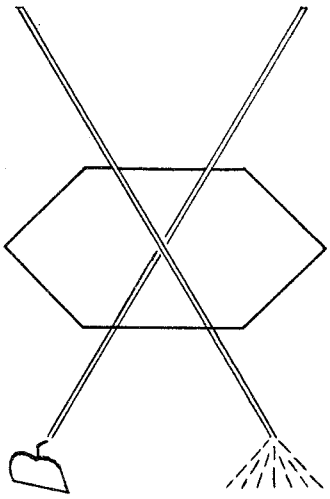
PROCEEDINGS



Fourteenth

WESTERN WEED CONTROL CONFERENCE

1954

Tucson, Arizona

March 22, 23, 24

PROCEEDINGS

OF

THE FOURTEENTH
WESTERN WEED CONTROL CONFERENCE

TUCSON, ARIZONA

MARCH 22-24, 1954

OFFICERS OF THE WESTERN WEED CONTROL CONFERENCES

Fourteenth (1954)

President: C. I. Seely
Department of Agronomy
University of Idaho
Moscow, Idaho

Vice President: Rex Warren
Department of Farm Crops
Oregon State College
Corvallis, Oregon

Secretary-Treasurer: W. A. Harvey
Department of Botany
University of California
Davis, California

Fifteenth (1956)

President: W. S. Ball
State Department of Agriculture
Sacramento, California

Vice President: W. A. Harvey
Department of Botany
University of California
Davis, California

Secretary-Treasurer: W. C. Robocker
Section of Weed Investigations, USDA
Nevada Agricultural Experiment Station
Reno, Nevada

TABLE OF CONTENTS

* * * * *

THE CONTROL OF PERENNIAL WEEDS WITH GROWTH REGULATING TYPE HERBICIDES

Lowell W. Rasmussen
Department of Agronomy, Washington State College, Pullman, Washington

The control of weeds depends upon several factors which should be kept in mind regardless of whether weeds are to be controlled by the use of growth regulating herbicides, soil sterilizing herbicides, clean cultivation, or other methods. Often it is thought that if the plant can be identified, a control measure can be specified; this, however, certainly does not follow. The plant species is an important factor in determining the method of control and the effectiveness of the method of control, but other factors also must be considered. The location of a weed infestation is important to the control method inasmuch as location may have a bearing on soil type, soil moisture, moisture availability throughout the year, temperatures, day length, and competition with other species. All of these factors have a bearing on the growth and development of a plant species which in turn affects its reaction to herbicides or other control treatments. Weed infestations which occur in agricultural lands are affected by the land use and management being carried out on the area. Whether the land is plowable crop land, permanent pasture, or range land, the land use practices definitely affect the growth and development of the weed plants. Other reports on this panel and occurring in this publication deal with clean cultivation and cropping competition as methods of weed control and it was pointed out in these reports that the land use has a definite bearing on the effectiveness of such methods in controlling weeds. The size of weed infestations also determines to a certain extent which method of control should be used.

The use of growth regulating type herbicides which do not cause soil sterilization have particular merits for controlling weeds in plowable land where it is desirable and necessary to continue crop production as much as possible. In many cases it is possible to use a growth regulating type herbicide simultaneous with crop production since these herbicides are selective for certain weeds in certain crops.

The control or killing of perennial weeds by growth regulating type herbicides is affected by certain plant characteristics. For example, the morphological characteristics of the vegetative portion of the plant as well as the root systems have a definite bearing on the effectiveness of the herbicide. A herbicidal material which is sprayed on plants has to get into the plant to be effective; consequently, the characteristics of the leaf surface play a major role. The relative number and location of stomatal openings on the leaf surface has a bearing on the entry of herbicides. The nature of the cuticle and the leaf hairs have a bearing on the entrance of the herbicide. Furthermore, the size and shape of the leaves may affect the interception and retention of herbicidal sprays. The root systems of perennial weeds are of prime significance in determining whether or not the plant can be controlled by non-soil-sterilizing chemicals inasmuch as the plants can regenerate from such root systems and if the plants are to be killed the chemical must be moved from the aerial portion into the root system in sufficient quantity to inactivate that system. The more extensive the root system and better it is supplied with food reserve materials the more it is likely to resist the action of non-soil-sterilizing chemicals.

Certain physiological processes are significant from the standpoint of the action of growth regulating herbicides. Growth processes, particularly the regeneration and growth of shoots from the root system, have a bearing on whether or not the plant can be killed. Any chemical which does not move into the root system and inhibit such regeneration will not be effective in controlling that weed species. Furthermore, the rate of vegetative growth is related to the composition of the plant, and this in turn relates to the reaction to growth regulating sprays. The differentiation processes that take place in perennial plants relates to the reaction to herbicides inasmuch as it affects the leaf surface characteristics, the cellular composition, and the quantity of reserve food supplies. It has been shown in numerous studies that conditions which tend to inhibit or restrict growth processes tend to favor differentiation processes and these in turn bring about a condition in the plant which generally makes for higher resistance to herbicidal chemicals.

In tests at Washington State College the growth regulating materials, 2,4-D, 2,4,5-T, and MCP, have been used in tests over a period of several years to determine their effectiveness for the control of Canada thistle and morning glory. Single applications of any of these chemicals has never proved sufficient to kill these deep rooted species. On the other hand, with repeated application over a period of two or more years the growth can be sufficiently inactivated to cause the death of the plants. In a study initiated in 1948 comparison was made between the effectiveness of 2,4-D and 2,4,5-T when applied at three different rates of application at three different times in the development of Canada thistle. It was found that 2,4-D applied at the bud stage of development and at a rate of two pounds per acre gave the most complete kill of the plants. Applications made at the early bloom stage of development were nearly as effective as those at the bud stage, but failed to suppress all seed formation. In the infestation where this test was conducted, the thistle was very vigorous and no effect of the chemical was evident until after two years of treatment. After four years making one application each year, many of the plots were completely free of any thistle plants.

Early tests on morning glory or bindweed indicated that applications made in May when the plants were growing vigorously gave rapid kill of the top growth but very little effect on the root system. In later tests it was postulated that if applications could be made to a succulent growth during the fall of the year when carbohydrates were normally being translocated into the root system more of the 2,4-D might be moved into the root system and effect greater kill. Furthermore, it was reasoned that treatment at that time of year could not be overcome so readily since the plant would not be able to regenerate during the late fall or winter time and thereby overcome the effects of the chemical. A test to study these postulations was initiated on bindweed and it was found that the root kill was very much increased. In some cases 90 to 95% kill of a stand was achieved with one fall application. It must be re-emphasized that this fall application must be made on a succulent growth. Later tests were made on Canada thistle to determine the relative effectiveness of fall applications and here also it was found that the damage to the root system was very much more extensive than where applications were made during the active growing season. For the control of perennial weeds on crop lands this practice can be very effective inasmuch as the weeds can be kept in a succulent condition by periodic cultivation during the early season

and then allowed to make an abundant vegetative regrowth in the late summer. The 2,4-D should be applied around the first part of September or in any case three to four weeks previous to the expected fall killing frost. In areas such as eastern Washington where the normal cropping is fall wheat, a late summer application of 2,4-D must be made a month to six weeks previous to the time the wheat is to be seeded in order to avoid toxic effects to the wheat. If a month to six weeks time lapse is allowed between treating and seeding there has not occurred any ill effect to the wheat. Tests have been run both on morning glory and Canada thistle in wheat fields and the result has been a marked reduction of the weeds and after two years a very substantial increase in the yield of wheat.

THE PLACE OF SOIL STERILANTS IN A WEED CONTROL PROGRAM

Paul J. Torell
President, Idaho Noxious Weed Association, Moscow, Idaho

I accepted a place on this panel to discuss soil sterilants with considerable apprehension because I do not in any sense of the word regard myself as an expert on soil sterilants. I was also apprehensive because I was not quite sure what was precisely wanted. Should it be research, theory, or practical field use? In an attempt to find something new or interesting on soil sterilants, I scanned the recent literature on herbicides. After completing this task my apprehension increased. With the exception of several relatively new materials, there was very little recent information on soil sterilants. Also, from my experience in Latah County I can say that soil sterilants are being used very little by the farmers as a whole.

This leads me to pose this question: Do soil sterilants still have a place in a weed control program on agricultural land?

In seeking an answer to this question a brief appraisal of the perennial weed problem is in order. In this regard, for the sake of time and brevity, I would like to cite an example of one meeting and one weed.

The one meeting was that of the Board of Directors of the Idaho Noxious Weed Association which I attended last month at Boise. At this meeting one weed, Canada thistle, received the major consideration. After threshing over the pros and cons of this weed, the group was pretty well agreed on two rather disturbing conclusions: (1) Over the State as a whole, the Canada thistle problem is not getting better; it is not remaining static; it is getting worse. (2) The principal reason why thistles are getting worse is the galling fact that the present control and eradication methods that we have are not being used to the extent nor as effectively as they should be to get the upper hand on thistles. Certainly it was agreed that the methods we have, namely, soil sterilants, the hormone sprays, clean cultivation, and competitive cropping are far from perfect. These methods can stand plenty of research in themselves, and also new materials that research might develop certainly could be used. Notwithstanding this obvious point, the problem of immediate concern is the fact that the teaching of weed control methods to the farmers, who in the end are our ultimate weed killers, has lagged behind research.

One of the major reasons why our educational program has not been nearly so successful as it could be is the fact that numerous weed control programs have literally flopped flat on their faces because they attempted to "put all their eggs in one basket" by depending on one method alone. This results in a not-too-successful type of weed control specialization in one method. In Latah County we have three different specialists whom I think have their cohorts elsewhere. One is the chlorate specialist. He believes in the scorched earth policy for all perennial weeds. Four pounds to the square rod; no, a can to the patch is better. Another is the 2,4-D specialist who seeks to live with the thistles. The third specialist is the clean cultivation man. He does nothing till the thistles get so bad he can't raise anything, then he fallows for a summer. And finally, we have the person who aspires to become a specialist by insisting on an answer to the one question: What is the best way to get rid of morning glory, and so forth. As the thistles and other perennial weeds get worse these specialists often will literally throw up their hands and quit. Their weed control program has, indeed, flopped.

To us, I think the moral is that somewhere along the line we have missed the boat in not stressing a need for a balanced weed control program where soil sterilants along with other methods and materials have a certain definite place. Though new materials may cause certain shifts and adjustments in order to keep soil sterilants in their proper perspective with a given weed control problem, they do have a definite place.

In order to specifically assign soil sterilants to their proper place, it should first of all be realized that there never has been and probably never will be a definite formula that will provide any easy answer for all instances where a soil sterilant is indicated. For each region, state, county and area within a county it becomes a matter of individual judgment based on research and past experience together with a liberal sprinkling of plain common sense to determine what, where, how, and when a soil sterilant will be used. Perhaps the closest single criterion for the use of a soil sterilant is to weigh the major disadvantage of these materials against their chief advantage. On the negative side the conspicuous disadvantage is high cost. On the positive side the notable advantage is one of speed of eradication. In general, then, it might be said that where speed of eradication outweighs a relatively high cost, then a soil sterilant moves into its proper place in a weed control endeavor. Such instances will normally be found where high unit costs can be tolerated on areas small enough that the absolute cost does not become prohibitive and where the cost can be justified as a protective measure. In this regard three instances might be cited where this condition might be meant:

1. To eradicate small perennial weed infestations before they spread and become large patches.

2. To eradicate stray straggling weeds following clean cultivation.

3. To eradicate small patches of weeds on waste land not accessible to tillage equipment.

A second consideration is that of which sterilant to use. Again in a broad way, the answer must not fail to recognize that just as there is seldom a one best method of weed control, so there is seldom a one best soil sterilant

for all weed problems. All chemicals have their particular places. For example, in Latah County sodium chlorate is of major importance on such weeds as Canada thistle and morning glory. However, it has not replaced borax for the eradication of small patches of goatweed (and I might inject that neither have the goatweed beetles). For small patches of white top and Russian knapweed, carbon bisulphide has a very limited, but yet a very important place in Latah County. Finally, for small infestations of quackgrass, TCA is often more desirable than sodium chlorate.

In summary then, I would say soil sterilants do have an important place in a weed control program chiefly as protective instruments to keep a small infestation of perennial weeds from jeopardizing large areas of clean land. Unfortunately, the true position of soil sterilants has suffered some abuse mainly because of two extremes: (1) Those who mistakenly attempt to treat large areas with sterilants, and (2) those who try to replace sterilants entirely with would-be easy methods, such as by squirting only 2,4-D.

To use Latah County as a whipping post once more, I would say that we would like to see a lot of farmers use a small amount of chlorate rather than see a few farmers use a lot of chlorate. We would like to see farmers having no more goatweed than what 100 pounds of borax would take care of, and to use the borax rather than sit back and holler for goatweed beetles!

CROPS PLAY A VITAL ROLE IN PERENNIAL WEED CONTROL

D. C. Tingey
Utah Agricultural Experiment Station, Logan, Utah

Weeds and crops have at least one thing in common and that is they both depend on man for their perpetuation. It is largely because of crops that we have weed problems. Weeds would probably survive longer in competition with natural vegetation than would crops. Since both weeds and crops are adapted to similar conditions, through faulty land management, they are often in serious competition with each other. Crop plants and varieties have been selected for purposes other than to compete with weeds, and it would be only by accident if they were highly successful in doing so. While crop plants play a vital role in weed control, they, in general, are not able to survive in competition with weeds without some protection. Where weeds have become serious, it is because they are better adapted than the crop, and the land management has been such as to provide conditions more favorable to the weed than the crop. The protection which is so essential to crop survival was obviously lacking. Some crops are much more effective in competition with weeds than others. In addition, certain crops because of the way they are grown, make it easy for the farmer to give the necessary protection.

Farmers can give the most effective protection to the crop by destroying the weed. Man is constantly searching and devising new and improved ways to accomplish this. Elimination or reduction in weed competition may be done through cultivation, mowing, pasturing, smothering, burning and use of herbicides, or by managing the crop so that it will be well advanced in stage of growth before the weed becomes competitive, or by planting the crop after the weed ceases to be competitive. Crops that do well in cool seasons have an

advantage over weeds that grow only in warm seasons. Likewise, warm season crops have an advantage over those weeds that grow only in cool seasons.

A successful farmer manages the land through the right selection of cropping programs combined with effective tillage practices, and by other means available to him to prevent perennial weeds from becoming serious; or if he acquires land that is infested, he will use similar methods to rid the land of the infestation.

Crops Vary in Their Usefulness in Weed Control

Based on the method of production, crops may be classified into two groups. They are either row crops or non-row crops. A number of crops may be grown in either way. Non-row crops, or those grown in solid stands, may be re-divided into two classes: perennials, grown largely for pasturage and hay, and annuals grown for seed, hay, or pasturage. Crops within one of these classes are not of equal value on perennial weed infested land. Each group has its advantages and disadvantages in weed control. Wherever possible, crops should be selected from the different groups and grown in rotation. This makes it possible to capitalize on all the advantages possessed by the three classes of crops in addition to the favorable effects of the rotation.

Row Crops: Crops are grown in rows to allow for inter-tillage or cultivation, a practical, effective, and economical method of eliminating or reducing the competition from weeds. Since man settled down and began to grow his own food, instead of wandering around in the wilderness in search of it, he has undoubtedly been confronted with weed-control problems. A savage would not have to be a biometrician to realize that weeds were robbing him of some of his food. At first, his implements of cultivation were crude, but they have continued to improve until now there are numerous devices for taking weeds out of crops. The modern techniques developed for taking annual weeds out of sugar beets are spectacular. It is evidence of what can be accomplished when a group of people with determination set out to improve methods of weed control by tillage methods.

Some of the more important row crops are corn, cotton, potatoes, sugar beets, beans, sorghums, sunflowers, grasses, clovers, alfalfa grown for seed, and most horticultural and vegetable crops.

Some of these crops may be planted in hills to provide for cross cultivation which is a further advantage in perennial weed control. Growing crops in hills and cross cultivating is a close approach to cultivation without cropping. The effectiveness of this method of weed control is well known (11).*

Some recent studies at the Utah Agricultural Experiment Station indicate that corn planted in hills, on land infested with perennial ground cherry, and cultivated both ways without any hoeing will yield about as well as corn cultivated one way and the weeds hoed out within the row. In other studies, with corn grown for silage on morning-glory or white-top infested land and cultivated at two-week intervals, weeds have been eradicated in three years and, at the same time, high yields of silage have been produced (12 and 13). The cultivation method is non-selective and can be used on any weed.

*Reference to literature cited.

Some of the taller, more rapidly growing leafy row crops such as corn, sorghums, and to a lesser extent sunflowers, serve as smother crops by shutting out the sunlight with their heavy vegetative growth late in the season when cultivation is not possible without "high-boy" cultivators. This lack of light greatly retards and prevents some species from making any growth (2).

Furthermore, tall-growing crops also permit the use of general herbicides applied under the leaves next to the base of the plants to control certain species of weeds resistant to selective herbicides. Some of these row crops are also resistant to selective herbicides which may also be used on susceptible perennial weeds.

Some row crops such as sugar beets, potatoes, and beans are not desirable for planting on perennial weed-infested land because they do not provide sufficient growth for smothering after they are too far along to cultivate (12). Often the mere shifting from one crop to another will solve a serious weed problem. Morning glory is a serious problem in sugar beets, but it ceases to be much of a problem in a crop like corn which can be planted in hills to provide for cross cultivation. It becomes an even lesser problem if the area is seeded to a good pasture mixture of grasses and legumes and grazed with livestock. The weed problem may, however, reappear when the land is plowed out of pasture, but it will be less severe (6).

Perennial weed control in orchards and some small fruit plantings, because of the way they are grown should present no serious problem.

Strawberries, like some of the field crops and many vegetables, are not suitable for growing on land infested with perennial weeds. If grown on such lands, the problems of weed control are more difficult. For some of these crops, however, the returns per acre are relatively high in comparison, and they can justify more expensive methods of weed control.

Perennial Pasture and Hay Crops: Perennial crops grown for pastures and hay also serve a valuable purpose in weed control. These crops hold the weeds in control with the minimum of effort on the part of the farmer. Ordinarily, with these perennial hay and pasture crops, complete eradication of perennial weeds does not occur, but they are valuable in keeping these weeds from spreading (1, 2, 4, 6, and 12). They often reduce the weed density and weaken the weeds so that they are easier to control when plowed up and the land placed in row crops and cultivated. Frequent clipping of perennial grasses has been shown to eradicate morning glory completely (10). Some of the more common crops in this group are grasses, clover, and alfalfa.

Annual Crops Grown in Solid Stands: The third group consists of annual crops usually grown in solid stands, and harvested as seed, hay, or pasturage. Included in this group are all the small grains, flax, sudan, soybean, rape, millet, and even corn and sorghums. Many crops in this group also serve effectively in perennial weed control. Since some of them are short-seasoned crops, it is possible to use cultivation to advantage either before the crop is planted or after harvest (1, 8, and 9). It is with members of this group where 2,4-D has had its greatest success.

Crops in this group, if managed properly even with weeds resistant to selective herbicides, can be used effectively to control perennial weeds.

When used in combination with tillage or herbicides, some weeds can be completely eradicated (3, 9, 11, 12, and 13).

In studies at the Utah Agricultural Experiment Station under irrigation, fall-sown wheat in combination with tillage has proved to be an effective means of eradicating perennial weeds that make their most rapid growth during the summer months, such as morning glory, Canada thistle, and perennial sow thistle (12). The method consists of sowing a stiff-strawed variety of wheat in the early fall between September 1 to 15, in a well-prepared moist seedbed. It is desirable to make plowing part of the seedbed preparation. The plowing and cool nights retard the weed growth to the extent that there is no further surface growth during the fall. During the following season the soil is kept moist by irrigation to stimulate a dense leafy growth which serves to shut out the light and retard the weed growth. As soon as possible, the crop is harvested and the land plowed or cultivated immediately. Weed growth is kept down by cultivating as needed until time for replanting. With susceptible species herbicides may be used in addition (13). Wheat, however, is often headed before the weeds emerge sufficiently to justify spraying, and at this critical stage, it would be unwise to use 2,4-D.

For those perennials that make their growth in the fall and early spring, like white top, a different technique is employed (12 and 13). In this case, a spring sown grain crop is used. Barley is well suited for the conditions in Utah though wheat or oats could be used instead.

The method consists of plowing the white top under in the early bud stage or before, preparing a good seedbed and planting immediately. The soil should be moist to encourage early emergence. Barley is sown at the rate of 2 bushels to the acre.

Other details of the procedure are the same as for fall wheat. As previously indicated, it is desirable to use different crops to get the benefit of rotation (13). These various methods are like any others; they are dependent on timeliness and thoroughness with which the details are carried out.

Perennial Weed Control on Non-tillable Land

Appropriate crops such as smooth brome, western wheatgrass, and crested wheatgrass and in some cases, legumes, have an important place in the control of perennial weeds on non-tillable land. One of the most effective methods of controlling weeds along ditch banks is to seed desirable grasses and legumes and graze with livestock (14). This practice converts a potential weed problem into a profitable enterprise. Numerous waste areas around farms now infested with perennial weeds might be replaced by planting useful plants. To replace weedy vegetation with desirable vegetation is a field little explored but one of great potential possibilities.

Crops for Weed Control on Dry Lands

Choice of crops for use on dry lands is more limited than where the moisture supply is ample either through natural precipitation or irrigation. Because of the limited water supply, the number of perennial weeds that invade dry lands is also more restricted. Furthermore, wheat is grown in rotation with fallow. Fallow has provided a means of weed control through cultivation.

Fall-sown wheat is one of the most profitable crops adapted to these conditions. Except on the more favorable soils and with higher than average rainfall, most other crops are not as desirable as wheat. For those perennial weeds susceptible to selective herbicides, wheat is an ideal crop. For perennial weeds resistant to selective herbicides, wheat is still about as desirable as any other crop that could be grown. Wheat and fallow combined with an intensive cultivation program should provide a means of controlling these species (9).

Under dry-land conditions in Utah, except in a few areas, perennial weeds have never presented a serious problem. In the central part of the State, the rainfall limits dry-land farming largely to fall-sown wheat and grass-seed production. Under these conditions a few perennial weeds have become established. Infestation is largely spotty, and the total acreage of solid stands is small. Principal species are morning glory, perennial ground cherry, and poverty weed. Since the introduction of 2,4-D, morning glory has been somewhat reduced, but ground cherry has increased under the herbicidal program. This perennial weed problem was permitted to develop many years ago when farmers were advised to cultivate summer fallow as little as possible as frequent cultivation destroys the surface soil structure and permits erosion. Many farmers followed this program to the letter and let the weeds take over. More intensive cultivation after the crop is harvested and during the fallow year will be required to clean up these weeds. A more drastic program is 2 years of fallow which presents some erosion hazards.

These few examples have been presented to show how important crops are in the control of perennial weeds. It was not intended nor was it possible with the limited space allotted to this assignment to review all the ways in which crops aid in weed control. With the great diversity of climate throughout the Western States, the different types of agriculture, and the relative importance of various crops, there are numerous other situations where crops could and do play a vital role in perennial weed control.

Literature Cited

1. Ball, W. S. Weed control. Calif. Agr. Exp. Sta. Cir. 97. 1936.

2. Bakke, A. L. Control and eradication of European bindweed. Iowa Agr. Exp. Sta. Bul. P61. 1944.

3. Davis, C. H. and T. J. Smith. Eradication of white horse nettle in southern Arizona. Ariz. Agr. Exp. Sta. Bul. 195. 1945.

4. Harvey, W. A. Weed problems and weed control in the Yakima Valley. Wash. Agr. Exp. Sta. Bul. 448. 1944.

5. Sherwood, L. V. and R. F. Fuelleman. Experiments in eradicating field bindweed. Ill. Agr. Exp. Sta. Bul. 525. 1948.

6. Stahler, L. M. Controlling bindweed by grazing with sheep. Amer. Soc. Agron. Jour. 39: 56-64. 1947.

7. Stahler, L. M. Shade and soil moisture as factors in competition between selected crops and field bindweed (Convolvulus arvensis). Amer. Soc. Agron. Jour. 40: 490-502. 1948.

8. Stahler, L. M. and L. A. Derscheid. Cultural methods of noxious weed control in South Dakota. S. Dak. Agr. Exp. Sta. Cir. 75. 1948.

9. Timmons, F. L. Results of bindweed control experiments at the Fort Hays Branch Station, Hays, Kansas, 1935-1940. Kans. Agr. Exp. Sta. Bul. 296. 1941.

10. Timmons, F. L. Competitive relationships of different lawn grasses with field bindweed and dandelion under frequent close clipping. Ecology 31: 1-5. 1950.

11. Tingey, D. C. The comparative cost and effectiveness of tillage and chlorates in the control of morning glory, Canada thistle, and perennial sow thistle. Amer. Soc. Agron. Jour. 26: 864-876. 1934.

12. Tingey, D. C. and R. J. Evans. Effective method of controlling perennial weeds. Utah Agr. Exp. Sta. Mimeo. Series 328. 1946.

13. Tingey, D. C. and F. L. Timmons. Weeds, methods for their control and eradication. Utah Agr. Exp. Sta. Cir. 127. 1950.

14. U. S. Bureau of Reclamation. Control of weeds on irrigation systems. 1949.

COSTS OF WEEDS, AND ECONOMICS OF CONTROL

D. C. Myrick

Production Economics Research Branch, Agricultural Research Service, U. S. Department of Agriculture, Montana State College, Bozeman, Montana

Mr. Chairman and gentlemen, I welcome this opportunity to discuss with you this subject--the costs of weeds. However, you will find that my paper is in some ways a little more specific and in others more inclusive than the title, as listed on the program, might suggest. When Mr. Warren wrote to me about the possibility of such a paper, he added "and no doubt it would be an opportunity for you to outline some of the plans of your committee." I shall take advantage of that suggestion.

My first contact with this organized attack on weeds, as exemplified by the Western Weed Control Conference, the Research Section, and the Agricultural Marketing Act (RMA, Title II) sponsored regional research project W-11, Physiological and Ecological Factors of Weed Control, dates from 1949 when W-11 was organized at a meeting in Bozeman. Before that time only as a layman had I witnessed the magic of selective weed killers in fields, and even a little on my own lawn. In continued association with the research, educational, regulatory, and industry personnel in this field since that time, the diligent and extensive research and systematic scientific knowledge this magic represents have become apparent.

It was also apparent that this was, and is, a field that economists have neglected. About the only value figure that was used freely was the oft-quoted total annual loss of 3 billion dollars from weeds in the United States, reported

by the Agricultural Committee of the U. S. Chamber of Commerce in 1930. I have recently heard quoted a revised version of 5 billion dollars of more current applicability, but have not been able to trace it to its source. At any rate, I am not prepared to tamper with this figure. It seems to me that an authentic current figure of this sort would need to be built up from information not now readily available. Rather, what I propose to do is to mention briefly some of the costs of weeds, indicate the kinds of economic analyses that are needed, illustrate some analysis based on research data, discuss the data that are needed for significant economic analysis, and report some plans for economic analysis.

Costs of weeds, or losses due to weeds, have been listed and classified many times, and are well known to all of you. Therefore, my review of this will be brief and with little amplification. Most of us think of weeds in relation to agriculture. Here they compete with growth and reduce yields of desirable plants, through competition for water and light, and hence the nutrients transported by one and further synthesized in the presence of both. Their presence increases costs of power, equipment, and labor in production of crops. They require expensive control practices such as tillage and cultivation, fallow, companion crops for certain new plantings, and application of chemicals. Many of these practices in themselves depress yields. They cause losses in the product such as increased marketing costs because of cleaning or transportation of "dockage," and losses in quality which often lead to diversion of the product to lower uses. Weeds serve as alternate hosts or protective cover that harbor crop pests and diseases. Among livestock, they cause losses through fatal or debilitating poisons, through mechanical injury, and reduced quality in products such as burrs in wool and off-flavors in milk. Net effects of weed infestations are reflected in land values, a major factor in capital assets and borrowing ability in agriculture.

Weeds have non-agricultural significance also. One of their most annoying, costly, and widespread effects is the supply of pollen that causes the hay fever suffered by hundreds of thousands of us every year. They detract from aesthetic values, from dandelions in lawns to overgrown fence rows and vacant lots. They create fire hazards in numerous locations, and obstruct vision at highway intersections. Operational costs and efficiencies of transportation systems, canals and drains, and industrial establishments are increased by weed control practices and direct damage of various kinds.

One should not ignore some possible contributions of weeds, the most important of which is erosion control on newly disturbed soil. In such locations weeds frequently serve as a volunteer "companion crop" while desirable species are becoming established. Weeds, notably the Russian thistle, have supplied livestock feed in drought years in the Great Plains. They supply cover and food for small game and other valuable wildlife. But in most cases these benefits are spurious--weeds are so aggressive that they occupy space which often could be used by more suitable and desirable species of plants.

In summary, losses from weeds are encountered in almost everything we do, in agriculture and elsewhere. Their cost in our daily living is tremendous.

What economic analysis is needed? First, appealing and impressive as the "total losses due to weeds" figure mentioned above is, I would settle for something much less and somewhat different on losses. Figures on losses serve several purposes. Most important may be the justification for attacking

a problem, in research, education, production of means of control, and applied control. The bulk or total figure might be related to the need for an overall weed research and control budget. But budgets we now have are usually related to problems broken down to deal with problems, or built up from problems. In this regional research project, W-11, the total budget is broken down to deal with problems. Although I know little of the inside workings of an industry, I would guess that when a firm undertakes to produce a chemical that is effective for a given use, or to design a tillage implement for a certain job, the extent of the problem is carefully appraised, translated into potential market, and then into budget for development work. Certainly the farmer budgets, in some degree, his operating expenses for weed control in relation to his problem.

This is why I believe we should work on losses or costs related to specific problems. These may be those losses caused by a given weed, either wherever it may be found or in certain associations, or losses related to a specific crop and the weed problems associated with that crop. Other restrictions might be geographic, such as the weed problem, in economic terms, faced by a county weed control district; or a type of farming area such as an irrigation project; or a management problem such as the weed control problems of irrigation districts. We need analysis of losses at the level of the individual farm, and specific problems within the farm. Such analysis demonstrates the need for action, the need for budgets or operating expenses for research, education, regulation, and applied control.

Second, analysis is needed of the costs and returns of weed control practices, and their effects on net farm income. Costs and returns are related to the methods to be used, intensity of application, degree of weed infestation, effects on yields, and in combination their relation to net farm income. In other words, where is the highest profit combination in applying weed control practices? A farmer attempts to answer this question constantly, in connection with each weed control measure. Can we help?

Third, we need to analyze the economics of public, group, and individual participation in weed control activities. This is in terms of the incidence of costs and returns, particularly in relation to benefits derived from group action.

Now, I would like to report the results of a little translation into dollars and cents of some physical data. This is based on work Mr. Krall has done at the Central Montana Branch Station and on nearby farms, in the control of broadleafed annual weeds in winter wheat. The data were reported in his 1950 annual report, and some that are used here are 1949 experiences only, and other items are the averages of the results of 4 years of continuing experiments, 1947 through 1950. Time will not permit it in the first place, and in order to avoid the confusion of too many figures I will not attempt to report the physical data on which this is based. Mr. Warden of the Agronomy Department at Bozeman was consulted in order to avoid misinterpretation of the data.

It was assumed that the findings at the Experiment Station could be generally applied to the winter wheat production of Judith Basin and Fergus counties. The former Bureau of Agricultural Economics reported that in 1949 in the Central Montana crop-reporting district, which includes these counties, 77.3 per cent of the wheat was treated with chemicals (2,4-D) for weed control.

My second major assumption is that this extent of treatment in the district represents the extent of treatment in the two counties. This first part is the analysis of a problem related to a specific crop in the geographic area of two counties.

In 1949, on 180,300 harvested acres, Judith Basin and Fergus counties produced winter wheat worth $6,434,500. If there had been no weeds in the fields to begin with, this 1949 crop might have had a value of $7,383,000. With an average infestation and no treatment, the value of this crop might have been reduced to $5,611,000. The difference between weed-free and average infestation without treatment, $1,722,000, represents the loss in crop production due to competition from weeds, without an estimate of other costs that would be involved. It expresses the original problem--good farming practices but without chemical control. The difference between the actual crop, and the value with weeds and without treatment, $823,500, represents the contribution made by chemical treatment of winter wheat in 1949 in two Montana Counties. It represents the progress that has been made.

The difference between the crop actually produced and the potential had there been no weeds, $948,500, represents losses arising from infested crop not treated, damage to the crop from weed growth before treatment and from surviving weeds, and yield-depressing effects from the chemical on the wheat--it represents the margin for further research, education, and application of control practices. One other point should be made. The increased value of production of $823,500 is attributable to treatment costing somewhere between about $125,000 and $210,000, depending upon the proportions applied by farmer-owned ground equipment and by custom airplane spraying.

Using similar data, the analysis can be slanted in the direction of information more meaningful to farm operators, by making comparisons on a per-acre basis on and including a few additional items that are of particular importance in his operations. This section is based on Mr. Krall's observations during four seasons on winter wheat fields in the vicinity of the Experiment Station at Moccasin, and also on experiments at the Station. The fields studied, all of which were sprayed at the proper time at rates recommended for easy-to-kill weeds, yielded an average of approximately 25 bushels per acre for the four seasons. On the basis of 1950 prices, the value of this yield was $48 per acre. Yields on test areas that were protected during the spraying operation were only 21 bushels per acre, valued at $40.32. Thus, the return from spraying was $7.68 per acre. The cost of treatment varied from about $0.90 to $1.50 per acre, leaving a net return of from $6.18 to $6.78 per acre.

An estimate of a comparable average yield on these fields if there had been no weed infestation in the first place is 27.6 bushels, worth $53 per acre. Even with present apparently effective and decidedly profitable methods of chemical control, weeds still were costing these farmers $5 per acre in reduced yields.

Earlier, I used the expression "sprayed at the proper time at rates recommended for easy-to-kill weeds." Plots of weed-free winter wheat treated at the rate of 1/3 pound of acid-equivalent per acre yielded 6 per cent less than untreated check plots. Even at this low rate, sufficient to control only the more susceptible weeds, there is appreciable damage to

the grain. Applying these results to the returns from the fields mentioned above, if clean wheat were sprayed, the loss would be $3.18 per acre. When 1 pound acid-equivalent was applied, an amount often used for certain hard-to-kill perennials, yields were reduced 16 per cent, which would have a per-acre value of $6.89. If these fields had been treated at too-high a rate, the loss above the required treatment could have been $3.71 per acre.

In applying 2,4-D to growing grain, care is rewarded. Coverage must be complete; for every weed-infested acre missed under these conditions, the loss is $7.68. Overlapping, or slowing down, with the sprayer set at the proper rate may be costing more than $3.50 for every acre over-treated. In spot-treating patches of hard-to-kill weeds it will very likely pay to shut the machine off between patches. These data suggest that it might well be worth considerable effort to avoid spraying weed-free areas within fields.

Timing is also important. Mr. Krall tested the effects on the crop yield of spraying at different stages of growth. He found the least damage between the stages of tillering and early boot, with reductions in yields up to 25 per cent at critical times, either too early or too late, as compared to his check plots. In these same fields, untimely application could have cost $9.70 per acre in damage to the crop.

The preceding analysis is somewhat rough, in that I have used data developed on experiment station plots and nearby fields, and applied it to two entire counties, and have also combined data from these sources to draw some interpretations on a per-acre basis. In general, these assumptions of applicability have considerable justification, certainly in direction even if not in exact amounts. The results are impressive. The fact that farmers have so universally accepted chemical weed control practices in wheat shows that they are aware of the wide margin of returns. But is awareness of the room for further improvement in practices so universal? Are the hazards, in dollars and cents, of variations from proper rates and timing generally known? These are less conspicuous but very real.

No doubt much research data of this kind is already available to demonstrate the value and the hazards of weed control practices. Some important contributions could be made. But more data are needed, data especially designed to provide answers to specific questions. I have in mind, especially, data that will assist farmers in the making of decisions--the cost and adequacy of various control measures or combinations of measures, their effects on crop and forage production, and finally translated into effects on net farm incomes. At what level of weed infestation are the effects of 2,4-D on wheat offset by a treatment that controls the competition from weeds? So far, we do not have the data that can be used to answer that. In Idaho a few years ago, data were obtained that made possible a regression analysis, which demonstrated that with 4-cent peas and $3 per pound for I.P.C. herbicide, the break-even point on wild oats in peas is seven wild oat plants per square yard." This suggests that other price relationships could be substituted and answers under various conditions be made readily available. It illustrates the usefulness of data of the kind that are needed.

What are our plans for "economic studies of weed problems and control"? Two months ago this would have been much easier to answer. We had progressed to a point at which an RMA project had been set up with a preliminary project

outline, tentative approval by the Western Directors had been obtained, and members of a technical committee had been named. But the project has now been dropped, at least temporarily, for reasons associated with the complexities of administration of Regional Research. This is something of a set-back, and it is disappointing. However, the idea is very much alive.

As far as I know, there are two formal research projects under way in this field in the Western States. One is at Oregon, but I do not know what work it includes. The other, at the Montana Station, is entitled Economic Evaluation of Alternative Methods of Control of Canada Thistle in Irrigated Crops of the Gallatin Valley. It is under the leadership of Dr. C. B. Baker of the Department of Agricultural Economics and Rural Sociology and with R. L. Warden, Department of Agronomy and Soils, J. M. Hodgson, Agricultural Research Service, USDA, and myself as consultants. The objectives are stated, in part, as follows: "to determine the economy of alternative techniques for controlling Canada thistle in small grain and associated crops where economy is measured in terms of increased net value of product." This project is tied in closely with and dependent on the results of Mr. Jesse Hodgson's project now under way at the Montana Station, Canada thistle control with cropping, and cultural and chemical treatments. In his statement of procedure, Dr. Baker lists five points or steps, the first three of which are to be developed in Mr. Hodgson's project, as follows: "The fulfillment of this objective requires that functional relationships be established (or approximated) between (1) the yield of relevant crops and the population of noxious weeds, (2) the thistle population and alternative control practices, (3) inputs required in the various control practices, and (4) price expectations for (a) product(s) and (b) inputs. Finally, for practices which entail substantial farm reorganization (e.g. rotation changes) a study of the economy thereof will require (5) at least partial budgeting of such reorganization(s)." This study was intended as a contributing project to the regional project, although not dependent on funds from that source.

In 1953, the first year of his study, Mr. Hodgson collected in one field some data that will help in establishing the significance of Canada thistle infestations. Because thistle patches spread aggressively and are a hazard to ever-increasing areas beyond their existing perimeter, the effects within patches are not the only criteria of their seriousness. But illustrative of the material needed in evaluating costs and returns of treatment are his data on spring wheat yields in relation to degree of weed infestation as measured by thistle shoots per yield sample area, 2 ft. by 8 ft. These data were collected in one field, with four replications. In each case samples with no shoots were taken just outside the thistle patch and each sample with an increased number of thistle shoots was taken toward the center of the patch where the desired level of infestation occurred. The degrees of infestation in terms of thistle shoots per yield sample area were 0 shoots, 3 to 8, 20 to 30, and 45 to 55. The field was low in fertility, not irrigated in 1953, and yields were low. The average yield without infestation was 15.09 bushels; it was reduced at various levels of infestation to 13.84, 10.57, and 7.12 bushels. These points, if plotted, describe almost a straight line from 100 per cent to 47.1 per cent, and represent per-acre losses at current prices of about $2.60, $9.45, and $16.65. Even in relatively low-yielding fields, preliminary indications are that with severe infestations expensive practices will probably pay, even if infestation is reduced only moderately. Mr. Hodgson hopes to be able to expand this phase of his study this year,

which will provide important information for analyzing and extending the applicability of the data from his experimental plots.

Besides this Montana project on the control of Canada thistle in irrigated crops (spring wheat and associated crops) in the Gallatin Valley, three other stations had selected studies that together could be considered a regional approach. The Idaho people were interested in Canada thistle in the wheat-pea area, Washington in field bindweed in their wheat-pea area, and Oregon in broadleafed annual weeds in wheat in Umatilla County. More recently four additional Stations had indicated interest in participation, but they had not indicated the nature of the studies they hoped to make. We have put considerable emphasis on the advantages of a regional project in developing methodology, especially important in this case because it is a new field.

In general, research resources are committed to established programs in the various experiment stations and the Department of Agriculture. To introduce a new field of study, and get resources diverted to it, takes time. As older studies are completed, usually there are several alternatives, all of high priority, demanding attention; or additional resources are required. Expanded resources likewise are allocated to what are considered the most pressing of numerous possible uses. A major objective will be to convince administrators of research resources that in this field there are problems of high priority, and that adequate material with which to work is or will be available.

WEED CONTROL AND FEDERAL SEED ACT ENFORCEMENT

W. D. Hay
Federal-State Seed Laboratory, Agricultural Marketing Service, U. S. Department of Agriculture, Sacramento 14, California

The control of weeds is a problem that rests primarily with the individual, firm or government agency operating a given piece of land. Seed laws assist in weed control by restricting the dissemination of weeds in seeds intended for planting purposes.

The Federal Seed Act requires that agricultural seed transported or offered for transportation in interstate commerce shall be labeled with information giving the kind; kind and variety or kind and type of seed, the lot number; the percentage by weight of pure seed, inert matter, other crop seed, and weed seed, including noxious weeds; the percentage of germination; the percentage of hard seed, if present; the date of test; and, if known, the origin of alfalfa, red clover and open pollinated corn. The shipper's name and address must be given on the label, or in lieu thereof the consignee's name and address, together with the shipper's code number previously secured from the federal agency responsible for enforcement. The kinds of noxious weeds must be shown on the label in accordance with and the rate of occurrence shall not exceed the rate permitted by the law and regulations of the State into which the seed is transported.

The maintenance of a federal inspection force large enough to adequately inspect all seed shipped in interstate commerce would be prohibitively expensive and would mean duplication of inspection already made by county or state employees. Therefore, in Federal Seed Act enforcement we rely to a large extent on the cooperative efforts of State Agencies.

Cooperative arrangements have been worked out with all forty-eight States whereby violations of the Federal Seed Act discovered by State Inspectors are reported to their District Federal Seed Laboratory. Thus, without duplicating inspections or expense, the results of routine inspections by more than 320 State and County officials are made available for the enforcement of the interstate provisions of the Federal Seed Act. Since these arrangements were completed, over 90 per cent of the Federal Seed Act violations investigated have been called to our attention by State officials.

During the past five years the complaints of Federal Seed Act violations received from all sources have numbered from 680 to 948 yearly. A breakdown as to the factors involved in the violations reported during the past two years shows the following distribution:

Germination	37.5%
Noxious weed seeds	24.0%
Purity	20.0%
Variety	5.0%
Origin	2.5%
Not labeled	2.5%
Advertising	3.0%
Miscellaneous	5.5%

This breakdown shows that approximately one-fourth of the Federal Seed Act violations reported during the past two years were due to a misrepresentation of the noxious weeds present.

Effective control of the dissemination of noxious weeds in seed transported in interstate commerce for seeding purposes has to some extent been frustrated by the variation in the noxious weed requirements of the different States. Noxious weed seed requirements in seed laws have been arrived at by various methods. Some weeds are considered noxious because of the difficulty in separating them from crop seeds. Others are considered noxious because of the difficulty in controlling them under field conditions; or the prevalence of the plants in the State; or the fear of introduction of weeds from other States.

The "Suggested Uniform State Seed Law", approved by the Association of Official Seed Analysts and the National Association of Seed Control Officials divides noxious weeds into two classes. These are defined as follows:

"Prohibited noxious-weed seeds are the seeds of perennial weeds such as not only reproduce by seed, but also spread by underground roots, stems, and other reproductive parts, and which, when established, are highly destructive and difficult to control in this State by ordinary good cultural practice."

"Restricted noxious weed seeds are the seeds of such weeds as are very objectionable in fields, lawns and gardens of this State, but can be controlled by a good cultural practice."

Using the principles set forth in these definitions, Regional Associations of Seed Control Officials, such as the Western Seed Officials Association, have made some progress in reducing the variation in the noxious weed requirements of the various State Seed Laws. These Associations have approved recommended lists of noxious weeds on a regional basis and recommended uniform principles to be followed under seed laws in the control of noxious weeds. The noxious weed list approved for the Western States by the Western Seed Officials Association includes 19 weeds, with three additional recommended for California, Arizona and New Mexico. The laws of those States include 65 additional species in their noxious weed lists. 118 species are listed as noxious in the forty-eight States. The regional recommended lists of noxious weeds includes a total of 46 species. It appears that many laws include species which should not be on the noxious weed list.

Although seed control officials have recommended changes to bring about greater uniformity in the noxious weed requirements of State Seed Laws on a regional basis they have in many instances experienced difficulty in getting the recommended changes approved. Greater progress will be made if seed control officials, seed analysts, agronomists, seedsmen, farmers and weed specialists combine their efforts in determining and recommending uniform noxious weed requirements for their State Seed Laws. Enforcement efficiency should increase as greater uniformity in noxious weed requirements is obtained.

LEGISLATION AND WEED CONTROL

Hale Holgate
District Agricultural Inspector, Roosevelt, Utah

I noticed many of the previous speakers during this conference have mentioned problems.

We inspectors who have the responsibility of the regulatory work in weed control meet up with these problems face to face every day out in the field. Besides, we do not make the laws, we just try to enforce the laws that you men have made or caused to be made. We do not recommend methods for weed control but try to encourage the use of the methods recommended by the Experiment Station and State Weed Committee.

Aside from the weed control work, we have many other responsibilities in other fields of regulatory work. Yet, we feel the weed work is one of

our most important jobs. We run up against many problems like those that have been mentioned here today. We find many of the farmers and seed dealers who cooperate very nicely in the weed program. Yet there is always that certain one that fails to cooperate. Many times we are told if we will kill all the weeds on the watersheds and the heads of rivers, and make all the farmers around them clean up their weeds, then they will clean theirs up. This is where we use the enforcement method.

One of our greatest problems is to control the sale of lawful agricultural seeds. Many times while checking the seed stores and plants we find seed offered for sale which is not properly labeled, and many times where it is properly labeled we draw samples which we have tested and find noxious weeds in them. How they get there I cannot say, but they are there. Then we find the farmer buying uncleaned, untested seed from his neighbor. And after he finds he has infested his field, he blames us for it. Well, I suppose it is our fault; we should have caught up with him and quarantined the whole amount of seed that was offered for sale.

We have the problem of controlling the scattering of noxious weed seeds by machinery, livestock, infested hay, grain, straw, screenings, etc. I believe when a uniform weed and seed law for the whole United States is brought into effect, many of these problems will be solved. As of now, seed going through interstate shipment is quarantined because one state has a greater or lesser tolerance than another and a difference in labeling laws.

We also need a list of common names of all noxious weeds and seeds. In my district we have Russian knapweed. In one of our neighboring states they call it black root, which is very confusing to many people. At the Federal Seed Meeting in Kansas City a year ago last November, we were working on a uniform seed law and a list of common names for noxious weeds, and I understand they are about ready for legislation.

THE SENSITIVITY OF ACALA 44 COTTON TO 2,4-D*

H. F. Arle
Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture, Phoenix, Arizona

Introduction

In Arizona the use of 2,4-D as a weed-killing agent in grain sorghum and pastures, or for the control of weeds and brush growth along irrigation canals, has resulted frequently in claims of damage from cotton growers of the immediate vicinity. In addition to direct drift of spray particles onto adjacent cotton fields, other methods of contamination also have been noted. These include the following: (1) The volatilization of 2,4-D esters. Numerous claims of injury have been reported following the use of short-chain ester formulations of 2,4-D. Also, the so-called low-volatile esters have been suspected as the cause of injury in several instances. (2) The use of spray equipment in cotton fields following previous use for 2,4-D applications. Airplane and ground-operated sprayers have affected cotton because of improper cleaning to remove the 2,4-D. (3) 2,4-D used along canal banks has been carried by irrigation water, and when such water was used to irrigate cotton, symptoms of 2,4-D action have become evident. Experimental evidence presented later indicates that this method of contamination would cause little injury to cotton. (4) Burning of weeds and brush that have been killed by 2,4-D. Apparently 2,4-D can be carried by smoke and when this happens, symptoms on cotton are usually quite severe. (5) The re-use of containers after previous use for shipping 2,4-D.

In many instances it has been observed that affected cotton plants show remarkable recovery, and although yields have been somewhat delayed, they nevertheless have been considered entirely satisfactory. Some cotton growers have suspected increased yields following light applications of 2,4-D.

During the past several years, the sensivity of a short staple cotton, Acala 44, to an amine salt of 2,4-D, has been investigated. These studies have involved applications of known quantities of 2,4-D to the foliage of cotton plants, and also applications of this material to water which was used to irrigate small field plots.

Experimental Foliage Applications

On April 15, 1952, cotton (Acala 44) was planted on bordered plots, each of which covered 300 square feet. Each plot consisted of three cotton rows at 40-inch spacing. Several weeks following emergence, the stand was thinned to an average of one plant per 12 inches of row. The thinning reduced the original population to a standard of 84 plants per plot.

---

*Investigations conducted cooperatively by the Section of Weed Investigations, Agricultural Research Service, U. S. Department of Agriculture, the Arizona Agricultural Experiment Station, and the Salt River Valley Water Users Association.

To study the effect of 2,4-D at various stages of cotton growth, applications were made on June 7, July 7, and August 7. On the first application date, cotton was growing vigorously and a few squares were present on each plant. On July 7 the plants had attained an average height of 23 inches. Squares were very numerous and a considerable number of blooms were now evident. By August 7 plants averaged 41 inches in height and had completed most vegetative growth. The development of squares and blooms continued to be vigorous and many immature bolls were evident.

On each of these dates, applications of an amine formulation of 2,4-D were made at concentrations of 25, 50 and 100 parts per million. These concentrations were sprayed at a volume of 40 gallons per acre, and resulted in applications of 1.0 lb. 2,4-D per 120, 60 and 30 acres, respectively. A low-volatile ester formulation of 2,4,5-T was also included in this series of plots. It was applied at only one concentration, 100 ppm, and only on the first application date.

Results and Discussion

Following the application of 25 ppm on June 7, the first evidence of 2,4-D action became evident in 10 days. New foliage was completely deformed and squares were becoming chlorotic. During the following weeks, all new foliage continued to be badly "crowfooted" and most squares failed to develop. The few blooms that did appear were abnormal (tubelike), and most of them did not produce bolls. By the latter part of July a few bolls were observed; however, signs of complete recovery were delayed until approximately August 10. At this time new foliage was normal or showing very slight symptoms of 2,4-D action in the form of wrinkled or sawtooth leaf margins. Very few bolls were set; however, squares were now developing normal blooms and the boll set was heavy.

At application rates of 50 and 100 ppm, the first symptoms of 2,4-D action also became evident in approximately 10 days. The effect on foliage was somewhat more severe than at the lower concentration, but there were no obvious differences between the two higher rates. On August 10 some of the new foliage on plants treated at a concentration of 50 ppm was normal while other leaves were still deformed. Much of the foliage, however, was merely wrinkled or showed a sawtoothed effect on the margins. Most flowers were normal but developed bolls which appeared somewhat smaller than those on check plots.

On the same date, the concentration of 100 ppm was still causing distorted growth of top leaves of the main stem. New foliage of lateral branches was wrinkled or sawtoothed and some was moderately crowfooted. In spite of the continued formation of distorted leaves, blooms were normal and later developed bolls.

The application of a low-volatile ester formulation of 2,4,5-T at 100 ppm on June 7 caused some malformation of new leaves but symptoms were much less severe than those resulting from a similar concentration of amine 2,4-D. The effect on squares and bloom was also less drastic, and by July 20 the plants had fully regained normal productive capacity.

The second series of treatments were made on July 7. Again the effects of 2,4-D action became obvious in approximately 10 days. Deformed leaves and

Table 1.--Effect of 2,4-D foliage applications on yields of seed cotton.

Treatment	Date Applied	Pounds of seed cotton per plot (Av. of 3 replications) Picking dates Sept. 30	Oct. 27	Dec. 28	Total	Rank	Per cent of check
Check		15.08	6.04	4.48	25.56	3	100.0
2,4-D							
25 ppm	6/7	7.47	11.31	5.99	24.77	6	96.8
50 ppm	6/7	4.06	12.59	9.56	26.21	2	102.4
100 ppm	6/7	3.37	11.09	9.96	24.42	7	95.4
25 ppm	7/7	7.29	4.98	15.38	27.65	1	108.0
50 ppm	7/7	2.90	2.80	16.21	21.91*	9	85.6
100 ppm	7/7	1.39	2.28	15.94	19.62**	11	76.6
25 ppm	8/7	14.33	6.02	4.95	25.30	4	98.8
50 ppm	8/7	15.14	4.73	3.78	23.65	8	92.4
100 ppm	8/7	14.23	3.21	3.50	20.94*	10	81.8
2,4,5-T							
100 ppm	6/7	10.13	9.24	5.78	25.15	5	98.2

* Significant reduction at 5%
** Significant reduction at 1%

chlorotic squares were especially obvious at concentrations of 50 and 100 ppm. The effects of the lower rate were less evident and there appeared to be a fair set of bolls. By August 10, however, the terminal foliage was severely malformed and most squares did not develop. By mid-September the plants had fully recovered and boll set during the following weeks was exceptionally heavy.

The final series of 2,4-D applications was made on August 7. As in the case of earlier applications, symptoms were noted in approximately 10 days. Although new foliage was distorted, plants did not appear to be as severely affected as those treated earlier. This, however, was because most vegetative development had already been completed. On August 17 all concentrations caused yellowing and drying of new squares. At the lower rates blooms were normal; however, upon maturity the flower parts had a tendency to adhere to the developed boll. The concentration of 100 ppm caused abnormal blooms and inhibited the formation of bolls.

To further evaluate plant recovery, cotton was picked on September 30, October 27 and, the final pick, on December 28. The yield results are shown in Table 1.

An inspection of this yield table immediately indicates that the applications had an effect on cotton production. Most of the treatments caused some reduction in total yield; however, in some cases differences were very slight. Two of ten treatments resulted in greater yields than those harvested from check plots. Also, it is evident that the various concentrations and stage of growth at the time of treatment had a pronounced effect upon development and maturity of bolls.

Applications on June 7 caused great reductions in the quantity of mature cotton on September 30. Treatments of 25, 50 and 100 ppm resulted in yields which were 50, 27 and 23 per cent of checks, respectively. This trend was reversed at the second and third pickings. At the later picking dates, the yield from treated plots was consistently greater than the quantity harvested from check plots. On October 27 yields were 187, 208 and 184 per cent of untreated cotton, while on December 28 yields were 134, 214 and 223 per cent of normal. Totals for the three picks reveal that the treatment of 50 ppm yielded slightly more cotton than check plots. The other two concentrations resulted in small decreases.

The low volatile ester of 2,4,5-T also reduced the yields of the first pick. However, it should be noted that the immediate effect of 100 ppm was less severe than was an application of 25 ppm of amine 2,4-D. Second and third picks were higher than for untreated cotton so that final yields were almost identical.

The applications of July 7 caused greater reductions of first-pick yields than did the June treatments. At 25, 50 and 100 ppm the yields were 48, 19 and 9 per cent of normal. At the second picking this trend continued. However, late season recovery was very pronounced and on December 28, treated plots yielded 344, 362 and 356 per cent of the checks. The three-pick totals show the application of 25 ppm yielded 8 per cent more cotton than the checks. This increase, however, was not statistically significant. Treatments of 50 and 100 ppm significantly reduced yields at the 5 per cent and 1 per cent levels of probability, respectively.

The treatments of August 7 had little or no adverse affect on the quantity of cotton picked September 30. The lowest concentration resulted in slight increases at the second and third pick, and final figures were only 1.0 per cent below normal. At 50 and 100 ppm decreases were noted. Final yields at 100 ppm were 82 per cent of normal, the reduction being significant at the 1 per cent level of probability.

The experiment indicated that total yields were least affected by applications made during the early square stage of cotton development. Although applications made on July 7 or August 7 caused great differences in date of maturity, the final yields of cotton were almost identical. Also, it is clearly indicated that yields became progressively lower as concentrations were increased.

The fall months of 1953 were ideal for growth and development of late cotton. The first killing frost was experienced on November 18, approximately 10 days later than normal. Under less favorable conditions, it is conceivable that plots treated during July or August would tend to show less recovery.

Table 2.--Effect of 2,4-D in irrigation water on yield of seed cotton in pounds per plot (Av. of 3 replications).

Treatment	Picking date: Sept. 25	Oct. 22	Dec. 18	Total	Per cent of Check	Rank
Check	12.85	8.91	7.01	28.79	100.0	5
0.5 lb./A.	12.28	10.50	6.75	29.53	102.6	4
1.0 lb./A.	9.92	11.60	9.17	30.69	106.6	1
1.5 lb./A.	5.94	11.79	12.12	29.85	103.7	2
2.0 lb./A.	6.07	11.73	12.00	29.80	103.5	3

Experimental Applications of 2,4-D in Irrigation Water

During the past three seasons the effect of 2,4-D present in irrigation water also was studied. During 1951 and 1952 applications ranged from 2.0 to 8.0 lb./A. of 2,4-D (amine). Some treatments involved application of the entire quantity during a single irrigation. Other plots received repeated applications of 2,4-D during each of the first four irrigations. None of the treatments involved total treatment in excess of 8.0 lb./A. As a result of these treatments, cotton yields were usually reduced; however, these reductions were not as severe as originally anticipated. Several of the lower treatment rates resulted in slightly higher yields than those obtained from check plots.

During 1953 the effect of low-rate applications of 2,4-D was given additional study. Rates of 0.5, 1.0, 1.5 and 2.0 lb./A. were metered into water during the first irrigation (June 1) following emergence. Plots were completely bordered to prevent loss of treated water.

Symptoms of 2,4-D action were not as quickly apparent as those resulting from foliage applications. On July 3 plants which were treated at 0.5 lb./A. showed very slight symptoms of 2,4-D activity. New foliage was characterized by a sawtoothed effect on the margins. A few dry squares were observed but most were unaffected and developed into normal blooms and bolls. The higher rates caused more pronounced symptoms. New leaves were typically deformed and most squares did not develop.

Treatments of 0.5 and 1.0 lb./A. had no adverse affect on development of the terminal shoot. At these rates height growth continued normally and growth of lateral branches was observed to be more vigorous than on untreated plants. Treatments of 1.5 lb./A. stopped the growth of most terminals, and at 2.0 lb./A. they died prematurely. The higher rates also were characterized by a vigorous development of lateral branches. By mid-August very vew bolls had been set on plants treated at 2.0 lb./A. However, rapid recovery was evident and fruiting was exceptionally heavy during the latter part of the season.

To evaluate the speed of recovery and effect on production, cotton was picked on September 25, October 22 and December 18.

Table 2 bears out observations made during the months following treatment. Each of the treated plots yielded less cotton than the check in the first picking (September 25). The reduction was very slight at the lowest rate and more severe at 1.0 and 1.5 lb./A. It is interesting to note that there was no essential difference between the 1.5- and 2.0-lb./A. rates.

The pick of October 22 indicated plant recovery, and all treated plots yielded more cotton than the checks. On this date, greatest amounts of cotton were picked on the highest rates of treatment although there was practically no difference between the 1.5- and 2.0-lb./A. applications.

The trend established by the second picking continued in the third and final harvest made December 18. The lowest rate yielded slightly less cotton than untreated checks, while all other treatments yielded more. Again there was no difference between 2,4-D applications of 1.5 and 2.0 lb./A.

The three-pick totals show that all treated plots produced more cotton than the untreated checks. Greatest yields were obtained from plots treated at 1.0 pound of 2,4-D per acre. An increase of 6.6 per cent was noted, this being the equivalent of 0.2 bale per acre. It is also interesting to note that at this rate there was very little difference in the quantity obtained at each picking. Approximately 33 per cent of the total yield was taken at each date.

As in the case of foliage applications of 2,4-D to cotton, the treatments had a definite tendency to delay crop maturity. Ideal fall weather and a somewhat delayed first frost were especially favorable to cotton treated at 1.5 and 2.0 lb./A. of 2,4-D. The experiment strongly indicates that cotton can tolerate certain quantities of 2,4-D present in irrigation water without adversely affecting yields. Actually, the experiment lends support to the possibility of increasing cotton yields through the use of 2,4-D.

WHAT IS WRONG WITH THE AERIAL APPLICATION OF HERBICIDES*

John F. Neace
Manager, Marsh Aviation Company, Phoenix, Arizona

The biggest problems facing the aerial applicators of herbicides at this time are proper equipment and responsibility in the handling of herbicidal chemicals.

Modification of airplanes for spraying or dusting are costly, and the expense of maintenance is high. Despite arguments of others on details of equipment and the application of herbicides, Marsh Aviation has found a wind-driven pump, fast flying with a properly regulated discharge, a tank gauge

---

*Mr. Neace is a member of the board which administers Arizona's State Pest Control Applicators Act. A more complete context of his remarks was published in the Arizona Farmer-Ranchman, April 10, 1954.

and the boom behind the wing to be the most desirable and the most reliable.

Suits over real or imagined 2,4-D damage have driven liability insurance rates extremely high, and if the trend continues it may soon be impossible to buy such insurance. The only solution appears to be legislation regulating the sale and application of herbicides so that there will no longer be a question as to the responsibility in their use. Purchasers should register when buying herbicides!

WEED CONTROL BY CULTIVATION

L. M. Stahler
Pacific Coast Borax Company, Los Angeles, California

Cultivation of the soil used in production of food or fiber crops is an ancient art. Pictures of crude stone or wooden cultivation implements are found in the earliest records of civilization uncovered by archeologists. Over the centuries the implements and methods of cultivation have markedly changed and improved, but the need for cultivation in efficient crop production has not changed.

There are two essential purposes for cultivation of our soil:

1. As seedbed preparation.
2. As a weed control measure.

In preparing a seedbed, cultivation stirs up, loosens and mixes the soil to various desired depths. This buries dead or living organic plant material and speeds up decomposition of the plant residues to fractions useful in revitalizing the soil and which furnish essential elements for the growth of the newly planted crop seedlings. Bacteria and fungi useful in decomposing organic and inorganic substances in the soil are uniformly distributed by cultivation. Cultivation loosens the surface soil and improves the texture, facilitating planting and assuring uniform, rapid germination of seed and emergence of crop seedlings.

In using cultivation for weed control two distinct principals are involved. In the control of annual weeds or shallow rooted perennials, such as quackgrass (Agropyron repens) or Bermuda grass (Cynodon dactylon), cultivation is essentially a dehydration process. Shallow cultivation of annual weeds severs the roots--the weeds wilt and die. Repeated operations are necessary only when a new crop of weed seedlings emerge. With shallow rooted perennials, such as quackgrass, lifting the rhizomes to the surface and exposure to the desiccating action of sun and wind are the factors involved. Shallow cultivation with specialized equipment must be repeated several times to eliminate all of the perenniating stems or rhizomes. Dry surface soil and a rain-free period are essential to efficiently undertaking this type of perennial weed control. Only a few, well-timed, shallow cultivations are needed.

In eliminating deep rooted perennial weeds, such as field bindweed (Convolvulus arvensis) or Canada thistle (Cirsium arvense), cultivation

is both intensive and extensive procedure, requiring a full season or more, and involving from 6 to as many as 20 operations. In principal, it involves the systematic depletion of the organic food reserves stored in the deep and extensive roots of these weeds by repeatedly removing foliar growth that develops at the expense of the stored root reserves. Foliar growth must be removed just before it has matured to the point where the products of current photosynthesis exceed those consumed in leaf and stem growth. Carefully timed successive cultivation operations to coincide with this point are the secret of most efficient weed control. Timmons, Seely and others have thoroughly investigated and established the association between intervals of cultivation and trends of root reserves of field bindweed and other perennials. They also established that initial cultivation operations in the spring can be safely delayed until bindweed is in early bud stage as they found that root reserves are seasonally low at this time and earlier cultivations give no advantage.

Intensive cultivation for control of perennial weeds, such as field bindweed or Canada thistle, is an expensive process, and justified only where the infestation is general and extensive and where chemical herbicides are either too expensive or ineffective. In addition to the cost of the cultivation operation, one or more crops are lost. In these extreme cases, intensive cultivation must be considered as a major reclamation process.

Canada thistle or Johnson grass (Sorghum halepense) generally are eliminated in a single season of well-timed cultivation. Field bindweed or leafy spurge (Euphorbia esula) occasionally are eliminated in one season--often into the second; while reports show persistent species, such as horse nettle (Solanum spp.) or milkweed (Asclepias syriaca), may persist through two or even three seasons of repeated cultivations involving up to 30 operations. Such extended periods of intensive cultivation cannot be justified from a consideration of the high cost involved, and further, the physical structure of the soil is so changed that wind and water erosion hazards are developed. A carefully planned program of intensive cropping, "smother cropping," alternated with intensive cultivation is, in most cases, more efficient from all considerations than cultivation alone in control of persistent perennial weeds.

Neither intensive cultivation nor planned use of smother crops alternated with intensive cultivation has been popular in the immediate past period of our agricultural history. Now, with the Government program of regulated production of our major fiber and food crops, there will be a general trend amongst farmers to give first consideration to withholding planting on their "marginal acres." In many instances these marginal acres will be those infested with perennial weeds and intensive cultivation will again be widely employed in reclaiming these areas for efficient production in the time of need.

ADVANCES IN CHEMICAL CONTROL OF WOODY PLANTS

O. A. Leonard
Department of Botany, University of California, Davis, California

When 2,4-D and 2,4,5-T were first introduced, there was hope that these chemicals might be a cure-all for many of our woody plant problems; however, it was soon found that this was not the case. It was soon realized that merely killing a woody plant was not necessarily an objective within itself, but that combinations of methods might be necessary to achieve the desired objective. For example, there is little if any grass beneath dense stands of chamise; this condition still exists after the brush has been killed and remains thus for several years. Burning, crushing, or bulldozing chamise is necessary if a quick conversion from brush to grass is to be obtained. it was also found that many of our woody plants were not readily killed by 2,4-D or 2,4,5-T, whether the applications were made by aircraft or by the use of a ground spray rig. These facts do not mean that 2,4-D and 2,4,5-T do not have promise for considerable use on California woody plants, but that it will be necessary to find out just how these chemicals fit into a series of steps necessary in order to accomplish a given objective. For specific purposes, new chemicals may take the place of 2,4-D and 2,4,5-T.

New Chemicals:

Several new chemicals were tested on woody plants in 1953. The results of these tests are not far enough along to any more than to suggest how effective these chemicals may be on certain woody plants. Early tests in Michigan (1) indicate that 2(2,4,5-trichlorophenoxy) proprionic acid (Silvex) was considerably more effective on oak sprouts (*Quercus alba* and *Q. ellipsoidalis*) than 2,4,5-T. This chemical, 2,4,5-TP, appears to be more effective on live oak (*Quercus wislizenii*) or on blue oak (*Q. douglasii*) than either 2,4-D or 2,4,5-T; since these species are quite abundant in California, a better chemical than already available would be quite helpful. The 2,4,5-TP appears to be considerably less effective than 2,4,5-T on chamise sprouts and seedlings (*Adenostoma fasciculatum*).

A chemical similar to 2,4,5-TP, or 2(2,4-dichlorophenoxy) proprionic acid (2,4-DP), also appears to be of interest. Early tests with this chemical indicates that it may be better than 2,4,5-TP on blue and live oak. Tests in the South and Southwest indicate that this chemical has a low order of toxicity on coffee weed, Mexican weed, and curly indigo. It is evident that much testing remains in order to learn the different selectivities of 2,4-DP and 2,4,5-TP. Cotton is much less sensitive to both of these chemicals than it is to 2,4-D or 2,4,5-T.

Tests with 3,4-dichlorophenoxyacetic acid, 4-chlorophenoxyacetic acid, 2,3,6-trichlorobenzoic acid, and amino triazole have not been outstanding thus far. The latter chemical appears to have some promise against poison ivy in the east and may have some use on poison oak in California. CMU kills certain woody plants and will have some use for special purposes.

For an increase in water:

It is well known that woody plants use considerable quantities of water. When these woody plants are serving no useful purpose, and if water is

deficient in the area, there may be merit getting rid of them. An increase in spring flow following controlled burns has been reported by Biswell (2). By limited spraying of ravine-bottom woody plants by the use of a helicopter, George Wheelwright, Sausalito, California, has been able to recover enough water to irrigate about 8 acres of pasture. The control of woody plants in order to release more water for other purposes is becoming more common in the West.

Aircraft trials on chamise:

Chamise (Adenostoma fasciculatum) occupies over 7,000,000 acres of land in California. Many tests have been conducted on the use of chemicals for controlling this plant. This plant is not difficult to kill when the chemicals are applied using a fairly high volume of spray, but control has been much less satisfactory when the sprays have been applied by airplane using relatively low volumes of total spray material.

(a) Unburned mature chamise. Numerous trials have been conducted on the control of chamise by aircraft spraying. The control or kill that has been obtained has varied from slight to about 50%. It would seem, then, for most purposes that the kill of old chamise is not sufficient as to be satisfactory. Nevertheless, spraying may possibly be justified for some purposes, such as may be illustrated below.

Old chamise was sprayed by airplane in 1950, using 2 pounds of a mixture of 2,4-D and 2,4,5-T in enough diesel oil to make 5 gallons total fluid per acre. The kill of chamise was about 40%, but all of the bushes were severely damaged. The chamise was broken down with a tractor in October 1951 and smilograss (Oryzopsis miliacea) was seeded at once. A dense stand of smilograss developed on the area, as observed in December 1953. The down brush appeared to provide considerable value as a mulch, since an adjacent bulldozed and seeded area had very little smilograss on it. It will be necessary to spray the sprouts from the surviving chamise plants, if the area is to remain converted to a grass cover. The value of this method over others may be (1) a stand of perennial grass is more readily established, (2) the down brush protects the grass from being over-grazed, (3) the brush, decomposing over a period of several years, will gradually release nutrients, which can be absorbed by the grass.

(b) Burned chamise. The possible value of spraying chamise sprouts developing after a fire are more obvious than the value of spraying old mature chamise. First, fire opens up the area so that it is no longer an impenetrable barrier and second, grass does not become established when seeded beneath standing dead chamise. Quite a number of years must elapse after chamise has been killed before the old chamise breaks down and the area is taken over by native grasses.

When fire is employed to control chamise, it is generally advisable to apply grass seed to the area. The grass will help a great deal in controlling various types of brush seedlings and many of the native weeds and increases the chance for success with the use of chemicals.

Numerous aircraft trials have been conducted to determine how spraying might work on fields of burned chamise. Most of these trials have resulted in a 5 to 55% kill of the chamise sprouts, but excellent kills have been

obtained on the chamise and other brush seedlings. Chamise apparently becomes increasingly difficult to kill as the sprouts become older. Three different aircraft trials have resulted in what appears now to be a satisfactory kill of the chamise plants.

Test 1. This test was conducted on the L. J. Gamble ranch in Napa County. The area was burned in August of 1950. On May 29, 1952, an application consisting of 2 pounds of 2,4-D and 2 pounds of 2,4,5-T (propylene glycol butyl ether esters) in 4 gallons of Shell Tank Mix No. 1 (90% UR and 61 viscosity) per acre was applied using a helicopter. The kill as observed in January of 1954 was that over 90% of the chamise had been killed and that the area was converted, in a practical sense, from brush to grass. Considerable scrub oak (Quercus dumosa) present on the area was killed by the spray (about 70%).

Test 2. In cooperation with the State Division of Forestry, chamise that had been burned in 1952 was sprayed in May 1953. Most of the sprouting chamise appeared to be dead in February 1954. The application consisted of 2 pounds 2,4-D (butoxy ethanol ester) in one gallon diesel oil and enough water to make 5 gallons per acre. The kill of seedlings was excellent.

Test 3. In cooperation with W. C. Lusk, Farm Advisor, Lake County, chamise that had been burned in 1952, was sprayed in April 1953. The kill of chamise sprouts appeared to be over 80%. The application consisted of 2 pounds 2,4-D (propylene glycol butyl ether ester) in one gallon of diesel oil and water to make 10 gallons per acre.

The above tests, while preliminary, indicate that a satisfactory kill of chamise is possible, when combined in a proper fashion with burning. Many more tests will be necessary before the precise requirements necessary for success are well established.

Seasonal cycle of sensitivity:

The seasonal cycle of sensitivity of woody plants to 2,4-D and 2,4,5-T have largely been determined by the use of foliage sprays, principally on deciduous species. Foliage sprays on evergreen woody plants gives a more accurate picture on the actual seasonal changes in sensitivity; the cut-surface method is even better from this standpoint.

On live and blue oak. There is a marked seasonal cycle in sensitivity of both interior live oak (Quercus wislizenii) and blue oak (Q. douglassii) as has been determined by employing the cut-surface method of applying 2,4-D to trees. The period of maximum sensitivity in these tests was November through February. The transition in sensitivity in the fall was associated with (1) renewal of rainfall, thus allowing an increase in root activity, (2) cessation of shoot growth, (3) decrease in temperature, presumably resulting in a reduced rate of biochemical decomposition of 2,4-D. It is obvious that the period of maximum sensitivity will vary according to factors which affect the above. The termination of the period of maximum sensitivity in March was associated with an increased tendency to develop basal sprouts. The period of minimum sensitivity in the summer and early fall was associated with an incomplete kill of the tops.

The above has greater theoretical than practical significance with respect to the cut-surface method. Trees can be killed at any time of the year, if sufficient care is exercised in the method of application; nevertheless, the average person is not likely to exercise this care, and will be most satisfied with winter and spring applications.

On chamise and toyon. Chamise (Adenostoma fasciculatum) and toyon (Photinia arbutifolia) were sprayed at different times of the year. Both species have leaves at all times of the year.

Chamise was most resistant to 2,4-D in the summer and fall. After the fall rains had started, chamise became much more sensitive to 2,4-D and remained sensitive throughout the winter and most of the spring months. An increase in resistance in the late spring was associated with a decline in soil moisture and higher air temperatures.

The seasonal cycle in sensitivity of toyon was somewhat similar to chamise, with the exception that it became more difficult to kill about mid-spring, while the soil moisture was still rather high. The reasons for the differences between chamise and toyon are, at least, partially understood, but will not be discussed now.

Live oak control with the amine of 2,4-D:

Walter Emrick, Farm Advisor, Madera County, sprayed some live oak sprouts in October of 1950 with amine of 2,4-D. It was over 2 years later before any appreciable kill of the sprouts became evident; by July 1953, approximately 56% of the stumps were dead. The kill of the sprouts was likely associated with some of the same factors noted above under the "Seasonal cycle of sensitivity of live and blue oak" and the same factors appear to be involved with chamise and toyon. An additional factor appeared to be that the amine of 2,4-D caused very little contact injury to the leaves; the esters, on the other hand, slowly killed the leaves during the winter time--the end result being a much poorer kill with the esters than with the amine salt. It is believed that this test represents an important demonstration of what can be accomplished on a difficult-to-kill species, when the conditions necessary for success are fulfilled.

Effect of chamise control with chemicals on the establishment of a grass cover:

Competition from chamise may prevent the establishment of a grass cover, as was illustrated in the following test. On the L. J. Gamble Ranch in Napa County, chamise was burned in 1949. In 1950-51 chamise plots were sprayed and chamise partially to completely controlled on about 3 acres. Resident annual grasses became established (by natural means) on the plot area, but not on the adjacent untreated chamise. The area was reburned in 1953. In January 1954, a fresh grass cover had become established on the treated area and little erosion had occurred on this site; however, on the unsprayed adjacent area, either no grass had become established or a sparse stand was present and the soil had eroded considerably. The same situation existed prior to the reburn, as well as after it.

Perennial grass response due to controlling chamise:

Chamise was crushed with a bulldozer and burned in October 1950 and seeded to Hardinggrass, smilo, tall fescue and some rose clover immediately after burning. (Rescue Project, State Division of Forestry, by Charles Carlson). Some plots were sprayed in April 1952 to control the chamise and other brush on the plots. The results as of July 1953 are indicated in the following table:

2,4-D per acre, lbs.	Kill of chamise sprouts, per cent	Dry weight of grass per acre, lbs.
0	0	639
1	50	1,378
2	87	1,771

The response of the grass due to reducing or eliminating competition from the chamise sprouts, brush seedlings, etc., was outstanding, and significant.

Combination of spraying brush and some other practices, in controlling mixed coastal brush:

Mixed coastal brush is being controlled by George Wheelwright, Sausalito, California, by applying a brush killer by a helicopter and then following this treatment by feeding hay (containing the desired grass seed and legume seed) at varying points through the brush and by doing some respraying of the brush using a sprayer mounted on a Jeep. The cattle invade and break down dense brush which otherwise they would not penetrate, in order to get to the hay. Grass and legume seed get scattered and planted in the process and the cattle browse some of the brush at the same time. In other words, by a combination of methods (1) use of chemicals, (2) browsing, (3) competition with grass, the brush is being killed and the area transformed from a brush cover to a grass cover.

Burning versus chemical control:

Although burning is necessary at present on much of the brush lands of California for the purposes of reclamation, burning may not be the best practice insofar as the site is concerned. For example, on the George Allen Ranch at Sutter Creek, California, two practices were compared on medium-sized chamise. On one area the chamise was broken down with a roto-beater and the subsequent sprouts were killed with 2,4-D. An adjacent area was burned. On the unburned site, grass developed abundantly over the entire area, but especially so around the former chamise plants. The mulch of broken stems was obviously beneficial. On the burned area, the stand of grass was sparse, with most of the chamise plants alive. Another example is on the Sedgewick Ranch in Santa Barbara County. California coastal sagebrush (Artemisia californica) was sprayed in April of 1950, while an adjacent area was burned in the fall of 1950. As viewed in December of 1953, considerably more grass was present on the sprayed area than on the burned site, but was practically absent on the sprayed site.

Effect of bear clover on survival of planted pine seedlings:

Norman E. Dircksen, forester, Stanislaus National Forest, U. S. Forest Service, compared the survival of transplanted yellow pine seedlings on sprayed and unsprayed bear clover sites. Bear clover (Chamaebatia foliolosa) was sprayed in March 1952 and trees were planted as soon as 3 days later without any adverse effect. Survival of trees on the area where the bear clover was sprayed and killed was good and the trees grew well; on the unsprayed area, even where bear clover was sparse, survival of trees was poor. Competition from bear clover was greater than superficially appeared evident.

Conclusions

The possibilities for using chemicals for the control of woody plants in California are numerous. It seems likely that when some of the possible uses have become better established as being desirable, that the use of chemicals for woody plant control will become much more common. In order to accomplish the latter, much time and research effort will be necessary. Fortunately, many different interests are involved, which adds up to considerable research effort being directed on the use of chemicals for controlling woody plants in California.

Literature Cited

1. Anonymous. Silvex Technical Bul. No. 1, p. 1-7. 1954. The Dow Chemical Company.

2. Biswell, H. H. Water Development. Abstract. Calif. Sec., Amer. Range Soc. Dec. 1953. p. 7.

THE CONTROL OF ANNUAL MORNING GLORY AND SUMMER GRASSES IN COTTON WITH CMU

H. F. Arle and E. H. Everson
Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture, Phoenix, Arizona, and Department of Agronomy, University of Arizona, Tucson, Arizona, respectively

The weed problems of the cotton-growing areas of the southern and southeastern United States differ greatly from those of the irrigated lands of the Southwest. In the old cotton-growing regions, annual weeds become prevalent almost simultaneously with germination of the cotton seed and emergence of the seedling plants. Rains which are common during the spring months frequently cause extended delays of cultural practices and thus allow unabated establishment and growth of weed plants. The experimental development and practical use of pre-emergence techniques in addition to the use of selective oils have been very beneficial in solving this problem. The irrigated lands of the arid Southwest present an entirely different situation. Rainfall during the months of April, May and June is negligible and therefore does not interfere with cultivation schedules. In general, annual weeds with the exception of annual morning glory (Ipomoea

hirsutula) are readily controlled during the developmental stage of the cotton plant. This is rather fortunate because pre-emergence measures which can be used with much success with rain-grown cotton in the South have thus far been completely without beneficial effect in the Southwest.

Many cotton fields in Arizona become infested with annual weeds and grasses after "lay-by" time. As grass is a late season development, it has little or no effect on yield. In earlier years, the grass was of little concern since hand-picked cotton contained very little foreign matter. With the advent of the mechanical picker, however, these late-growing weeds have become of serious concern. The mechanical picker gathers a considerable quantity of the dried weed residues which become imbedded in the lint. This material is difficult to remove with standard lint cleaning equipment during processing and frequently appears in the final product. Harvested cotton which includes foreign material is consequently lowered in quality and the farmer is forced to sell his product at reduced prices.

Annual morning glory presents another problem to the farmer. The weed twines around the cotton plants tying the rows together. This tangled condition hinders both hand and machine picking, raising the harvesting costs and losses. An attempt to control the weed by hoeing can rapidly eliminate the margin of profit.

The first experimental work on herbicides for use in suppressing weedy plants after lay-by time was started in mid-July of 1951. Chemicals included in this test were sodium trichloroacetate, (TCA), isopropylphenyl carbamate (wettable IPC), isopropyl N-(3-chlorophenyl) carbamate (3-chloro-IPC), alkanolamine salt of dinitro-ortho-secondary-butyl phenol (Premerge), phthalamic acid and three-(chlorophenyl)-1, 1-dimethylurea, (CMU). In 1952 the experiment was repeated on a much larger scale. From the standpoint of weed control, the results of the two-years' study clearly indicated that CMU was most effective in the control of annual morning glory and grass. Rates of 1.0 to 4.0 pounds per acre appeared to be within the range required to maintain control throughout the last half of the growing season. The effect of CMU on the yield of seed cotton or quality of lint was not studied in these experiments.

During the 1953 season, a much more extensive series of experiments were undertaken on the University of Arizona Experiment Station located at Mesa to study the effect of CMU at various stages of cotton growth.

An unreplicated series of plots were treated at rates of 1.0, 2.0 and 4.0 pounds of CMU per acre on May 11. This was three weeks after planting with cotton being in the seedling stage. On these plots no effects were evident until immediately following the first irrigation on May 27. Several days later the cotton foliage became chlorotic at all rates of treatment. The degree of discoloration was slight at the 1.0-pound rate, more pronounced at 2.0 pounds and very severe at 4.0 pounds per acre. There was also a pronounced effect upon height, growth, and development of the young cotton plants. The low rate had little or no persistent effect; however, at higher rates, growth of the cotton plants was retarded, and a considerable number of plants died on the plot treated with 4.0 pounds of CMU per acre. Marked reductions in grass population became evident. However, because of the very open stand of cotton in the plot treated at 4.0 pounds

per acre, much grass eventually became established, and by picking time this plot was more grassy than untreated areas. This indicated a loss of residual toxicity during the latter part of the season.

In more detailed tests, applications of 1.0, 2.0 and 4.0 pounds per acre were made on June 8 (early square stage), June 29 (early flower stage), July 9 (flower stage with a few bolls set), July 22 (prior to final cultivation) and July 27 (following final cultivation). A low rate of 1/2 pound per acre was included on the two final dates of application. Each of these treatments was replicated four times in a split plot design and included two cotton varieties, Acala 44 and Cal. 4-42.

The effects of these later treatments on cotton plants were similar to those of the first application. Cotton foliage tended to become chlorotic, being most pronounced at the higher rates. These conditions continued for three to six weeks after the first irrigation following treatment in each instance. The 4.0-pound rate resulted in partial defoliation of the cotton plants and it was observed that bolls matured more rapidly than on check plots. At this rate a definite reduction in the number of squares, blooms and bolls was also noted.

There appeared to be no difference in treatments made before or after the final cultivation. The control of grass, even at a rate of 1.0 pound per acre was very satisfactory under either method. Similarly, both the cotton plants and the seed cotton yield were similar for the two methods of application. In spite of the fact that results showed no advantages for applications prior to or after the final cultivation, there are reasons for preferring the earlier treatment. A cultivation would serve to distribute the CMU throughout the surface soil thereby placing it in direct contact with germinating weed seeds. Also mixing the CMU with surface soil would tend to prevent its movement with irrigation water.

The following table indicates the yield results for the various dates of application and rates of treatment. The yield figures represent the average weight of seed cotton in pounds picked from replicated plots 120 ft. by 22 ft. in size. It will be noted that yields are markedly reduced as rates of treatment are increased from 0.5 pound to 4.0 pounds per acre. This was true for all treatment dates. With few exceptions the 4.0-pound application rate resulted in yield reductions which were significant at the 1% level of probability. In several instances, the 2.0-pound rate resulted in significant reductions at the 5% level.

Several supplementary experiments were conducted during the 1952 and 1953 seasons on farmers' fields badly infested with annual morning glory. Rates of CMU, ranging from 1.0 to 4.0 pounds per acre, were applied immediately prior to the final cultivation. Applications of 1.0 pound per acre were very effective in reducing the morning glory population but did not eliminate them completely. However, the results were considered satisfactory from a standpoint of commercial control. At rates of 2.0 pounds per acre and above, control of morning glory was virtually complete. It was not possible to obtain cotton yields from these plots. However, it is entirely within reason to suspect that control of severe infestations of morning glory with low-rate applications of CMU would lead to increased yields as well as making harvesting easier. On these plots it was also

Seed cotton yields (pounds) from plots receiving varying rates of CMU

Variety - Acala 44

Application date	Rate of application, lb. CMU/A.					
	Check	Hoed check	0.5	1.0	2.0	4.0
May 11 1/	8.52	-	-	10.04	6.77	3.31
June 8	11.67	-	-	10.47	10.53	9.16
June 29	10.72	-	-	10.19	8.19*	6.15**
July 9	10.04	-	-	9.36	9.66	5.81*
July 22	10.66	10.51	10.75	10.39	9.61	9.06*
July 27	10.14	10.50	10.20	9.23	0.25	7.26**
Variety - Cal. 4-42						
May 11 1/	8.04	-	-	10.27	7.78	5.58
June 8	11.77	-	-	11.50	9.69	7.60*
June 29	10.18	-	-	10.00	9.46*	6.10**
July 9	11.24	-	-	10.14	9.96	6.17*
July 22	11.05	9.94	11.10	10.87	9.21*	8.86**
July 27	9.49	10.28	10.52	8.89	9.42	7.35**

*Significant at 5%
**Significant at 1%
1/ May 11 application not replicated

indicated that low-rate applications of CMU would control annual ground cherry and purslane.

In addition to the field tests, complete fiber analyses were run on the lint from the experiment where CMU was applied prior to and after the last cultivation at lay-by time. Ten-boll samples were taken for the fiber tests from each of the plots in all the replications. The data on weight per boll, per cent lint, fiber length, fiber strength, and fiber fineness (micronaire) were subjected to an analysis of variance. In no instance was there any significant difference between treatments in any of the tests. It would appear that CMU at these rates has no deleterious effects on cotton fiber quality.

The work described in this paper has primarily been conducted on medium clay loam soil types. Several small applications have been attempted in cotton growing on a light, sandy soil. On these light soils, cotton was severely affected by comparable rates of CMU. More experimentation is a necessity, especially work involving the selectivity and residual capacity of CMU on various soil types.

Summary

Results of 3 years of work involving applications of CMU to control annual grasses and morning glory in cotton indicate that this chemical shows considerable promise as a selective herbicide. Although cotton is definitely

susceptible to injury by CMU when applied in excessive amounts, it does appear sufficiently tolerant to withstand rates which will control annual grasses and annual morning glory. Rates of 1 or 2 pounds of CMU per acre gave a good commercial control of both annual morning glory and annual grasses without any serious reduction in yield. In most cases the 4.0-pound rate significantly reduced the cotton yield.

Complete fiber analyses were run on the cotton from the experiment where CMU was applied at lay-by time. There was no significant difference between treatments, thereby indicating that CMU has no deleterious effects on cotton fiber quality.

SOIL-HERBICIDAL RELATIONSHIPS OF 3-(P-CHLOROPHENYL)-1,1-DIMETHYLUREA AND 3-(3,4-DICHLOROPHENYL)-1,1-DIMETHYLUREA

L. E. Cowart
E. I. duPont Company, Wilmington, Delaware

Extensive experiments have shown that 3-(p-chlorophenyl)-1,1-dimethylurea and 3-(3,4-dichlorophenyl)-1,1-dimethylurea are promising pre-emergence herbicides. It is important to determine whether these herbicides will disappear from the soil so that succeeding crops are not affected.

Partial or complete loss of herbicidal activity may result from at least the following factors:

(1) Breakdown by either chemical or biological decomposition.
(2) Leaching from the soil.
(3) Inactivation by adsorption on the soil.

Only the first two factors are discussed in this paper.

Ogle (4), using crabgrass as an indicator plant, concluded that a 4-pound-per-acre rate of the p-chloro compound was inactivated in muck soil after 12 weeks at 46° F and after 3-1/2 weeks at 96° F. Little or no loss of herbicidal activity was noted in a sand or a silt loam over a 12-week period at similar temperatures when the p-chloro compound was used.

Danielson and Easley (2) found that a 5-pound-per-acre rate of the p-chloro compound worked into a 5-inch layer of sandy loam soil was non-toxic to sweet corn and snap beans after 3 months when 11.5 inches of rainfall was applied.

The program designed for the study of soil relationships of the p-chloro and dichloro compounds included: (1) the growth of field crops in treated plots to measure residual activity, (2) chemical analysis and bio-analysis of soil samples from these treated plots over a 12-month period, and (3) laboratory studies which evaluated the effects of a temperature differential and a soil sterility differential on the relative breakdown rates of these herbicides in different soil types. Since it has not been possible to study persistence on all soil types, these results are presented as a

progress report.

An 80% wettable powder formulation of the two materials was used in all of these tests. All rates of herbicidal application, both pounds per acre and parts per million, are expressed on an active ingredient basis.

Persistence Under Field Conditions

Field experiments were conducted on Leon-Immokalee sand at Palma Sola, Florida; Cecil loamy sand at Raleigh, North Carolina; and Lintonia silt loam at Essen Lane, Louisiana. The analytical method as described by Baker, Lowen, and Levitsky (1) for 3-(p-chlorophenyl)-1,1-dimethylurea with minor changes for 3-(3,4-dichlorophenyl)-1,1-dimethylurea was used for the chemical determination of residues in treated soils. This procedure includes the alkaline hydrolysis of the soils treated with 3-(p-chlorophenyl) 1,1-dimethylurea and 3-(3,4-dichlorophenyl)-1,1-dimethylurea to p-chloroaniline or 3,4-dichloroaniline, which is determined colorimetrically. Likewise, an untreated sample of soil is analyzed for apparent p-chloroaniline or apparent dichloroaniline content and the values for treated soils determined by difference. All soils contain some naturally occurring materials which interfere with the analysis. Because the amounts of these materials vary widely (plus or minus 50% from the average) even in a given soil, the figure obtained by analysis of the untreated soil is not absolute. Therefore, treated soils which analyze no more than the untreated are not reported as containing zero residue but as containing less than one-half the amount of the blank, since this is believed to be the significant level of detection.

Leon-Immokalee Sand - Palma Sola, Florida.

The results of chemical analyses of soil samples (0- to 4-in. depth) taken at 4, 8, and 12 months after treatment from plots which received 1, 2, and 4 pounds per acre of the p-chloro or the dichloro compound as a blanket application are given in Figure 1 and Figure 2.

In bio-analyses of the Leon-Immokalee sand, 8 months after treatment (37.9 inches of rainfall), oats and tomatoes grew normally in soil samples removed by layers from those plots which received 1, 2, and 4 pounds per acre of either compound. Further, 4 months after treatment, neither of these crops showed phytotoxic effects from either herbicide in plots that were treated at the 1- and 2-pound-per-acre rates.

Cecil Loamy Sand - Raleigh, North Carolina.

The results of chemical residue determinations of soil samples (0- to 4-in. depth) taken at 4, 8, and 12 months from plots which received 1, 2, and 4 pounds per acre of the p-chloro or the dichloro compound as a blanket application are given in Figure 3 and Figure 4. These data show that the concentration of both herbicides was reduced to low levels in the soil.

These results were corroborated by bio-assay determinations when these plots were planted to cotton, peanuts, soybeans and field corn 12 months (48.9 inches of rainfall) after the herbicide applications. None of these crops was injured in the one-year-old residual plots of either compound

at rates of 0.5, 1, 2, and 4 pounds per acre.

When cotton was planted in 1953 in plots which received a treatment in May, 1952, and a retreatment in May, 1953, no injury was noted from either compound at rates of 0.5 or 1.0 pound per acre per year. The 2- and 4-pound rates under similar conditions, as would be expected from a single treatment on this light soil at 2 or 4 pounds per acre, reduced the plant stand somewhat and caused some chlorosis of cotton leaves.

Cotton replanting studies were conducted on the Cecil loamy sand in 1953. Plots were treated pre-emergence with the p-chloro and dichloro compounds at rates of 0.5, 1.0, 2.0, and 4.0 pounds per acre. Seven weeks later cotton was replanted in these disked plots. During the ensuing 6 weeks, no phytotoxic effects were observed on the cotton at the 0.5-, 1-, and 2-pound rates and only trace symptoms of chlorosis were evident at the 4-pound rate.

Lintonia Silt Loam - Essen Lane, Louisiana.

The results of chemical soil residue analyses of samples (0- to 4-in. depth) taken at 4, 8, and 12 months (66.4 inches of rainfall) after initial blanket applications of 1, 2, and 4 pounds per acre of the p-chloro and dichloro compounds appear in Figure 5 and Figure 6. These data follow the same general pattern revealed in the Florida and North Carolina studies in that the residual amounts of either herbicide are insignificant after 12 months, especially at the 1- and 2-pound rates. Twelve months after the initial application of herbicides, field corn, sweet corn, and cotton grew normally on plots treated with either herbicide at rates of 1, 2, and 4 pounds per acre.

The presence of low concentrations of herbicide, varying from a trace at the 1-pound rate to 0.2 ppm at the 4-pound rate, in the 4- to 8-inch layer in each soil type suggested that very little movement occurred from the 0- to 4-inch layer.

Relative Rates of Breakdown in Certain Soils

Loustalot, Muzik, and Cruzado (3) concluded that the decomposition of the p-chloro compound in soil was hastened by those factors favoring soil microbial action, such as warm temperature, adequate moisture supply and the presence of organic matter.

Laboratory studies were conducted to evaluate the effect of a temperature differential and a soil sterility differential on the decomposition or inactivation of the p-chloro and dichloro compounds.

Temperature Study.

Both compounds, at rates of 0.5 and 1.25 pounds per acre were applied to the surface of soil samples representative of three soil types: (1) Cecil loamy sand from Raleigh, North Carolina, (2) unclassified sandy loam from near Raleigh, North Carolina, and (3) loam soil from Eagle Pass, Texas. The treated samples representing all combinations of chemicals, rates, and soil types were divided into two lots and stored at a medium moisture level

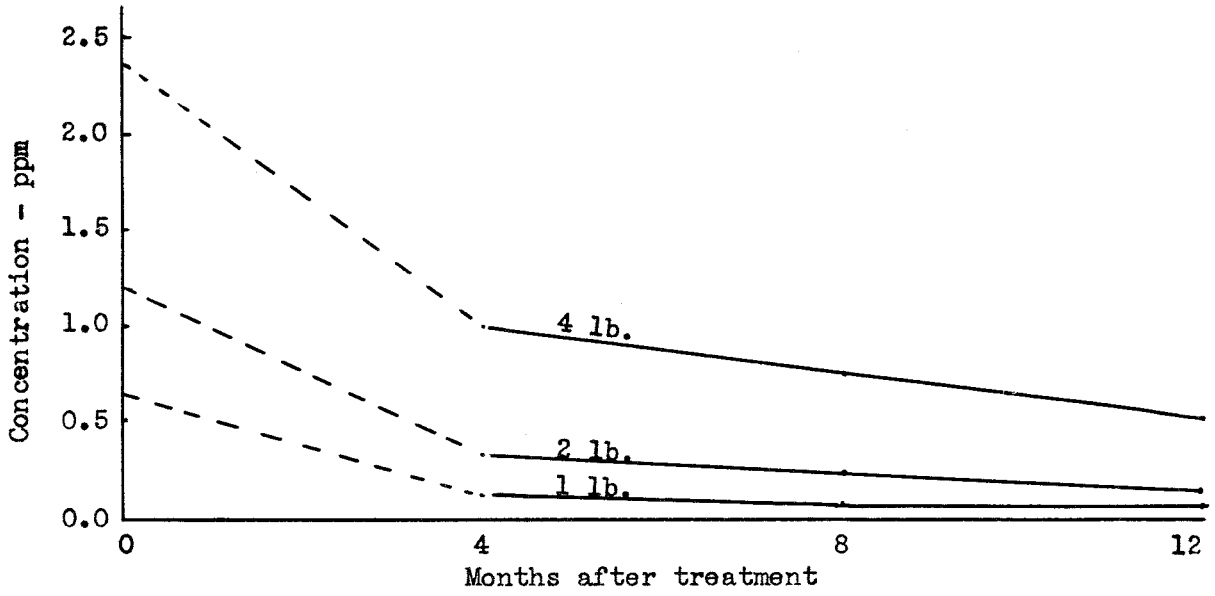


Figure 1. Chemical analyses of Leon-Immokalee Sand (0- to 4-in. depth) after treatment with 3-(p-chlorophenyl)-1,1-dimethylurea. Palma Sola, Florida.

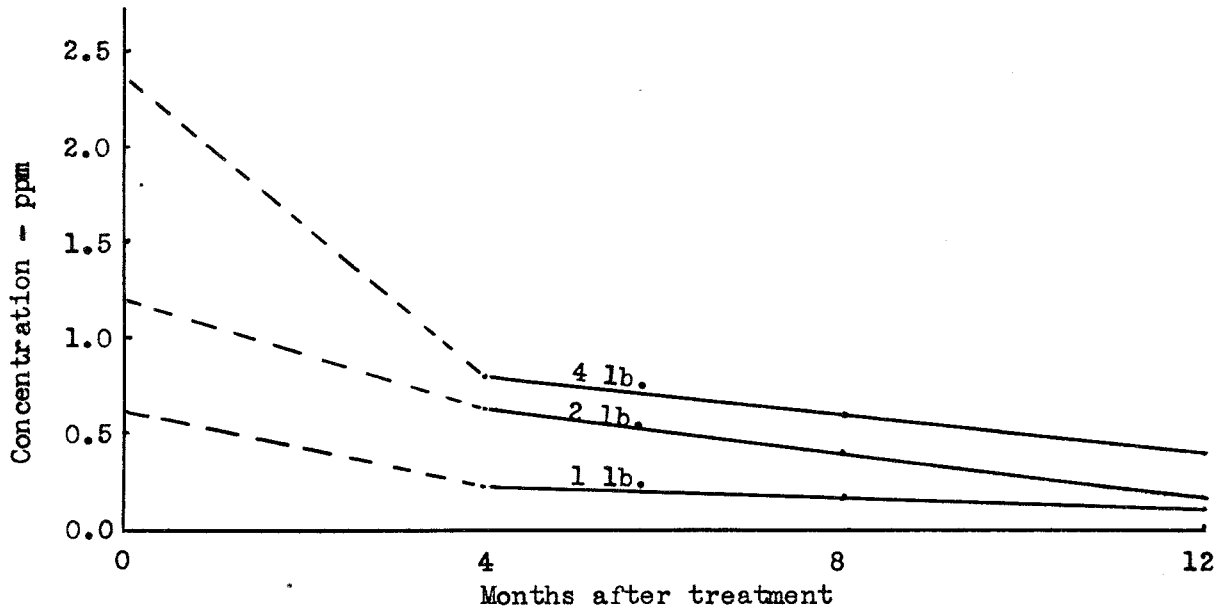


Figure 2. Chemical analyses of Leon-Immokalee Sand (0- to 4-in. depth) after treatment with 3-(3,4-dichlorophenyl)-1,1-dimethylurea. Palma Sola, Florida.

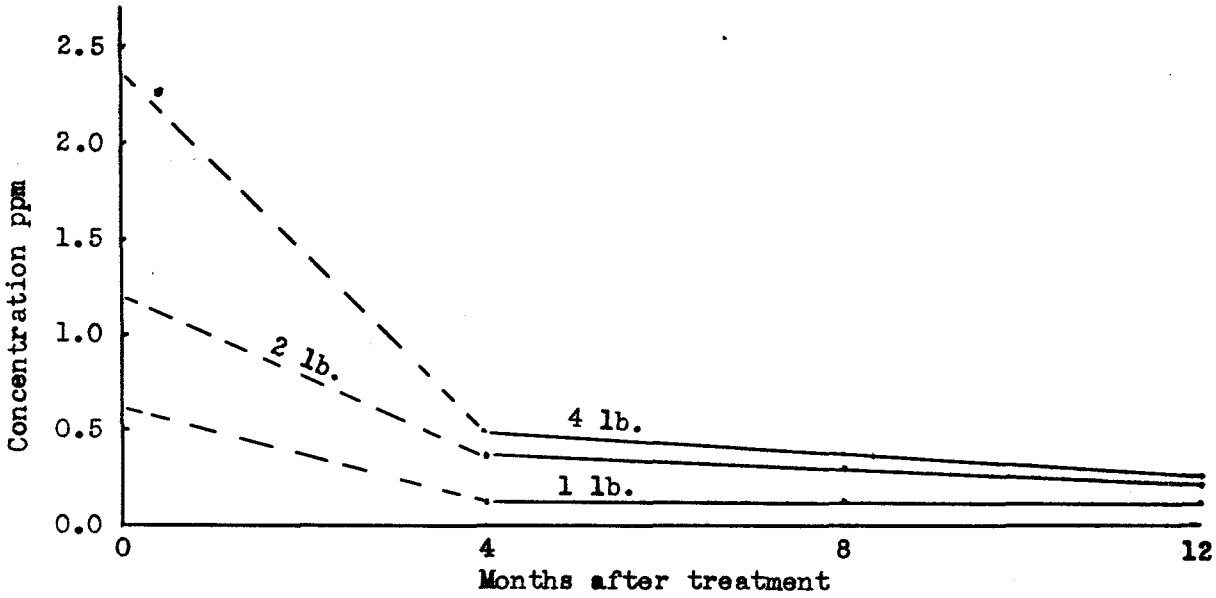


Figure 3. Chemical analyses of Cecil Loamy Sand (0- to 4-in. depth) after treatment with 3-(p-chlorophenyl)-1,1-dimethylurea. Raleigh, North Carolina.

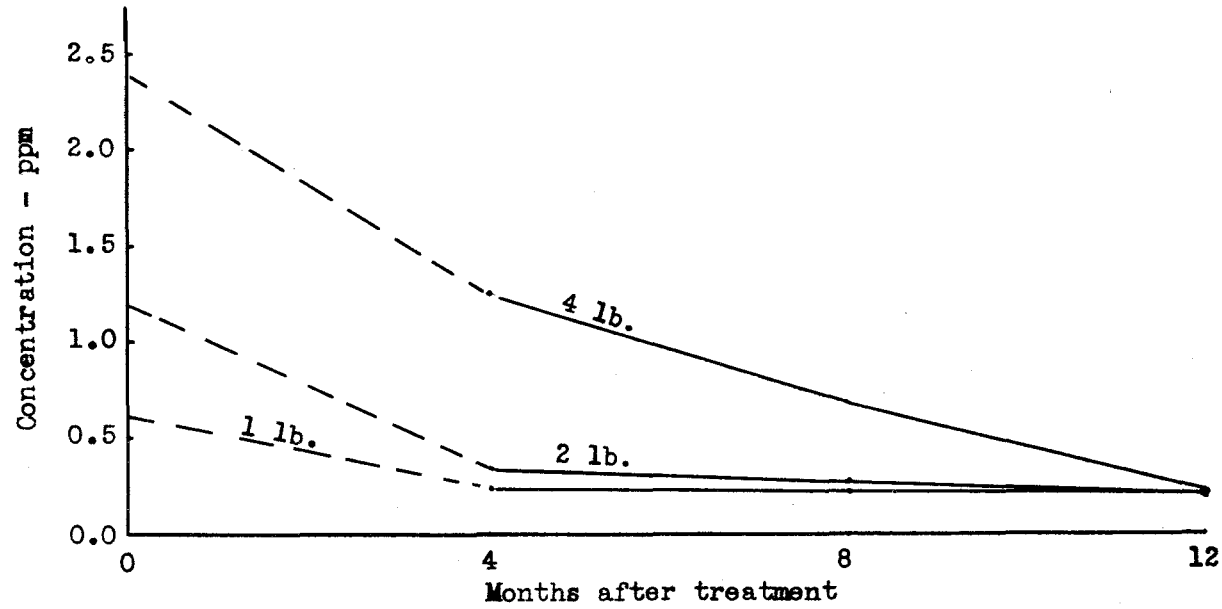


Figure 4. Chemical analyses of Cecil Loamy Sand (0- to 4-in. depth) after treatment with 3-(3,4-dichlorophenyl)-1,1-dimethylurea. Raleigh, North Carolina.

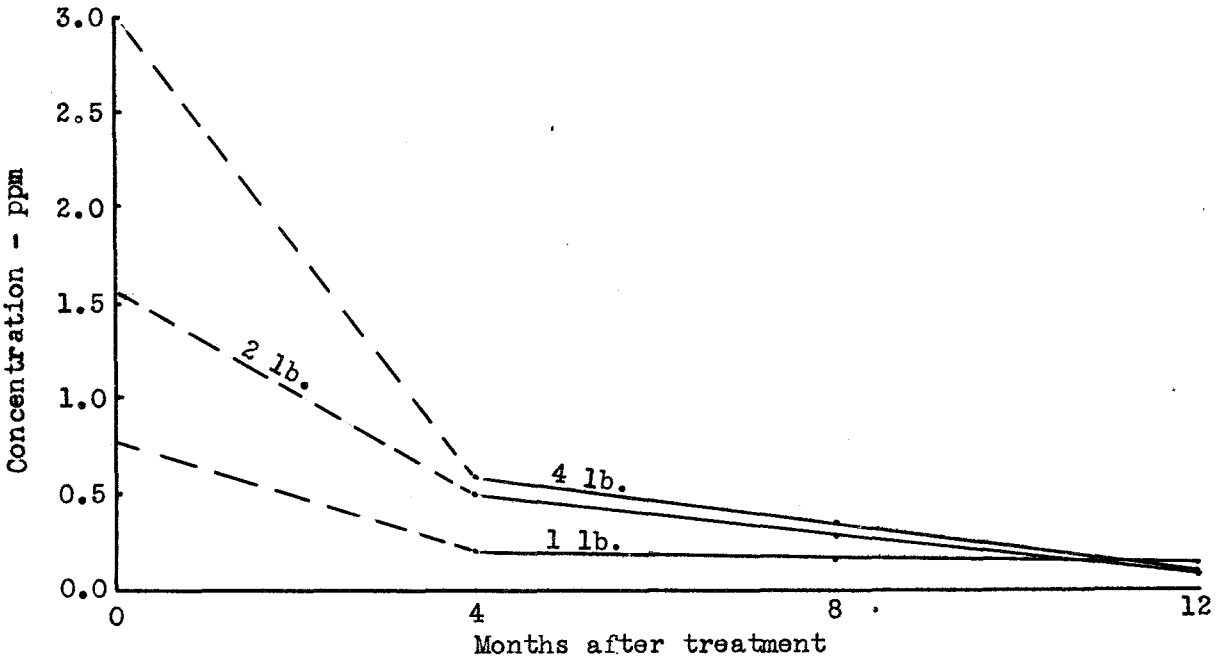


Figure 5. Chemical analyses of Lintonia Silt Loam (0- to 4-in. depth) after treatment with 3-(p-chlorophenyl)-1,1-dimethylurea. Essen Lane, Louisiana.

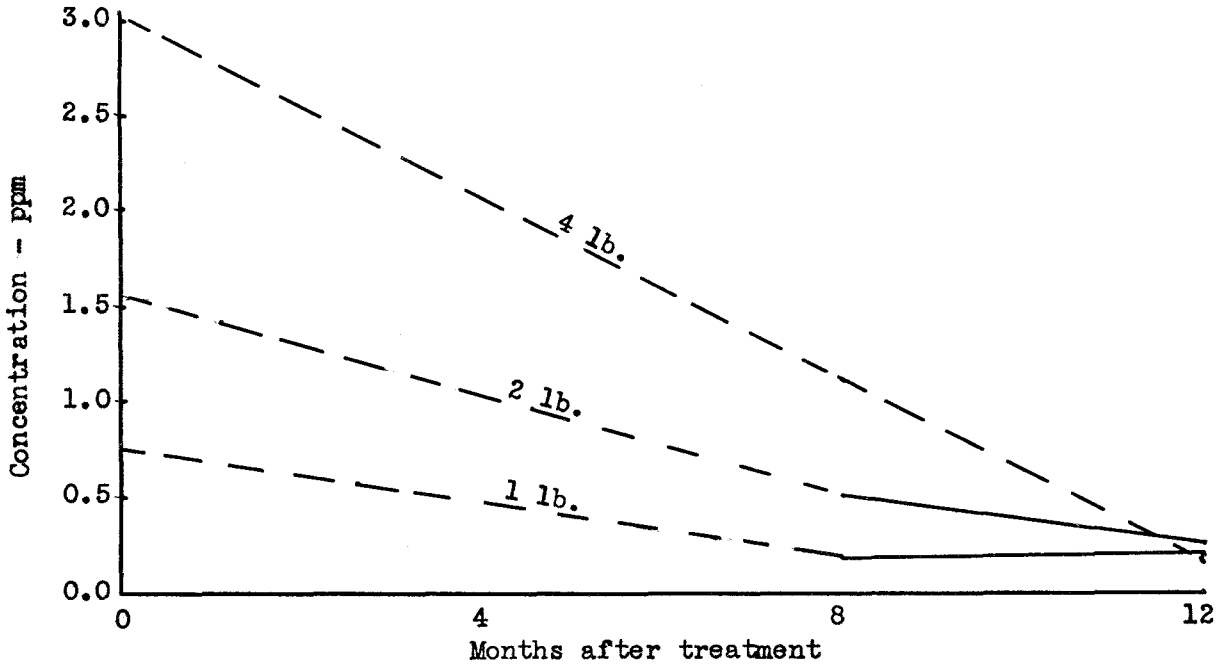


Figure 6. Chemical analyses of Lintonia Silt Loam (0- to 4-in. depth) after treatment with 3-(3,4-dichlorophenyl)-1,1-dimethylurea. Essen Lane, Louisiana.

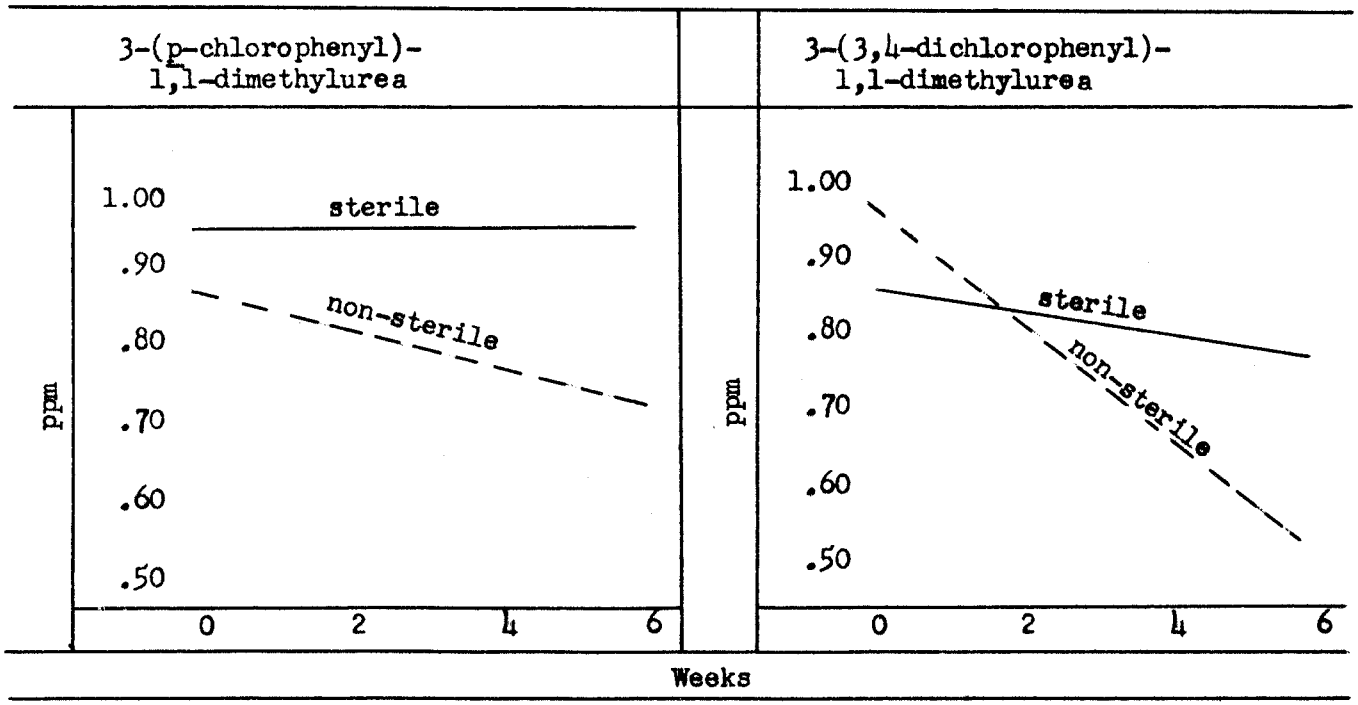


Figure 7. Bioassay of herbicide-treated sterile and non-sterile Cecil Loamy Sand after 0, 2, 4, and 6 weeks incubation at 80° F.

for 22 weeks at 41° F and 80° F.

Upon removal from storage, each soil sample was mixed thoroughly, placed in a 250-ml. pyrex beaker, and planted to oats to test for residual herbicidal effects. Loss of the herbicide by leaching was not a factor in this experiment. Residual effects as measured by the growth of oats 15 days after planting are shown in the following slides. It is evident from these data that the breakdown of both herbicides, at the 0.5- and 1.25-pound rates, in each soil type was greater at the 80° F. temperature (than at the 41° F. temperature).

Loss of Activity in Sterile and Non-sterile Soils.

The p-chloro and dichloro compounds were applied to Cecil loamy sand at the rate of 1 ppm, based on the weight of air-dry soil. The treated samples were watered and one-half of the samples were sterilized with chloropicrin. Both the sterile and non-sterile samples were stored at 80° F and 65% relative humidity. Representative soil samples were removed from storage at 0, 2, 4, and 6 weeks and planted to oats to determine the concentration of herbicide. Results of the bio-assay of soil samples at 26 days after planting are reported in Figure 7.

From these data, it is concluded that biological activity plays a role in the inactivation of both these urea herbicides.

Summary

Studies were conducted to measure the persistence of 3-(p-chlorophenyl)-1,1-dimethylurea and 3-(3,4-dichlorophenyl)-1,1-dimethylurea under field conditions in Cecil loamy sand at Raleigh, North Carolina; Leon-Immokalee sand at Palma Sola, Florida; and Lintonia silt loam at Essen Lane, Louisiana. On the basis of chemical and bio-analyses, it was concluded that both of these herbicides when applied at rates of 1, 2, or 4 pounds per acre as a blanket treatment were reduced to innocuous levels in each soil type at 4 to 12 months after initial application. Laboratory studies were conducted to evaluate the effect of a temperature differential and a sterility differential on the residual activity of the p-chloro and dichloro compounds. The residual effects of both herbicides disappeared more rapidly in soil samples stored at 80° F. than in samples stored at 41° F. Further, treated soil samples which were stored for 6 weeks under sterile conditions retained the initial toxic effects of both herbicides, while treated samples stored under non-sterile conditions showed a marked reduction in the toxicity of both herbicides. These results indicate that soil microbes play a role in the disappearance of these urea herbicides.

References Cited

1. Baker, H. M., W. K. Lowen and M. Levitsky. Determination of 3-(p-chlorophenyl)-1,1-dimethylurea in soils. Paper presented before the Pesticide Sub-division of the Division of Agricultural and Food Chemicals of American Chemical Society, Chicago, Illinois. 1953.

2. Danielson, L. L. and L. W. Easley. Progress report on the crop toxicity period of CMU in a sandy loam soil. Proceedings of the Seventh Annual Meeting of Northeastern Weed Control Conference. Pp. 11-15. 1953.

3. Loustalot, A. J., T. J. Muzik, and H. J. Cruzado. Persistence of CMU in soil. Agricultural Chemicals, 8(11): 52-53, 97-99, 101. 1953.

4. Ogle, Robert E. Activity and fate of herbicides of soils. Purdue University doctoral thesis. 1953.

CHEMICALS FOR PRE-HARVEST DRYING OR SPRAY-CURING

Luther G. Jones
Department of Agronomy, University of California, Davis, California

The term defoliation has inadvertently become associated with practically all chemicals and processes used to condition standing crops for harvesting. In the case of cotton, the term defoliation is correct when chemicals are applied to hasten or cause abscission and normal shedding of leaves. In the case of small-seeded legumes and grasses, however, where contact sprays are used, it is not desirable to cause the leaves to shed and drop to the ground. The primary purpose of treating with chemicals is to cure or desiccate the leaves and stems so that combining can be accomplished in one operation. Thus the term spray-curing is more appropriate.

The use of contact sprays to cure legume seed crops in California has increased greatly in the past 4 or 5 years. In 1948 only a few acres of alfalfa were treated. In 1953 more than 25,000 acres of alfalfa, considerable ladino clover, red clover, alsike clover, and trefoil were spray-cured for direct combining.

For spray-curing legume seed crops in California dinitro-ortho-secondary butyl phenol (DNBP) and dinitro-ortho-secondary amyl phenol (DNAP) in an oil carrier are generally used. Pentachlorophenol (PCP) in oil and endothal are also used to a limited extent.

Endothal in general is not as effective as the dinitros and oil. The time required for it to kill the leaves and stems is 3 to 5 days longer than for the dinitro-oil sprays. In thick, lush stands and under cool weather conditions, however, endothal is superior.

Similarly sodium cyanamid, sodium monochloroacetate, and chlorate-borate mixtures are usually less effective than the dinitros and oil. Pentachlorophenol, DNBP and DNAP alone are inferior to the same materials when used in combination with oil. The different oils when used alone were also less effective than PCP plus oil and DNBP and DNAP plus oil.

Pre-harvest sprays, or chemical formulations for curing, must meet specific requirements before they can be recommended for general use on a

particular crop or for a group of related crops. These requirements are: (1) effectiveness - materials must cause quick drying of the leaves, stems, and pods but with no harmful effect to the stand and the viability of harvested seed; (2) availability and form - materials must be easily available and in a convenient form for handling; (3) price - the cost to the grower must be reasonable, comparing favorably with the cost of windrow or swath curing; and (4) the residue and toxicity problems must be known. If the seed, grain, and/or straw are to be used for food or feed, they must meet purity standards as prescribed by the pure food and drug act.

The dinitro products in an oil carrier meet most of the requirements for conditioning legume seed crops for harvesting. The fact that they are readily available and in a convenient form for handling is an important factor favoring their wide use. The lack of accessibility and the bulky form of certain other materials may explain why they have failed to become more widely used.

Why is it desirable to spray-cure certain crops? The basic reasons are to improve quality, reduce production cost, and increase per-acre yields.

Alfalfa is commonly cured in the windrow and harvested by a combine equipped with some sort of pick-up device. This method may sometimes pose certain problems. To avoid excessive shattering of seed, the mowing and windrowing must be done when the humidity is high. In many localities over the State the humidity is normally high enough to allow swathing or windrowing to be carried on for at least a part of every day. In these areas windrowing will perhaps continue to be the preferred method.

In other areas of the State, however, the humidity is low, with little or no dew for long periods of time. Mowing and windrowing under these conditions would result in excessive shatter and serious reduction in seed yields. Likewise, if action is delayed for better condtions, the crop might pass beyond the optimum stage for harvesting, and seed is again lost by shatter and pod drop. On the other hand, spray-curing and direct-combining make an effective combination for harvesting alfalfa in these areas where the humidity is unusually low.

Another drawback to the swathing method is that windrows are easily damaged by wind. In localities where strong winds are prevalent during the harvest season, the windrowed crop is frequently mauled. As a result, seed shatter may be heavy, often to the point of complete loss of the crop. Spray-cured alfalfa is not immune to wind damage. However, it is more tolerant and losses are much lower.

In short-season areas, in late-maturing fields, and where rain is common during the harvesting period, spray-curing followed by direct-combining is also most effective. Under these conditions spray-curing will make it possible to speed up harvesting operations by more than 50 per cent over windrow-combining.

The normal curing procedures for ladino clover are the same as for alfalfa. A typical method involves four major operations: (1) mowing-windrowing for curing; (2) combining, chopping, or hay-hogging for moving to

stationary thresher; (3) threshing or re-threshing by stationary machine; and (4) vacuuming the field to recover shattered seed.

Because of the large amount of equipment used, most of the seed is custom-harvested. The mowing-operation may be done by the farmer, the combining-threshing by a contractor, and the vacuuming by still another operator, often requiring a period of 30 to 45 days to complete harvesting. The long period without water is detrimental to the clover stand, causing it to thin, and as a result, subsequent seed and/or forage yields are reduced.

Pre-harvest spraying as a means of curing ladino clover for threshing minimizes the amount of specialized harvesting equipment necessary. The time required to complete harvesting is much reduced, and deterioration of stands as a result of prolonged droughty conditions may be eliminated. Spray-conditioned clover can be direct-combined in one operation with a standard or slightly modified combine. The more moist straw does not break up, making separation easier, and head shatter losses are low, making a vacuum operation unnecessary. Using this method, total seed losses, including free seed, unthreshed seed, and shattered heads, may be less than 4 per cent of the total yield.

Trefoil seed crops are subject to extreme shattering, and if the fields are permitted to dry out normally, shattering will occur to the extent of 70 to 90 per cent of the crop. Harvesting trefoil by the ordinary methods of mowing, windrowing, and field-curing for combining are almost always unsatisfactory. Shattering is so severe that upwards to 90 per cent of the seed may be lost. The spray treatment causes the foliage to wilt, dry out, and toughen up rapidly enough to permit harvesting before the pods have dried sufficiently to cause any appreciable shatter.

Alsike clover is grown in a short season area (90 to 120 days), and the harvest period is brief. When ordinary harvesting methods are used (mowing, windrowing, and curing), severe seed losses are common, because of the short season and accompanying bad weather. Spray-conditioning hastens the harvest and greatly reduces the weather hazards.

Limitations

There are certain limitations in the use of spray conditioners. The stand should be open and erect to allow the spray to penetrate properly. With a thicker, more matted stand, two applications of spray may be successful, the first to kill the external growth and the second, a day or two later, to hit the lower and protected foliage.

Timing is very important. There must be close coordination between the spraying and harvesting operations. The crop must be allowed sufficient time to dry out following application of the spray. However, too long a delay will result in seed shatter and pod dropping with some of the crops and/or regrowth in others. The period during which harvesting can most successfully be done following the spraying may vary from a few hours with trefoil to a week with alfalfa.

Depending on the maturity of the crop, some loss in yield may be experienced if spray-curing is used, all other factors being equal. Once the spray has been applied, all further seed development ceases. Green pods that are hit by the spray will not develop viable seed, although the dry pods and mature seed will not be affected. With windrowing, seeds will continue to develop for another 5 days after mowing. Thus, windrowing would be preferable in a crop containing a large percentage of immature seed, providing some other factor does not rule out the use of this method.

The seed of a spray-cured crop usually has a higher moisture content at the time of harvest than that from a windrowed crop, and may be subject to heating. If so, the seed should be aired within 24 hours of harvesting. One good method of doing this is to run the seed over a fanning mill.

Straw that has been sprayed can or cannot be fed to livestock, depending on the material used and type of stock to be fed. In any case, however, it should be allowed to air out for 10 to 14 days before feeding, baling, or stacking.

Other crops. -- Spray curing is being used more and more to condition crops other than legumes for direct-combining. They include rice, sorghum, milo, sudan grass, blue panicum, wheat, flax, safflower, and castor beans. The materials used include PCP, NAPCP alone and with oil, DNBP and DNAP alone and with oil, chlorate-borate, endothal, sodium monochloroacetate, sodium cyanamid, sodium chloroacetate, aromatic oils, Dalapon, and others.

Rice.-- Experimental spray-curing and commercial field applications of chemicals to dry rice in the field prior to harvesting have shown considerable promise. The materials tested were DNBP, DNAP, sodium pentachlorophenate, sodium monochloro-acetate, and clorate-borate. The dinitro materials and sodium pentochlorophenate were undesirable because of a yellow color and objectionable odor imparted to the rice. Sodium monochloroacetate and chlorate-borate were effective on standing rice under favorable conditions. Although the residue problem of these materials has not been fully determined, commercial applications of both have been made.

The chemicals are applied when the moisture content of the standing grain is near 25 per cent. When conditions are favorable for drying, the moisture may drop to nearly 15 per cent in 4 days. Under less favorable climatic conditions drying is much slower. Deterioration in quality because of sun checking is more prevalent in spray-cured than in dehydrated rice.

Pre-harvest spraying would seem to have its most practical application in seed production. Field-drying would eliminate drying in dehydrators where rice seed is likely to become mixed. The lowering of quality because of sun checking is less objectionable in seed rice.

Flax.-- Pre-harvest spraying of flax is usually done to eliminate weeds rather than to dry the crop for harvesting. The dinitros, DNBP and DNAP at 1 to 3 pints in 8 to 15 gallons of oil, are usually effective. Pre-harvest spraying has a definite advantage where weeds are a problem in harvesting the crop. It will pay in increased yields and earlier harvesting as compared to windrowing.

Castor beans. -- For spray-curing castor beans, PCP and oil does an excellent job when the beans are uniformly mature. It is less effective when young growth or lush green foliage is prevalent in the field. Endothal is more effective than PCP under conditions of new growth and heavy green foliage. Other materials, chlorate-borate, DNBP and oil, and sodium cyanamid are usually less effective.

Safflower. -- Spray-curing is recommended to condition unevenly maturing stands of safflower for harvesting. The dinitros, DNBP and DNAP at 1 quart in 10 gallons of oil per acre, are usually effective. Other contact sprays would probably be equally satisfactory.

Milo. -- The dinitros, DNBP and DNAP at 1 quart in 8 to 15 gallons of oil (annalos 11) gave satisfactory results. In 1953, California used 100,000 gallons of oil in spray-curing milo.

Seed Damage. -- Pre-harvest spraying of a table-beet seed crop resulted in low seed germination. The spray used, DNBP at 1 quart in 10 gallons of oil (annalos 11) per acre effectively dried the crop. Moreover, when the seed were separated from the corky hull, germination was unimpared. In processing beet seed, however, the corky hull is not removed. Therefore the pods, containing one or more seeds, are, in effect, the clean seed. In this condition enough spray was retained to impair germination.

Tall Fescue. -- Two applications of DNBP at 3 pints in 10 gallons of road oil per acre applied on successive days was sufficient to kill top growth. Combining was possible within 5 days after treating. The germination of treated seed, however, was lowered by 20 to 25 per cent, and the vigor of seedlings resulting from them was below normal.

These two examples of damaged seed point up an important fact: Blanket recommendation of materials for spray-curing is not possible. For successful spray curing, chemical formulations must be effective in causing leaves, stems and pods to dry, and must be harmless to perennial crop stands and to the viability of harvested seed. When the crops are used for food or feed they must be free of harmful residue.

The information on rice was furnished by (1)L.L. Davis, on safflower and flax by (2)P.F. Knowles, on castor beans by (3)L.H. Zimmerman, and on table beets by (4)J.F. Harrington (Vegetable Crops).

(1) Associate Agriculturist, Extension Service, U. C., Davis, California
(2) Assistant Professor Division of Agronomy, U. C., Davis, California
(3) Associate Agronomist, U. S. D. A. Division of Agronomy, U. C., Davis, California
(4) Associate Professor Division Vegetable Crops, U. C., Davis, California

BRACEROS, BURROS, CHEMICALS, AND JOHNSON GRASS

J. Wayne Whitworth
Department of Agronomy, A & M College of New Mexico,
State College, New Mexico

Many farmers in the Rio Grande Valley of southern New Mexico and west Texas need an effective substitute for the hoe-wielding "bracero" from Mexico whose labor formerly furnished a cheap method for controlling Johnson grass on farm waterways. Cheap labor and the burro that fed on Johnson grass hay have passed from our agricultural scene, and so goes the precious water that seeps away from the grass-clogged ditches.

Irrigation ditches in New Mexico cannot be economically kept free of all vegetation by the use of chemicals. Soil sterilization has proved to be a costly, ineffective method of controlling Johnson grass. This inefficiency is indicated by the data in Table 1. Three rates of all chemicals were applied, but only the higher, more effective rates are reported.

Table 1. Acre yields of Johnson grass in tons per acre (air dry wt.) following single applications of herbicides, and percentage regrowth eight months after a second application (average of three replicates)[1]

Herbicide					Johnson grass	
	Rate - lb./A (active)				Yield,	Regrowth,
	Date of application			Approx.	T/A	%
Kind*	4/29/52	8/4/52	Total	cost/A	7/29/52	5/3/53
Polybor-chlorate	2560	2560	5120	$512	1.92	5
TCA	200	200	400	226	2.34	18
CMU	80	80	160	700	2.90	63
MH-30	40	0	40	380	0.56	27
Shell 20[2]	360 gpa	0	360 gpa	72	**	33
CHECK					4.14	49

*Full names of herbicides are as follows: TCA, trichloroacetic acid; CMU, 3-para-chlorophenyl 1,1-dimethylurea; MH-30, maleic hydrazide; Shell 20, aromatic oil.

**An application of oil made just before yields were taken killed Johnson grass topgrowth on these plots.

1 Soil texture: Silt loam (sand 14%, silt 67%, clay 19%, O.M. 2.5%)
Rainfall: May 0.16 inches, June 1.07, July 1.11, Aug. 1.22, Sept. 0.37, Nov. 0.19, Dec. 0.12, Feb. 0.68, Mar. 0.41, Apr. 0.03.

2 Three separate applications totaling 360 gallons per acre were made each time the Johnson grass regrowth attained a height of 10 inches.

In a few tests, TCA successfully controlled Johnson grass, and Texas blueweed (Helianthus cilaris) on these plots increased almost 100 per cent. Nutgrass (Cyperus rotundus) also increased when applications of soil sterilants reduced the stand of Johnson grass.

Workers in Arizona (1) and Texas (3) have reported that applications of TCA as low as 120 pounds per acre, or less, have been effective in reducing Johnson grass on ditchbanks by 95 per cent. Lack of rainfall at the proper time and inadequate amounts appeared to be the most logical reason for the failure of similar treatments made in New Mexico.

An experiment was started at State College, New Mexico, in 1952, to determine the effect of leaching TCA into the soil by applying water to similate rainfall. A series of plots were laid out on a high, rounding ditchbank heavily infested with Johnson grass. In November, each of three plots received a single treatment of 160 pounds per acre (acid equivalent) of TCA applied in 80 gallons of water. Each month following, three additional plots were treated. Shortly after the TCA was applied, one-half of each plot received the equivalent of 3/4 of an inch of water sprinkled onto plots to similate rainfall. Results of these treatments were very disappointing. Differences in favor of the irrigated over the non-irrigated were evident on June 1, 1953, as indicated in Table 2, but by September 1953, over-all control was so poor that it was impossible to distinguish the TCA-treated plots from the non-treated check plots.

Table 2. Estimated percentage density of Johnson grass June1, 1953, following applications of 160 pounds of TCA per acre (acid equivalent) (average of three replicates.)[1]

Treatment		Rainfall in inches	Percentage density of Johnson grass	
Month applied	Stage of growth when applied		Irrigated	Non-irrigated[2]
Nov. 1952	Dormant	0.19	25	47
Dec. 1952	Dormant	0.12	12	25
Jan. 1953	Dormant	0.00	25	45
Feb. 1953	Dormant	0.68	42	57
Mar. 1953	Emerging	0.41	33	63
Apr. 1953	4-in. culms	0.03	*	67
Check			63	63

* Plots were not irrigated
1 Soil texture: Sandy loam (58% sand, 30% silt, 12% clay, 2.5% O.M.)
2 An equivalent of 3/4 inches of water was sprinkled on irrigated plots.

Many farmers would like to retain the soil-binding qualities of their present ditchbank vegetation without suffering water losses due to the obstruction of the flow of water by heavy topgrowth. Accordingly, maleic hydrazide (MH-30), which had proved to be a growth inhibitor of promise in the 1952 tests, was further tested to find ways of increasing its effectiveness and reducing the cost of such treatments.

The sodium salt of maleic hydrazide (MH-40) was used in the 1953 tests in place of the triethanolamine salt formulation (MH-30) because the manufacturer had found that the triethanolamine fraction was hazardous to men and animals. One test involved the effect of stage of growth, and the other involved the use of such additives as oils, 2,4-D and wetting agents. MH-40 at rates as high as 40 pounds per acre (MH equivalent) was applied to Johnson grass at various growth stages ranging from early emergence to early boot. Effects of the treatments on Johnson grass were so slight

that only immeasurable stunting and discoloration of the vegetation were visible at any time following the application of the MH-40 growth inhibitor.

Recent work by the manufacturer (4) indicated that low humidity had a more adverse effect on the action of the sodium salt of maleic hydrazide than on the triethanolamine salt formulation. Low humidity is an outstanding characteristic of the climate of southern New Mexico. Johnson grass resistance to the growth inhibitor may also have been increased by the exceptionally cold and windy spring of 1953.

Aromatic oils and fortified oil-water emulsions have proved to be the least expensive and most dependable herbicides for controlling Johnson grass and other ditchbank weeds in our area. Arle of Arizona (2) has shown that oils which contain a high percentage of polycyclic aromatic compounds are the most effective weed killers. However, unless such oils are produced locally, shipping costs make their use prohibitive.

In 1953 tests, the toxicity of two oils produced locally[1] was compared with an oil of known performance and composition. One of the local oils, a No. 2 furnace oil, was applied with and without the addition of 5 quarts of 60 per cent pentachlorophenol per 100 gallons. At rates of 120 and 160 gallons per acre, all the oils gave a good topkill of Johnson grass vegetation. On September 18, 1953, one month after the third and just before the fourth and last application of oil, data on the percentage regrowth of Johnson grass were taken. These data along with information on the aromatic content of the oils are reported in Table 3.

Table 3. Percentage regrowth of Johnson grass on September 18, 1953, one month after the third application of oils containing various amounts of aromatic compounds.

Treatment				Percentage regrowth of grass			
Date and rate of application in gal./A.				Ratio of poly- to monocyclic[1] aromatic content of oils used			
5/25	6/24	7/29	Total	35:6	24:21	8:24	8:24 (Fort)[2]
40	80	80	200	33	96	78	80
80	120	120	320	12	52	48	80
160	160	160	480	1	9	22	48
Check (not treated)							95

1 First number refers to percentage polycyclic aromatic content and second number to monocyclic. Analysis by Richfield Oil Co.
2 Fortified with 5 quarts of 60% pentachlorophenol per 100 gallons.

Final effects of the 1953 treatments cannot be accurately determined until regrowth data on Johnson grass are taken during the 1954 growing season. However, the data in Table 3 agree with results obtained in

1 Furnace Oil No. 2, Standard Oil of Texas, El Paso, Texas; aromatic content, 8 per cent polycyclic and 24 per cent monocyclic.
Cracked or petroleum distillate, McNutt Oil Co., El Paso, Texas; aromatic content, 24 per cent polycyclic and 21 per cent monocyclic.

Arizona (2) and indicate that the toxicity of an oil on Johnson grass depends largely on the content of polycyclic aromatic compounds. Lesser amounts of oils high in polycyclic content are required to kill topgrowth. These oils are also more effective for the eradication of Johnson grass. Oil sprays are more severe on Johnson grass than on the more desirable Bermuda grass. If Bermuda is present in any amount, it will eventually replace the Johnson grass under a controlled oil spray schedule.

Perhaps further work will show that the replacement of Johnson grass on ditchbanks can be better accomplished by fortified oil-water emulsions at half the cost of the straight oil treatments. Or, perhaps some of the new grass killers which are translocated through the foliage may be the answer. If the solution to the Johnson grass problem on ditches is to include the use of chemicals, the herbicide used must be cheaper than those in current use, easier to apply, with fewer applications for control, and more effective in encouraging the increase of desirable vegetation while destroying the undesirable types.

Literature Cited

1. Anon. Control of Johnson grass with sodium TCA. Down to Earth. 6 (2):8-9. 1950.

2. Arle, H. F. Control of Johnson grass with oils. Research Progress Report 13th Western Weed Control Conference. p. 19-20, 1952.

3. Stiver, E. N., H. E. Rea, and J. R. Johnston. Chemical control of Johnson grass at the Blackland Station. Progress Report 1318, Texas Agri. Exp. Sta., Texas A. & M. College System, 1950.

4. Zukel, J. W. Letter dated December 10, 1953.

RESPONSE OF VELVET MESQUITE IN SOUTHERN ARIZONA TO AIRPLANE SPRAYING WITH 2,4,5-T

Abstract

Mack E. Roach and George E. Glendening
Range Conservationist (Research), Agricultural Research Service, Tucson, Arizona, and Agricultural Representative, Copper State Chemical Company, Tucson, Arizona, respectively.

The response of velvet mesquite (*Prosopis juliflora var. velutina*) to 2,4,5-T was observed in two southern Arizona studies. One study on the Santa Rita Experimental Range consisted of extensive tests of forms, carriers, and volumes. The other less extensive study compared forms and volumes at three sites in southern Arizona.

The study at the Santa Rita Experimental Range was designed to compare all combinations of: (1) an amine salt and a low volatile ester of 2,4,5-T at 3/4 lb. acid equivalent per acre; (2) application of 5, 10, and 20

gallons of solution per acre; (3) 1:3 and 1:7 oil-water emulsions as carriers; and (4) diesel oil and nonphytotoxic oil (Helix 20) as the oil phase of the carrier. The second study was a comparison of the effects of ester and amine forms of 2,4,5-T applied at rates of 5, 10, and 20 gallons per acre at three sites. Sites were of about the same elevation and received average annual rainfall varying from 15 to 17 inches.

All plots were sprayed at a growth stage when velvet mesquite has been shown to be most susceptible to 2,4,5-T. Spraying was in 42-foot swaths from a Stearman airplane flying just above the tree tops.

Results

An analysis of variance of the results (table 1) of the Santa Rita Experimental Range study show: (1) the differences in plant kill and top kill between the amine form and ester form are significant at the 1 per cent level. (2) The difference in plant kill between the 5-gallon and 10- or 20-gallon plots was significant at the 1 per cent level. The differences in top kill between the three rates or in plant kill between the 10- and 20-gallon rates were not significant. (3) The comparison of a nontoxic oil and diesel oil showed little difference in plant kill or top kill. (4) The comparison of the 1:3 and 1:7 ratio showed no important differences.

The study installed at three sites was designed only to compare site, form, and volume (table 2). An analysis of variance of the results of this study showed the differences in both plant and top kill at all three sites due to form to be highly significant (1 per cent level). The difference in plant kill between the 5- and 10-gallon rates was highly significant, but the difference between the 5- and 20-gallon rates was not significant. In terms of top kill the differences in the 5- and 10-gallon rates and the 5- and 20-gallon rates were highly significant. The differences in plant kill and top kill due to site were highly significant.

Discussion

The ester form of 2,4,5-T was superior to the amine form at one site, about equal at the second site, and inferior at a third site. The mean figures for all treatments show that ester produced higher plant kills than did the amine. The 10-gallon-per-acre volume of spray with either the ester or amine was generally the best in terms of plant and top kill, although the relationship for volume varied between form at the three sites (table 2). Careful thought must be devoted before selecting the 10-gallon rate for use in preference to the 5-gallon rate because of the added cost of using the higher volume. The comparison of the nontoxic oil and diesel oil in the carrier favors diesel oil because of its much lower cost. Cost also favors the use of the 1:7 oil-water emulsion over the 1:3. The differences in plant and top kill due to site might be climatic differences, variations in soils, or genetic differences in plants. These studies point up the need for further research on effect of site on spraying of velvet mesquite in southern Arizona.

Table 1. Comparison[1] of 3/4 pound per acre acid equivalent of 2,4,5-T form, carrier, and volume sprayed by airplane on velvet mesquite May 1951, Santa Rita Experimental Range, Arizona, expressed as percentage plant kill and percentage top kill.

Volume*	Ester				Amine				Mean	
	1:3		1:7		1:3		1:7			
	K[2]	TK[3]	K	TK	K	TK	K	TK	K	TK
5 g.p.a.										
D.O. [4]	22	70	28	74	22	69	26	74	24.5	71.8
NTO	24	68	28	68	24	65	28	69	26.0	67.5
Mean	23	69	28	71	23	67	27	71.5	25.2	69.6
10 g.p.a.										
D.O.	44	79	40	78	30	67	22	71	34.0	73.8
NTO	40	81	40	69	18	69	22	69	30.0	72.0
Mean	42	80	40	73.5	24	68	22	70	32.0	72.9
20 g.p.a.										
D.O.	44	81	52	83	32	68	20	61	37.0	73.2
NTO	30	83	30	70	38	76	20	69	29.5	74.5
Mean	37	82	41	76.5	35	72	20	65	33.2	73.9
Av. all										
D.O.	36.7	76.7	40.0	78.3	28.0	68.0	22.7	68.7	31.8	72.9
NTO	31.3	77.3	32.7	69.0	26.6	70.0	23.3	69.0	28.5	71.3
Mean mean	34.0	77.0	36.3	73.7	27.3	69.0	23.0	68.8	30.2	72.1
Av. all 1:3									30.7	73.0
" " 1:7									29.7	71.2
" " Ester									35.2	75.3
" " Amine									25.2	68.9

* Gallons per acre

1 Observations made in August 1953.

2 Percentage of trees with tops dead and no sprouting.

3 Percentage of crown rendered nonfunctional, based on individual trees.

4 Type of oil used in the oil phase of the carrier. D.O. = diesel oil, NTO = nontoxic oil.

Table 2. Comparison of 3/4 pound per acre acid equivalent of 2,4,5-T form and volume at three sites[1] expressed in percentage plant kill and percentage top kill.

Volume	Santa Rita				Ranch A				Ranch B				Average				Mean	
	Ester		Amine		Ester		Amine		Ester		Amine		Ester		Amine			
Gals./A.	K	TK	K	TK	K	TK	K	TK	K	TK	K	TK	K	TK	K	TK	K	TK
5	26	66	20	58	30	78	5	78	16	61	20	67	23.7	68.3	15.0	67.0	19.3	67.7
10	53	79	30	70	20	88	20	91	25	79	15	75	32.7	82.0	21.7	78.7	27.2	80.3
20	65	90	20	58	10	82	10	86	15	81	25	80	30.0	84.3	18.3	74.7	24.2	79.5
Av.	47.7	78.3	23.3	62	20	82.7	11.7	85	18.7	73.7	20	73.3	28.8	78.2	18.3	73.5	23.6	75.8

1 Kill and top kill percentages are based on counts of 20 marked trees in each 5-acre plot, except for the Santa Rita 10-gallon ester figures, which include only 19 trees.

CONTROL OF WEEDS IN FLAX IN ARIZONA[1]

H. P. Cords and H. F. Arle
Department of Agronomy, Arizona Agricultural Experiment Station, Tucson, Arizona, and Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture, Phoenix, Arizona, respectively

Because Punjab seed flax is a close-drilled crop that notoriously does not compete well with weeds, the use of chemical weed control is of special importance in this crop. Consequently, the use of various herbicides has been intensively investigated in Arizona during the past several years.

This project began in the fall of 1948. At that time emphasis was placed on the possible applications of 2,4-D for the control of broadleaf weeds and IPC for the control of grasses. These two materials were applied both pre-emergence and post-emergence. Amine, ester, and sodium salt formulations of 2,4-D were applied at rates varying from one-fourth to one pound per acre while IPC was applied at rates varying from 1 to 6 pounds per acre. Postplanting pre-emergence treatments were discontinued in 1949 because of the possibility of injury to the flax, especially in the case of 2,4-D. Rain prior to flax emergence has reduced stands when either of the chemicals was used. In the case of 2,4-D these reductions in flax stands have ranged up to 90 per cent. Furthermore, unless rain follows within a reasonable period after emergence, these treatments are likely to be completely ineffective on weeds. Sodium salt formulations were dropped because they were less effective on weeds than the amine formulation. In 1949, 2,4-D was applied at rates varying from one-half to one pound per acre and IPC at rates varying from 2 to 3 1/2 pounds. In an attempt to reduce the 2,4-D injury to the flax at rates capable of controlling certain resistant weed species, flax was also planted in 18-inch rows and a basal spray applied in such a manner as to minimize the amount reaching the flax foliage. The results at two locations did not indicate any advantage for this method as against conventional over-the-top spraying.

A severe freeze in January, 1950, virtually eliminated flax stands. At this time the IPC applications had been made but 2,4-D applications had not. Flax was replanted January 23, and all results reported for 2,4-D treatments are on this late-planted flax. Flax was also replanted in the area previously treated with IPC. The flax emerged and grew normally in this area and excellent control of wild oats was obtained.

The work during the past 3 years was designed largely to confirm results previously obtained and to test new materials. Among the latter were TCA, 3 chloro IPC, Maleic hydrazide, ester and amine formulations of MCP, and a number of other materials. Most of these tests were unreplicated screening applications, made either pre- or post-emergence. The MCP formulations, however, were fairly thoroughly tested, and appeared to be no more selective than

[1]Investigations conducted cooperatively by the Arizona Agricultural Experiment Station and the Field Crops Research Branch, Agricultural Research Service, United States Department of Agriculture.

2,4-D. Practically all of the other materials tested proved to be either excessively damaging to flax or ineffective against weeds.

Probably the most prevalent broadleaf weed of flax fields in southern Arizona is silversheath knotweed (Polygonum argyrocolean). Unfortunately, it has considerable resistance to 2,4-D and cannot be effectively controlled at rates considered safe to use on flax (1/2 to 3/4 lb./A.). Consequently, considerable effort to find means of increasing the selectivity of 2,4-D has been made. The first of these attempts involved the use of foliage sprays of a nitrogenous fertilizer (Nu-green) in conjunction with 2,4-D applications. When 20 pounds per acre of the fertilizer were applied along with 2,4-D, a considerable reduction in the apparent symptoms on flax was noted. However, yield figures did not reflect these observed differences. Furthermore, if flax is planted at the proper date, it appears to recover completely from light 2,4-D injury inflicted at the 4- to 5-inch stage. Consequently, the practice of using Nu-green with 2,4-D has not been recommended.

The general conclusions from these herbicide trials in flax may be summarized as follows:

1. IPC has been used quite successfully for the control of wild oats and other winter annual grasses without injury to flax at rates from 2 1/2 to 3 pounds per acre.

2. IPC enters the plant through the roots and must be present in the root zone to be effective. This condition has been achieved by following IPC applications with a light irrigation.

3. In order for IPC to be effective in the control of wild oats, it must be present in the soil in effective quantities, either prior to emergence or during the seedling stage of the oats. Applications made after the oats have begun to tiller have been much less effective.

4. The amine formulation of 2,4-D is the most generally satisfactory one for use in controlling broadleaf weeds in flax.

5. Rates of amine 2,4-D up to one-half pound per acre have not adversely affected yields of weed-free flax when applied prior to the appearance of flower buds and after the flax has reached a height of 4 to 5 inches. Applications of one pound per acre or more have resulted in substantial reductions in yield. Applications of 3/4 pound per acre have resulted in slight, though usually not significant yield reductions.

6. Amine 2,4-D at one-half pound per acre will control, but not eliminate, a number of troublesome broadleaf weed species. However, knotweed (Polygonum argyrocolean) has not been successfully controlled by rates that can safely be used in flax fields.

7. Many materials have been tested, none of which appear to be equal to 2,4-D and IPC for general weed control in flax.

THE USE OF INSECTS FOR THE BIOLOGICAL CONTROL OF WEEDS

James K. Holloway
Entomology Research Branch, Agricultural Research Service, U. S. Department of Agriculture, Albany, California

Most of you are familiar with the investigational procedures associated with the development of chemicals for the control of weeds. In this country we have so far attempted only one project for the biological control of weeds by the use of insects, so possibly you are less familiar with the procedures associated with this type of work. Hawaii, Australia and New Zealand have been very active in the biological control of weeds for a long time and have made many notable contributions. With this background and from the experience gained in this country on the biological control of Klamath weed, we have formulated a few fundamentals of procedure and research which I would like to discuss.

Before a program for the biological control of weeds by the use of insects is begun, it must be definitely determined that the undesired plants are universally unwanted throughout all the areas in which the weed occurs. Introduced insects will be selective as far as plant species are concerned but there may be no selectivity as to locale.

A few years ago, Dr. Harry S. Smith, former Chairman of the Department of Biological Control of the University of California, was considering the possibility of controlling Opuntia. Mexico seriously objected to the proposal on the grounds that Opuntia was a source of food in many parts of that country.

Certain weeds may be an important source of pollen and nectar for bees. The control of such plants would affect primarily the bee industry and secondarily growers of many crops dependent on bees for pollination.

Weed problems associated with range and pasture lands are much more suitable to biological control than are weeds occurring under conditions of intensive cultivation. In most cases the continued disturbances of the environment in cultivated areas would not permit the insects to multiply continuously and in all probability the populations would not become large enough to be sufficiently effective.

Native plants are not well suited to the biological control approach because as a rule they have gained their competitive advantage because of interference with natural conditions.

The most desirable plant species for control would be those which are not closely related to economic species; such is the case with Hypericum perforatum L.

Many species, tho close to economic plants, have an unusual chemical content so that insects associated with them would by adaptation be selective. Because of the high oxalic acid content of Halogeton glomeratus, it is

possible that insects which continuously breed on this plant would be specific.

Some insects are specific because of a highly specialized life history which is dependent on specific plant characteristics. The adult gorse weevil is unable to free itself from seed pods which do not dehisce. The opening of the pods must also be synchronized with the life history of the weevil. If pods open too soon the immature stages will be expelled, and if it opens too late the adult will die. Gorse is a legume but it can be seen that due to a highly specialized life history the weevil would have difficulty breeding on many members of this family.

In the foreign exploration for insect enemies of weeds, an intensive study must be made on the life history of the insects, and records of parasitization by other insects should also be made. Local pest records, if available, should be examined to see if the insects being studied have any bad habits. Surveys should be made on crop plants in the areas in which the insects are being investigated. If the insects, thus far have good records, they should be submitted to starvation tests on closely related species and ultimately on representatives of other plant families. Those insects which meet the required specificity are then ready for importation.

The approved insects are received and reared for at least one generation in quarantine. During the quarantine interval it may be necessary to make additional starvation tests on plants which were not available in the country of origin. Also it may be necessary to remove any parasites which may be present, and become acquainted with the habits and life histories of the insects.

Initial field releases should of course be made in the best possible locations and at an optimum time which will afford the introduced insects the greatest opportunity of establishment. At the time of release some information is available on the life histories and the climatic requirements of the insects in their country of origin plus insectary observations. However, it is quite possible to make errors in judgment as to their optimum requirements in the new environment. In making the initial releases of two species of Chrysolina beetles for Klamath weed control, the total rainfall in the release areas was given major consideration. Field studies have subsequently shown that the difference in effective control by the two species in California has been in part associated with the total rainfall, but the rainfall pattern in the fall of the year has proved to be more important. Chrysolina gemellata Rossi is very responsive to light early fall rains which brings this species out of aestivation. The ensuing egg-laying activities and larval development, as a result of this response, are better synchronized with the basal growth period of Klamath weed.

After the establishment of the insects, detailed studies should be made, in order to determine the degree of synchronization between the life histories of the introduced insects and the growth phases of the weed. One or two initially introduced species may be unable to control a plant if its distributional range is extensive. This could well be the case with Klamath weed, which occurs from the Canadian border southward into Central California. In California C. gemellata has been the dominant species in all of the heavily

infested counties. In a few abnormally moist locations, such as the banks of irrigation ditches, it is possible for the weed to have regrowth after the beetle feeding period has been completed in the spring. Under these conditions it is very difficult to completely destroy the plants. A gall fly Zeuxidiplosis giardi Kieff has shown promise in curtailing late summer growth. During the egg laying period in the fall and winter the female adults of both species of Chrysolina are reluctant to enter shady areas. A root borer Agrilus hyperici Creutzer works well in the shade and has shown its ability by depleting a sizeable infestation scattered among oak and pine trees. The ability to work in the shade could be very important in the control of infestations on the north slopes of hills which would be partially shaded during the winter.

The biological control of Hypericum perforatum, through cooperation with the various experiment stations, has been extended to include other States in the Northwest. It is entirely possible that, after a more thorough study of the existing introduced species in these new locations it would then be desirable to consider the introduction of other species which may be better synchronized to the plant growth as it occurs under the climatic conditions encountered.

The most satisfactory control is obtained by insects which completely destroy the plants without having to rely on other additional competitive factors. This type of control has been effected on the Opuntia in Australia and Klamath weed in many counties of California.

Partial destruction can be effective in the presence of other competitive factors. An insect Liothrips urichi Karny which attacks the growing tips of plants was introduced into Fiji for the control of Clidemia hirta D. In the presence of competitive plants injury to the growing tip was sufficient to deprive Clidemia of the advantage it previously held and as a result it has been crowded out. In open pastures it was still necessary to grub out the large plants but any resulting regrowth following the clean-up was controlled by the insects.

The spread of plants can be limited by the use of insects to destroy the seeds. This type of control is exemplified in the case of Lantana in Hawaii and Gorse in New Zealand.

One of the most outstanding examples of the results which can be obtained by the use of insects to control a weed is the control of Opuntia cactus in Australia. In 1900 it was estimated that there were 10,000,000 acres of cactus and by 1920 the infestation had increased to the alarming amount of 60,000,000 acres. They attempted mechanical and chemical control but both methods proved too costly. A biological control research unit was organized to explore the native habitat of Opuntia. This exploration resulted in the introduction of mite and insect enemies. In 1925 a moth Cactoblastus cactorum (Berg.) was introduced from Uruguay. The moths were bred in the insectary and the eggs were distributed in large numbers throughout the infested areas. In a short while the insects became so numerous that it was no longer necessary to resort to insectary breeding and in 8 years after the initial releases the cactus was controlled sufficiently so that millions of

acres were returned to useful agricultural production.

In the United States the first project to control a weed by the use of insects was begun in California.[1/] At that time Klamath weed, or Saint Johnswort had made serious inroads to the pasture lands in the northern part of the State. The county Agricultural Commissioners in 31 counties estimated a total of 2,325,201 acres were infested by the weed. The first insects were introduced into the field in 1946; 4 years later each of the heavily infested counties had one or more successful colonies of Chrysolina gemellata which by that time had proven to be the dominant species. The county Agricultural Commissioners engaged in an intensive distribution program within the counties which greatly hastened the spread. At the present time, 1954, the beetles have become so numerous that it is almost impossible to find an infestation of Klamath weed whether it be large or small which does not show evidence of beetle injury. All counties report that at least half of the acreage has been destroyed and in view of the progress made it is no longer necessary to allocate money for control. The indications are that within the next 3 years in California the weed will no longer be of any economic importance. It is also interesting to note that in the last two annual California Weed Conferences there was no formal or informal discussion of Klamath weed during the meetings.

In this talk it was hoped to point out some of the general procedures, and research approach associated with this kind of biological control program. It requires a great deal of painstaking work, a lot of time and patience which must be shared by the research worker and those who have requested the program of research. However, if success is obtained, the time and patience will be adequately rewarded.

NEW CHEMICALS FOR WEED CONTROL

C. E. Minarik and A. S. Newman
Camp Detrick, Frederick, Maryland

This review on "New Chemicals for Weed Control" is based on papers on the same subject which were presented at the 1953 North Central Weed Control Conference. In most instances these papers were complete reviews of data from all sections of the country. In several instances data were presented which were not available in the research reports or proceedings of the various weed control conferences. Consequently, in preparing this review we have borrowed heavily from these authors.

Acknowledgment is made to the following for the use of their reviews:

Dr. D. D. Hemphill, University of Missouri -- phenyldimethylurea
Dr. K. C. Barrons, Dow Chemical Company -- Dalapon

---

1 Biological control of Klamath weed has been a cooperative project with the University of California Agricultural Experiment Station.

Dr. G. F. Warren, Purdue University -- N-1 naphthyl phthalamic acid
Dr. Lyle Derscheid, South Dakota State College -- 4-chlorophenoxyacetic acid and 3,4-dichlorophenoxyacetic acid
Dr. J. P. Mahlstede and Dr. E. L. Denisen, Iowa State College -- analogs of sodium 2,4-dichlorophenoxyethyl sulfate
Dr. Richard Behrens, USDA, College Station, Texas -- amino triazole

In some cases these authors' reviews are presented here with only minor changes.

Phenyldimethylurea

This evaluation of 3-phenyl-1,1-dimethylurea is based on experimental results from 22 groups of investigators from 15 States and 3 Provinces. It must be pointed out, however, that at best this report must be considered as preliminary because this herbicide has been in the hands of most investigators for only one season.

Phenyldimethylurea can be considered as a general herbicide with a high order of toxicity to a wide variety of plants. Possibilities of this chemical as a pre-emergence herbicide have been tested in numerous agronomic crops including corn, wheat, soybeans, cotton, flax, sugar beets, barley, oats, sunflower, safflower, sesame, alfalfa, timothy, and red clover. For cotton, corn, soybeans, and wheat, results are contradictory and therefore its use is questionable at this time. Flax, sugar beets, sunflower and safflower appear more sensitive than the above-mentioned crops, and its use on these crops does not seem advisable.

Phenyldimethylurea has been tested also as a herbicide on several horticultural crops including asparagus, carrots, grapes, snap beans, onions, squash, sweet corn, and cranberries. Pre-emergence and post-emergence application on onions and peas and selective foliage application on cranberries appear promising. Results of treatments on other crops were contradictory or indicated that this chemical was too toxic.

In the control of woody plants such as mesquite, post and blackjack oak, and wild currants (Ribes spp.) insufficient time has elapsed to obtain accurate readings; however, 75 to 100 per cent defoliation has resulted in all experiments.

This chemical gave approximately 90 per cent control of curled dock, perennial sow thistle, ox-eye daisy and king devil at the rate of 20 pounds per acre. Couchgrass and toadflax require 40 to 80 pounds per acre for 90 per cent control and only approximately 50 per cent control of chicory is obtained with 80 pounds per acre. For sod killing, 20 pounds per acre is effective against Colonial Bent grass. One investigator reported this chemical to be less effective than CMU, Dalapon or TCA for Bermuda grass control.

Field bindweed, bladder campion and sedge appear quite resistant.

As a soil sterilant for treating railroad rights-of-way and similar areas, it did not appear to have adequate residual properties.

Due to the similarity in chemical and physical properties, phenyldimethylurea was compared with CMU in most experiments. It appears that there is little difference between these two chemicals as to effectiveness in controlling annual grasses and broadleaved weeds. Some results indicate that CMU may be more effective in annual grass control while other data indicate that phenyldimethylurea gave slightly better control of all types of annual weeds.

In the control of perennial weeds, the mode of killing appears the same, and species resistant to CMU are also resistant to phenyldimethylurea. The most significant factor seems to be the difference in persistence of these two chemicals in the soil.

Considering the toxicity of these materials to the various crop plants, there may be some difference in selectivity; however, the results are not conclusive. Barley, oats, wheat, flax and sugar beets were reported to be more sensitive to phenyldimethylurea, while carrots, peas, onions, snap beans, squash and bluegrass were reported to be more sensitive to CMU. Results for corn and soybeans were contradictory.

The related compound, 3-(3,4-dichlorophenyl)-1,1-dimethyl urea, as a pre-emergence application has given excellent weed control in cotton without injury to the crop. Established cotton appears to be tolerant to this compound. Pre-emergence applications of this compound had no effect on carrots but seriously injured onions. 3-(3,4-dichlorophenyl)-1,1-dimethyl urea has provided good sterilant-type weed control for longer periods than CMU.

Amino Triazole

Only a few investigators have tested this herbicide. Amino triazole is a white, crystalline solid which is soluble in water and ethanol but insoluble in ether and acetone. It forms salts with most acids. The salts of the phenoxy acids may be of particular interest as herbicides. Other derivatives can be made by reacting amino triazole with ketones and aldehydes. Ingestion tests with rats indicate that it is relatively nontoxic.

Little is known of the mode of action of amino triazole. It is readily absorbed by roots and aerial parts of plants. Once inside the plant, it is translocated, mostly to the growing point and younger tissues, which show the greatest response. The plants develop a chlorotic condition. The degree of chlorosis varies but can develop to the point where there is a complete absence of chlorophyll, and the plant looks like an albino. Sometimes the development of chlorosis is followed by death of the affected plant or plant parts though this is not always the case. The chlorotic tissues may remain alive and eventually regain their normal color. It is believed that amino triazole disrupts the balance between the plant processes involved in chlorophyll synthesis and destruction. Other plant processes must also be affected by amino triazole applications since very low concentrations will cause root inhibition.

The use of amino triazole in cotton defoliation appears very promising at the present time. As an additive to other defoliants, amino triazole acts as a synergist and regrowth inhibitor. Used alone, it also appears

quite effective as a defoliant.

Crop plants and weeds have varying degrees of tolerance to amino triazole. Oats, sorghum, sudan grass, kenaf, soybeans, vetch, peas, lima beans, cucumber and snap beans showed considerable tolerance to pre-emergence applications. Ladino clover, common millet, alfalfa, birdsfoot trefoil, and rape were very susceptible to pre-emergence applications. Sorghum, kenaf, and oats were more tolerant to post-emergent applications of amino triazole than barley, flax, sugar beets, cotton, ladino clover, common millet, alfalfa, birdsfoot trefoil, squash, and rape. Other crops were intermediate in response. Broadleaf weeds were controlled effectively by both pre- and post-emergence applications. In preliminary experiments amino triazole appears to have promise as a pre-emergence herbicide for the control of annual weeds in corn and cotton. As a directional spray on 24- to 26-inch tall field corn it was more effective in controlling quackgrass, nutgrass, and annual grasses than Dalapon but was highly injurious to the corn. One experiment indicated that amino triazole was effective in controlling milkweed.

Effective control of poison ivy seems to be a possibility with amino triazole. Blackbrush and mesquite seedlings were not killed by the application of 0.5 per cent amino triazole in water. Mixtures of amino triazole and 2,4,5-T appeared to be more toxic to mesquite seedlings than 2,4,5-T alone. Similar applications to mesquite trees in field plots have been made but preliminary observations on the effectiveness of the mixture have not been encouraging.

Analogs of Sodium 2,4-dichlorophenoxyethyl Sulfate

Sodium 2,4-dichlorophenoxyethyl sulfate, also known as SES and Crag Herbicide 1, has been unique among herbicides in that it is relatively inactive when applied. Following its application to soil under favorable environmental conditions, it is converted to an active form, presumably by soil microorganisms. In the active form it kills germinating weed seeds as well as emerging weeds of many species. SES should be used following cultivation and before weed emergence.

In repeated tests during the past 5 years SES has given comparatively good weed control in strawberries, respberries, asparagus, and a large variety of nursery stock. Many commercial growers of these crops are using SES as a standard cultural practice. SES has given variable results with many annual vegetable and field crops such as corn, soybeans, snap beans, and onions. The usual treatment rates are 2 to 4 pounds per acre with the lower rates for sandy soils and the higher rates for finer textured soils.

SES normally controls weeds for 3 to 6 weeks under normal growing conditions. If the soil is dry at the time of application, there will be a delay in the conversion to the active compound during which time weed seeds will germinate and emerge without any evident injury. Rain on a dry soil within 2 to 3 days after application allows conversion of the SES in time to affect the germinating weed seeds. Temperature apparently also is a factor in determining the effectiveness of weed control. Better control has been noted in Iowa with summer and fall applications than with early spring applications. There appears to be no drift hazard in the application

of SES.

Several analogs of SES were tested during the 1953 season. Presumably these compounds are similar to SES in physiological inactivity as sprays and conversion to active forms in soil. Soil environmental factors which determine the effectiveness of SES should also determine the effectiveness of the analogs. Results for 1953 probably are not typical because of drouth conditions at many of the experimental sites.

Natrin, which is sodium 2,4,5-trichlorophenoxyethyl sulfate, is the 2,4,5-T analog of SES. Encouraging results on the control of trumpet vine in cotton were obtained with this compound without cotton injury, while SES controlled the vine but injured the cotton. Natrin applied pre-emergence to peas at 4 pounds per acre gave good weed control, but the peas were moderately injured. On tomatoes Natrin looked promising for both transplants and pre-emergence. Natrin gave good control of broadleaves and excellent control of grasses in asparagus, but not as long a residual weed control as sodium 2-methyl-4-chlorophenoxyethyl sulfate, CMU, or phenyldimethylurea. Natrin has given fair to good weed control in an established nursery and excellent weed control in a conifer transplant bed.

Sesin, which is 2,4-dichlorophenoxyethyl benzoate, is 50 per cent active by weight. It has been tested more extensively than any of the other analogs of SES. Sesin has shown longer residual activity than SES or Natrin. In many experiments its action has been identical or similar to that of SES. In post-emergence treatments on soybeans Sesin, SES, and Natrin at 4 pounds per acre were ineffective in controlling weeds. In a pre-emergence experiment on soybeans, 4 pounds of Sesin gave 83 per cent control of grasses and 93 per cent control of broadleaves, while Natrin was ineffective in weed control and stunted the beans. Alanap, Premerge, and CMU were more effective than Sesin. In two experiments Sesin was injurious to onions when applied pre-emergence. It also was injurious to snap and lima beans in pre-emergence applications.

2,4,5-Trichlorophenoxyethyl benzoate in soybeans has given fair to good control of grasses and broadleaves at 4 pounds per acre. In corn it has given excellent weed control with some temporary stunting.

Bis-(2,4-dichlorophenoxyethyl) oxalate, another analog, gave erratic control of weeds and injury of peas. It also was less effective than SES on corn. Applied pre-emergent to tomatoes it drastically reduced the yields and produced poor quality fruit.

Further investigations are needed on these analogs of SES in order to evaluate them properly.

3,4-Dichlorophenoxyacetic Acid and 4-Chlorophenoxyacetic Acid

These two compounds will be discussed together, since they have been compared in several experiments. Neither compound has a standard common name or symbol. Hereafter in this report 3,4-dichlorophenoxyacetic acid is referred to as 3,4-D and 4-chlorophenoxyacetic acid as 4-C. No reports on these compounds were available from the Southern Weed Conference.

4-C was less effective in controlling Canada thistle than 2,4-D at rates of 1 to 8 pounds per acre; 4-C was also less effective in controlling perennial sow thistle than 2,4-D at rates of 1 to 2 pounds per acre. This compound at rates of 10 and 20 pounds per acre was ineffective in controlling quackgrass. Also a mixture of esters of 2,4-D, 2,4,5-T, and 4-C was less effective on leafy spurge than esters of 2,4-D alone.

Workers in Saskatchewan compared 4-C with 2,4-D and MCP for control of 14 species of annual weeds at 3 stages of growth in 4 experiments. The amine of 4-C was consistently more effective than comparable rates of amines of MCP or 2,4-D in the control of tumbling mustard, shepherd's purse, flixweed, Russian thistle, redroot pigweed, blue bur, tartary buckwheat, and purple cockle, while the butoxy ethanol ester of 4-C was superior to the same esters of 2,4-D and MCP for controlling redroot pigweed and night flowering catchfly.

In Maryland 0.25 to 2 pounds per acre of 4-C applied in the fall controlled winter cress and field peppergrass but reduced the stand of alfalfa and had no effect on chickweed. In New York 4-C was much less effective than MCP in controlling yellow rocket in alfalfa and red clover.

In Saskatchewan 8 and 12 ounces per acre of 4-C slightly decreased yields of barley while an ester and an amine salt of 2,4-D and MCP and the amine salt of 4-C increased yields. The same workers reported that ester and amine formulations of 4-C were more injurious to field peas 3 and 6 inches in height than various formulations of 2,4-D and MCP with one exception. At the 6-inch stage 2,4-D acid was the most injurious. They also reported that 4-C was ineffective in controlling Russian pigweed in alfalfa, red clover, and sweetclover. At a very early seedling stage, 6 ounces per acre of 4-C as well as various formulations of 2,4-D and MCP were injurious to the crops. At a slightly later state the legumes were highly tolerant to 4-C.

Another investigator reported that the stand of Ladak alfalfa seedlings treated in the second true leaf stage with 2 to 8 ounces per acre of 4-C suffered a 26 to 30 per cent reduction in stand. This was about the same as for comparable rates of 2,4-D and MCP. As much as 1 pound of 4-C caused only slight damage to 2-year-old alfalfa treated at 1-, 3-, and 5-inch stages. This rate resulted in only fair to moderate weed control.

Amine and ester formulations of 4-C caused an abundance of floral abnormalities in established alfalfa treated at the 2- to 3-inch and 5-inch stages. An earlier application was less injurious. Formulations of 2,4-D, 2,4,5-T, and MCP had no effect on floral development or caused only occasional abnormalities. These investigators suggest that it would be inadvisable to use 4-C for weed control in alfalfa seed fields.

Pre-emergence applications of 4-C amine and ester at 1.5 and 3 pounds per acre to soybeans resulted in stunting and epinastic response and in a 20 to 25 per cent reduction in stand at the higher rate. Injury was greater with a low-volatile ester of 2,4-D and MCP than with 4-C. In Pennsylvania 4-C at 0.5 to 1 pound per acre delayed the maturity of oats 1 to 2 weeks.

On asparagus 4-C was less effective than CMU in weed control, although it did not damage the crop. A pre-emergence application of 1.5 pounds per

acre of 4-C greatly reduced the stand of onions; 1 pound CMU was highly effective in controlling weeds without harming the crop.

In South Dakota 4-C ester and 3,4-D amine and ester were compared with amines of MCP, 2,4-D, and 2,4,5-T on flax. One-quarter pound per acre of 4-C delayed flowering 7 days and a similar rate of 3,4-D delayed it 10 days. Both delayed it long enough to allow foxtail to take over. In four experiments these two compounds consistently decreased flax yields more than MCP or 2,4-D and also gave poorer control of lambsquarters and wild mustard.

In preliminary trials 0.5 pound per acre of 3,4-D appeared to be effective for controlling yellow rocket, mustard, ragweed, rough pigweed, and lambsquarters.

Several workers have noted that 3,4-D was less toxic than 2,4-D, MCP, and 4-C to peas and alfalfa. Similar results have been obtained with red clover, ladino clover, and birdsfoot trefoil. 3,4-D in comparison with 2,4-D was relatively more injurious as a foliage spray than as a pre-emergence spray on 18 species. The selective toxicity of 3,4-D was different from that of either 2,4-D or MCP. 3,4-D was more injurious to snap beans, squash, flax and pigweed but less injurious to alfalfa.

3,4-D was more persistent than 2,4-D in a greenhouse experiment.

The data on 4-C and 3,4-D are not conclusive. Further investigations should be made. It appears that these compounds may find use in specific weed control problems.

N-1 Naphthyl Phthalamic Acid

N-1 naphthyl phthalamic acid is a selective herbicide that has been included in weed control experiments during the past four seasons and was marketed in limited quantity in 1953. It has often been classed as a growth regulator but its type of action and selectivity are decidedly different from that of 2,4-D and closely related compounds. When applied to the foliage of sensitive species, it severely inhibits growth and causes epinastic responses but usually does not kill the plant. When used as a pre-emergence application, root growth of seedlings is greatly restricted, negative geotropism often occurs, and sensitive species either fail to emerge or show extreme stunting. In most experiments, therefore, it has given best weed control when applied to the soil surface before weed emergence.

N-1 naphthyl phthalamic acid, also known as Alanap-1, is almost insoluble in water and has been used primarily as a wettable powder. The sodium salt is water soluble and has been tried in a few experiments. N-1 naphthyl phthalimide used as a wettable powder is much less toxic to plant foliage than the acid or sodium salt formulations. In the soil the imide, also known as Alanap-2, is slower in taking effect, and weed control has been generally poor. However, mixtures of the acid and imide have sometimes given better results than the acid alone due apparently to a longer residual life. In other experiments the mixtures have not performed as well as the acid alone when used at equal rates per acre.

The most extensive experiments with this herbicide have been conducted on cucurbits. Cucumbers, muskmelons and watermelons have shown good

resistance to both pre-emergence and post-emergence applications under most conditions. The only cases of injury reported were in very early plantings when the soil was wet and cold and in one experiment conducted during extremely hot, dry weather. Pumpkins and squash have shown somewhat less resistance than the other cucurbits, and differential responses between varieties have frequently been reported. In Delaware squash grown in Norfolk loamy sand was severely injured by 2 pounds per acre of Alanap-1, but other cucurbits were not injured by this treatment and weed control was good.

Experimental results over a 3-year period have shown good weed control and in general no crop injury with asparagus and with directed sprays on established nursery stock. Performance of this herbicide on cotton has been exceptionally good in the drier areas, notably Texas, New Mexico and Arizona, while in high rainfall areas it has caused some injury. Promising results have also been reported in less extensive trials on soybeans, peanuts, gladiolus and for crabgrass control in turf. Results on lima beans have been variable. In the case of turf, treatments have been more effective when applied at a very high gallonage or when lightly watered-in.

Crops that are reported to be especially sensitive to N-1 naphthyl phthalamic acid include beets, spinach, parsnips, tomatotes, tobacco, strawberries and many of the crucifers. Sweet potatoes frequently have been severely stunted by applications after transplanting but pre-planting treatments appear promising.

A large number of annual weeds have been selectively controlled in the above-mentioned crops. Among these are several annual grasses, pigweed (Amaranthus spp.), purslane (Portulaca oleracea), chickweed (Stellaria media), galinsoga (Galinsoga ciliata), lambsquarters (Chenopodium album), carpetweed (Mollugo verticillata), and ragweed (Ambrosia spp.). Partial control of nutgrass has been given by a 30-pound-per-acre treatment. Weeds that have not been controlled include most established perennials, wild sunflower (Helianthus annuus) and smartweeds, knotweed and wild buckwheat (Polygonum spp.).

Effective rates of application have varied from 1 to 8 pounds per acre with the lowest amounts being used on sandy soils. Results on muck or peat soils have been poor even at rates up to 12 pounds. As with most pre-emergence herbicides, weed control is greatly influenced by soil moisture conditions. The compound is effective in controlling weeds only if the soil is moist.

Its residual life in warm, moist soil appears to be somewhat longer than for 2,4-D, averaging in general from 4 to 6 weeks. At least part of the normal amount of N-1 naphthyl phthalamic acid applied is retained in the soil surface even when heavily leached. Heavy rains soon after application have therefore not destroyed its effectiveness. It has also been reported to remain active on the soil surface through periods of prolonged drought. The chemical has been shown to have a very low animal toxicity and no residues have been found in several crops from treated fields.

Dalapon

Dalapon, which is alpha, alpha-dichloropropionic acid, was first available to most research workers in 1953. Dalapon is effective primarily in

controlling grasses. A large number of investigators evaluated this compound during this past season. It has been employed for the most part as the sodium salt, which is a white, free-flowing powder readily soluble in water. The sodium salt is not readily soluble in most common organic solvents except alcohols.

There appears to be no appreciable hazards from handling Dalapon. Orally, a single dose is less toxic than common table salt. It is only slightly irritating to the skin and no serious damage is likely to result from contamination of the eye.

Dalapon is actively absorbed and translocated by living grass foliage. It is also absorbed by roots. New growth of grasses is often malformed and there is frequently some proliferation of tissue. At suitable rates old foliage yellows and dies; at lower rates there may be stunting and eventual recovery.

With established peremnial grasses this compound appears to induce dormancy of crown and rhizome buds for varying lengths of time depending on dosage and environmental conditions. With suitable rates of treatment the dormant buds fail to recover, and a high degree of kill results. In many respects the physiological response of plants to Dalapon is similar to TCA.

Under greenhouse conditions a 10-pound-per-acre treatment of Dalapon persisted less than 4 weeks, while a 40-pound treatment persisted more than 8 but less than 12 weeks. Apparently the compound is not highly persistent.

Dalapon appears to be highly promising for controlling quack-(couch) grass. In general 20 pounds per acre was necessary to obtain effective control. In some instances 10 pounds per acre has given as much as 80 per cent reduction in stand. Tillage shortly after treatment seems to limit maximum response, but it may be desirable to cultivate 6 to 8 weeks after treatment. Since only a few plants are required to rebuild an infestation, follow up tillage, retreatment or special cropping may be necessary to maintain the desired degree of control.

With foliage applications Dalapon has been much more effective than TCA. Since Dalapon is absorbed by the foliage, the subsequent rainfall does not play the important part that it does with sodium TCA which is absorbed primarily by roots.

Dalapon is approximately four times as effective as TCA in controlling Johnson grass. Complete top kill has been obtained with as little as 10 pounds per acre in some experiments. However, higher rates are required for injury of the rhizomes. In one test 85 per cent rhizome kill was obtained with 30 pounds per acre of Dalapon. In areas of high rainfall it may be necessary to apply a second treatment to control new seedlings. Young, succulent Johnson grass was more susceptible than mature grass or grass in a hardened condition due to moisture stress.

In renovation of permanent pastures good kill of bluegrass-bromegrass sod has been obtained with 5 pounds per acre of Dalapon. Dalapon was more effective than TCA in killing the grass. Also Dalapon was without effect on subsequent grass seeding, while TCA greatly reduced the stand.

Dalapon also looks promising in the control of annual and perennial grasses in alfalfa. Six pounds per acre gave complete control of downy brome grass without any apparent injury to established alfalfa. Similar results were obtained in the control of crabgrass and other grass seedlings.

In one experiment good control of Johnson grass was obtained with 10 pounds per acre without reducing yields of alfalfa. In another experiment with irrigated alfalfa in bloom, Dalapon caused top injury of alfalfa but top injury of quackgrass was greater. Permanent injury of the alfalfa apparently was slight.

Cotton was highly tolerant of Dalapon as long as the spray was kept off the foliage. Young cotton was injured moderately with 2 pounds per acre. Older cotton was injured and bloom and harvest were delayed, by 5 and 10 pounds applied as a foliage spray. However, except for a late treatment at 10 pounds, yields were not reduced. Directed sprays of Dalapon to hit only the lower stems of older cotton hold much promise in controlling crabgrass, water grass and other annual grasses.

Water grass in sugar beets was controlled by 3.5 to 5 pounds of Dalapon from the seedling to the early stooling stage without serious injury to the beets. Wild oats in flax 3 to 5 inches tall was controlled by 3.3 pounds of Dalapon, but the yield of flax was reduced.

Grasses, including giant foxtail, in corn were controlled by Dalapon. In about one-half of the experiments the corn was injured slightly to severely.

Apple and pear trees showed no response to 20 pounds per acre of Dalapon applied to grass beneath the trees. Plum and sour cherry were injured by 3 and 5 pounds, while Concord grape and Elberta peach were intermediate in response. It appears that Dalapon can be used in controlling grasses in certain fruit crops.

Preliminary experiments suggest that Dalapon may be effective in controlling cattails, phragmites, and para grass.

Potatoes, onions, and young birdsfoot trefoil were not highly sensitive to Dalapon. Soybeans, wheat, oats, and barley (3 to 4 inches tall) and pine seedlings were highly sensitive.

Silvex

Silvex, which is 2,4,5-trichlorophenoxypropionic acid, appears promising as a selective herbicide on herbaceous, broadleaved weeds and woody plants. It was superior to 2,4,5-T in controlling various species of oak in Oklahoma experiments. Silvex appears to be as effective as 2,4,5-T on a wide range of woody plant species, when applied as a foliage spray.

It is less injurious to cotton than 2,4-D or 2,4,5-T. Silvex has been as effective as 2,4-D in controlling certain weed species in rice without apparent injury to the crop. It is more persistent in soil than 2,4-D and 2,4,5-T.

CONTROL OF SUBMERSED WATERWEEDS IN IRRIGATION CANALS [1]

J. M. Hodgson
Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture, Bozeman, Montana

Irrigation, the practice of applying water artificially to the soil to assure plant growth, has reduced the uncertainty of crop production. However, many problems peculiar to irrigation must be overcome to make the practice successful. One of the big problems is to control submersed waterweeds.

Certain submersed aquatic plants thrive in irrigation channels causing costly water loss and increased maintenance costs. To overcome this weed problem water users and researchers have tried a multitude of ideas with results ranging from very poor to highly successful. As a result of research in the past few years chemical treatments have been developed for controlling certain submersed aquatics which provide more effective control than older mechanical or hand methods in many situations.

Aromatic solvents of petroleum or coal tar origin have effectively controlled certain submersed aquatics. Rosine amine D acetate and copper sulfate are effective against algae. Other chemicals have given good results in recent screening trials and with further testing may prove valuable in controlling waterweeds.

The following information concerning the use of aromatic solvents to control submersed aquatic weeds is summarized from a U.S.D.A. circular (3) which is in the process of publication at the present time.

Aromatic Solvents for Control of Submersed Aquatic Weeds

Aromatic solvents as here referred to include aromatic hydrocarbons of the following specifications: distillation range 280° to 420° F with about 80% of the material distilling between 290° and 390° F and an aromatic content of 85% or more. Most of the aromatic solvents used are of petroleum origin. However, those of coal tar origin are equally effective.

The first tests of these materials for waterweed control were made by personnel of the Bureau of Reclamation, Department of Interior, and the Bureau of Plant Industry, Soils, and Agricultural Engineering, Department of Agriculture, at the Denver laboratories of the Bureau of Reclamation in 1947 (6).

Since that time extensive experimental tests have been conducted at field stations at Prosser, Washington; Meridian, Idaho; Phoenix, Arizona; Logan, Utah, and on various irrigation projects throughout the Western States. During the past irrigation season thousands of gallons of aromatic solvents were used to control submersed aquatic plants in irrigation ditches.

---

[1] The studies herein reported were conducted in cooperation with the Idaho Agricultural Experiment Station.

Applications of aromatic solvent to control waterweeds are made by spraying beneath the surface of the water with conventional weed spray nozzles. These materials are insoluble in and lighter than water and must be mixed with an emulsifying agent prior to release beneath the water surface.

Extensive testing has shown that rates of 5.5 to 10 gallons of aromatic solvent per cubic foot per second flow of water are required to control different species of submersed waterweeds under the various conditions encountered.

As the material is emulsified in the water the dilute emulsion passes through the irrigation channel and is absorbed by the waterweeds. The first effects of the chemical upon the waterweeds is observed immediately following the treatment and is usually characterized by a greenish black color, the foliage appearing quite limp. Within 24 to 48 hours the waterweed plants sink toward the bottom of the channel and the water delivery is greatly increased. The water level often drops several inches during this period in some ditches.

The plants continue to disintegrate and are often entirely removed to the silt line by the moving water within 2 weeks following the treatment. Dead plant tissue does not become a clogging problem as it decomposes and breaks in small pieces. However, one of the disadvantages of this treatment is that a contact type of kill is obtained and plants usually regrow from the roots. As a result, two or more treatments per season are required under some conditions.

Water temperature and velocity, silt content and dissolved salts are all factors that affect the amount and types of plant growth in irrigation channels. These factors also influence the effect of aromatic solvent treatments on the waterweeds. These conditions and other factors influencing the effectiveness of aromatic solvents on waterweeds were studied from 1948 to 1952 (3).

In determining the amount of aromatic solvent to apply in a ditch, accurate measurement of water flow is necessary. Reducing the water flow so that less chemical is required is sometimes advantageous. However, in several tests it was found that too much reduction of water flow caused failure of the chemical to adequately contact all of the waterweeds resulting in poor kill. In any case thorough water movement around all plants is necessary for good results.

The relationship between amount of aromatic solvent and length of application period or period of contact of weed growth by the emulsion was investigated quite extensively in the testing program. It was found that when maintaining a constant amount of material and varying the time of application from 5 up to 60 minutes the results were more consistent and slightly better for the longer application periods. However, there was a big advantage in time saved by the 30-minute period of application over the 60-minute period, and since results were very little different, the 30-minute period is being recommended. This means that the entire amount of aromatic solvent at the rate of 5.5 to 10 gallons per cubic foot per second

should be applied in approximately 30 minutes.

There was some difference in response of species to aromatic solvent treatments in irrigation channels. Apparently this variation is caused by morphological differences, as plants with thicker stems and leaves usually suffer less damage by a given rate of application than plants with thinner stems and leaves. A variation in the recommended rates of application is therefore necessary. From 5.5 to 6 gallons per c.f.s. gave control of waterweed (Anacharis Canadensis (Mech.) Planchon), horned pondweed (Zannichellia palustris L.) and leafy pondweed (Potamogeton foliosis Ref.). A rate of 8 gallons per c.f.s. gave effective control of these species for periods up to 8 weeks and also controlled the more resistant sago pondweed (Potamogeton pectinatus L.). Ten gallons of solvent per c.f.s. was found necessary for control of Richardson's pondweed (P. Richardsonii (Benn.) Rydb.), gigantic sago pondweed (P. pectinatus var. interruptus), American pondweed (P. nodosus, Pairet) and water stargrass (Heteranthera dubia (Jacq.) Maom.).

The distance from point of application that aromatic solvents were effective in controlling waterweeds in irrigation channels was also dependent on several factors. When proper mixing was accomplished at the point of application the emulsion would hold for at least $2\frac{1}{2}$ hours and the velocity of the water, amount of chemical applied, and density of weed growth all influenced the distance of control. Even the lightest rate of 5.4 gallons per c.f.s. gave good results for 3/4 mile under adverse conditions of density and velocity. The very high rate of 10 gallons per c.f.s. usually was effective for at least 3 miles and sometimes up to 5 miles from the point of application.

Aromatic solvent treatments for waterweed control are most effective if applied as soon as waterweeds have begun vigorous growth and there is a noticeable rise in water level in the channel and before the plants have extended to the water surface.

The cost of waterweed control with aromatic solvent treatments is usually less and control is better than hand or mechanical methods in channels smaller than 50 to 70 c.f.s. in capacity. However, the cost of commercial aromatic solvent waterweed killers is quite variable in different locations. Other available means for waterweed control may vary in cost according to conditions and equipment. For these reasons no definite statement as to the cost relationship can be made for all localities.

Equipment costs can be kept to a minimum since other weed sprayers or cattle sprayers, or orchard sprayers can be used to make the applications. Oil-resistant hoses and gaskets should be used because of the deleterious action of the solvents. Also every caution should be exercised in handling since it is an inflammable product much the same as gasoline.

Effect on Crops:

The effect of this material on crop plants was also studied since all available water is often needed for crop production. Greenhouse tests at one station and field tests at two stations over a period of 1 to 3 years with irrigation water containing aromatic solvents at rates found necessary to control the most resistant submersed aquatic weeds caused no significant

reduction in yield to alfalfa, beans, carrots, cotton, grain sorghum, ladino clover, lettuce, lima beans, oats, orchard grass, potatoes, sugar beets, or sweet corn. Also laboratory tests indicated no damage to soil bacteria from the experimental applications to crops.

Effect on Animal Life:

Aromatic solvent treated water for waterweed control is usually lethal to fish, crayfish, snails and many types of insects that are found in the water. Livestock apparently will not drink the treated water. On several occasions some farm animals actually tasted the treated water and then refused to drink it. There have been no reports of ill effects to livestock due to the use of aromatic solvents in irrigation channels. In a test with guinea pigs in Utah, Shupe and Timmons (7) found that even though the animals were forced to consume aromatic-solvent-treated water at concentrations used for waterweed control, none showed any visible ill effects.

Waterweed control with aromatic solvents has become a standard method of control on many of the western irrigation projects.

The Use of Soil Sterilants:

The possibility of using soil sterilants in controlling rooted pondweeds in irrigation canals where the water is turned out during the winter months was explored by Timmons (9) with rather disappointing results. Applications of CMU at 5, 10, 20, 40 and 80 pounds per acre, sodium chlorate at 160, 320 and 640 pounds per acre and Borascu at 960 and 1,920 pounds per acre did not prevent growth of pondweed from becoming a serious problem in irrigation ditches the following season.

Other Chemical Screening Tests:

Several chemicals have given very good results in recent waterweed control screening tests in the greenhouse and in a few field tests (10). Endothal, Rosine Amine D Acetate, pelletized 2,4-D and CMU and a few others are in this group. With further testing some of these may improve the means of controlling submersed waterweeds in irrigation channels.

Control of Algae:

Another group of plants that causes trouble in irrigation systems are the algae. These plants become attached to various structures or other plants or obstructions in the ditches.

A method of control of algae in static waters by the use of copper sulfate was worked out as early as 1905 by Geo. T. Moore and Karl F. Kellerman (5). Very effective control of algae was obtained with this material and it is still an important chemical for control of algae.

They found that the quantity of copper sulfate necessary to destroy algae growth varies greatly with genus or species, temperature, alkalinity and organic content of the water. They recommended 0.8 pound and 1 pound of copper sulfate per million gallons of water to control Hydrodictyon and

Spirogyra, respectively. These are two of the common kinds of algae found in irrigation systems. They stated that more chemical is needed when the water is colder than 59°F and less when the water is warmer. Also an increase in alkalinity or organic content requires an increased amount of copper sulfate.

One pound of copper sulfate per million gallons of water gives a concentration of 0.12 parts per million, which is considered non-injurious to humans, domestic animals and most fish.

In adapting the use of copper sulfate to control of algae and other water-weeds on irrigation systems, results have varied considerably. Mostly applications of one to five parts per million of copper sulfate for about 30 minutes have given good control of algae. However, rooted submersed aquatics generally have not been controlled successfully by copper sulfate except at much higher concentrations, and many tests were unsuccessful in attempting to control various potamogeton species. The fact that copper sulfate readily becomes unavailable to weed growth in alkaline irrigation waters high in bicarbonates has been a limiting factor in its use.

Rosine Amine D Acetate:

Recently another chemical was found to be highly toxic to algae. Preliminary tests of this material were made by Bureau of Reclamation personnel at the Denver laboratory in cooperation with the Hercules Powder Company. This material is Rosine Amine D Acetate. However, the name given it by the manufacturer is Hercules Algicide D. Curtis Bowser (2) reported this material to be highly successful in controlling a free-floating filamentous red algae (Compsopogon sp.) in the Yuma Drain in 1949, and during 1950 and 1951 two treatments two months apart sufficed to maintain the drain relatively free of algae for the entire season at a great saving in operation expense. A concentration of 10 parts of the Algicide D per one million parts of water was maintained for 15 minutes in these treatments and treatments were made approximately 2 miles apart through the drain.

In Idaho (4) another test of Hercules Algicide D on algae at 21 ppm applied for 20 minutes effectively controlled filamentous green algae in a small irrigation ditch for a period of 6 weeks.

A few field tests at higher concentrations for control of rooted aquatic weeds has shown Algicide D to have some promise for control of these types also.

Very little is known concerning the toxicity of Rosine Amine D Acetate to crop plants and livestock or fish as used under conditions of irrigation. Toxicity studies on fish under static water conditions (8) indicate that treatments as used for algae in irrigation waters may not be injurious to fish. H. F. Arle (1) irrigated grain sorghums with Rosine Amine D Acetate and found no apparent injury or effect on yield by as much as 80 ppm in 3 acre inches of water applied three times during the season.

Considering the good results that have been obtained in waterweed control with Rosine Amine D Acetate, further testing should be completed to establish the limits and means of using it to the best advantage in the control of submersed waterweeds in irrigation canals.

References Cited

1. Arle, H. F. Effect of Rosine Amine D Acetate on grain sorghum. Research Report of WWCC. 1952.

2. Bowser, Curtis. Rada for Algae. Reclamation Era, Western Weed Control Conference, Nov. 1951. Pp. 247-248.

3. Bruns, V. F., J. M. Hodgson, H. F. Arle, and F. L. Timmons. The use of aromatic solvents to control waterweeds in irrigation channels. USDA manuscript to be published.

4. Hodgson, J. M. Annual Report, Weed Control Investigations. Division of Weed Investigations, ARS, USDA, Idaho State Experiment Station, and Ada County Weed Control cooperating. Meridian, Idaho. 1952.

5. Moore, George T. and Karl F. Kelleman. Copper as an algacide and disinfectant in water supplies. USDA Bul. 76. 1905.

6. Moran, W. T. and J. M. Shaw. A new killer for waterweeds. The Reclamation Era, 34 (5): 81-84. 1948.

7. Shupe, J. L. and F. L. Timmons. Toxicity of aromatic solvents to guinea pigs. Div. of Weed Investigations, ARS, USDA, and Utah Agr. Exp. Sta. Unpublished report.

8. Renn, Charles E. Cooperative studies of tolerance of blue-gill sunfish to Rosine Amine D Acetate. Johns Hopkins Univ. Mimeo. Report. Sept. 1953.

9. Timmons, F. L. Correspondence. November 1953.

10. Western Weed Control Conference Research Report. Aquatic weed control. Compiled by J. M. Hodgson. Pp. 67-74. 1952.

CONTROL OF EMERGENT AQUATIC WEEDS IN IRRIGATION CANALS

W. O. Lee and F. L. Timmons
Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture, Logan, Utah

Abstract

Emergent aquatic weeds are an important problem on irrigation systems in 17 western states. They reduce capacity and rate of water flow in canals, increase seepage losses, and cause heavy losses of water through transpiration.

Cattails (Typha spp.) are the most important and widespread of the emergent aquatic weeds. Others which are important in certain sections are

the bulrushes (Scirpus spp.), the sedges (Carex spp.), parrot's feather (Myriophyllum spp.), watercress (Nasturtium officianale), and marsh smartweed (Polygonum spp.).

There has been much improvement in the methods of controlling some of the aquatic weeds during the past five years. However, little research work has been done on the sedges or smartweed and no really satisfactory methods of controlling them are known. Parrot's feather and watercress have been successfully controlled with 2,4-D in oil-water emulsions after the original infestation was removed mechanically. Narrowleaved cattail (Typha angustifolia), which predominates in the Southwestern States, is being successfully controlled by spraying at the preheading stage with 400 to 600 gallons per acre of water, containing 1.5 pounds of 2,4-D, 8 to 10 pounds of sodium TCA, and 3/4 to 1 pint of a spreader-sticker per 100 gallons. This method has proved much less effective on broadleaved cattail (T. latifolia), which predominates in the northern two-thirds of the region.

Experiments conducted at Logan, Utah, during 1949 to 1953, have revealed several effective methods of controlling broadleaf cattail. Cutting below the waterline, trampling below the waterline, and spraying with 160 gallons per acre of aromatic weed oil three times during the season at preheading stages each reduced cattail 80 to 90 per cent in one year.

Applying these treatments twice during the season, beginning at the heading stage, was nearly as effective in one experiment but much less effective than three applications in another experiment.

Spraying with 2,4-D or 2,4,5-T alone at rates of 3 to 6 pounds per acre in either amine or ester forms was ineffective. Adding ammonium sulfamate or sodium TCA at 20 to 40 pounds per acre with a spreader-sticker to an amine or sodium salt of 2,4-D resulted in fair to good kills of cattail. However, best results were obtained by using a low volatile ester of 2,4-D and 10 gallons per acre of diesel oil in 200 gallons total spray solution.

In experiments comparing amine and low volatile ester forms of 2,4-D at rates of 4, 6, 8, and 12 pounds per acre in combination with 10 gallons per acre of diesel oil in 200 gallons of total spray solution, the ester consistently gave much better results at equivalent rates. The ester at 4 pounds per acre gave good results but there was some advantage for higher rates up to 8 pounds per acre.

Low volumes of 20 or 80 gallons per acre were ineffective regardless of the amount of 2,4-D applied. The minimum effective volume was 160 gallons per acre and the optimum volume was 200 to 240 gallons per acre.

Two spray applications per season at preheading stages of growth were necessary for satisfactory control and were much more effective than one application at the heading stage.

Usually, the stands of cattail were reduced 90 per cent or more by two applications the first year and were eliminated or nearly so by the third spray treatment, which was applied in the spring of the second year.

Exploratory experiments with soil sterilant herbicides, including sodium chlorate, borates, and borate-chlorate mixtures, sodium TCA, and CMU showed them to be mostly ineffective on cattail.

THE HALOGETON-CONTROL PROGRAM OF THE BUREAU OF LAND MANAGEMENT

E. J. Palmer
Bureau of Land Management, U. S. Department of Interior, Washington, D. C.

The Bureau of Land Management is gravely concerned over the halogeton threat on public lands. The plant's poisonous qualities, explosive spread, and widespread adaptability has created a problem of serious magnitude.

Halogeton Problem

While halogeton is poisonous to both sheep and cattle, stockmen are attempting to avoid widespread serious losses by avoiding heavy infestations. Through these precautionary measures serious losses are being prevented except in local areas. An example of disastrous losses is that of 1,000 sheep in the spring of 1953 suffered by Messrs. Pete Elia and Chandler Church in Nevada. If halogeton is allowed to spread throughout the range it is recognized that it will be much more difficult to make satisfactory progress in range improvement and in practicing good range management. Widespread losses are also likely to occur if this condition is allowed to develop.

As livestock are forced from infested range areas, adjacent uninfested ranges are subjected to heavier uses, thus increasing their susceptibility to invasion. Operators are faced with the prospect of changing to a different class of livestock, making radical and expensive changes in ranch organization or going out of business. An example is the once important Raft River Valley sheep range in Idaho where 13 large sheep owners were forced out of business in 1945 and 1946.

The explosive spread of the plant is by far the most serious aspect. Its prolific seeding habits, wide range of adaptability to various conditions of soil, topography and climate and the relative ease with which the seed is transported by wind, animals, and other means are its most serious potentials. The explosive spread of the plant is illustrated in the following table. (See Table 1.) The first verified infestation of halogeton in Oregon was observed in October 1953. In December 1953 a small spot infestation was also reported in the State of Washington.

Prior to the enactment of the Taylor Act in 1934, and subsequent transfer of the 180 million acres of public lands to BLM for administration, most of these lands had been seriously overgrazed for years. More than half of the 180 million acres are classified as severe to critically eroded and therefore are highly susceptible to the invasion of halogeton. Experience has shown that halogeton will not invade full stands of grass and may not, or at least would be slow to invade full stands of other forage. The problem is that most of the public-land ranges do not support full stands

Table 1. Halogeton infestation.

State	Estimated Acreage, 8/1/52 BLM lands	Other lands	Estimated Acreage, 9/1/53 BLM lands	Other lands	Increase BLM	Other
Idaho	190,000	105,000	228,700	115,220	38,700	10,220
Nevada	490,100	232,500	522,000	448,000	31,900	215,500
California	1,000	22,600	300	21,400	-700	-1,200
Montana	5,000	-	30,040	36,590	25,040	36,590
Wyoming	85,000	-	494,100	384,600	409,100	384,600
Colorado	45	10	310	150	265	140
Utah	314,530	292,930	2,620,326	908,827	2,305,796	615,897
Oregon				3		3
Totals	1,085,675	653,040	3,895,776	1,914,790	2,810,101	1,261,750

of grass and other forage. Many of these ranges, because of unfavorable soil and moisture conditions are not capable of supporting sufficient stands of forage to keep halogeton out.

Halogeton Control

The Halogeton Control Act of July 1952 provided specific authorization for a halogeton research and control program. This Act provides for the protection of the livestock industry from losses caused by halogeton, for maintenance and development of valuable forage plants on range and pasture land and to prevent destruction or impairment of range and pasture lands, and other lands by the growth, spread, and development of the poisonous weed known as Halogeton glomeratus.

In the BLM soil and moisture conservation, range management and halogeton programs, gratifying results are being obtained in improving the Federal range, but it is a long-time job and most of the area has not been fully recovered. It would be much easier to improve the Federal range much more quickly if all livestock and other uses could be temporarily eliminated in areas that are seriously eroded and highly susceptible to invasion by halogeton. While heavy reductions in use have been made in many of these areas it is not possible or practical to completely eliminate all grazing uses, since under the Taylor Act we are required to stabilize the livestock industry.

The BLM halogeton program consists of the following: (1) Surveys to locate and map infested areas. (2) Reseeding depleted rangelands to perennial grass in advance of a spreading infestation to serve as a barrier to intensive spread and on infested areas to choke out and replace halogeton. At both locations reseedings serve the dual purpose of control and production of forage needed for livestock removed from the infested lands not suitable for reseedings. (3) Chemical and other direct treatment to all spot infestations, reseeded areas, and avenues of spread to prevent seed production and spread. (4) Using waterspreading practices, protection fencing and good range management to aid in establishing full stands of reseeded grasses and native vegetation to provide maximum competition for halogeton.

Table 2.

Action taken	Completed Miles	Completed Acres	Scheduled balance Miles	Scheduled balance Acres
Seedbed preparation		312,285		36,981
Reseeding		310,015		23,481
Protection fencing	631		279	
Chemical control	4,353	36,367	33	17,045
Forage development (other than reseeding)		43,082		42,587
Weed surveys		5,850,938		941,980

The success of some of the reseedings is yet to be determined, but in general they have been successful in crowding out and preventing the spread of halogeton and increasing the livestock grazing capacity of the land. It has been conservatively estimated that the average grazing capacity of the reseeded land has been increased by at least five times through reseedings. The use of these fenced reseeded areas will make it possible to reduce grazing on adjoining public lands not susceptible to reseeding and thereby give the range a chance to re-establish itself to its full grazing capacity and provide more competition to halogeton. The highway unit of 30,000 acres in the Raft River Valley of Idaho and the 4,000-acre Mitchell Creek unit in Nevada are good examples of the effective way crested wheatgrass reseedings can be used to control halogeton on the reseeded lands and at the same time divert use from the surrounding range. The highway unit was infested with halogeton and had very little if any grazing value prior to reseeding but it is now being conservatively grazed at the rate of 3 acres per AUM and the halogeton has been practically eliminated. The Mitchell Creek unit is producing 2,000 AUMs per year.

The chemical control program is mainly a holding program, but it has been effective in controlling small spot infestations, and in reducing seed production along many routes of spread. The following table shows BLM accomplishments from inception of the program to December 31, 1953, and expected accomplishments from December 31, 1953, to June 30, 1954. (See Table 2, above.)

In addition, BLM has been cooperating with the U. S. Department of Agriculture, state departments of agriculture, universities and colleges, county weed organizations, railroads, state and county highway departments, and individuals in halogeton control.

Anticipated Program for F. Y. 1955

Due to the necessity for curtailing the national budget, BLM decided to temporarily subordinate its weed program for fiscal year 1955 in order to make its contribution to a balanced budget. A tentatively proposed program, in order of priority, is as follows:

(1) Continued support and cooperation with applied research and field study work of the land-grant colleges of Idaho, Utah, and Nevada and cooperation with the basic research

work of the Agricultural Research Service.

(2) Cooperation with other local, state and Federal agencies to the fullest extent possible.

(3) Make complete analysis of past BLM methods and accomplishments in order to carry out an improved program when a major program is resumed.

(4) Carry out reconnaissance surveys to determine the extent of spread and acreage infested.

(5) Control by chemical or other means small isolated spot infestations as far as possible within the limits of funds available.

In conclusion, I want to emphasize that the Bureau is vitally concerned with the loss of range resources and livestock on the Federal range as a result of halogeton. We are also seriously concerned over the problems connected with the management and use of halogeton ranges and the potential disaster from halogeton if allowed to spread throughout the range. If halogeton continues to spread at its present alarming rate, BLM will make every effort to resume a major control program as soon as the fiscal situation will permit.

We appreciate the fact that through the important work of the various colleges, the Agricultural Research Service and other agencies we are learning how to live with halogeton and more about its life history and habits which will lead to better methods of control. The Bureau considers this the highest priority work on halogeton and wants to encourage the research agencies to continue their efforts to find new and improved methods of control. BLM will support and cooperate with this work to the fullest extent possible.

THE USE OF CHEMICALS IN CONTROL OF HALOGETON

Leonard L. Jansen
Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture, Logan, Utah

As you no doubt realize from Mr. Palmer's figures on halogeton infestations in the Intermountain Region, chemical control of halogeton poses a number of problems. In the first place, the extent of the infestations and the low value of much of the land involved relegate the economics of any control program to a position of prime consideration. Secondly, the use of chemicals on the range, just as on agricultural lands, should not be considered a panacea for weed problems. It is only one leg of the three-legged stool mentioned by Mr. Torrell on Monday. In the case of halogeton, however, the other two legs are reseeding and sound range management. Each has its place.

When national attention was dramatically focused on the halogeton problem in 1950 by one of the leading pictorial magazines, a cry went up for immediate action. Both state and Federal monies were rapidly appropriated for halogeton control. Since halogeton is an annual while most of the native range plants are perennials, it appeared that chemicals might be the answer. Previously, some, but certainly not extensive, spraying operations had been carried out under range conditions in Nevada. In consequence the extensive range spraying program, which was initiated under the pressure of the situation, was able to benefit from only very limited knowledge of chemicals to use, dosage rates, suitable equipment, times of spraying, or precautionary measures. It wasn't until 1952 that preliminary screening experiments could be carried out and evaluated for the issuance of spraying recommendations. These recommendations had also to take into account 1) the economics of range application, 2) availability of the chemical, 3) its adaptability to quantity storage, and 4) its suitability for routine handling.

Although the early attempts to control halogeton with chemicals failed to realize their objective, they did serve the valuable purpose of pointing out and pinning down some of the problems and obstacles involved in range spraying operations. In the first place, the most logical chemical, 2,4-D, behaved much more as a contact herbicide on halogeton than as a systemic one and high rates were necessary to achieve any sort of kill. The Idaho Agricultural Experiment Station recommended in 1952 that 2,4-D low volatile ester formulations at 2 pounds per acre in low gallonages of water was the minimum dosage rate with which one could expect to obtain results. In addition it was necessary to obtain complete coverage and to spray early in the growing season; late in the season plants were not prevented from producing seeds. The Nevada State Department of Agriculture obtained some measure of success with contact herbicides and aromatic oils. For routine spraying operations the Bureau of Land Management adopted the 2-lb. rate of 2,4-D in an oil-water emulsion. Sprays were applied by hand sprayers, motorized ground rigs, and airplanes.

I believe it is quite correct to say that to date no one spray technique or chemical formulation has given the desired degree of control; however, much of this lack of success has undoubtedly been due to complicating factors. Brushy terrains and high wind conditions have frequently accounted for incomplete coverage. Many areas are essentially inaccessible and seed produced on these areas has probably been the source for constant reinfestation of adjacent sprayed areas. Injury to native vegetation with little or no damage to halogeton has probably even aided the spread of the pest plant. A final barrier to achieving successful control has resided in the difficulty of identifying new infestations during the early part of the growing season when the plants are most susceptible to 2,4-D; the plants do not become conspicuous until the seeds are fairly well developed.

At a Halogeton Workers Conference held in Salt Lake City in the fall of 1952, various workers repeatedly stressed the need for more basic information about halogeton before intelligent chemical control measures could be applied in the field. At that time the Federal Government was already in the process of establishing a coordinated program of basic research on this plant in cooperation with the State Agricultural Experiment Stations of Utah, Idaho,

and Nevada. This program has now been in full operation for almost a year and in partial operation for a year and a half. The coordination of the program is a function of the Section of Weed Investigations of the U. S. Department of Agriculture.

One year of experimental research is perhaps too short a time to reasonably expect many answers to the complex problem of control of halogeton. Nevertheless, considerable progress has been made, and despite the exploratory nature of the initial experiments, some results have useful application to the control phases. On the Utah project, for example, studies of germination and survival of field populations revealed that approximately 40 per cent of the seeds that germinated in 1953 survived to maturity and produced seeds. About 33 per cent of the survivors germinated during a single week. Continuation of such studies should help define the period when sprays can be applied most effectively. Incorporation of 2,4-D into lipoid solvents demonstrated that this growth regulator herbicide is readily translocated in the plant once it gets in. Penetration of the chemical, then, appears to be the major problem. Some of the solvent mixtures used permitted reduction of the 2,4-D concentration to about one-fourth of the recommended rate without loss of effectiveness. The use of CMU as a soil sterilant for gravel dumps has given excellent preliminary results, but it does not appear to be useful on finer textured range soils, where it has deleterious effects on native vegetation without preventing germination of halogeton. One can only hope that the basic research program can provide much more pertinent information in the future.

In conclusion, I would like to restate something I said at the beginning of this discussion, and that is that chemical control has a place in the control of weeds on the range. Although it now seems we must elevate our sights in the case of halogeton and aim for eradication, there are now, and undoubtedly will appear in the future, many isolated spot infestations in which such control measures can and should be effective. In the case of a spot infestation which threatens a large region, it may be possible to disregard the economics of the control measures as well. However, it is important in such instances to realize both the advantages and limitations of the use of chemicals. On the other hand there are a number of areas in which the use of chemicals has hardly been scratched, if at all. Total sterilization of invasion routes used by halogeton--that is, roadsides, gravel dumps, railroad embankments, etc.--is one of these. The use of chemicals to supplement other control measures, for instance to reduce the weed stands in new reseedings or to reduce heavy and potentially lethal populations of halogeton around watering holes and on livestock trails, also well deserve investigation and exploitation. It seems to me that chemical control measures for range weeds in general should receive more consideration and offer a definite challenge to all who are interested in the growth and redevelopment of productive grazing lands in the West.

MANAGEMENT OF HALOGETON-INFESTED RANGES

Joseph H. Robertson
Department of Agronomy and Range Management, University of Nevada,
Reno, Nevada

Dr. Jansen has just given you what may be not the key to the halogeton problem, but rather one number to the combination. My purpose is to suggest another number to this combination.

The first proper botanical collection of halogeton in the United States was made in 1934. The first identification was made in 1935. The plant was first grown experimentally as a possible fire-line plant in 1942. It was first proved poisonous to sheep in the winter of 1942, and the toxic principle was shown to be oxalates.

Crested wheatgrass was first sown on a halogeton-infested burn in big sagebrush in 1944 where, in 2 years, it excluded halogeton. The experiment was repeated on the same burn for 4 years with the same results. Nevada was the locale of the work mentioned thus far. The toxicity studies were by the Nevada Agricultural Experiment Station, the others by the Intermountain Forest and Range Experiment Station. More recently other State Agricultural Experiment Stations including Idaho, Utah and Wyoming with cooperation from the Bureau of Land Management have published on halogeton. I borrow freely from their results.

Certain facts regarding halogeton help in applying ecology to its control. Halogeton is (1) a summer annual, i.e. a warm-weather grower, (2) a succulent plant with a low transpiration rate and a high oxalate content, (3) disseminated by winged and wingless fruits that can lie dormant in the soil, (4) quick to invade disturbed ground, e.g. burns, (5) adapted to a wide range of soils excepting sand, (6) slow to invade higher elevations, (7) tolerant of high soil pH, (8) of low palatability not related to salt hunger, (9) very competitive with itself and with perennials in low density or low vigor, and (10) weakly competitive with most well-adapted perennials, either native or introduced.

Each range type that is subject to invasion by halogeton probably has a critical density above which it virtually excludes halogeton. This density of Eurotia lanata, whitesage, was found to be 22 per cent in 1953 in two valleys of eastern Nevada.

Density and vigor of whitesage are largely controlled by (1) insects and diseases, (2) variations in climate, and (3) grazing by stock and rodents. In certain types fire is also an important factor.

The goal of range management should be to raise the competitive ability of all range types above the critical level.

Whitesage stands which were invaded by halogeton were found to be deficient in younger age classes of whitesage plants.

Removal of 20 per cent or more of the height growth of whitesage during the summer prevented any seed formation in 1953. Therefore, the practice of summer grazing seems sufficient in itself to pave the way for invasion of whitesage by halogeton.

Whitesage and other dominant range shrubs are being attacked by insects. This is a cause of extensive halogeton invasion in sagebrush and shadscale, less extensive in other types.

Perhaps the most effective practice will be seeding of depleted sagebrush ranges to produce grazing capacity for the relief of range types in which seeding has not been successful.

A whole new field of range entomology is on the horizon. Both biological control of range weeds and control of insects that encourage such weeds are wide open to investigation.

* * * * * * *

REPORT OF COMMITTEE ON NOMENCLATURE AND TERMINOLOGY

V. F. Bruns, Chairman

Mr. President:

Realizing a real need for standardization in plant nomenclature and some system of uniform terminology for herbicides, especially new herbicides, the Research Section of this Conference established a committee on nomenclature and terminology at Reno two years ago. Since that time, contact has been maintained with similar committees of other regional weed conferences and the National Committee on Nomenclature and Terminology.

For the most part, the chairmen of the committees in each of the regional conferences make up the National Committee, with Dr. Warren Shaw, Section of Weed Investigations, U. S. Department of Agriculture, as its chairman. The National Committee has held several meetings, one of which was held in December, 1953, during the National Weed Conference at Kansas City.

Because of national interest and concern, the Research Section decided to elevate this committee from one of Research Section standing to one of Conference standing during the interim meeting at Boise, Idaho, in 1953. Dr. A. N. Steward, Oregon State College, was chosen to head up the work on plant nomenclature and Virgil Freed of the same institution was chosen to lead the work on chemical terminology. Dr. Steward has been working diligently on the phase of plant nomenclature and here to report on his progress is Bill Furtick. (Report by Furtick).

From this report, it is evident that considerable progress has been made in this phase of committee work. Dr. Steward and all those who have contributed to this phase should be commended highly.

Since the list of plant names may need further revision, Dr. Steward will be encouraged to complete this revision for consideration by the Research Section at its next interim meeting. If accepted by the Research Section, the list will be presented for adoption by the Conference two years hence.

Virgil Freed, who is on sabbatical leave, has had little time to work on the phase of chemical terminology. However, we have with us Dr. Warren Shaw who has consented to give us a brief resume of the progress which the National Committee has made on this particular phase. (Report by Dr. Shaw).

It is evident from Dr. Shaw's report that the task of the National Committee is a tedious and complicated one. Your committee pledges to support and assist the National Committee in every way possible.

This, Mr. President, is the report of the Committee on Nomenclature and Terminology.

REPORT OF THE NOMINATING COMMITTEE

The following members have been elected to serve as officers through the Fifteenth Western Weed Control Conference:

President: Walter S. Ball, State Department of Agriculture, Sacramento, California.

Vice President: W. A. Harvey, Department of Botany, University of California, Davis, California.

Secretary-treasurer: W. C. Robocker, Section of Weed Investigations, USDA, Nevada Agricultural Experiment Station, Reno, Nevada.

REPORT OF THE RESOLUTIONS COMMITTEE

Resolution No. 1

WHEREAS, the success of the Fourteenth Western Weed Control Conference at Tucson, Arizona, March 22, 23, and 24, 1954, has been in large measure due to the efforts and facilities furnished by the following organizations,

THEREFORE, be it resolved that the Western Weed Control Conference assembled at Tucson, Arizona, March 22, 23, and 24, 1954, express its appreciation to:

University of Arizona at Tucson
Associated Students of the University of Arizona
Tucson Chamber of Commerce

Resolution No. 2

WHEREAS, our officers for the past year, Clarence Seely, President, Rex Warren, Vice President, and William Harvey, Secretary-treasurer, have spent much time and effort in making this a successful convention, and

WHEREAS, Howard Cords and Fred Arle have contributed greatly to the success of the Conference in so ably taking care of the local arrangements,

THEREFORE, be it resolved that we express to these persons our deepest appreciation and thanks for these services.

Resolution No. 3

WHEREAS, research is the basis of weed control, and

WHEREAS, reports of research projects are important to the members of this conference,

THEREFORE, be it resolved that the Fourteenth Western Weed Control Conference assembled at Tucson, Arizona, March 22, 23, and 24, 1954, commend the Research Committee for the preparation of the Research Progress Report, and,

BE it further resolved that this Conference commend Lowell Rasmussen for leadership in organizing the Research Committee to make the report possible.

BE it further resolved that this Conference commend F. L. Timmons for preparing and distributing the Regional Newsletter as a means of coordinating the research efforts within the Region.

Resolution No. 4

WHEREAS, the first meeting of the National Weed Control Conference was held in conjunction with the North Central Weed Control Conference, and

WHEREAS, the present plans call for the second meeting of the National Conference to be held in conjunction with the Northeastern Weed Control Conference, and

WHEREAS, the Western Weed Control Conference was the first such Weed Control Conference formed in the United States and therefore is the oldest of the Weed Control Conferences now in existence in this country and in Canada,

THEREFORE, be it resolved that the Fourteenth Western Weed Control Conference, at this meeting held in Tucson, Arizona, on March 24, 1954, hereby invite and request that the Third National Weed Control Conference be held in conjunction with the Sixteenth Western Weed Control Conference at a time and place yet to be determined, and that the Secretary extend such invitation and request to the Officers of the National Weed Control Conference.

Resolution No. 5

WHEREAS, noxious weed control is a state, county and community problem, and

WHEREAS, noxious weeds do not recognize geographic boundaries, and

WHEREAS, States having noxious weed laws expect noxious weeds on lands within their boundaries to be controlled or eradicated, and

WHEREAS, many States have areas of federally owned or controlled lands which are infested with weeds declared noxious by such States, and

WHEREAS, it is difficult for weed control officials in States where organized weed control is being carried out to obtain full cooperation of their people due to the inability of carrying out weed control on Federal lands, and

WHEREAS, weeds now cause farmers an estimated annual loss of four to five billion dollars, and

WHEREAS, Senate bill S. 627 and House bill H.R. 2115 have been introduced in 83d Congress and read as follows: Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That every department, agency, and independent establishment in the executive branch of the Government having control of or jurisdiction over land located in any State shall hereafter comply with all laws and rules and regulations of such State providing for the control of noxious weeds,

BE it resolved that this Conference urge members of the United States Congress to use their best efforts in the passage of legislation provided for in S. 627 and H.R. 2115 and the secretary of this Conference be instructed to transmit to the members of Congress and the Secretary of Agriculture copies of this resolution.

(The above resolution was passed by the National Weed Control Conference on December 9, 1953, and by the North Central Weed Control Conference on December 10, 1953.)

Resolution No. 6

WHEREAS, weed control efforts are in the public interest as well as of benefit to individuals directly concerned, and

WHEREAS, the public participates in weed control programs through education by the Agricultural Extension Services and by the activating of Weed Control districts and other organized groups, and

WHEREAS, the effectiveness of such programs can be enhanced greatly through various advertising media such as signs, posters, newspapers, magazines, and other printed material, and

WHEREAS, the preparation of the basic designs, cuts and mats involve costs beyond the means of district, county or even State organizations,

THEREFORE, be it resolved that the Federal Extension Service and/or the Agricultural Research Service be hereby requested to undertake the preparation of appropriate basic designs, cuts and mats and related material for distribution to and for the use of the various weed control organizations in promoting and conducting weed control educational programs, and

BE it further resolved that the above Services give every consideration to other means of assisting the local smaller organizations and bringing them together in a unified and extended program in the interest of weed control promotion and education.

Resolution No. 7

WHEREAS, Mediterranean Sage (Salvia althropes) is a biennial weed which now covers over 100,000 acres of sagebrush land in southern Oregon and also is found in northern California, and

WHEREAS, this weed is a heavy seed producer and a vigorous competitor and as such is a serious threat to range and pasture lands,

NOW, THEREFORE, be it resolved:

(1) That control and educational agencies become acquainted with this weed so that its further spread may be prevented.

(2) That the Western Weed Control Conference cooperate with other groups in requesting that the Bureau of Entomology and Plant Quarantine conduct active search for biological control methods.

(3) That appropriate information be furnished Extension agronomists and weed control specialists in the associated States by the Conference Secretary, urging that they initiate support for a biological control program in the States affected.

* * * * * * *

WESTERN WEED CONTROL CONFERENCE

Constitution and By-Laws

CONSTITUTION

ARTICLE I--Name

The name of this organization shall be "Western Weed Control Conference," hereafter referred to as the "Conference." It shall include the States of Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming and such other States and Provinces of Canada that may become members.

ARTICLE II--Objects

The objects of the Conference shall be:

1. To function as a clearing house on weed matters.
2. To foster state and regional organizations and a national organization of weed control agencies to act as state, regional, and national clearing houses in connection with weed problems.
3. To cooperate with other regions and with governmental, private, and commercial agencies in the solution of weed problems.
4. To foster educational work in weeds and weed control through all appropriate agencies.
5. To foster plans for organized weed research and control programs.
6. To encourage national and state research in weed control and foster legislation to that end.
7. To assist in the development of uniform state weed and seed regulations and quarantine legislation.
8. To foster adequate national weed and seed regulations and quarantine legislation.

ARTICLE III--Membership

Any person, cooperative association, governmental agency, corporation, or other organization operating within the region covered by the Conference and actively interested in weeds and weed control shall be eligible to one of the following types of membership:

1. Voting membership.
2. Associate membership.
    a. Individual.
    b. Organization.
3. Sustaining membership.

ARTICLE IV--Officers, Executive Board and Official State Delegates.

The officers of the Conference shall be: President, Vice President, and Secretary-Treasurer.

The Executive Board shall be: President, Vice President, Secretary-Treasurer, Immediate Past-President, Chairman of the Research Committee and one associate member to be appointed by the other members of the Executive Board.

The officers shall be elected at the annual meeting of the Conference and, unless otherwise provided, shall serve for one year beginning at the close of the annual meeting and ending with the close of the next annual meeting or until successors have been elected. All voting members of the Conference shall be eligible to hold an elective office.

Official state delegates shall be elected from among the voting membership of each state concerned by the voting members of that particular state. Whenever a vacancy occurs in the present line of state delegates a replacement

shall be elected and shall serve for three years beginning at the annual meeting where the election takes place and concluding at the close of the annual meeting three years hence. Alternate delegates shall also be elected in the same manner. It shall be the duty of the alternate delegate to fill out the delegate's unexpired term in the event the delegate vacates his office.

ARTICLE V--Sections and Committees.

The president shall appoint all committee chairmen and committee members. The chairman of the research committee shall also be chairman of the research section. The chairmen of the education and regulatory committees shall be co-chairmen of the education and regulatory section. All voting members and individual associate members shall be eligible for committee duty, providing, however, that no one person may hold membership on more than three committees of which not more than one may be a major committee. The sections and committees shall be as follows:

1. Sections.

    a. Research (this section will be conducted as an open meeting or meeting where subjects of a research or new information nature are presented and discussed).

    b. Education and Regulatory (this section will be conducted as an open meeting where subjects of educational and regulatory natures are presented and discussed.)

2. Permanent Committees.

    a. Major committees.

        (1) Research, with sub-committees as desired.
        (2) Education, with sub-committees as desired.
        (3) Regulatory, with sub-committees as desired.

    b. Minor committees.

        (1) Resolution.
        (2) Nomination (to submit two candidates for each elective office).
        (3) Auditing.
        (4) Membership.

3. Temporary Committees as the need arises.

ARTICLE VI--Election of Officers.

Officers shall be elected by ballot.

ARTICLE VII--Voting.

All voting members in good standing shall be eligible to vote for officers and on all matters brought to a vote in the Conference.

ARTICLE VIII--Vacancies.

Should a vacancy occur in the Presidency, the Vice President shall become President. In case of vacancy in any other elective office the same may be filled for the unexpired term by a person appointed by the President.

ARTICLE IX--Dues.

Annual dues for the classes of membership shall be as follows:

1. Voting membership $3.00

2. Associate membership.

   a. Individual 3.00
   b. Organization 25.00

3. Sustaining 50.00

ARTICLE X--Meetings.

The annual meeting shall be held at such time and place as shall be determined by the Executive Board.

Special meetings of the Conference or the Executive Board may be held at the call of the President, subject to the approval of the Executive Board.

ARTICLE XI--By-Laws.

The Conference shall adopt By-Laws.

ARTICLE XII--Amendments.

The Constitution and By-Laws may be amended by a three-fourths vote of the members present at any regular meeting.

BY-LAWS

BY-LAW I--Duties of Officers.

1. It shall be the duty of the President to preside at all meetings of the Conference, to perform the usual duties of such office and in addition:

   a. Serve as Chairman of the Executive Board.
   b. Appoint all Committee Chairmen.
   c. Appoint all Committee Members, with the advice of the respective Chairmen of the Executive Board if he so desires.

2. The Secretary-Treasurer shall perform the duties common to that office.

3. The Executive Board shall:

a. Transact the business of the Conference when the Association is not in session.
b. Be responsible for the program at the annual meeting.

4. The official state delegates shall:

a. Be the liaison between the Conference officers or executive board and Conference members within each delegates state.
b. Promote Conference activities within the various states as requested by the Conference officers or executive board.
c. Be responsible for preparation of state reports to the Conference.

BY-LAW II--Membership.

1. All members in good standing in the year of adoption of this Constitution shall automatically become members of the Conference.

2. Application for membership shall be submitted to the Membership Committee. If approved, applicant shall become a member of the Conference upon payment of dues.

BY-LAW III--Publications.

The annual proceedings shall embrace reports, papers and the minutes of the annual meeting. Copies of the "Proceedings of the Conference" shall be furnished to members in good standing. Other copies may be distributed or sold as the Executive Board shall direct.

BY-LAW IV--Order of Business.

Business at all regular meetings of the Conference will be conducted according to Robert's Rules of Order.

BY-LAW V--Quorum.

A quorum at any regular meeting shall consist of representation of five states, including two members of the Executive Board.

BY-LAW VI

All previous rules and regulations of the Conference shall become null and void with the adoption of this Constitution and By-Laws.

REGISTRATION AND ATTENDANCE, FOURTEENTH WESTERN WEED CONTROL CONFERENCE

University of Arizona, Tucson, Arizona, March 22-24, 1954

ARIZONA

Arle, H. Fred	USDA, Room 24, P. O. Bldg., Phoenix
Bagley, R. W.	Supervised Pest Control Service, Box 1013, Eloy
Blackledge, G. E.	County Agent, 122 N. Warren, Tucson
Buck, Wm. L.	Colo. River Irrig. Proj., U. S. Irrig. Service, Parker
Carter, James R.	Agricultural Extension Service, Box 751, Phoenix
Clayton, R. S.	Mathieson Chemical Corp., 418 W. 13th St., Tempe
Cords, Howard P.	Agronomy Dept., University of Arizona, Tucson
Dana, Joe	Dana Butane, 402 W. First, Tempe
Davis, Geo. C.	Calif. Spray Chemical Corp., 1042 N. 21st Ave., Phoenix
Douglas, Ernest	Arizona Farmer, 842 N. Central, Phoenix
Ellwood, Chas. C.	University of Arizona, Tucson
Evans, Stuart	Arizona Fertilizers, Box 2191, Phoenix
Face, Al	County Agent, Yuma
Fisher, Robert A.	Calif. Spray Chemical Corp., 1042 N. 21st Ave., Phoenix
Glendening, Geo. E.	Copper State Chemical Co., 817 N. Longfellow, Tucson
Gookin, W. S.	San Carlos Irrig. & Drainage Dist., 840 W. Pinkley, Coolidge
Hall, Phil	Stauffer Chemical Co., 5745 N. 18th Pl., Phoenix
Hamilton, L. P.	Soil Conservation Nursery, 2640 E. 9th St., Tucson
Hull, Herb	ARS, USDA, Box 951, Tucson
Irvine, Milt	Dow Chemical Co., Phoenix
Jones, R. C.	Jones Arra Ranches, Box 18 Sells Star Rt., Tucson
Kelsey, Will	Mathieson Chemical Corp., 932 E. King St., Tucson
Madigan, John I.	General Chemical Div., Phoenix
Madsen, L. S.	Mathieson Chemical Corp., 1206 E. Pierce St., Phoenix
McAlister, D. F.	Agronomy Dept., University of Arizona, Tucson
McCormick, A. P.	Character-Intelligence Researchers, Box 6337, Tucson
Milne, Ray L.	Maricopa County Agr. Ext. Service, 1201 W. Madison, Phoenix
Neace, John F.	Marsh Aviation Co., 2407 Airline Way, Phoenix
Nichols, Elmer	Bureau of Indian Affairs, Phoenix
Owens, A. E.	Goodyear Farms, Litchfield Park
Page, C. G.	Agricultural Extension Service, Box 476, Willcox
Perham, Edgar	San Carlos Irrig. & Drainage Dist., 341 Northern Ave., Coolidge
Purvis, Kirke J.	Cotton Chemical Co., Box 817, Eloy
Reeder, H. M.	Agricultural Seed Laboratory, Phoenix
Roach, Mack E.	ARS, USDA, Box 951, Tucson
Rogers, J. R.	Goodyear Farms, Litchfield Park
Shelby, Carl	White Chemical Co., 1310 W. Watkins Rd., Phoenix
Skoug, Wm. C.	Copper State Chemical Co., Box 1110, Tucson
Smith, Fred A.	American Cyanamid Co., 1232 W. Palo Verde Dr., Phoenix
Sonntag, Otto A.	American Cyanamid Co., Box 1286, Coolidge
Stafford, C. H.	Goodyear Farms, Box 283, Litchfield Park
Stern, Vernon M.	Producers Cotton Oil Co., Box 1984, Phoenix
Swoboda, M. K.	Arizona Pest Control Co., 61 W. Edgemont, Phoenix
Tschirley, F. H.	University of Arizona, Tucson
Van Deren, J. L.	Rancher's Spraying Service, 207 E. Pennington, Tucson

Warren, Jack	Arizona Fertilizers, Box 801, Eloy
Wilson, D. G.	Dept. of Botany & Range Mgt., Univ. of Arizona, Tucson

CALIFORNIA

Andrews, O. W.	Columbia Southern Chemical Corp., 625 Market St., San Francisco
Ball, Walter S.	State Dept. of Agriculture, Sacramento
Braghetta, Lloyd	Pacific Coast Borax Co., 530 W. Willow St., Stockton
Bronson, Art	Richfield Oil Co., 555 So. Flower, Los Angeles 17
Brownell, John C.	John Brownell & Co., Brawley
Burgoyne, D. L.	P. O. Box 137, Cupertino
Daehnert, R. H.	Allied Chemical & Dye Corp., 7610 Dunfield Ave., Los Angeles 45
Day, B. E.	University of California, Riverside
Dresher, P. F.	American Chemical Paint Co., 1598 Hanchett Ave., San Jose
Ferris, C. A.	Geigy Chem. Corp., P. O. Box 1335, Fresno
Foy, Chester L.	USDA Cotton Field Station, Shafter,
Fudge, Oscar L.	Imperial Irrigation District, Imperial
Hall, Vernon L.	Chipman Chemical Co., Inc., 2724 Cowper, Palo Alto
Hampton, J. E.	General Fertilizer & Supply Co., Chula Vista
Hargett, E. G.	Stauffer Chemical Co., 3200 E. 26th St., Los Angeles
Harvey, W. A.	Botany Dept., University of California, Davis
Haskell, H. S.	P. O. Box 411, Davis
Hay, W. D.	Federal-State Seed Laboratory, Sacramento
Hill, John M.	Dow Chemical Co., 900 Wilshire, Los Angeles
Hippert, R. H.	Pacific Coast Borax Co., 630 Shatto Pl., Los Angeles 5
Holloway, J. K.	USDA and Univ. of Calif., 1050 San Pablo Ave., Albany
Holmes, G. R.	B & H Equipment, 2100 El Camino, Mt. View
Hughes, Wm. J.	Shell Development Co., Modesto
Jensen, A. O.	American Cyanamid, 106 Las Vegas Rd., Orinda
Kortsen, R. A.	Univ. of Calif. Agr. Ext. Service, Court House, El Centro
Leonard, O. A.	University of California, Davis
Lewton, T. G., Jr.	Pittsburgh Coke & Chemical Co., 155 Montgomery St., San Francisco
Lindsey, M. D.	Kem-Kil Co., 1815 W. Chapman Ave., Orange
Matley, Jack	Std. Agricultural Chemicals, 3388 Lyric Ave., Los Angeles
Medberry, C. J.	Pacific Coast Borax Co., Los Angeles
Miller, John H.	USDA Cotton Field Station, Shafter
Miner, L. H.	Niagara Chemical, 2332 Carquinez Ave., El Cerrito
Nail, Jack	DuPont Co., 111 Sutter St., San Francisco
Naylor, John	DuPont Chemical Co., 111 Sutter St., San Francisco
Preston, Merle S.	Preston Weed Control Co., P. O. Box 602, Whittier
Quick, C. R.	6 Forestry Bldg., Univ. of Calif., Berkeley
Raynor, R. N.	350 Sansome St., San Francisco (Dow Chemical Co.)
Roberts, Harry H.	DuPont Chemical Co., 301 LeRoy Ave., Arcadia
Sherman, R. F.	General Chemical Div., 1151 S. Broadway, Los Angeles
Spohn, Sam	Pacific Coast Borax Co., 630 Shatto Pl., Los Angeles
Stahler, L. M.	Pacific Coast Borax Co., 630 Shatto Pl., Los Angeles
Stone, James	Pacific Coast Borax Co., 630 Shatto Pl., Los Angeles
Swezey, Art	Dow Chemical Co., 13201 Cypress St., Garden Grove
Swingle, M. C.	DuPont Chemical Co., 15521 Glen Ura Dr., Los Gatos

Turner, J. H.	Atlas Powder Co., 411 W. 5th St., Los Angeles
Westgate, W. A.	Std. Agr. Chemicals, 429 Forum Bldg., Sacramento

COLORADO

Blouch, Roger M.	Colorado A & M, Ft. Collins
Dybing, C. D.	Colorado A & M, Ft. Collins
Fults, Jess	Colorado A & M, Ft. Collins
Moran, W. T.	U. S. Bureau of Reclamation, Denver
Oborn, E. T.	ARS, USDA, Weed Investigations, Denver
Reeves, A. B.	U. S. Bureau of Reclamation, 1657 Harrison St., Denver
Thornton, B. J.	Colorado A & M, Ft. Collins

DELAWARE

Borglin, J. H.	Hercules Powder Co., 215 W. 37th St., Wilmington
Cowart, L. E.	duPont Experimental Station, Wilmington
Rosher, Ronald	Hercules Powder Co., Wilmington

DISTRICT OF COLUMBIA

Balcom, R. B.	Bureau of Reclamation, Interior Bldg., Washington 25
Palmer, E. J.	Bureau of Land Management, Interior Bldg., Washington 25

HAWAII

Gowing, Donald P.	Pineapple Research Inst., Box 3166, Honolulu 2

IDAHO

Crofts, F. H.	Bonneville County Court House, Idaho Falls
Gass, M. W.	Jerome County Weed Dept., Jerome
Guthrie, Wm. N.	Gem County, Emmett,
Hall, D. M.	Power County, Box 45, American Falls
Jensen, Frank	Ada County Weed Control, Box 264, Meridian
Jensen, W. L.	Madison County, Rt. 1, Rexburg
Johannesen, E. J.	County Ext. Agt., 301 Courthouse, Emmett
Lindley, L. C.	Power County, American Falls
Mason, W. L.	Nez Perce County, Lewiston ·
Miller, M. H.	Brigham County, Box 46, Blackfoot
Moffett, Rex	Stauffer Chemical Co., 175 Alpine Drive, Idaho Falls
Moss, Irwin	Power County, Rockland
Nyblad, Ralph	Simplot Soilbuidlers, Caldwell
Ross, L. A.	Ada County Weed Control, Meridian
Roylance, Howard	Agricultural Extension Service, Boise
Seely, C. I.	Dept. of Agronomy, University of Idaho, Moscow
Squires, Walter	Clearwater County, Orofino
Torell, Paul	Idaho Noxious Weed Association, Moscow
Van Riper, L. H.	Jerome County Commissioner, Jerome
Welch, Ralph	Weed Supervisor, Gem County, Emmett

Whornham, George	American Chemical Paint Co., 154 7th St., Idaho Falls
Wilcox, Fred O.	Fremont County Weed Control, 226 W. Main St., St. Anthony

MARYLAND

McLane, S. R., Jr.	U. S. Army, Camp Detrick, Rt. 3, Box 316, Frederick
Newman, A. S.	U. S. Army, Camp Detrick, Frederick
Parker, M. W.	Section of Weed Investigations, ARS, USDA, Beltsville
Shaw, W. C.	Section of Weed Investigations, ARS, USDA, Beltsville

MICHIGAN

Otis, Chet	Dow Chemical Co., Midland
Smith, H. L.	Dow Chemical Co., 3600 Boston, Midland
Southwick, L.	Dow Chemical Co., Midland

MINNESOTA

Johnson, A. W.	Hallock
MacDonald, W. P.	F. H. Peavey & Co., 912 Grain Exchange, Minneapolis 15
Wirth, J. F.	Hypro Engineering, Inc., 404 Washington N, Minneapolis

MISSOURI

Fosse, Dick	Monsanto Chemical Co., 800 N. 12th Blvd., St. Louis

MONTANA

Baker, L. O.	Northern Montana Branch Station, Havre
Hodgson, Jesse	ARS, USDA, Bozeman
Krall, James	Montana Agr. Experiment Station, Moccasin
Myrick, D. C.	Production Economics, USDA, Bozeman

NEVADA

Bowser, Curtis	Bureau of Reclamation, Boulder City
Burge, Lee	State Dept. of Agriculture, Box 1027, Reno
Robertson, J. H.	University of Nevada, Reno
Robocker, W. C.	ARS, USDA, Nevada Agr. Exp. Station, Reno

NEW JERSEY

Antognini, Joe	Geigy Chemical Corp., 62 W. 2d St., Bayonne

NEW MEXICO

Thompson, C. B.	New Mexico State Engineers Office, Santa Fe
Whitworth, J. W.	New Mexico State College, Box 306, State College
Yeo, Richard	New Mexico State College, State College

NEW YORK

Porter, R. P.	Ethyl Corp., 100 Park Ave., New York 17
Zedler, R. J.	Carbide & Carbon Chemical Co., 9 E. 41st St., New York

OKLAHOMA

Gibson, J. W.	Dow Chemical Co., 2541 Cashion Pl., Oklahoma City

ONTARIO, CANADA

Anderson, E. G.	National Weed Committee, Science Service, Dept. of Agriculture, Ottawa

PENNSYLVANIA

Beatty, Bob	American Chemical Paint Co., Ambler
Newton, W. F.	Columbia Southern Chemical Corp., 1 Gateway Center, Pittsburgh
Turner, M. B.	American Chemical Paint Co., Ambler
Witman, E. D.	Columbia Southern Chemical Corp., 1 Gateway Center, Pittsburgh
Woofter, H. D.	Pittsburgh Coke & Chemical Co., Pittsburgh 25

OREGON

Finnell, H. E.	Oregon State College, Corvallis
Furtick, W. R.	Oregon State College, Corvallis
Miller, Roy E.	Miller Products Co., Ft. S.W. Caruthers St., Portland 1
Sturges, K. L.	Stauffer Chemical Co., Box 68, North Portland
Taylor, Hugh	Oregon Dept. of Agriculture, Salem
Taylor, L. F.	DuPont Chemical Co., 616 N. 31st St., Corvallis
Warren, Rex	Oregon State College, 529 N. 31st, Corvallis

UTAH

Andersen, E. L.	District Agr. Inspector, Court House, Brigham
Blanchard, T. L.	District Agr. Inspector, Court House, Logan
Cronin, E. H.	ARS, USDA, Box 14, USAC, Logan
Davis, C. G.	Wasatch Chemical Co., 391 So. University Ave., Provo
Ellison, B. R.	State Dept. of Agriculture, Capitol Bldg., Salt Lake City

Gore, H. W.	State Dept. of Agriculture, Richfield
Hall, Horace	State Dept. of Agriculture, Cedar City
Holgate, Hale	State Dept. of Agriculture, Roosevelt
Jansen, L. L.	ARS, USDA, Box 14, USAC, Logan
Jensen, L. A.	Utah State Agr. College, Logan
Jorgensen, A. M.	Utah State Dept. of Agriculture, 2205 Emerson, Salt Lake City
Klomp, G. J.	ARS, USDA, Ogden
Lee, W. O.	ARS, USDA, Box 88, USAC, Logan
Stark, A.	Wasatch Chemical Co., 2225 So. 5th E., Salt Lake City
Timmons, F. L.	ARS, USDA, Box 88, USAC, Logan
Tingey, D. C.	Utah State Agr. College, 271 Preston Ave., Logan
Whiting, Ray	State Dept. of Agriculture, 722 C & C Bldg., Ogden

WASHINGTON

Bruns, V. F.	ARS, USDA, Prosser
Rasmussen, L. W.	State College of Washington, Pullman

WYOMING

Bohmont, Dale W.	University of Wyoming, Laramie