.0	1.0	1.2
Tricalcium arsenate	610.0	0.5	0.8
Diphenatrile	22		0.5
Diphenatrile	40		0.5
Dipropalin	5		0.8
Dipropalin	10		0.3
Diphenamid	2		4.0
Diphenamid	4		4.0
NIA-6370	2		8.0
NIA-6370	4		7.5
CPA	43		2.8
CPA	86		0.3

All of the pre-emergence materials used—zytron, dacthal and calcium arsenate—gave very good control of crabgrass at all rates used. At emergence, the same three gave equally good results. The other materials used only at emergence—diphenatrile, dipropalin, and CPA at the 86 lb. rate—also gave very good control. The 43 lb. rate of CPA was somewhat less effective, being rated as good. Unsatisfactory results were obtained from diphenamid and NIA-6370, with the former rated as poor and the latter as no control. Turf density in the experimental area was poor at the time of treatment making evaluation of turf injury difficult. No obvious injury to turf from any of the treatments was noted.

Results obtained from post-emergence applications on Area A are given in Table 3.

Very good control, as evaluated July 18, 1961, was obtained from the zytron M-2025, the CPA formulations and the 4 lb. rate of trifluralin. The 2 lb. rate of trifluralin gave fair to good control, while dipropalin gave poor control. Neither NIA-6370 nor diphenatrile gave control at this stage of growth at the rates used.

Table 3. Post-emergence Control of Crabgrass in Turf as Evaluated by Stand Estimates—Area A

Chemical	Pounds Active Material per acre	Crabgrass Control Ratings (0 = no cover; 10 = complete cover)
Check	—	6.5
Zytron M-2025	15	0.8
CPA	43	0.3
CPA	86	0.0
CPA in 10-6-4 fertilizer	43	0.1
NIA-6370	6	6.1
Dipropalin	4	4.7
Trifluralin	2	2.1
Trifluralin	4	1.0
Diphenatrile	30	7.1

Table 4 gives the results of post-emergence applications on Area B.

Table 4. Post-emergence Control of Crabgrass in Turf as Evaluated by Stand Estimates—Area B

Chemical	Pounds Active Material per acre	Crabgrass Control Ratings (0 = no cover; 10 = complete cover)
Check	—	4.0
CPA in 10-6-4 fertilizer	43	1.5
CPA	43	0.3
Diphenatrile	30	3.0
Zytron granular	15	2.0
Zytron M-2025	15	2.0
PMA	4	1.0

It was found that the higher rate of CPA (86 lb.) gave control of common white clover (Trifolium repens).

Turf injury was noted by mid-summer on the plots treated with trifluralin with the 4 lb. rate giving an average of 20 percent decrease in the density of the bluegrass.

Only two materials were rated as giving very good control at this relatively advanced stage of growth, namely, PMA and CPA. When the CPA was included in the fertilizer, the rating was lower; however, this was due in part to the greater vigor of the remaining crabgrass. The relatively low value given diphenatrile in this situation did not indicate adequate control since the stand of crabgrass was quite thin on the entire area.

Both formulations of zytron gave fair control despite the relatively advanced stage of growth. The zytron emulsion (M-2025) gave the quickest results as judged eleven days after treatment. By July 26 there was little difference evident between formulations.

<u>Injury to Turf Grasses</u>: Dacthal, granular zytron and zytron M-2025 at rates of 10, 15 and 15 pounds per acre respectively were applied on June 16, 1961 on well established stands of Kentucky bluegrass and colonial bent. As judged on July 2, bent was seriously injured with the M-2025 causing the most injury. Kentucky bluegrass was not injured at this time except on areas cut regularly to one inch. The lowest cut on the bent also demonstrated the most injury.

As evaluated in October 1961, the bents had largely recovered. At the time, however, injury was noted on Kentucky bluegrass evidenced principally by thinness of stand. The granular zytron had caused a greater reduction in stand than either dacthal or M-2025, a pattern which contrasted to the greater early injury to bent from the M-2025 formulation.

Summary

Satisfactory control of small crabgrass was obtained from applications of all materials applied as a pre-emergence application: zytron, dacthal, and tricalcium arsenate. At emergence, good control was obtained from the same materials as well as from diphenatrile, dipropalin and CPA at the 86 lb. rate. Unsatisfactory control at this stage was obtained from NIA-6370, diphenamid, zytron at 8.8 and CPA at 43 lb. per acre.

Post-emergence applications of CPA alone or mixed with fertilizer, PMA and trifluralin gave very good crabgrass control. The zytron emulsion (M-2025) gave good control at the 2 leaf stage but only fair control at the 4 leaf stage. Granular zytron, used only at the 4 leaf stage was also rated as fair only. Diphenamid used at the two leaf stage rated poor. Control from NIA-6370 and diphenatrile was unsatisfactory.

PRE-EMERGENCE AND POST-EMERGENCE CRABGRASS CONTROL IN TURFGRASS[1]

C. D. Kesler, R. H. Cole, and C. E. Phillips[2]

The objective of this study was to evaluate the effectiveness of several chemicals for the control of crabgrass on established Kentucky bluegrass turf.

Materials and Methods

The experimental area was located on the Agricultural Experiment Station Farm at Newark, Delaware. Chemicals were applied to a Kentucky bluegrass turf heavily infested with crabgrass the previous season. The crabgrass population consisted of approximately 90 percent smooth crabgrass, Digitaria ischaemum, and 10 percent common crabgrass, Digitaria sanguinalis. The plot layout was a randomized block design consisting of 2 replications and 17 treatments. Each plot measured 12 feet by 20 feet.

The soil was a Matapeake silt loam of medium fertility with a pH of 6.0. Fertilizer was applied in the early spring as indicated by soil tests. The area was mowed once a week to a height of 1 1/2 inches.

Pre-emergence materials were applied on March 20. Emulsifiable concentrates and wettable powders were applied in water with a modified bicycle-type sprayer. A lawn spreader was used for the dry formulation applications.

The crabgrass stand developed later than usual for northern Delaware because of the cool spring. Initial crabgrass germination occurred during the week of May 14. The first application of the post-emergence materials was made when the crabgrass was at the 3-leaf stage on June 15; the second application, on June 26; and the third application, on July 5. Three applications of each of the post-emergence chemicals were made except for Niagara 6370 post-emergence treatment which received only one application on June 15 as suggested by the manufacturer.

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[2] Research Assistant, Assistant Professor and Professor, Agronomy Department, University of Delaware, respectively.

The area was not irrigated. Within 24 hours after the application of the first and second post-emergence treatments, there were .70 inches and .62 inches of precipitation, respectively. No precipitation occurred within 8 days after the third post-emergence application.

Periodic observations for turf injury and crabgrass control were made following application of the chemicals. Discoloration readings were taken 5 days after each post-emergence application. The percentages of crabgrass control and turfgrass injury were determined by averaging estimates of three independent observers.

The herbicidal materials used and rate of active ingredients per acre are included with the data in tables 1 and 2.

Results and Discussion

Tables 1 and 2 show the results obtained with the chemicals used in this experiment.

None of the pre-emergence chemicals produced any observable turf discoloration or turf injury. Zytron liquid formulations were the only treatments producing excellent control of crabgrass during the entire growing season. Granular zytron and dacthal W-50 gave good control.

Tricalcium arsenate and calcium propyl arsonate produced excellent control early in the season. By mid-summer, control did not exceed 50 percent with either chemical. All of the granular PEWC formulations gave consistent control ratings except for F-2B. PEWC F-108, PEWC F-111, and PEWC F-113 produced between 75 and 95 percent control during the entire season. Niagara 6370 was ineffective at either the pre-emergence rate of 5 pounds per acre or the post-emergence rate of 10 pounds per acre.

Phenyl mercuric acetate was the most effective post-emergence chemical. It also produced the least turf discoloration.

The third application of disodium methyl arsonate and calcium methyl arsonate produced moderate and severe discoloration respectively of the Kentucky bluegrass turf. This could have been attributed to the 8-day rainfall-free period following

Table 1. Crabgrass Control with Pre-emergence Herbicides

Chemical	Rate # a.i./A.	Percent Control of Crabgrass July 10	 Aug. 15	 Sept. 13
Zytron, gran.	15	100	91	80
Zytron M-1329	15	100	94	92
Zytron M-2025	15	100	93	92
Dacthal W-50	10	90	88	82
Tricalcium arsenate	653	90	48	48
Calcium propyl arsonate	43.6	90	50	42
PEWC F-2B	30.8	75	69	65
PEWC F-108	30.8	85	85	82
PEWC F-111	30.8	90	83	82
PEWC F-113	37.9	95	82	75
Niagara 6370	5	10	0	0
Control	---	0	0	0

Table 2. Crabgrass Control and Kentucky Bluegrass Discoloration with Post-emergence Herbicides

Chemical	Rate # a.i./A.	Percent Control of Crabgrass 7/10	 8/15	 9/13	Discoloration * After 1 trt.	 After 2 trts.	 After 3 trts.
AMA ammonium methyl arsonate	7.2	100	81	58	1	1	2
DMA disodium methyl arsonate	6.3	100	84	72	1	1	3
CMA calcium methyl arsonate	5.4	100	83	40	1	2	4
PMA phenyl mercuric acetate	.8	95	91	81	1	1	2
Niagara 6370	10	30	10	2	0	-	-
Check	---	0	0	0	0	0	0

* Kentucky Bluegrass Discoloration Index: 0 = none; 1 = very slight; 2 = slight; 3 = moderate; 4 = severe; 5 = very severe.

the application of these treatments. Evidences of discoloration were noticeable for more than 3 weeks after the last application. Both DMA and CMA permanently injured the Kentucky bluegrass reducing the stand by one-third. At least 90 percent control of white clover was recorded in areas treated with AMA, DMA, and CMA. The broadleaf population in these same treatments was reduced by more than 50 percent.

Summary and Conclusions

Pre-emergence and post-emergence crabgrass control chemicals were evaluated at the University of Delaware during the spring and summer of 1961.

Zytron liquid gave excellent control of crabgrass during the entire season. Zytron granular, dacthal W-50, PEWC F-108, PEWC F-111, and phenyl mercuric acetate produced good control (at least 80 percent control) of crabgrass during the entire season.

Tricalcium arsenate, calcium propyl arsonate, ammonium methyl arsonate, disodium methyl arsonate, and calcium methyl arsonate gave good to excellent control early in the season. Niagara 6370 was ineffective.

Disodium methyl arsonate and calcium methyl arsonate caused severe discoloration of the Kentucky bluegrass and permanently reduced the stand by one-third.

Acknowledgement

Acknowledgements are gratefully made to Amchem Products, Inc., Chipman Chemical Co., W. A. Cleary Corp., Diamond Alkali Co., Dow Chemical Co., E. I. duPont deNemours and Co., Niagara Chemical Co., and O. A. Scott and Sons for the chemicals used in this experiment.

Pre- and post-emergence crabgrass control in lawn turf[1]

R. B. Ames and C. R. Skogley[2]

If man could find a cheap, efficient and safe chemical to control the common crabgrasses, Digitaria ischaemum and Digitaria sanguinalis, turf technicians would be able to solve many chronic complaints. The crabgrasses are versatile in that they grow vigorously under the various cutting heights normally employed for turfgrasses, even 3/16 inches. Under unmowed conditions, they grow into robust plants often reaching three feet in height. Because of their sun-loving habit and heat tolerance they persist and grow under very high temperatures when basic lawn grasses fail. These grasses can also readily adapt to fertile or infertile soil conditions varying greatly in reaction. All of these factors may need to be considered in attempting to develop a chemical control.

Methods and Materials

All rates of application are given in pounds per acre. Injury readings are read as: 0 = no injury, 5 = complete kill. Plant counts were made by counting crabgrass plants in two one-foot squares per plot. The average of plant counts was calculated and used to compute the percent control over check.

Pre-emergence

The area selected for the pre-emergence trials was a level, well-drained site on Bridgehampton silt loam. The grass stand was several years old and consisted, in diminishing order, of Colonial bentgrass, Kentucky bluegrass and Red fescue.

In order to provide a uniform stand of crabgrass the test area was overseeded with crabgrass seed in November of 1960. Seed from 1959 and 1960 was mixed and broadcast over the entire area after it had been mowed to 3/4 of an inch and scarified with a verticut.

Throughout the 1961 growing season the grass was mowed as needed at a height of 3/4 of an inch. Heavy clippings were removed. Frequent light applications of water were applied to insure ample soil moisture for crabgrass seed germination and later growth.

No fertilizer was applied until early July, after the crabgrass had emerged. At this time 12 1/2 lb of an 8-6-2 fertilizer was applied for each 1000 square feet.

A randomized block design with three replications was employed to locate the chemical treatments. Each replication consisted of 44 chemical treatments and one check plot.

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[1] Contribution No. 1053 of the Rhode Island Agricultural Experiment Station.

[2] Graduate Assistant and Associate Professor of Agronomy, respectively.

The chemicals were applied May 3. The day was clear and windy with an air temperature of 50°F. The soil was wet and cold.

Injury to the basic grasses was recorded three times throughout the season and crabgrass coverage estimates were made on August 11th and September 19th. Crabgrass counts were made on September 19th.

The chemicals included, the rate of application, and the companies supplying the materials are as follows:

1) Trifluralin (N,N-di-n-propyl-2,6-dinitro-4 trifluromethylaniline) at 2, 4 & 6 lb. Eli Lilly Company.
2) Dipropalin (N,N-di-n-propyl-2,6-dinitro-4-methylaniline) at 2, 4 & 8 lb. Eli Lilly Company.
3) Diphenatrile (diphenylacetonitrile) at 30 lb, Eli Lilly Company; at 26 lb, Agrico Crabgrass Killer; at 30 lb, International Minerals and Chemical Company.
4) Dacthal G-1.5 (Dimethyl ester of tetra chloroterephthalic acid) at 5, 10 & 15 lb. Diamond Alkali Chemical Company.
5) Dacthal W-50 (Dimethyl ester of tetra chloroterephthalic acid) at 9.8 (Rid), at 10.8 (Vitogrow) - Swift Chemical Company.
6) Niagara 6370 experimental at 6 lb. Niagara Chemical Division, Food Machinery and Chemical Corporation.
7) Bandane E.C. (polychlorodicyclopentadiene isomer) at 10, 20 & 30 lb. Velsicol Chemical Company.
8) PEWC F-108 (Chlordane and polychlorodicyclopentadiene isomer) at 47 lb. O. M. Scott Company.
9) PEWC F-111 (Chlordane and polychlorodicyclopentadiene isomer) at 57.5 lb. O. M. Scott Company.
10) PEWC F-113 (diphenylacetonitrile) 37 lb. O. M. Scott Company.
11) PEWC F-114 (polychlorodicyclopentadiene isomer). O. M. Scott Company.
12) Halts F-2b (Chlordane) at 59.6 lb. O. M. Scott Company.
13) Tricalcium arsenate (Purge) at 355 lb. Asgrow Seed Company.
14) Calcium propyl arsonate (No Crab) at 40 lb. Amchem.
15) Zytron (0-(2-4-dichlorophenyl)0-methyl isopropyl-phophoromidothioate) at 15 lb. Dow Chemical Company.
16) Corenco 106 (Diphenylacetonitrile and Disodium methyl arsonate Hexahydrate) at 31.1 and 5.4 lb respectively. Consolidated Rendering Company.
17) SD 6623 (Tri methyl sulfonium chloride) at 6 lb. Shell Oil Company.
18) 75% Bandane and 25% Chlordane at 15 and 5, 20 and 6.6, and 30 and 10 lb. Velsicol Chemical Company.

Post-emergence

This area was located on a sandy loam soil that was heavily infested with smooth crabgrass. The stand of turf was thin and consisted of Colonial bentgrass, creeping red fescue and Kentucky bluegrass with the former being the most prevalent. The soil in the test area was of low fertility and the turf was mowed regularly at a height of 1 1/2 inches.

Prior to each chemical application the area was watered to assure sufficient moisture for growth and to comply with the directions for the application of the dry materials.

The first chemical applications were made on July 18 at which time the crabgrass plants were in the 2-3 leaf stage. The day was clear and the air temperature was 85°F. The second application was made July 28. The air temperature at time of application was 82°F. The third application of chemicals was made on August 10. The air temperature on this day was 85°F.

Table II shows that some chemicals were applied only once while others were applied two or three times. Certain chemicals, or rates of various chemicals, caused serious injury to the turf after the first application. These treatments were not repeated. Certain other treatments controlled crabgrass satisfactorily with two applications so these chemicals were not applied a third time. The third application was made only when it appeared necessary for safe and adequate control.

Throughout the growing season soil moisture was not limiting for any prolonged period of time even though the test area received no irrigation except on treatment dates.

Four injury ratings on the basic grasses were taken during the season with the final ones, plus plant counts, on September 19.

An analysis of variance was run on these plant counts and the percent control over the checks was calculated.

The materials included, the rates used and the companies supplying the chemicals are as follows:

1) Niagara 6370 (experimental) at 6 lb. Niagara Chemical Division, Food Machinery and Chemical Corporation.
2) Stam F-34 (3,4-dichloropropionanilide) at 2 and 4 lb. Chipman Chemical Company, Inc.
3) Ansar A-12 (organic arsenical, As 44.3% by wt.) at 1, 1 + Wetting Agent, 1 1/2, 2, 2 + WA and 4 lb. Ansul Chemical Company.
4) Ansar A-35 (organic arsenical, As 24.5% by wt.) at 1 1/2, 1 1/2 + WA, 2 1/2, 3 1/2, 3 1/2 + WA, and 5 lb. Ansul Chemical Company.
5) Super Crab-E-Rad (Calcium acid methyl arsonate) at 21.5 lb. Vineland Chemical Company.
6) Methar 80 (Disodium methyl arsonate Hexahydrate) 7.2 lb. W. A. Cleary Corporation.
7) Super Methar (Ammonium methyl arsonate) 16.1 lb. W. A. Cleary Corporation.
8) Lofts Crabgrass Killer (Disodium methyl arsonate Hexahydrate) at 2.85 lb. Pedigreed Seed Company.
9) Void (Disodium methyl arsonate Hexahydrate) at 4.1 lb. International Minerals and Chemical Company.

The wetting agent used was "Dupont Spreader-Sticker", sodium sulfates of mixed long chain alcohol fatty acid esters.

The liquid materials for both pre- and post-emergence trials were applied with a 2 gallon pump sprayer at 30 lbs pressure and a volume of about 250 gallons per acre. The dry chemicals were applied with a calibrated spreader set according to labeled directions or by mixing weighed amounts with dry sand and broadcasting by hand.

Results

Tables I and II relate the chemicals, rates of application, number of applications, average plant counts per square foot, percent cover of crabgrass, injury readings and percent control of each treatment over the check.

Pre-emergence

When working with living organisms one can rarely expect perfection or exact results. It is pleasing to note that fifteen of the 44 chemical treatments resulted in 100% control of crabgrass. These chemical treatments are as follows: Trifluralin at 2, 4 and 6 lb; Dipropalin at 8 lb; Dacthal G-1.5 at 10 lb; Rid (Dacthal W-50) at 9.8 lb; Vitogrow (Dacthal W-50) at 10 lb; Agrico's Diphenatrile on fertilizer; Purge (Tricalcium arsenate 355 lb); Null (Diphenatrile at 30 lb); Dow's crabgrass killer (Zytron at 15 lb) and finally Corenco 106 (Diphenatrile & DSMA 31 and 5.4 lb).

There were also four chemical treatments with over 90% control, namely: Dipropalin at 4 lb, Diphenatrile at 30 lb, PEWC F-108 at 47 lb and Trifluralin E.C. at 4 lb.

Some materials which gave 90 - 100 percent control also discolored severely. They were Trifluralin at 4 and 6 lb, Dacthal G-1.5 at 15 lb and Zytron. Most of the chemicals that resulted in only fair control showed little phytotoxicity to the turfgrasses.

It was noted that some of the chemical treatments, Niagara 6370, Bandane atta. at 10 lb, Bandane Verm. at 10 lb, Halts F-2b, No Crab, SD 6623 at 6 lb and Dipropalin E.C. at 4 lb had a higher crabgrass count than the check plots. There may be many factors involved here. Two which stand out are that the infestation of crabgrass was not heavy enough to cancel experimental variation due to crabgrass stand or possibly because treatments actually created a more favorable condition for germination and growth of crabgrass plants.

Post-emergence

Again in this test it was encouraging to find that fifteen of the treatments controlled over 90 percent of the crabgrass. Within this range of control there were other interesting results, mainly:

1) Ansar A-12 at 2 lb + WA and 4 lb and Methar 80 controlled significantly with only one application but injured the basic grasses severely.

2) These chemical treatments - Ansar A-12 at 2 lb, Ansar A-35 at 3 1/2 lb, 3 1/2 lb + WA, 5 lb, Super Crab-E-Rad and Super Methar all controlled over 90 percent of the crabgrass after two applications. These treatments caused little to moderate temporary injury to the perennial grasses.

3) Those treatments which were applied 3 times, gave little injury, and controlled significantly were Ansar A-12 at 1 lb, 1 lb + WA, 1 1/2 lb, Ansar A-35 at 1 1/2 lb, 1 1/2 + WA and 2 1/2 lb.

Two chemicals, Lofts Crabgrass Killer and Void, controlled significantly but were under 90 percent.

The Niagara 6370 and Stam F-34 at 2 lb and 4 lb per acre gave very little control.

At the time of final crabgrass counts, no injury was apparent on the basic lawn grasses from any of the treatments.

Summary and Conclusions

Because of the continued interest in crabgrass control in turf, the University of Rhode Island Agricultural Experiment Station conducted pre- and post-emergence crabgrass trials during 1961 to evaluate 22 chemicals. The chemicals were evaluated for effectiveness in controlling crabgrass and for safety to perennial turfgrasses. The rates of applications and other specifics were followed according to manufacturers' recommendations or suggestions. Those chemicals which showed satisfactory chemical control at one or more rates are as follows:

Pre-emergence

1) Trifluralin
2) Dacthal G-1.5 and Dacthal W-50
3) Dipropalin
4) Diphenatrile and Diphenatrile + DSMA
5) Zytron
6) PEWC F-108
7) Tricalcium arsenate

Post-emergence

1) Ansar A-12 and Ansar A-35
2) Calcium acid methyl arsonate
3) Ammonium methyl arsonate
4) Disodium methyl arsonate

Table I. Average percent crabgrass cover, injury rating, crabgrass plants present and control over check plots for the various formulations and rates of pre-emergent herbicides tested.

Treatment	% act.	Rate Lb/A	% Crabgrass Cover, ave. 9/18/61	Injury ratings*		Ave. no. crabgrass plants/sq. ft. 9/18/61	% control Over check
				7/5/61	9/18/61		
1. Trifluralin (Verm.)	2.00	2	0.0	1.0	0.1	0.0	100
2. Trifluralin (Verm.)	2.00	4	0.0	1.3	0.5	0.0	100
3. Trifluralin (Verm.)	2.00	6	0.0	2.0	1.5	0.0	100
4. Trifluralin (Fert.)	.92	4	0.0	1.0	0.5	0.0	100
5. Dipropalin (Verm.)	2.00	2	2.7	0.0	0.0	2.2	54
6. Dipropalin (Verm.)	2.00	4	0.7	0.0	0.1	0.2	96
7. Dipropalin (Verm.)	2.00	8	0.0	0.0	0.0	0.0	100
8. Dipropalin (Fert.)	.92	4	1.7	0.0	0.0	1.7	64
9. Diphenatrile (Verm.)	11.50	30	0.3	0.0	0.0	0.2	96
10. Diphenatrile (Fert.)	6.89	30	1.3	0.0	0.0	0.8	82
11. Dacthal G-1.5	1.50	5	1.3	0.0	0.0	0.5	89
12. Dacthal G-1.5	1.50	10	0.3	0.2	0.1	0.0	100
13. Dacthal G-1.5	1.50	15	0.0	0.2	0.5	0.0	100
14. Dacthal W-50 (Rid)	2.30	9.8	0.0	0.2	0.1	0.0	100
15. Dacthal W-50 (Vitogrow)	2.53	10.8	0.0	0.3	0.7	0.0	100
16. Nia 6370	5.00	6	16.3	0.0	0.0	13.2	0
17. Bandane E.C.	4 lb/gal.	10	14.3	0.0	0.0	4.8	0
18. Bandane E.C.	4 lb/gal.	20	5.0	0.0	0.0	4.7	0
19. Bandane E.C.	4 lb/gal.	30	5.7	0.0	0.2	2.5	46
20. Bandane Atta.	4 lb/gal.	10	16.7	0.0	0.0	8.8	0
21. Bandane Atta.	4 lb/gal.	20	3.0	0.0	0.0	2.8	39
22. Bandane Atta.	4 lb/gal.	30	2.7	0.0	0.0	1.0	79
23. Bandane Verm.	4 lb/gal.	10	16.7	0.0	0.0	10.5	0
24. Bandane Verm.	4 lb/gal.	20	10.3	0.0	0.0	1.7	64
25. Bandane Verm.	4 lb/gal.	30	2.0	0.0	0.0	1.0	79
26. Diphenatrile (Agrico)	5.85	26	0.0	0.0	0.0	0.0	100

Table I (Cont'd)

Treatment	% act.	Rate lb/A	% Crabgrass Cover, ave. 9/18/61	Injury ratings* 7/5/61	Injury ratings* 9/18/61	Ave. no. crabgrass plants/sq. ft. 9/18/61	% control Over check
27. PEWC F-108	18.4	47	0.3	0.0	0.0	0.3	93
28. PEWC F-111	22.3	57.7	4.0	0.0	0.0	1.0	79
29. PEWC F-113	14.5	37	0.0	0.0	0.3	0.8	82
30. PEWC F-114	11.8	30	0.7	0.0	0.0	0.5	89
31. Halts F2b	23.0	59.3	18.0	0.0	0.0	7.7	0
32. Tricalcium arsenate	51	355	0.0	0.0	0.0	0.0	100
33. Calcium propyl arsonate	20	40	5.0	0.0	0.0	6.0	0
34. Diphenatrile(Null)		30	0.0	0.0	0.0	0.0	100
35. Zytron	4.4	15	0.0	0.7	0.9	0.0	100
36. Corenco 106	15.9+3 DSMA	31.1+5.4	0.0	0.0	0.0	0.0	100
37. SD 6623	4 lb/gal.	6	31.7	0.0	0.0	12.5	0
38. Zytron E.C.	3 lb/gal.	15	1.7	0.0	0.0	1.2	75
39. Dipropalin E.C.	4 lb/gal.	4	21.7	0.0	0.0	8.3	0
40. Trifluralin E.C.	4 lb/gal.	4	0.0	0.2	0.0	0.2	96
41. 75% Bandane 25% Chlordane	10	15+5	3.3	0.0	0.5	2.8	39
42. 75% Bandane 25% Chlordane	10	20+6.6	3.0	0.0	0.1	3.2	32
43. 75% Bandane 25% Chlordane	10	30+10	1.7	0.0	0.0	1.5	68
44. Dacthal G-1.5 SY	1.5	10	0.0	0.7	0.8	0.0	100
45. Check			18.3	0.0	0.0	4.7	0

*Injury ratings 0 - 5; 0 = no injury, 5 = complete kill.

Table II. Average injury ratings, crabgrass plants present, control over check plots and number of applications for the various formulations and rates of post-emergent herbicides tested.

Treatments	% act.	Rate Lb/A	No. of Appli- cations	Injury ratings				Average No. crabgrass plants/sq. ft.	% control Over check
				7/28/61	8/7/61	8/10/61	8/15/61		
1. Nia 6370	5% gran.	6	2	0.0	0.0	0.0	0.0	93.8	13
2. Stam F34	15% verm.	2	2	0.0	0.0	0.0	0.0	95.2	12.
3. Stam F34	15% verm.	4	2	0.0	0.0	0.0	0.0	94.0	13
4. Ansar A-12	25%	1	3	1.3	0.0	0.2	0.1	8.2	92
5. Ansar A-12	25%	1+WA	3	0.0	0.0	0.0	0.0	4.0	96
6. Ansar A-12	25%	1 1/2	3	1.0	1.5	0.5	0.3	1.3	98
7. Ansar A-12	25%	2	2	2.0	1.5	0.0	0.0	7.2	93.
8. Ansar A-12	25%	2+WA	1	2.0	0.3	0.0	0.0	9.0	91
9. Ansar A-12	25%	4	1	4.0	2.3	0.0	0.0	7.7	92
10. Ansar A-35	21%	1 1/2	3	0.0	0.0	0.0	0.0	7.5	93
11. Ansar A-35	21%	1 1/2+WA	3	1.3	0.3	0.3	0.0	4.8	95
12. Ansar A-35	21%	2 1/2	3	1.3	0.5	0.3	0.3	2.3	97
13. Ansar A-35	21%	3 1/2	2	1.7	1.0	0.0	0.0	6.7	93
14. Ansar A-35	21%	3 1/2+WA	2	1.7	1.2	0.0	0.0	6.2	94
15. Ansar A-35	21%	5	2	2.0	1.5	0.0	0.0	4.7	95
16. Super Crab-E-Rad	8%	21.5	2	0.7	0.2	0.0	0.0	9.5	91
17. Methar 80	75%	7.2	1	3.0	0.7	0.0	0.0	7.0	93
18. Super Methar	15%	16.1	2	1.7	0.8	0.5	0.4	10.0	90.
19. Lofts	2.5% gran.	2.85	3	0.7	0.0	0.0	0.0	13.0	88
20. Void	3.15% gran.	4.1	3	0.3	0.0	0.0	0.0	17.7	83
21. Check								108.3	0

LSD .05 = 16.49
.01 = 21.71

*Injury ratings 0 - 5; 0 = no injury, 5 = complete kill.

EXPERIMENTS ON THE CHEMICAL CONTROL OF CRABGRASS IN LAWN TURF

Clayton M. Switzer *

Considerable variability in the response of crabgrass (Digitaria spp.) to herbicides has been found by many investigators. This variability is influenced by such factors as soil moisture, relative humidity, soil and air temperature, soil fertility, time of treatment relative to stages of growth, and to variety (or species) of this grass. Since it is impossible for a home owner to control such factors to any great extent, it would appear that the most acceptable crabgrass herbicides will be those that are effective over the widest range of conditions.

At present it appears that in general the pre-emergence crabgrass killers are most effective. While the use of this type of herbicide fits in well with the operations of professional gardeners and golf-course superintendents, it has not been widely accepted by the average home owner, probably because of the tendency of the layman not to worry about weeds, insects or diseases until they become apparent to him. Therefore, investigations on the control of crabgrass in turf should continue to include chemicals capable of killing this weed after emergence, as well as the pre-emergence materials. An ideal herbicide would seem to be one with both pre- and post-emergence activity, and having sufficient residual effect to make yearly application unnecessary.

This paper reports on the results of experiments using pre- and post-emergence chemicals, and on the residual effectiveness of some of these chemicals on crabgrass.

METHODS

All experimental work was carried out on the campus of the Ontario Agricultural College. The turf grasses were mainly Kentucky and Canada blue with some creeping red fescue and creeping bent grass. Plots were 100 sq. ft. in area and in most experiments treatments were replicated 4 times in a randomized block design. The areas selected were covered with sparse turf and had been infested with a heavy crabgrass population the year previous to treatment. Sprays were applied (100 gal/A) with a knapsack sprayer and granulars were distributed by means of a small fertilizer spreader.

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RESULTS

Pre-emergence treatment: The effects of chemicals applied April 27 - May 1, 1961 are presented in Table 1. Rainfall on the plot area between April 29 and May 3 was 0.78 in. First crabgrass emergence was noted in the control plots on May 15th.

Excellent control of crabgrass with no injury to other grasses was given by all rates of zytron (both liquid and granular formulations), dacthal (wettable powder and granular), diphenatrile (diphenylacetonitrile) and dipropalin. Diphenylacetonitrile (Agrico formulation) gave good control (over 90%) at the lower rates and excellent control at the highest rate. Calcium propyl arsonate was good at 60 lb/A but not satisfactory at lower rates. This chemical had a strong inhibitory effect on clover.

Pax (36.5% metallic arsenic) and Chip Cal (50% tricalcium arsenate) gave good control at the highest rates but were poor at lower rates. Trifluralin caused marked burning of all plants in the plots and, therefore, was not satisfactory even though it gave 100% control of crabgrass.

Similar results were obtained in 1960 in an experiment in which zytron (liquid and granular), dacthal (granular) and calcium arsenate were tested.

Residual effects: The 1960 plots were maintained and observations on the residual effects were made periodically during the summer of 1961. Some crabgrass was found in all the plots, but those treated with all rates of zytron (8, 16, 24 lb/A both liquid and granular) and those treated with tricalcium arsenate at 15 lb/1000 sq. ft. or with dacthal granular at 15 lb/A, had considerably less than the others. Control with both 16 and 24 lb/A of zytron exceeded 90% throughout the summer. The 8 lb rate gave fair control (50-70%) as the granular formulation, but liquid zytron at 8 lb/A did not have as much residual effect.

In another experiment, set up to study the effectiveness of application of pre-emergence crabgrass herbicides in the fall, plots were treated on Nov. 14, 1960 with zytron, liquid and granular (10,20,30), dacthal, wettable powder and granular (10,15, 20), and tricalcium arsenate (5,7½,10,15). Rates of zytron and dacthal are lb active/A, and of tricalcium arsenate are lb active/ 1000 sq. ft. Only the plots receiving the low rate of dacthal granular and the lowest two rates of tricalcium arsenate were not completely free of crabgrass on July 21, 1961. However, by August 31, crabgrass was noted in all plots except those receiving 20 or 30 lb of zytron or 20 lb of dacthal, although plots treated with zytron 10, dacthal 15, or tricalcium arsenate 15, contained only a few crabgrass plants. Only the highest rate of zytron caused any turf damage (some thinning) and even these plots recovered by early June. A marked stimulation of

Table 1: Control of crabgrass by chemicals applied before emergence.

Chemical	Rate lb/A*	Crabgrass Control Rating** July 21	August 23	Turf Injury
Zytron (liq.)	8	4	4	None
	16	4	4	"
Zytron (gran.)	8	4	4	"
	16	4	4	"
	24	4	4	"
Dacthal (W-50)	5	4	4	"
	10	4	4	"
	15	4	4	"
Dacthal (gran)	5	4	4	"
	10	4	4	"
	15	4	4	"
Calcium propyl arsonate (No-Crab)	20	2	1	"
	40	4	2	"
	60	4	3	"
Diphenatrile (Lilly)	20	4	4	"
	30	3	4	"
	40	4	4	"
Trifluralin (Lilly)	4	4	4	Slight
	6	4	4	Heavy
	8	4	4	Heavy
Dipropalin (Lilly)	4	4	4	None
	6	4	4	"
	8	4	4	"
Pax (36.5% metallic arsenic)	10*	0	0	"
	20*	1	1	"
	30*	4	3	"
Diphenylacetonitrile (Agrico)	25	4	3	"
	50	4	3	"
	75	4	4	"
Chip-Cal (50% Tricalcium arsenate)	10*	1	1	"
	15*	1	1	"
	20*	3	3	Slight

* Rates are pounds of active material per acre - except Pax and Chip-Cal, which are pounds of product per 1000 sq. ft.

** 4 = 100% control; 3 = over 90%; 2 = 60-90%; 1 = 25-60%
0 = less than 25% control.

Post-emergence applications. Data from several experiments carried out during the summer of 1960 are summarized in Table 2.

Table 2: Effects of various post-emergence treatments on crabgrass and turf (1960 data)

Chemical Treatment		Date of ** Application	Control 0-4 ***	Turf Injury
Pot. Cyanate	1 oz/3 gal *	1	2	None
	2 oz/3 gal *	1	2	Sl.Burn
	3 oz/3 gal *	1	3	Burned
Pot. Cyanate (repeated sprays)	1 oz/3 gal *	2,4,5	4	Sl.Burn
	2 oz/3 gal *	2,4,5	4	Sl.Burn
FW 734 (Rohm and Haas)	2 lb/100 gal/A	1,4,5	0	None
	4 lb/100 gal/A	1	1	Sl.Burn
	8 lb/100 gal/A	1	1	Burned
Zytron	10 lb/100 gal/A	4,5	1	Sl.Burn
	20 lb/100 gal/A	4	3	Burned
	30 lb/100 gal/A	2	4	Sev.Burn
Disodium Methyl Arsonate	6 lb/100 gal/A	2,4	3	None
Ammonium Methyl Arsonate	4 lb/200 gal/A	2,3,5	2	Slight

* Applied to 400 sq.ft. only, all rates in terms of active material.

** 1 = June 6; 2 = June 28; 3 = July 15; 4 = July 25; 5 = Aug.4

*** 0 = no control; 4 = 100% control

Good control was produced by potassium cyanate even at the lowest rate tested when treatments were repeated 3 times. Two sprays gave fair control but one was not sufficient. Temporary turf burning occurred in all plots. Similar results were obtained with the arsonates but they were considerably slower in action and not as effective as cyanate. It was noted that the effectiveness of ammonium methyl arsonate was increased when applied during a hot day (85°F)

Zytron burned crabgrass, bent grass and fescue at all rates and killed them completely in the plots sprayed with 30 lb/A. However, the blue-grasses in these plots were strongly stimulated by the treatment, so that a healthy, dark-green, pure blue-grass stand of grass was produced. The greater injury to turf from zytron in the post-emergence plots as compared to the pre-emergence may have been partly the result of higher temperature at the time

In a similar post-emergence experiment carried out in 1961, herbicides were applied June 27 when the crabgrass seedlings had 5-8 leaves and were 1-3 inches in height. Data from this experiment are presented in Table 3.

Table 3: Effects of various post-emergence treatments on crabgrass and turf (1961 data)

Chemical Treatment		Date of ** Application	Control 0-4 ***	Turf Injury
Calcium propyl arsonate	60 lb/A	1	4	None
PMA (10% liquid)	1 oz*/3 gal	1	2	None
	2 oz*/3 gal	1	3	Slight
	2 oz*/3 gal	1,2	4	Slight
	2 oz*/3 gal	2	4	Slight
Disodium methyl arsonate	2.2 lb/A	1	1	None
	3.4 lb/A	1	1	Slight
	3.4 lb/A	1,2	4	Slight
	4.5 lb/A	1	4	Slight
	3.4 lb/A	3	3	Slight
Ammonium methyl arsonate	6 lb/A	1	3	Slight
	6 lb/A	1,2	4	Slight
	12 lb/A	1	4	Moderate
Potassium cyanate	1 oz/3 gal 400 sq. ft.	1	1	Slight
	2 oz/3 gal 400 sq. ft.	1	3	Moderate
Highland granular (1.87% disodium methyl arsonate)	100 lb*/A	1	0	None
	200 lb*/A	1	1	None

* Weight of product per 400 sq. ft. - all other rates are in terms of active material.

** 1 = June 27; 2 = July; 3 = August 1.

*** 0 = no control, 4 = 100% control

Excellent control of crabgrass was obtained throughout the summer of 1961 in the plots treated with calcium propyl arsonate, and in those treated with the higher rates, or given repeated treatments with PMA, DMA, or AMA. The latter three materials caused slight burning of turf grasses for a few days but there was no permanent effect. The late application of DMA (Aug.1) to partially headed-out crabgrass reduced the stand markedly, indicating that there may be value in such a treatment where earlier applications have not been carried out.

Control with the granular formulation of DMA was poor. Potassium cyanate was used only once. It caused discoloration for a few days, and gave good control of the crabgrass present at time of application. The effectiveness of calcium propyl arsonate when applied post-emergence to the crabgrass was interesting. At 60 lb/A (of active material) good control was producted by applications from April 29 to June 27.

In another experiment, certain chemicals that usually have been regarded as pre-emergence herbicides for crabgrass control were applied shortly after germination (May 23, 1961) when the crabgrass seedlings were in the 2-3 leaf stage. The results of this experiment are presented in Table 4. All of the herbicides listed gave good control when used as early post-emergence treatments.

Table 4: Effects of certain chemicals on crabgrass when applied soon after emergence.

Herbicide	Rate (lb/A)	Control (0-4)*	Turf Injury
Calcium propyl arsonate (No-crab)	40 60	3 4	None None
Diphenatrile (Lilly)	40	4	Slight
Zytron (liq.)	16	4	None
Dacthal (gran.)	15	4	None

* 0 = no control; 4 = 100% control

DISCUSSION

On the basis of two years results, the outstanding pre-emergence crabgrass herbicides in the Guelph, Ontario area appear to be zytron and dacthal. Data for 1961 alone indicate that diphenatrile and dipropalin could be as good. However, growing conditions were excellent for turf throughout the summer of 1961, and it is probably safe to assume that the chance of obtaining good control would be better than if the turf grasses offered little competition.

Several chemicals applied after crabgrass emergence (Potassium cyanate, PMA, DMA, and AMA) controlled crabgrass, but more than one application per season seemed to be required and some degree of turf injury was brought about by each. The use of some "pre-emergence" herbicides (calcium propyl arsonate, zytron dacthal and diphenatrile) at early post-emergence appeared promising. If such results could be repeated consistently, chemicals of this nature would seem to offer the best possibilities for becoming widely accepted crabgrass herbicides.

The question arises whether the residual effect of some chemicals (zytron in particular) was due to retention of the chemical in the soil, or to lack of crabgrass seed at the surface because of 100% control in 1960. Since there was also 100% control in 1960 in the plots treated with potassium cyanate, and since these plots were as heavily infested as the check plots in 1961, it would appear that stopping seed production for one year has little effect on the next year's population. Apparently the residual activity of some herbicides is due to their resistance to leaching and decomposition. While less response of this nature would be expected further south because of higher rainfall and temperature, the possibility remains that yearly application, at least with the original concentration, may be unnecessary in certain areas.

CRABGRASS CONTROL OBTAINED IN ESTABLISHED TURF WITH PRE-EMERGENCE HERBICIDES

R. E. Engel, R. N. Cook, and R. D. Ilnicki[1]

Good results with pre-emergence crabgrass herbicides in past seasons have encouraged continued research and development in this field. Tests were conducted in 1961 to obtain further information on some of the more promising chemicals and evaluate several new materials. Ability to provide crabgrass control consistently and safely to the turfgrasses were questions of prime importance.

Procedure

Calcium arsenate, calcium propyl arsonate, chlordane, dacthal, diphenatrile, and zytron were applied at rates determined by past performance (table 1). In addition, bandane (polychlorodicyclopentadiene isomers), dipropalin (N,N-di-n-propyl-2,6-dinitro-4-methylaniline), and trifluralin (N,N-di-n-propyl-2,6-dinitro-4-trifluoromethylaniline) were used at rates of 10-30, 2-8, and 2-6 pounds per acre, respectively. All chemicals were applied in late March. April and May treatments were made with all chemicals except dipropalin. The turf area contained a predominance of Kentucky bluegrass with traces of red fescue and colonial bentgrass. Plots were 3 x 20 feet for dry applications and 4½ x 20 feet for spray applications. The tests were replicated three times. Clippings were removed through the crabgrass season. The treatments were observed regularly for injury and were rated for crabgrass control in late September. Control ratings were made by three observers on a percentage basis.

Results

Dacthal, trifluralin, and zytron attained crabgrass control ratings of 94 percent or better in 1961 (tables 1 and 2). Bandane, diphenatrile, and dipropalin, chlordane, and calcium arsenate gave control in the range of 62 to 79 percent, respectively. No consistently serious turfgrass injury was observed for any of the chemicals. Trifluralin gave some discoloration in the early weeks after application, but consistent injury was not measurable at the close of the season.

The optimum rate of application for bandane appears to be 30 pounds per acre or higher (table 2). Dipropalin improved in effectiveness by increasing the rate from 4 through 8 pounds per acre. A slight trace of injury suggested the 6 to 8 pound rates were approaching the tolerable maximum. Trifluralin gave good crabgrass control at rates of 2 through 6 pounds. Injury observations suggested 6 pounds was near the maximum rate.

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[1] Professor in Turfgrass Management; formerly Research Assistant in Farm Crops; and Associate Research Specialist in Weed Control, respectively, Rutgers--the State University, New Jersey Agricultural

Table 1. Crabgrass control obtained with advanced pre-emergence herbicides. New Brunswick, New Jersey. 1961.

Chemical	Rate/A	Treatment Date	Crabgrass Control %
calcium arsenate	525	March	79.4
calcium propyl arsonate	40	May	40.5
chlordane	80	May	77.2
dacthal	12	March	94.1
diphenatrile	45	May	62.2
zytron	20	May	96.8

Table 2. Pre-emergence crabgrass control obtained with three chemicals at three different rates of application in March. New Brunswick, New Jersey. 1961.

Chemical	Carrier	Rate/A	Crabgrass Control %
bandane	clay	10	8.3
"	"	20	37.2
"	"	30	61.6
dipropalin	vermiculite	4	49.4
"	"	6	59.9
"	"	8	76.6
trifluralin	vermiculite	2	80.0
"	"	4	91.7
"	"	6	96.2

Dry application gave consistently higher crabgrass control ratings than applications made with water as a carrier. The influence of carriers was great with bandane, chlordane, and dipropalin; however, it was comparatively small for trifluralin and zytron.

Summary

1. Dacthal, trifluralin, and zytron gave 94 to 97 percent pre-emergence crabgrass control as used in 1961.

2. Bandane, diphenatrile, dipropalin, chlordane, and calcium arsenate gave crabgrass control that ranged from 62 to 79 percent.

3. Bandane, dipropalin, and trifluralin treatments suggested the respective optimum treatment rates of 30 pounds or higher, 4-8 pounds, and 2 to 6 pounds per acre.

4. Dry applications of several chemicals were more efficient than water application of the same chemicals. The degree of dif-

THE EFFECT OF THREE SPRING DATES OF PRE-EMERGENCE HERBICIDE APPLICATION ON CRABGRASS CONTROL IN ESTABLISHED TURF

R. E. Engel, R. N. Cook, and R. D. Ilnicki [1]

Abstract

The effect of date of treatment on pre-emergence crabgrass control in turf was studied with eight herbicides and three treatment dates. Bandane, calcium arsenate, calcium propyl arsonate, chlordane, dacthal, diphenatrile, trifluralin, and zytron were applied on March 29, April 20, and May 17, 1961. All treatments were in triplicate on a lawn turf with a predominance of Kentucky bluegrass. The spring season and crabgrass germination were approximately 2 to 3 weeks later than normal.

Crabgrass estimates taken in September showed: (1) calcium arsenate and dacthal gave best results when applied in March; (2) chlordane, diphenatrile, and calcium propyl arsonate gave their highest ratings as May treatments; and (3) trifluralin and zytron produced good control at all three dates. Bandane gave its highest rating with March application, but it did not appear to be affected severely by treatment date. Since this chemical is closely related to chlordane, it is of interest to note that chlordane had given better control with early spring treatment in previous seasons. Results show clearly that application date is an important factor in pre-emergence crabgrass control. Chemicals vary in specificity and range of satisfactory treatment dates.

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THE RECOVERY OF C^{14} AMIBEN FROM A TYPICAL GREENHOUSE TYPE SOIL

by M. L. Sutherland[1]

INTRODUCTION

The effectiveness and dependability of a soil active herbicide is greatly influenced by such variables as leaching, photodecomposition, bacterial decomposition, and adsorption by soil colloids. If a chemical method for the compound in question is not available a bioassay technique is often utilized to measure the residual activity of a herbicide. However, with bioassay techniques alone it is difficult to determine which of the above variables is contributing to the disappearance of the herbicide being studied. Bondarenko in 1958 demonstrated with C^{14} labeled ATA the utility of tagged materials in following their fate in soils. (1)

The work reported in this paper is actually a by-product of a C^{14} Amiben tracer study in soybeans. Pre-emergence treatments of C^{14} Amiben were applied to containers in the field on June 20, 1961. Periodic soybean plants were harvested from the treated containers up until October 20, 1961. Examination of the treated soil at that time revealed a considerable amount of radioactivity was still present.

It was then decided to investigate the nature of this radioactivity. Steps were taken to: 1) determine the distribution of the radioactivity in the soil, 2) determine if any of the radioactivity could be attributed to Amiben and 3) determine if any of the radioactivity was available to germinating soybeans.

METHODS AND MATERIALS

Experimental conditions for C^{14} Amiben field tracer study:

Nine terracotta tile cylinders 18 inches in diameter by 24 inches long were sunk in the ground so that only 2 inches protruded above the soil surface. The soil used to fill the containers was a normal greenhouse mixture consisting of 5 parts of a field soil with a heavy loam texture mixed with one part of concrete sand. An appropriate amount of lime and complete fertilizer were also added.

Treatments consisting of 0, 3 and 6 pounds per acre of Amiben, replicated three times, were applied directly to the soil surface. Fifty percent of the Amiben in the 3 pound per acre treatment and 25 percent of the Amiben in the 6 pound per acre rate was C^{14} carboxyl tagged material whose specific activity was 1.1 mc/mM. This amounted to 147 microcuries of C^{14} Amiben on each treated cylinder.

The treated containers received a total of 8.9 inches of water during the growing period from June 20 to September 28, 1961.

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Distribution of radioactivity through soil profile:

A procedure was developed where layers of soil in 1/8" increments could be counted directly in a gas flow, windowless proportional counter. A stainless steel tube with 1/8" wall, 1 3/4" diameter, and 6" long was sharpened on one end. This tube was forced by hand into the treated containers with a rotary motion until only 1½" of the tube remained above the soil surface. Moisture conditions were such that the soil remained inside the steel tube when it was pulled back out of the soil. The core was then extruded out the top of the tube 1/8" at a time by inserting 1/8" shims at the bottom. Since the planchets used for counting the soil were only 1¼" in diameter this allowed ¼" of the outer edge of the soil layer to be trimmed away. This minimizes any shifting of the soil profile due to friction between the soil core and the tube as the core was first formed or extruded. Planchets containing the soil layers were dried at 125° C for one hour prior to counting.

Chemical recovery and identification of radioactivity from different soil levels.

Larger samples of ½" soil layers for chemical analysis were collected in a very similar fashion to that described previously. The aluminum tube used to obtain the coil core had a 1/8" wall and measured 4" in diameter and 10" long. The tube was forced into the ground by hand and a soil core 4½" deep was removed. The soil core was extruded out the top in ½" increments and collected in a petri dish. The average dry weight of each ½ layer was 80 grams.

Fifty grams of soil from each ½ layer was placed in a 250cc beaker and mixed with 50cc of a 10% $Ba(OH)_2$ solution. The mixture was boiled on a hot plate for 30 minutes with occasional stirring. The slurry was then transferred to high density polyethylene centrifuge bottles and centrifuged at 2500 rpm for 10 minutes. The supernate was decanted into a 250cc beaker and the precipitate resuspended in 25cc boiling water and centrifuged. The combined supernates were adjusted to pH 2.5 with concentrated H_2SO_4. The barium sulfate that was formed was removed by centrifugation and supernate decanted off. The barium sulfate was resuspended in 15cc water and centrifuged. The pH of the combined supernates was readjusted to 2.5 and extracted with three 25cc portions of diethyl ether. The ether extract was backwashed with 5cc of pH 3 water. The ether extract was then placed in a 125 round bottom flask containing 5cc of methanol and evaporated to 5cc on a rotating flash evaporator. The 5cc of methanol concentrate was transferred to a 10cc stoppered graduate and diluted to 10cc with methanol. One milliliter aliquots of this concentrate were pippetted directly onto a stainless steel planchet with raised concentric rings in the floor (Nuclear - Chicago Corp. GC -12 sample pan). The planchets were dried on a rotating platform under an infra-red lamp located approximately 6" above the samples. The samples were heated several minutes after all of the volatile liquid appeared to have disappeared and then counted.

Availability of the radioactivity in the various soil levels to germinating soybeans:

Twenty Monroe soybeans were planted in each ½" x 3½" petri dish containing ½" layers of soil from each treatment. Only the three ½" layers from the top 1½" of soil were sampled. The petri dishes were placed on sand containing a heating cable to maintain the bench temperature from 75°C to 80°C. The seeds were allowed imbibe for four days and were then removed from the petri dishes. Soil was washed off and the seed coat was removed from each seed to minimize any surface contamination.

Analysis of the imbibed seeds included an alkaline digest to hydrolyze any Amiben plant complex. The 5 to 6 grams of soybean seeds were ground in 25 grams of glycerol with a mortar and pestle and transferred to a 2½ cm x 20 cm test tube. Five grams of KOH pellets was added and the contents mixed with a thermometer. The test tube is then immersed in a 150°C oil bath for 15 minutes. The test tube is adjusted in the oil bath so that the glycerol reflures on the walls of the test tube and only a minimum amount of stirring is required.

After the hydrolyses is completed the contents of the test tube is transferred to a 250cc centrifuge bottle with the aid of 50cc of distilled wash water. The solution is then acidified with concentrated H_2SO_4 to a pH of 1 or lower. The fatty acids that are precipitated on addition of the sulfuric acid are removed by extracting the acidic solution with two 25cc portions of petroleum ether. Any emulsions that were formed were readily broken by centrifugation. The pH of the solution was adjusted to pH 2.5 with NaOH and the solution was then extracted with three 25cc portions of diethyl ether. The evaporation of the diethyl ether and plating of the methanol concentrate is the same as outlined previously for the recovery of radioactivity from the soil.

The radioactive solutions obtained from the analysis of the treated soil and imbibed soybeans were examined by one dimensional paper chromatography. Sheets of Whatman No. 4 filter paper 23 cm by 19 cm were used in an ascending chromatagraphic tank. The development solution used was two parts n-butanol : one part 3-A alcohol : one part 2 N NH_4OH. The sheets were scanned after development with a windowless gas flow detection head connected to a scaler. C^{14} Amiben standards were located on either side of unknown spots for accurate comparison.

RESULTS

The distribution of radioactivity in the top four inches of soil four months after a 6 #/A treatment of C^{14} Amiben can be seen in Graph I. It is to be noted that the highest concentration of radioactivity is found in the layer of soil 1/8" to 1/4" below the soil surface. From that point on there is a gradual decline in radioactivity. Direct counting of untreated soil under the same conditions yields an average of 13 counts per minute of above background due to the naturally occurring radioactivity K^{40}. The low counts received therefore, from the 3" to 4" layer are still greater than that received from the untreated soil.

The comparison in distribution of radioactivity between the 3 #/A treatment and the 6 #/A is shown in Graph II. Here 1/2" soil layers were collected and counted directly. Obviously one does not obtain as quite a clear picture of the radioactive distribution when 1/2" layers are counted as compared to 1/8" layers. The close similarity in counts received between the 3 #/A and 6 #/A treatments is understandable since both applications contained exactly the same amount of C^{14} Amiben. If Graph II had been drawn to show the total amount of Amiben for each layer instead of the C^{14} fraction then the relative length of the bars for the 3 #/A rate would be twice as long as indicated while the bars for the 6 #/A rate would be four times as long.

Of the various chemical procedures tried a barium hydroxide digestion was the most efficient in removing the radioactive components from the soil. The choice of this particular alkali was based upon the work conducted by Ercegovich in recovering Amitrole from the soil. (2)

Table I is a summary of the results of analyses of the various soil layers using the barium hydroxide digestion. In each case only a part of the radioactivity is removed. For instance the alkaline digestion of 50 grams of soil from the 0-1/2" layer only decreased the counts from 457 c/m to 295 c/m. This drop of 162 c/m from the soil surface represents a recovery of 62,420 c/m in the purified extracts. By plotting the recovery data in Table I from the various layers of soil it is possible to approximate the total amount of radioactivity present in the soil. If one assumes that all of the radioactivity in the top four inches of soil is Amiben then this would account for approximately 17% of the Amiben that was originally applied.

Paper chromatography was used to examine the alkaline digests to determine how much of the recovered radioactivity could be attributed to Amiben. Examination of the Rf values in Table I indicates that the activity recovered from the lower two layers was not Amiben. It may be a complex of Amiben that is stable to the alkaline digestion used or possibly an entirely different compound synthesized by soil organisms utilizing C^{14} from Amiben.

GRAPH I - Distribution of radioactivity in the top 4" of soil four months after a 6#/A treatment of C^{14} Amiben.

```
SOIL       COUNTS PER MINUTE ( direct counting of soil )
DEPTH
                   100       200       300       400       500       600
  0"   ---------/---------/---------/---------/---------/---------/------
       XXXXXX 418 XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
       XXXXXX 679 XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
       XXXXXX 589 XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
       XXXXXX 416 XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
       XXXXXX 350 XXXXXXXXXXXXXXXXXXXXXXXX
       XXXXXX 357 XXXXXXXXXXXXXXXXXXXXXXXXX
       XXXXXX 248 XXXXXXXXXXXXXX
  1"   XXXXXX 226 XXXXXXXXXXXX
       XXXXXX 191 XXXXXXXX
       XXXXXX 213 XXXXXXXXXX
       XXXXXX 200 XXXXXXXXX
       XXXXXX 178 XXXXXXX
       XXXXXX 209 XXXXXXXXXX
       XXXXXX 174 XXXXXX
       XXXXXX 148 XXXX
  2"   XXXXXX 149 XXXX
       XXXXXX 132 XX
       XXXXXX 117 X
       XXXXXX 116 X
       XXXXXXXXX   92
       XXXXXXXX    81
       XXXXXXX     68
       XXXXXX      63
  3"   XXXXXX      56
       XXXXXX      61
       XXXXXX      56
       XXXX        35
       XXXX        38
       XXXX        44
       X           14
       XX          16
  4"   XX          21
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GRAPH II: Comparison of the distribution of radioactivity in soils treated with 3# and 6#/A C^{14} Amiben four months after application

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        3#/A Amiben (50%)C14)                         6#/A Amiben (25% C14)

Soil        Counts per minute                 Soil      Counts per minute
Depth         100   200   300   400           Depth        100   200   300   400
 0"       -----/-----/-----/-----/             0"       -----/-----/-----/-----/
          XXXXXXXXXXXXXXXXXXXXXXXXX                     XXXXXXXXXXXXXXXXXXXXXXXXXXX
          XXXXXXXXXXXXXXXXXX 425 XX                     XXXXXXXXXXXXXXXXXXXX 485 XX
 1/2"     XXXXXXXXXXXXXXXXXXXXXXXXX            1/2"     XXXXXXXXXXXXXXXXXXXXXXXXXXX
          XXXXXXXXXXXXXXX                               XXXXXXXXXXXXXXX
          XXXXXXXX 254 XX                               XXXXXXXX 244 XX
 1"       XXXXXXXXXXXXXXX                      1"       XXXXXXXXXXXXXXX
          XXXXXXXXXXXXX                                 XXXXXXXXX
          XXXXXX 224 XX                                 XX 153 XX
 1 1/2"   XXXXXXXXXXXXX                        1 1/2"   XXXXXXXXX
          XXXXXXXX                                      XXXXXXXXX
          XX 163 X                                      XX 152 XX
 2"       XXXXXXXX                             2"       XXXXXXXXX
```

TABLE I: Recovery and identification of C^{14} activity from soil four months after a 6#/A treatment of C^{14} Amiben.

Soil Depth	Direct counting of Soil		Radioactivity recovered	R_f
	before hydrolysis	after hydrolysis		
0"-1/2"	457 c/m	295 c/m	62,420 c/m	0.58
1/2"-1"	266 c/m	195 c/m	39,420 c/m	0.58
1"-1 1/2"	171 c/m	112 c/m	35,430 c/m	0.50
1 1/2"-2"	167 c/m	113 c/m	34,150 c/m	0.42

The analyses of soybeans germinated in 1/2" layers of soil previously treated with 6 #/A of C^{14} Amiben are tabulated in Table II. These results are strikingly different than those received from the soybeans originally planted in this same soil just prior to application of the chemical. In that case 222,500 c/m were recovered from a comparable stage and weight of soybean. In addition paper chromatography of the radioactivity recovered from the soybeans treated pre-emergent revealed that the material was Amiben. Rf values found in Table I clearly indicate that the radioactive component absorbed by the soybeans planted in soil 4 months after application was not Amiben.

The results reported in this paper do not eliminate the possibility that significant losses may also occur by way of leaching, photodecomposition or microbial breakdown.

TABLE II: Recovery of C^{14} activity from imbibed soybean seeds planted in different layers of soil 4 months after a 6 #/A treatment of C^{14} Amiben

Soil Depth (inches)	Seed Weight (gm)	Radioactivity Recovered	Rf *
0 - 1/2"	5.6	2,220 c/m	0.34 - .41
1/2 - 1"	5.1	1,560 c/m	0.34 - 0.41
1 - 1 1/2"	5.3	53 c/m	---

* Rf value for Amiben in same tank 0.55

SUMMARY

Normally the herbicidal activity of Amiben disappears within 6 to 8 weeks after application to soil. It was generally believed that this loss of activity was due to an actual disappearance of Amiben by either leaching, photodecomposition or microbial decomposition. A tagged field tracer study is described that showed significant amounts of Amiben still remained in the soil four months after an application of 3 #/A and 6 #/A rates of C^{14} Amiben.

Of the various methods tried, an alkaline digestion was found to be the most efficient in recovering radioactive material from the soil. Most of the radioactive material removed by digestion was identified as Amiben by paper chromatography. However, the majority of the radioactivity still remained tightly bound to the soil even after repeated alkaline digestions.

The distribution of radioactivity resulting from an application of C^{14} Amiben to the soil surface was determined by direct counting of soil collected in 1/8" segments from the soil profile. The highest concentration of radioactivity was in the layer of soil located 1/8" to 1/4" below the soil surface.

Soybeans germinated in the top 1/2" layer of four months old treated soil contained 2,200 c/m. In contrast when the soybeans had been planted in the soil just prior to the application of C^{14} Amiben and harvested 5 days later the plants contained 100 times as much radioactivity. Furthermore, chromatographic examination of the soybeans planted in the soil four months after application of C^{14} Amiben revealed that the small amount of radioactive component present was not Amiben. In contrast it had previously been shown that the majority of radioactivity found in soybeans planted just prior to the treatment was Amiben.

It is hoped that the availability of the chemical methods described in this paper will encourage other investigators to examine various soil types for their ability to combine with Amiben so tightly that it is not biologically available.

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