Western Weed Control Conf.

SECRETARY'S FILE

Proceedings

TWELFTH ANNUAL
WESTERN WEED CONFERENCE
DENVER, COLORADO
JANUARY 30, 31 AND FEBRUARY 1, 1950

A great deal was added to the success of the meeting by the fine cooperation of the exhibitors which included both chemical and equipment companies and we wish to take this opportunity to thank the following exhibitors for their cooperation:

AERO CHEMICAL INDUSTRIES
Ong Aircraft Corporation
Kansas City, Missouri

AGRICULTURAL PROCESSING INDUSTRIES
1300 South Lipan
Denver, Colorado

AMERICAN CHEMICAL PAINT CO.
Ambler
Pennsylvania

AUTOLENE LUBRICANTS
1331 West Evans Avenue
Denver, Colorado

BARTELDES SEED COMPANY
1521 - 15th Street
Denver, Colorado

CALIFORNIA SPRAY CHEMICALS CORPORATION
PO Box 876, Grand Junction, Colorado
PO Box 2266, Denver, Colorado
PO Box 428, Caldwell, Idaho

CHEMICAL CORPORATION OF COLORADO
12th at Quivas
Denver, Colorado

CLARK MANUFACTURING CO.
Atherton
Missouri

COLORADO FARM & PAINT SUPPLY COMPANY
425 Lincoln
Denver, Colorado

CONSUMERS COOPERATIVE ASSOCIATION
3600 East - 48th Street
Denver, Colorado

DENVER FIRE CLAY COMPANY
2301 Blake Street
Denver, Colorado

DUPONT COMPANY
Wilmington
Delaware

E & E SPRAYER COMPANY
Waverly, Nebraska

GEORGE BROS., INC.
973 Broadway
Denver, Colorado

HYPRO ENGINEERING, INC.
404 North Washington
Minneapolis, Minnesota

JULIUS HYMAN & COMPANY
Rocky Mountain Arsenal
Denver, Colorado

KUPFER PRODUCTS, INC.
1041 East Wilson Street
Madison 3, Wisconsin

LIBERTY TRUCKS & PARTS CO.
690 Lincoln -- PO Box 1889
Denver, Colorado

ROBERT W. LOEFFLER
Box 236
Clifton, Kansas

MONARCH MANUFACTURING WORKS, INC.
2501 East Ontario Street
Philadelphia, Pennsylvania

OWEN PRODUCTS
44 South Kalamath
Denver, Colorado

PARKER COMPANY
1520-24 Wazee Street
Denver, Colorado

PITTSBURGH AGRICULTURAL CHEMICALS
350 - 5th Avenue
New York City, N. Y.

ROHM & HAAS COMPANY
Washington Square
Philadelphia, Pennsylvania

SPRAYING SYSTEMS COMPANY
3201 Bellwood Street
Bellwood, Illinois

STAZ-ON SPRAYING & DIPPING SERVICE
Wellington
Colorado

STONE LIVESTOCK SUPPLY COMPANY
217 Livestock Exchange Building
Denver, Colorado

E. C. STONE COMPANY
136 West 12th Avenue
Denver, Colorado

THOMPSON HAYWARD CHEMICAL
1501 West 12th Avenue
Denver, Colorado

WHITWORTH SUPPLY COMPANY
PO Box 236
Denver, Colorado

TWELFTH ANNUAL

WESTERN WEED CONFERENCE

DENVER, COLORADO

JANUARY 30, 31 AND FEBRUARY 1, 1950

OPENING REMARKS - WESTERN WEED CONFERENCE

Eugene W. Whitman - President

I should like to take just a few moments this morning to comment briefly on some of the developments of the past year and to make one or two suggestions which seem to be for the good of the Conference.

As we gather here for this Conference I think it is fitting to say a word in tribute to a friend of weed control. Dr. L. W. Kephart, who this year retires from active duty, leaves behind him many accomplishments of which he and all of those interested in weed work can be proud. We wish him a future filled with the many satisfactions which his service has earned for him.

We welcome Dr. Lovvorn who is here with us and to whom we will look for active leadership. Demands upon him and his newly created division will be many. While his work will naturally cover the whole country, we can assure him that many serious weed problems exist in the Western part of the United States. I am sure I speak for all of us when I pledge the support of the Western Weed Conference to Dr. Lovvorn and his work in helping to solve these problems.

The Bureau of Plant Industry weed research stations in cooperation with the Bureau of Reclamation located in the Western States have been a valuable addition to our weed research programs. The spirit of cooperation between the personnel of these stations and the local state research people has been outstanding. It has been my personal privilege to work rather closely with one of these stations and to observe this fine relationship. The contributions which have come from these stations are a credit to F. L. Timmons and his fellow workers.

We shall hear more later in the program about a proposal for cooperation among the various weed conferences in this country. Walter Ball has represented us at a joint meeting of the four conferences held last fall in Kansas City. Pending his full report to this Conference, I should only comment on the desirability of a national outlook and national support for a program which is certainly nationwide in its scope and interest.

You have no doubt noted from the program that weed control on federal lands takes a very considerable portion of our time. Several facts are of interest in this connection. In many of our Western states federally supervised lands make up from 50 to 80 percent of the total land area. Unfortunately weeds have had no more respect for these areas than they have had for private, local government or utility lands. Weeds on federal lands are of concern to us - as a source of infestation for farm lands; as a menace to the carrying capacity of range lands; in direct losses to livestock from poisonous weeds; and as hosts and breeding grounds for insects and plant diseases. The advances made by Halogeton and St. Johnswort in several of the Western states have recently aroused additional interest in weed control on federal lands. In some specific cases these weeds have already affected the economy of some communities. I have no patience with farmers or stockmen who continually attach the administrators of federal lands when their own farms, ditches and roadways harbor serious weeds about which nothing is being done. This same attitude should extend to public and semi-public utilities and to local governments. On the other hand, in areas where private individuals, utilities and local governments are willing to participate in a concerted weed program agencies of the federal government have no moral right to ignore the weed menace on lands which they govern.

To those folks who are here representing government agencies may I say welcome to our Conference. We should like to sit down with you and discuss our mutual problems. It is our hope that we can cooperate in getting the necessary facilities for you to carry on the kind of a weed program which we know many of you would like to have in operation.

In many cases our laws and the enforcement of our laws governing seed, feed, forage and fertilizer need strengthening. In this connection I can speak from personal experience. More attention to standard laws and procedures and increased activity in enforcement is needed. In this work we would do well to consider the activities of crop improvement groups and lend them every aid possible.

In conclusion I would like to thank those who worked so faithfully in making this meeting and this program possible. While many have contributed to its development, Secretary Walter Ball and immediate Past President Bruce Thornton have carried the burden of final arrangements for the program. Our thanks also go to Bruce and his fellow Coloradoans for the local arrangements.

The major committees have been active in gathering information for their reports. The research committee has solved a knotty problem by presenting its material in two sessions, the one before the whole group being somewhat different from their closed session. It is regrettable that more of the major committee reports could not be given early in the program as has been suggested by last year's summarizing committee. I am sure that the work of these committees warrants fuller consideration. Perhaps in next year's program they can be given a fuller and earlier part in the program. Certainly serious consideration can be given to the publication of the reports of these committees.

I believe that with the appointment of a nominating committee, which will be made shortly, that this session of the Western Weed Conference is ready for full steam ahead.

ADDRESS OF WELCOME

Governor Lee Knous

Thank you for your invitation to be here this afternoon. I assure you, Ladies and Gentlemen, it is a privilege to come down today and extend from the State of Colorado and the people of Colorado a warm welcome to our State.

I understand this is the first meeting of this organization which has been held in Colorado, notwithstanding that the organization is now some eleven to twelve years old; and, I do hope that this will not be the last time you come here.

We are, of course, very much interested in your program and agriculture and I would like to contribute something inspiring.

However, in the way of a story -- you will recall Walter Johnson as being one of the greatest fast ball pitchers of organized baseball for Washington in the American League. One year when, about like last year, the teams came right down to the end of the season at a tie, Washington was playing the New York Yankees. The catcher being very observing and noticing the crowds moaning in the stands, called the pitcher aside and said: "When you wind up for the next pitch, give them one of your fastest balls but don't let loose of the ball. I'll thump my mit real loud and see what happens." The pitcher wound up, the catcher thumped his mit and the umpire shouted "Strike 3". The amazed batter yelled, "Liar, it was two feet wide".

We realize that the basic and lasting economy of these Western states rests in the fields of agriculture and agricultural pursuits. Naturally the problem of weed control is a very important factor in the progress of agricultural pursuits.

I have occasion, from time to time, to meet the agents of the health program, not only in Colorado but in other sister states in this region as well. Seemingly there is always the equivalent for the problem in that field, in soil conservation, in seed development, in farm methods and procedures and, of course, in weed control.

When we look over last year's progress made in weed control, it is truly remarkable. This progress, as you know, was due to a whole lot of efforts of a whole lot of people working together for the same end -- chemical companies, airplanes and all of you who are experts in coordinating this program. The more I consider our problems of water, the more convinced I am that the State lines in this West are geographical only and that we must continue to work together toward one common end and for one common objective.

It is gratifying as I look over your program to see that the Departments of the Federal Government are cooperating with you in this particular activity. Because of the tremendous public demand now existing in the West, we must have a unified program if we are to make the necessary progress.

I congratulate your organization on this meeting, on the fine program and on the fine things I know will be gained from this occasion.

Thanks for coming to Denver and Colorado and I sincerely extend our greetings and invitation to come again.

WEED CONTROL RESEARCH, BUREAU OF PLANT INDUSTRY SOILS, AND AGRICULTURAL ENGINEERING

K. S. Quisenberry 1/

My assignment is to summarize the research on weed control being conducted by the Bureau of Plant Industry, Soil, and Agricultural Engineering. First, let me say, that our Bureau controls no public lands and therefore we have a different type of program than was presented by the very interesting panel. The Congress has directed that our appropriations be used for certain research projects. Our objective then is to find out when, how and why, each possible weed control method works. All of our experiments are conducted in cooperation with various State agricultural experiment Stations, with other Federal agencies, or in some cases with commercial companies.

DIVISION OF WEED INVESTIGATIONS

As most of you know, the Bureau of Plant Industry, Soils, and Agircultural Engineering research on weed control has been centered in the Division of Cereal Crops and Diseases. Here it was organized as a project on the same basis as were the projects dealing with each cereal crop. From time to time various weed control conferences and other groups have suggested that there should be a weed division to take care of this rapidly expanding field. Two years ago it was announced that in due time there would be a division set up. A Bill was introduced in to the Congress to provide for this action. The Department of Agriculture requested that this Bill not be passed but that a new division would be established voluntarily as soon as it seemed feasible. With this in mind, plans were developed to take this action just as soon as it seemed to be the most effective way to handle the job. On December 8, 1949, Dr. R. M. Salter, Chief of the Bureau of Plant Industry, Soils, and Agricultural Engineering, speaking before the North Central Weed Control Conference at Sioux Falls, South Dakota, announced the formation of a new Division of Weed Investigation, this division to have equal rank with other divisions in the Bureau. He also announced that Dr. Roy Lovvorn of the North Carolina Agricultural Experiment Station, had accepted the position as Head of this new division, and would report for duty on January 16, 1950.

1/ Head Agronomist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soil, Agricultural Engineering, Agricultural Research Administration, U.S. Dept. of Agriculture, Beltsville, Md. Presented at the meeting of the Western Weed Control Conference, Denver, Colo., February 1, 1950.

The division is now established, Dr. Lovvorn is on the job, and, as many of you know, he is attending these meetings and I want all of you to meet him. According to Dr. Salter's announcement, the new division will conduct research on the control of weeds in all parts of the country and on all crops. Methods of control such as cultivation, crop rotation, crop competition, and the use of herbicides, will all be considered. Thus, the new division will continue much the same program as has been carried by the weed project during the last 14 years. The new division also will be charged with the responsibility of coordinating all of the weed control research carried on elsewhere in the Bureau. For example, some of the Divisions, such as the Division of Fruit and Vegetable Crops and Diseases, Cotton and other Fiber Crops, as well as Forage Crops and Diseases, are concerned with weed control and some projects dealing with the control of weeds in these crops are under way. The Division of Weed Control Investigations also will have the responsibility of coordinating experiments on weed control machinery that are being done by the Division of Farm Power and Machinery, with any other experiments under way. So you see that at last the plans are developing and it is felt that this new division will make for more efficient research on weed control. Dr. Lovvorn has not actively engaged in weed control except to keep weeds from smothering the grasses and legumes in his experimental plots. He has conducted some of the outstanding research with forage crops in the South and will bring to this new division a thorough knowledge of grasses and legumes. This will be doubly important since more attention is being given to weed control by the use of forage crops competition with weeds. The new weed division will be set up in close association with the present Division of Cereal Crops and Diseases in order to save money. One administrative unit will handle the business operations of both Divisions. It would be very difficult to divorce these two divisions immediately, because such matters as correspondence, inventories, payrolls and personnel records have been filed together for so long that it would take considerable time to separate them, but by having the one administrative unit take care of all of these matters, much confusion will be avoided and funds will be saved.

PRESENT RESEARCH PROGRAM

I am sure that this group is most interested in the weed research that is being conducted in the western part of the United States. As you know, several years ago we were granted an appropriation to work on the control of weeds on ditchbanks, reservoirs, canals, and irrigated lands in the West. The headquarters for these experiments is located at Logan, Utah, and F. L. Timmons is the coordinator. His coordinating assignment is to tie together our entire research program in the West and to see that there is no unnecessary duplication. Also, he is supposed to see that this program does not duplicate those of any State agricultural experiment stations or other Federal agencies. In addition to his activities as coordinator, he is also conducting research on the control of annual weeds in legumes, vegetable and row crops, as well as aquatic and ditchbank weeds and woody plants. Mr. Timmons has been in this western area for approximately 2 years and seems to be well established.

Another unit of the western weed research project is located at Phoenix, Arizona, where the emphasis is on the control of Johnson grass on ditch banks and the control of weeds in fields of flax, cereals and other crops. H. Fred Arle, who is in charge of this project, and other investigators in the area have also been experimenting with the use of solvent naptha in irrigation ditches.

A unit is located at Meridan, Idaho, where J. M. Hodgson cooperates with the Ada County Weed Control Board on the control of weeds in that area. His chief interest is with white top, groundcherry, and other weeds, electrovation and the effect of aromatic solvents on crops. Undoubtedly he will report on some of his findings at this meeting.

At Prosser, Washington, V. F. Bruns is in charge of the cooperative weed research and he is interested in the control of quackgrass, Canada thistle, dogbane, and heliotrope, and annual weeds in alfalfa, sugar beets, asparagus, and onions. One of the interesting problems that he is investigating has to do with the control of white top and he has seeded a large field to this weed in the hope of obtaining uniform stands so that he may start some control experiments.

At Denver, Colorado, E. T. Oborn is working on various physiological problems in cooperation with the Bureau of Reclamation. At present he is interested in the translocation of 2,4-D in various aquatic weeds. He has laboratory and greenhouse space at the Federal Center and you will see some of his experiments.

All of this western research is in close cooperation with the Branch of Operation and Maintenance, Bureau of Reclamation; in fact, the appropriation making possible this project was granted by the Congress with the support of this Bureau. All of our men work closely with personnel of Reclamation, each exchanging ideas with the other. According to the memorandum of understanding which has been drawn up, Bureau of Plant Industry men do the research while the Bureau of Reclamation men take these findings and try them out on a plot scale or even on a field scale. I should like to say that this arrangement has worked out very well, and I believe, sets a pattern which might be considered for other cooperative arrangements.

Although not in the western region proper, I think that you will be interested in some of the weed control research that is under way in neighboring areas. First of all I should mention that at Moscow, Idaho, where we have been cooperating very closely with the Idaho station in experiments for the control of bind-weed and other noxious weeds since about 1936, C. I. Sealy, who is in charge of this research is closing out some of the bindweed experiments while expanding his tests with some of the newer herbicides. At Hays, Kansas, the chief activity has been directed toward the control of bindweed under dry land farming conditions, and some very fundamental information on bindweed has been obtained over the years. At Lincoln, Neb., our man is especially interested in the control of weeds in pastures and meadows. He is setting up experiments on crop competition and is studying ways and means of controlling weeds in pastures and meadows by proper management practices, as well as by the use of herbicides. At Brookings, S. D., more bindweed work is under way, as are some screening tests with new herbidides. L. M. Stahler, the coordinator for the central area, is located there and in addition to his coordinating activities is doing some very productive research. At Fargo, N. D., and East Lansing, Michigan, we are experimenting on the control of weeds in sugar beets. This effort has only been under way for about 2 years but owing to several misfortunes has furnished not too much information to date. Another of our men is working in cooperation with the Minnesota Agricultural Experiment Station at St. Paul, Minn., on the control of various weeds, especially leafy spurge, and particularly on the control of weeds in corn. One of his problems is to establish the most effective methods for determining the resistance or tolerance of various corn inbreds and hybrids to 2,4-D.

Possibly of more interest to this group are some of our experiments under way on range lands in the south. For several years we have been cooperating with the Division of Forage Crops and Diseases on their brush control experiments at Woodward, Okla., This project was originally started to find ways and means for controlling brush, especially sand sagebrush, by mechanical methods and grazing practices. With the discovery of 2,4-D, experiments were started at this station on the use of this chemical and some very promising results have been obtained. It has been found that by the use of proper formulations applied by airplanes, a cheap method of sand sagebrush control is possible. Unfortunately the big sagebrush of the Far West is not so easy to control.

Additional experiments on brush weeds of range lands is under way at Spur, Texas, where Dale Young is cooperating with Mr. Fisher of the Texas Agricultural Experiment Station. As you know, ranchers have been attempting to control mesquite by various methods for many years. Since none of the methods tried has been too practicable from the economic standpoint it seemed desirable to intensify the research on this problem. Recently some new leads have been found which may contribute a great deal towards solving the mesquite problem. There is a great deal of enthusiasm in this area for additional research on the control of brush on range lands and to combine this with proper range management practices. In fact, plans are being drawn up for greatly expanding this work if the necessary funds are made available.

Permit me to tell you very briefly about the rest of our weed control research. At New Brunswick, N. J., our experiments include pre-emergence control of weeds in corn and the control of weeds in vegetable crops. In the South at Experiment, Ga., and at State College, Mass., we are working on the control of nutgrass. This has been under way for 2 or 3 years and some worthwhile leads finally are being obtained. As you may or may not know, this weed is a very difficult one to eradicate because it has some deep underground "nuts" that send up new shoots after the plants and the shallower "nuts" have been killed. However, recent results indicate that crop competition along with herbicides may be effective.

In the South, there is much interest in the control of weeds in cotton. As you know, with the coming of mechanical pickers it is highly important that grass weeds be kept out of the crop so the lint will not be contaminated. With this in mind we have been setting up plans for more research along this line and it is the intention to establish a new project at Stoneville, Miss. We are in the process of finding someone to take over this work and we are just about ready to proceed.

Just one more project that I should like to mention, and that is the one that has to do with the distribution of 2,4-D by airplane. At Beaumont, Texas, we had a small project for about a year to study this problem, and some very worthwhile information was obtained. This was of especial interest in areas of the South where 2,4-D was used for the control of weeds in rice paddies adjacent to cotton fields. There cotton often was severely damaged when improper methods were used.

COOPERATION WITH OTHER AGENCIES

As pointed out earlier in this talk, all of our work is in cooperation with State agricultural experiment stations or with other Federal agencies. I have mentioned our cooperation with the Bureau of Reclamation and I should like to say just a little more about this. From our standpoint, this type of cooperative effort has been very successful and we hope that the Reclamation folks are equally well satisfied. The Bureau of Reclamation had certain problems that needed to be solved, but were not in a position to establish the necessary research. So they asked us to do it and we were glad to help out, and we will be very glad to continue such cooperative research. The set up here at the Federal Center at Denver is an unusually good one and we have a man located right in their building, working on psysiological problems. In fact, the Bureau of Reclamation is more than carrying their share of the work and expense.

From time to time the question is asked whether or not our Bureau is in a position to initiate cooperative projects with other agencies. The answer to this is "yes" if funds are available and the necessary arrangements can be made. You realize, of course, that once we get an appropriation from Congress to do certain things, various projects are established and put into operation. Then, until such time as these projects are completed, it would be impossible to drop them just to pick up something new. The point I am trying to make is that, first of all, we have certain obligations under our appropriations, and, second, we have certain work under way which should be completed before it is replaced by anything new. For this reason, we would not be able to start many new experiments at this time unless the proper financial support were forthcoming. On the other hand, when and if we are financially able to initiate new projects we stand ready to do so. Some years back we assisted the Army in some cooperative research, with the Army paying the bill, in studying the control of water hyacinth in the South. This cooperative effort yielded some very valuable information that is now being applied in the clearing of waterways at a greatly reduced cost.

It is realized that in an organization as large and far-flung as is the United States Department of Agriculture, there is bound to be some duplication of effort. An attempt is being made to avoid this as much as is possible. As we see it, it is not necessary that all weed control research be done in one unit, although that might be desirable. On the other hand, as long as it is going to be scattered among various agencies, the important thing is to have some means of coordinating all the efforts in order to avoid unnecessary duplication. So far as our Bureau is concerned we have a Weed Committee which meets from time to time to discuss what is going on in the Weed Division as well as other divisions, and thus overlapping within the Bureau is avoided. It is my understanding that a committee of this same sort is going to be set up in the United States Department of Agriculture, and so far as we are concerned we would be more than glad to join with other Government agencies having coordinating committees, because after all we are obligated to make the best use of the dollars that are appropriated for our use. We all agree that there are some extremely important problems that must be solved, and solved quickly, and only by all working together in the most efficient manner will this be done.

Dr. Quisenberry introduced Dr. Roy L. Lovvorn who is in charge of the newly-created Weed Division in the U. S. Department of Agriculture.

Dr. Lovvorn stated he was very hopeful of having the same cooperation that has been carried on between the Department and the States. He anticipated no changes in his personnel and no immediate change in their program.

He expressed his desire to work with and assist wherever possible the committee organizing the national weed organization.

WEED CONTROL ON FEDERAL LANDS
Robert Balcom, Chairman

MR. BALCOM: Mr. Chairman, Ladies and Gentlemen of the Western Weed Conference:

I have had the pleasure on other occasions of telling you about the weed control work of the Bureau of Reclamation, but it is gratifying to me at this time to be chairman of several Government agency representatives who will discuss "Weed Control on Federal Lands".

In the past sessions of your conference there has been considerable discussion on this subject, and several resolutions have been passed concerning weeds growing on the public domain.

It is hoped that the information which will be presented by representatives of the principal agencies administering public lands in the 11 western states will give you a better insight of each agency's weed problems, the programs they are conducting, and their future weed control plans.

There is no doubt that considerable weed control work is needed on Federal lands. However, no one realizes this more than do the officials of the Government agencies who have the responsibility of administering these large areas. Also, I believe you will be impressed with the work now being accomplished and the plans for future programs to be initiated as soon as it is possible to do so. I can assure you that these agencies are extremely interested in their weed control problems and wish to cooperate with local, state and other Federal agencies.

About 7/8 of all the Federal lands administered by the agencies represented here are located in the 11 western states, You may be interested in knowing the approximate area which each agency has under its jurisdiction in this section of the United States comprising the Western Weed Conference:

Bureau of Land Management	189,865,000	acres
Bureau of Indian Affairs	44,761,000	"
Bureau of Reclamation	13,684,000	"
National Park Service	13,401,000	"
Fish and Wildlife Service	3,625,000	"
Forest Service	136,660,000	"
Soil Conservation Service	4,080,000	"
Department of the Army	844,000	"
Department of the Navy	1,500,000	"
Total	408,420,000	acres

There may be some questions which you would like to ask of the speakers and an opportunity for this will be given. However, in order to save time it is requested that all questions be reserved until the panel is completed.

Without further comment I wish to present the first speaker, Mr. William J. Endersbee, Assistant Director of Soil Conservation, Department of the Interior, Washington, D. C. As Mr. Endersbee is connected with the Office of the Secretary it is appropriate that he make a general statement for the Department — Mr. Endersbee.

****

Mr. W. J. ENDERSBEE: "WEED CONTROL IN THE DEPARTMENT OF THE INTERIOR".

During the past year or more, considerable criticism has been directed toward the Department of the Interior for failure to institute a more active weed control program. For this and other reasons, we in the Department were much gratified when your officers made it possible for us to discuss our problems with you at this conference.

I think it safe to say there is no weed problem confronting you as individuals which is not perplexing one or more of the bureaus in the Department. Many of these have been with us for generations, and thru adjustments and some control we have learned to live with them. In recent years, others, like salt cedar and halogeton, have been found to be equally or more serious, and so far no effective and economical method of control has been found for them.

While the Department has not done as much as it should and would like, it has, I think, made some progress. The details of much of this will be disclosed in the panel by the bureau spokesman.

Department-wise, the most important step in weed control is, I think, the formation and activity of a Departmental Weed Control Committee. This started out in August, 1948, as an informal gathering of technical people in the bureaus interested in overcoming the adverse effects of weeds in good land use. Early in January of this year, the Secretary issued a formal order giving the Committee his blessing as well as departmental recognition and status. So far as I know it is unique in that it is the first and only such Committee in any Federal Department.

Under committee stimulus, each bureau during the past 18 months has been reappraising its weed problems and taking stock of its activities. By consultation and experimentation they have been endeavoring to gather additional information and formulate plans for a more active program. One effective obstacle to programing is the dearth of reliable information on the satisfactory control of weed pests which are most critical in the bureaus.

Since the war rather rapid and phenomenal progress has been made in combating certain types of weeds and the bureaus have kept well abreast of these activities. I venture the assertion that every type of herbicide and other methods of weed control have been tried by some bureau of the Department. Work continues at the present time in testing the effectiveness of different herbicides, the methods of application, and the testing and development of equipment. Until these basic points are resolved, aggressive programs will lag for the control of those weeds which now are a serious menace to us in proper land use.

Most research, as you know, is carried on by the Department of Agriculture. The Committee has been active in support of expanded research in that Department and the establishment of a central agency there for the assembly and dissemination of reliable information. Now that the Committee has a formal status in the Department, it should be able to extend its activities. It becomes a more effective focal point of contact with organizations like your Conference, and with State agencies and private individuals. It is a central medium available to you for promoting and coordinating all weed activities pertinent to the Department.

The particular points I want to leave with you are these:

The goal of the Department of the Interior is to make every acre of the 280 million under its jurisdiction serve its most useful purpose in accordance with its capabilities and with the objectives for which the land has been set aside by the Congress. As any farmer knows, good land use, good husbandry, involves a great variety of activities and practices. One important practice in land use is to eliminate weeds which cut down crop and livestock production and rob useful plants of soil moisture.

More than 94 percent of the lands in the United States under the jurisdiction of the Department is in the eleven far Western States represented by your Conference. We realize that we have serious weed problems and the major ones are in your area. We are meeting those problems as rapidly and effectively as condition and funds will permit, and we will continue to do so.

Equally important with reliable control methods and money is the matter of cooperation. We recognize fully the wisdom of cooperating with the States and other public agencies, but especially with the users of the land. I want to repeat that cooperation with the users of the land is essential. There are over one hundred thousand people using public and Indian lands under our jurisdiction. Some of you are among that number. It is you on whom we must depend in the long run to carry out good husbandry practices on the land. The formal establishment of the Weed Control Committee should facilitate more direct and effective contact with you and others in controlling weeds.

It is for these reasons we welcome the opportunity to join hands with this Conference in its endeavor to find the proper solutions to weed control. We need your help and want to work closely with you and others in combating the weed menace in the western area. As a follow-up to these discussions, the Secretary has put the bureaus on notice that as soon as this conference is over, he wants a report covering the weed problems in this and other areas, and recommendations on methods of control, both directly and in cooperation with others.

MR. BALCOM: Our next speaker is Mr. Charles C. Sperry from the Denver Wildlife Laboratory of the United States Fish and Wildlife Service, Department of the Interior -- Mr. Sperry.

MR. SPERRY: "WEED PROBLEMS AND PROGRAMS OF THE U. S. FISH AND WILDLIFE SERVICE," prepared by Mr. A. C. Martin, Biologist, Branch of Wildlife Research.

The weed problems of the Fish and Wildlife Service center in two principal kinds of environment; aquatic and wet-land areas and upland. Both types are common on National Wildlife Refuges of the West. Since the two kinds of habitat as well as their characteristic vegetation and weed-control problems are distinct, they will be discussed separately. First, the marsh and aquatic weed problems confronted by our agency and then, secondly, weed control on rangelands, farms and upland wildlife habitat.

The service's program of managing marsh and aquatic vegetation represents a unique function in the field of weed control. Though the Bureau of Reclamation also contends with plants of aquatic or wet-land habitat, our problem is different since it aims at replacement of certain plants by other better suited to wildlife needs and does not simply attempt to eliminate vegetation. Naturally, in cases wherein reservoirs or other properties are managed jointly by our Service and other agencies, the aims and activities are adjuted to the dual or multiple purposes involved.

Most of the Service's participation in marsh and aquatic weed control represents effort to make good use of the limited waterfowl habitat now remaining. As such, it is of national or international importance in the maintenance of waterfowl populations. And, in addition to the value for ducks and geese, the management of marsh and aquatic vegetation often is significant for fish, muskrats, and other wildlife that utilize this type of habitat.

Determining just what is a weed in wildlife habitat is not as simple as in the case of a weedy cornfield or irrigation ditch. This is because reliable information on two biological matters is always prerequisite before plants can properly be classed as weeds to wildlife. In the first place the extent of usefulness, or lack of usefulness to certain forms of wildlife must be understood. Secondly, the designation "weed" cannot be applied accurately until it is definitely known that in any particular locality concerned, plants of low value to wildlife are precluding the presence of better ones which can be successfully introduced (by nature or man) after control operations.

Of the total area infested by weeds on the National Wildlife Refuges in Western states -- approximately 33,000 acres -- more than two-thirds of the aggregate is occupied by wet-land or aquatic plants. The principal problem-species are cattails, salt cedar, willows, and reed (Phragmites). The limited operational programs that have been conducted thus far have been directed chiefly against willows and salt-cedar -- plants that are doubly undesirable since they are handicaps to wildlife management and also to water conservation.

In addition to the many Federal refuges managed solely for wildlife, there is an increasing number of irrigation reservoirs and river-basin impoundments in which the Fish and Wildlife Service has a joint but secondary role of operation. In such projects the wildlife interests, though significant, should be and are subordinate to the primary objectives. The desirability of certain marsh and aquatic plants for wildlife uses may easily be outweighed by disadvantages of such plants. However, the experience of our Service in these jointly-managed developments has resulted in two conclusions about policy which seem to favor the interests of all. One is the old principle that "an ounce of prevention is worth a pound of cure" of undesirable water-margin plants in new reservoirs. This applies particularly to troublesome species such as willows, salt-cedar, and cattails. The other conclusion is that foresight in making provision for water-level manipulation in designing reservoirs will facilitate greatly the prevention and control of weed infestation.

Control measures employed by the Fish and Wildlife Service on marsh and aquatic weeds have consisted largely by the use of herbicides. The principal chemical agents used are

2,4-D (both its salts and esters), (ammonium-sulfamate) and atlacide (sodium chlorate). Application of sprays has been made by various types of equipment, including small power and hand-operated sprayers. Wherever possible, airplane equipment is being used. Underwater weed cutters have not been successful in combating aquatic vegetation on several refuges where they were tried but since this kind of equipment was a principal means of controlling thousands of acres of water caltrop (or water-chestnut) in the Potomac River, the method probably deserves further consideration. In some places salt-cedar has had to be eradicated by bulldozers because the plants were so large that killing with 2,4-D would leave obstacles to the establishment of desirable vegetation. Manipulation of water levels -- where such control of water is possible -- has proved an effective means of weed suppression. Also, in some places, fire has served as a useful tool.

This Service's program of research on the control of marsh and aquatic weeds is, thus far, very limited. Personnel assigned to this activity includes one man on a full time basis and part time attention of others. Obviously, it will take a long time to solve the country's wildlife weed problems at this rate. An amplified program of research is definitely needed in order to provide information for wise management of wildlife habitat. Investigations performed by our agency are, of course, confined to marsh and aquatic situations. Research on rangeland and farm weeds is the province of the Department of Agriculture insofar as the Federal government is concerned.

Recent and continuing studies by the Fish and Wildlife Service show that cattails, mowed at certain stages of growth, can be controlled effectively by this mechanical or manual means. A cutting made when the fruiting spikes are well-developed but not mature, followed by another cutting about a month later, when considerable vegetative re-growth has occurred, is, according to preliminary tests, likely to yield about 95% control of this plant.

Next, let's consider the weed problems which the Fish and Wildlife service faces on upland portions of its wildlife refuges in western states. In this connection, it should be recognized that common farmland pest-plants such as ragweed, pigweed, lambsquarters, and Russian thistle are very valuable to many forms of wildlife. Especially to upland gamebirds and to a great variety of songbirds and to small mammals. Whether or not these animals exercise a significant effect in curbing such weeds is another question -- and one in which, admittedly, the beneficial role is easily over-estimated.

On refuges managed primarily for big game such as antelope, deer, bighorn sheep or mountain goats, the same principles and ideals that guide management of range vegetation for domesticated livestock are likely to apply. Abuse of the land through overgrazing is a main source of weed problems. Annual "weedy" vegetation such as cheatgrass, whether introduced by overgrazing or other causes, is generally undesirable as compared to permanent sod. It is inevitable, however, that in many places the viewpoints of the farmers and of the wildlife biologist will not coincide as regards the obnoxousness of certain common weeds of rangelands and farms. Nevertheless, it is the policy of the Service to cooperate with other agencies, Federal, State and County in controlling farm and rangeland weeds that might conceivably serve as a source of dissemination to adjacent agricultural areas. Thus, in addition to controlling plants that are undesirable for upland wildlife habitat, the Service attempts to be a good neighbor by taking a broad view on public values in land-use. To this end, efforts are being made to eradicate plants toxic to range livestock and to curb other weeds that might be detrimental to agriculture in the general vicinity. Weeds of the agricultural category on the western wildlife refuges total about 10,000 acres. Principal species are thistles, cheatgrass, larkspur, knapweed, and St. Johnswort. Most of these have been subjected to control operations in the recent past and currently, thistles and St. Johnswort have been receiving special attention. Materials -- principally herbicides -- and methods of control are largely the same as those used on marsh and aquatic plants. In addition, however, borax, sodium arsenite, and arsenic trioxide have been used for soil sterilization, as in the maintaining of firebreaks.

The Service is impressed with the great need for intensified research on effective means of controlling plants that are objectionable in wildlife habitats, be they marsh, aquatic or upland. In particular, there is need for some better herbicide than 2,4-D for suppressing cattails and various undesirable grasses. Also more knowledge is needed on efficient methods of application. In some instances this may necessitate re-designing equipment for large-scale operations so that it will be suitable for boggy situations such as are inhabited by extensive stands of cattails, salt-cedar, and willows. One of the greatest needs appears to be closer coordination in weed-control and land-use programs throughout the country. Doubtless a central clearing house of published information on methods of controlling weeds would contribute greatly to this end.

* * * * *

MR. BALCOM: Our next speaker is Mr. Evan L. Flory from Washington, D. C. who is Chief of the Branch of Soil Conservation, Branch of Indian affairs, Department of Interior- Mr. Flory:

MR. FLORY: "WEED PROBLEMS AND CONTROL IN ELEVEN WESTERN STATES".

Weed Problems on Indian Lands. Weeds have been specifically defined in the Bureau's soil conservation handbooks as follows: "Those plants which constitute an undesirable ground cover inclusive of those which reduce crop production, reduce quality of crops or interfere with tillage operations as well as those toxic to domestic animals and man."

Acres of Weed Infestation on 44,761,000 acres of Indian Land:

STATE	Heavy Weed Irrigated	Infestation Dry Farm	TOTAL RANGE
Arizona	4,000	- - -	10,754,000
California	2,000	- - -	230,000
Colorado	5,000	2,000	347,000
Idaho	12,000	30,000	566,000
Montana	22,000	30,000	4,709,000
Nevada	8,000	- - -	780,000
New Mexico	20,000	- - -	3,749,000
Oregon	3,000	18,000	465,000
Utah	25,000	- - -	1,632,000
Washington	43,000	5,000	887,000
Wyoming	6,000	- - -	1,600,000
Total	150,000	85,000	25,719,000

Kinds of Troublesome Weeds: There are no figures on the infestation of rangelands by weeds but at least 75% of the 25,719,000 acres of rangeland has become infested with relatively useless or even harmful brush, weedy grasses and forbs, sagebrush, cheatgrass, juniper and mesquite in the order named - occupy the great acreages with snakeweed, Klamath weed, pingue, rabbit brush, St. Johnwort, sneezeweed, cacti, greasewood, lupines, locoes, whorled milkweed, death camas, water hemlock, larkspur, occupying lesser acreages but in many cases locally very serious.

235,000 acres of Indian farmland have been reported as having heavy weed infestation. Bindweed is a most prevalent, occuplying large acreages through the west on irrigated lands and the best dry land. Whitetop, Russian Knapweed, Canada thistle, Klamath weed and Johnson grass are the most serious on irrigated lands. Canada thistle and mustard are particularly serious in dryland grain-growing areas.

Tamarix, willows, Johnson grass, mesquite, cattails, are serious problems on ditch banks, lateral and drains. Aquatic weeds in canals and ditches are very serious in Arizona and Southern California.

Bindweed on some farms has reduced wheat yields at Umatilla from 60 bushels per acre to 8. Canada thistle and mustard decreased wheat yields in Montana very drastically in a few cases. Extensive areas of grazing lands have little carrying capacity because of replacement of grass by sage, juniper, mesquite, rabbit brush and other species of the same character. Klamath weed, Canada thistle, whitetop and others have practically destroyed productiveness of much irrigated pasture land and some rangeland.

Indian lands in the past in some instances still constitute a threat to local plans for progressive weed control because of untreated areas being a source of reinfestation, This, however, is being rapidly corrected because of stimulated interest among Indians.

Whorled milkweed causes heavy loss at times in the southwest on the range and in hay. Acorns caused the loss of 300 sheep in one drive in Colorado by compaction. Pingue has frequently killed Navajo sheep in high ranges entered too early. Indian lands because of their wide distribution in the west and wide range in altitude in one place or another have every poisonous or injurious plant found in the west. Halogeton and Syrian Rhu are two of the most recent ones causing us concern.

Operations and maintenance activities are seriously affected by weeds. Ditchbanks and water weeds cause great expense to control and cut down the flow of water materially, both onto and off the land. Brushy invaders seriously handicap the handling of livestock. Cattle in the tamarix thickets around San Carlos reservoir sometimes go for years before they can be rounded up. Mesquite and juniper, while not quite so bad, cause missing much stock and impede roundups greatly. Bindweed and similar weeds increase cultural costs greatly because of the additional cultivation necessary.

Cheatgrass constitutes our greatest fire hazard. It is highly inflammable and covers probably 2,000,000 acres of Indian range land in thick enough stands to constitute a serious fire hazard. Sagebrush contributes at least 3,000,000 acres in heavy enough stands to be a serious fire hazard. Inflammable weeds in fire lanes create an additional maintenance cost.

Erosian is materially increased when juniper, sagebrush and similar species replace grasses. Such brushy species are very poor protection against sheet and gully erosian.

In the great wheat-producing areas extra weeding operations break up and incorporate into the soil stubble mulch, pulverize cloddy rough structure creating surface conditions very susceptible to both wind and water erosian. Pollen of many weeds cause distress to people allergic to them. Rank growths of weeds like Russian thistle, sunflower, etc., cause drifting of snow into roads making them impassable. They also obstruct view at crossroads and entrances.

The Indian Bureau is doing no research in weed control as such. We follow the recommendations of state experiment stations, and other reliable sources and keep records on cost, results and experiences that will facilitate future operations.

On all leased Indian lands provisions are being included in the lease to eradicate and control weeds and to observe all rules and regulations of local weed districts. Indian tribal councils and the bureau are attacking the problem on tribal lands, canal banks and rights of way. Increasing cooperation between tribal group, local and state committees is taking effect toward community solution of weed problems.

Work is being carried out in control of all kinds of weeds in all situations in which they are found ranging from biologic control of Klamath weed, chemicals, fire, cultural methods and mechanical eradication. The extent and amount of work done has been determined by financial ability of Indians, recognition of need and available bureau personnel. During the past year 42,000 acres of wheat were dusted or sprayed with 2,4-D for control of bindweed, mustard, tar weed, Canada thistle and wild lettuce. General opinion was that treatment increased wheat yields 30%. 6100 acres of irrigated land were sprayed with 2,4-D for control of bindweed, Russian knapweed, star thistle, whitetop, and Canada Thistle; 2,000 acres of peas with nitro spray; approximately 10,000 acres weed control by intensive cultivation; 4,600 acres of juniper eradication; 100 acres of mesquite eradication; and the bank sides and bottom of 1103 miles of main canals; 668 miles feeder canals, 594 miles of drainage canals; and 4557 miles of field laterals were sprayed, mowed, dug, chained, dried up or burned for controlling tamarix, willows, water weeds, Johnsgrass, and other species.

The Indian Bureau is cooperating with local, state and federal agencies in making plans for a unified attack on weed problems in addition to the work just listed, but many Indian tribes and people are very poor. The first specific request by the Indian Bureau for weed control funds this year was denied. An adequate attack on the problem will depend on such funds.

Field men will be best served in their work if research is coordinated and results regularly published.

Indian bureau plans for future operations consist of the following:

1. Educational effort directed to both whites and Indians by conservationists, speeches, moving picture films, black and white picture displays, Kodachrome shows, field trips.

2. Incorporating weed control provisions in farm plans and lease stipulations as part of contracts.

3. Encouraging tribal councils to take firm affirmative positions and appropriate tribal funds.

4. Encouraging formation of weed control districts.

5. Within bureau encourage control on lands in which Branches of Roads, Irrigation, Extension and Credit, Schools and Forestry and Grazing are concerned.

6. Cooperation with other agencies and officials interested in wood control.

7. Obtain small amount of equipment where needed to introduce or augment weed control.

8. Emphasize weed control from national and regional levels in bureau.

9. Continue to present needs for funds for weed control. At the present time there is no appropriation nor specific funds for weed control in the Bureau, what is accomplished is as part of programs organized for other general objectives.

The chief limiting factors at present are:

1. Time required for and difficulties of educating people locally and officially in responsible agencies.

2. Lack of specific knowledge as to how best prescribe an exact solution to particular problem.

3. Cost of getting proper work performed.

MR. BALCOM: We will now hear from Mr. Kenneth B. Platt of Portland, Oregon, who has the position of Range Conservationist in Region 1 of the Bureau of Land Management. As you recall this is a rather new Bureau in the Department of the Interior which has combined the former Grazing Service and Land Office -- Mr. Platt.

MR. PLATT: This conference reminds me of the man who undertook some of his ideas for the good of the country from that oldtime editor, Horace Greeley. After given time for the ideas to soak in, he made a personal call on Mr. Greeley and asked him if he had yet carried out the ideas, to which Mr. Greeley replied: "Yes - not personally, but if you will check with the office boy on his way out, he was carrying out the ideas."

I shall not undertake to present any personal ideas on this subject, having at hand a paper that was prepared by Acting Chief of Soil Conservation in our Bureau in Washington, O. E. Gianni. I shall read Mr. Gianni's remarks:

Halogeton is travelling at the rate of about five miles a year in the direction of the prevailing wind which gives you some idea how fast weeds can spread.

The Bureau of Land Management administers about 180,000,000 acres of public lands in continental United States. 170,000,000 acres of this land is confined to the 11 western states, and most of it is included within grazing districts.

We are much concerned with the weed problem which exists on these lands. The weeds found on the public domain may be divided into three categories, (1) noxious weeds, such as Canadian thistle, White Top and Morning Glory; (2) poisonous plants such Halogeton, Death Camas, and Larkspur; and (3) intrusion plants, such as Sagebrush, Rabbit brush and Greasewood.

It has been estimated that one-half of the death losses of cattle and one-fourth the death losses of sheep can be attributed directly to poisonous plants. In some areas the presence of poisonous plants is not too much of a problem. By changes in seasons of use in most of these areas, death losses are being kept to a minimum. However, the presence of such plants and necessary seasonal adjustments to avoid using infested areas during high-hazard periods places a heavier burden on lands not infested. The presence of Halogeton on some parts of the public lands has become of increasing concern. Because of the air-borne character of the seed, the plant becomes widespread and its control is difficult.

The public lands under the jurisdiction of the Bureau adjoin and often surround cultivated lands and pastures. The presence of noxious weeds on the public lands is detrimental both to the range and to the cultivated lands. Public lands and cultivated lands have mutually infested one another. The damage to the range is measured in terms of loss in forage production and loss in soil protection, while the damage to crop lands is measured in terms of reduced crops and increased cost of cultivation.

Intrusion plants, such as sagebrush, cover wide areas of the public lands. Because of their low palatability and obstruction to grazing, the presence of these plants on the range causes heavy concentration of livestock on the more open grass areas, thereby causing over-grazing and depletion of forage species with consequent erosion. Because of their open woody nature, most intrusion plants are not an effective cover to conserve soil moisture and to retard erosion.

The problems connected with weed control on the public lands are difficult to solve because of the vast and scattered areas infested and numbers of species involved. Efforts on the part of the Bureau of Land Management to eradicate and control this infestation has been limited. It is estimated that 1,500,000 acres of public lands are infested with poisonous plants, 3,500,000 acres with noxious weeds, while there are 20,000,000 acres infested with instrusion plants. These infestations occur in varying degrees of intensity and combinations of composition. This presents a tremendous problem of eradication and control. Much can be done toward control by proper range management practices, but the problem of eradication is one that will require a great amount of effort and expense.

Since 1935, the Bureau of Land Management, and its predecessors, the former Grazing Service and the General Land Office have conducted weed eradication work on some 800,000 acres of public domain lands. Most of this was done by the Civilian Conservation Corps. Much of the value of this work can be considered as lost because of the lack of follow-up control.

Since the disbandment of the Civilian Conservation Corps, very little has been done towards the eradication of poisonous plants and noxious weeds on the public lands, except as it relates to particularly serious infestations. In fiscal year 1948, only 110 acres were treated by the Bureau of Land Management. Some control has been effected, however, by means of range management practices. Eradication of intrusion plants is proceeding very slowly when it is compared with the vast acreage involved. In fiscal year 1949, sagebrush was removed from only 36,000 acres of public lands. The eradication of these plants is usually carried out in conjunction with our range reseeding program, and in cooperation with the users of the range.

We hope to cooperate as fully as possible with local, State, and other Federal agencies in the mutual problem of weed control and eradication. The amount of work we can do to further this end will be dependent upon appropriations that will be made available. So far, we have been able to accomplish very little. It is hoped that weed conferences such as this will serve to point out the seriousness of the situation and that the influence of the conference will be far-reaching in furthering the program.

MR. BALCOM: The National Park Service of the Department of the Interior is represented here today by Mr. Bert H. Fraser from Estes Park. Mr. Fraser is District Ranger of the near-by beautiful Rocky Mountain National Park, -- Mr. Fraser.

MR. FRASER: Gentlemen: We are not here to tell you about weeds, we are here to learn.

Area of lands administered by the National Park Service in eleven western states.

The total area of public lands in the 11 western states administered by the National Park Service is 13,637,326 acres. They are also 456,342 acres of State or private lands within the boundaries of these Federal areas.

It may be of interest to note that 5,314,187 acres, nearly 40% of these public lands are classed as non-vegetated (either absolute desert, very high elevation, or water covered areas) where no weed problems exist. Another 45% is forest or woodland where weeds constitute little or no problem. It is the remaining 2,171,571 acres, or 15% which includes the grass-brush covered lands where weed problems may be important.

<u>Agency's definition of weeds</u>: The National Park Service definition of "weeds" is quite different from the commonly accepted definition of the word as used by most land managers. The Act of Congress which created this Service specified that it should conserve the scenery and natural objects for the benefit of future generations. The service construes this to mean the permanent conservation of all forms of native vegetation. All non-native or exotic plant species are, therefore, classed as weeds. No native plants are so classed unless poison oak can be so considered because an exception is made for control around public use areas to reduce the hazard to the public.

Estimate of acres infested with weeds: It would be very difficult to furnish an estimate of the acreage currently infested with weeds. In general, it may be said that the greater part of the area under National Park Service administration in the West is relatively weed free. However, there are some exceptions, and because of the Service's responsibility for conserving the native vegetation, even minor invasions of exotics are important. Most of our weed problem areas are adjacent to roads and other public use areas where spot infestations are found. Large areas of infestation are rare.

Kinds of troublesome weeds: The National Park Service is particularly concerned with those weed species which compete with or replace native plants such as common St. Johnswort (Klamath weed). Russian and Canadian thistle, cheatgrass, white and yellow sweet clover, Mexican whorled milkweed, Scotchbroom, puncture vine and cocklebur. Many others are also of local importance.

Problems and damages caused by weeds: The threat of weeds becoming established in the park areas, because of their aggressive habit of replacing native vegetation, is an important threat to the continued preservation of the scenic and recreational values of these areas which is a major national economic value.

Weed species, such as cheatgrass and Scotchbroom, when they cover extensive areas, greatly increase the fire hazard to adjacent native vegetation.

The Problem, insofar as it concerns national park areas, is seldom one in which these public lands harbor weeds which are a threat to adjacent agricultural or range lands. The reverse is the case.

Mention was made of poison oak as a weed. This pestiferous plant must be restricted near campground and other public use areas to reduce the hazard of people coming in contact with it.

Present control program: The National Park Service has not received funds specifically appropriated for weed control. However, the Service has, in a small way, accomplished considerable important control work through contributed time and funds. Employees maintain a close watch to prevent new invasions of exotics. There are some areas however, on which weeds occur in considerable numbers and funds for control are needed. Common St. Johnswort (Klamath weed), is a serious threat in several areas and control has been attempted on a small scale in Yosemite Valley, but much more extensive control there and in other areas is needed.

Mention might be made of one major, perhaps only related, project on which we and other forest conservation agencies are extensively engaged, altho it is not strictly a weed problem. This is the control of White Pine Blister Rust through the removal of currant and gooseberry plants which are adjacent to important white pine stands.

Active Control Program: The National Park Service definitely plans to continue its watchfulness to prevent new invasions of noxious weeds and hopes to obtain funds to control these infestations which are already present.

MR. BALCOM: The last speaker for the Department of Interior represented here will be Mr. John J. Maletic of Denver, Soils Scientist for the Bureau of Reclamation, Region 7, and also in charge of the Bureau's weed control program for his region. Mr. Maletic --

MR. MALETIC: I am very happy to be here this afternoon and present a brief insight from the Bureau of Reclamation program.

It will be noted that the number of acres of public lands under the jurisdiction of the Bureau of Reclamation is small in comparison with many of the other agencies. The land surrounding storage reservoirs constitutes the major portion of the area. In most cases these lands have secondary uses like grazing, forestry, recreation, or as wildlife refuges and therefore may be administered by other agencies in accordance with these uses.

However, the Bureau has cooperated with various Federal agencies in conducting weed control programs so far as funds and personnel were available. While no comprehensive survey of our lands have been made to determine the exact extent of noxious weed infestations, it is believed that the acreage is comparatively small. Perhaps the largest infestations of weed which may escape to cultivated areas consist of cocklebur and Canada thistle.

The most important plant problem from an operational standpoint on Bureau reservoirs is the control of salt cedar or tamarisk. These woody plants annually transpire huge quantities of potential irrigation water and are encroaching on land which should be used for more beneficial purposes.

A comprehensive program for the control of salt cedar is being planned in our two southwestern regions where the problem is most critical. Other local, state, and Federal organizations interested in better land use, flood control, or water conservation are aware of the salt cedar problem and have indicated their desire to aid in its solution. It will require the cooperation of all concerned to make the control program a success.

Our limited amount of test work on salt cedars is being performed under the soil and moisture conservation program which is administered by the Office of Land Utilization. Both ground-rig and aircraft applications of herbicides have been made. In most of the tests good results have been obtained with 2,4-D on young plants and both foliage and dormant sprays have given fair control of older trees. The best results have been observed where larger volume applications were made possible through the use of ground-operated equipment.

In addition to reservoir areas the Bureau of Reclamation maintains thousands of miles of distribution and drainage canal rights - of - way which in a sense may be considered as Federal lands but are not usually classed as public domain. The major portion of the Bureau's weed program is conducted on these rights - of - way. Here, noxious and other weeds may escape to infest farm lands and therefore must be controlled to eliminate this source of spread. Tall annual weeds, willows and other woody plants, and weedy grasses on the canal banks create numerous operational problems which are reflected in higher maintenance costs.

In addition to preventing proper inspection of the irrigation system, ditchbanks weeds catch floating debris resulting in a marked reduction of the carrying capacity of the canal. Waterweeds both emergent species like cattails and submersed species such as pondweeds, do even a more complete job of choking canals, often making it difficult to deliver sufficient irrigation water to project farmers. Besides these problems, weeds transpire large quantities of water and cause extra seepage, and evaporation -- a loss which is very important to some irrigation projects.

As has been discussed at other meetings of the Western Weed Conference, the Bureau is making a special study of the weed control problems on irrigation systems. The Bureau of Plant Industry, Soils and Agricultural Engineering is conducting research in cooperation with our Bureau for developing more permanent and economical methods of solving these problems. That Agency in turn cooperates with State Experiment Stations in this research program. The screening and the laboratory work is done in weed-control laboratories connected with our Chief Engineer's office here in Denver where both Bureau of Plant Industry and Bureau of Reclamation technicians are employed.

There is no doubt that much more research is needed, particularly for certain kinds of weeds. Perhaps the outstanding of these as far as our Bureau is concerned are cattails and weedy grasses. Research on these problems are underway and it is hoped that more efficient control methods will be forthcoming.

During 1949 the Bureau's weed control program on rights - of - way was the largest in its history. Much progress has been made through the use of 2,4-D for general weed and willow control, aromatic oils for grasses and canes, and aromatic solvents for submersed waterweeds. We are planning an even larger program of control for the 1950 season. Wherever possible reconnaissance surveys will be made on Federal lands to determine the existing weed problem and to aid in formulating a more effective control program.

More and better equipment has been purchased for weed control on canal and drain rights - of - way. Helicopters and airplanes will be used more widely for applying herbicides on areas inaccessible to ground equipment. More ditchbanks will be seeded to grasses to prevent further weed infestations and to replace weeds that have been eliminated through the use of herbicides. On new projects more consideration is being given to design and construction which will prevent weeds or facilitate their control.

The policy of the Bureau to cooperate with local, state and federal agencies will be continued. Also, we have been assured cooperation and assistance as we have enjoyed in the past for the development of even more permanent and economical methods of controlling weeds on irrigation systems.

MR. BALCOM: Our first speaker for the Department of Agriculture is Mr. C. Kenneth Pearce of Tucson, Arizona, Chief, Division of Range Management, for the Southwestern Forest and Range Experiment Station of the United States Forest Service. Mr. Pearce has been asked to tell you about the weed control research program of his Service, --Mr. Pearce.

MR. PEARCE: The Forest Service is charged with the responsibility, within the Department of Agriculture, for research on the management, improvement, and best use of native forage production on range lands. This responsibility is not confined to lands within the National Forests but includes lands in other ownerships, both public and private. In the eleven Western States our research is conducted at six regional Forest and Range Experiment Stations, each of which maintains several field centers in important forest and range types.

Our range research program includes studies for the development of economical and effective methods for control of plants that interfere with livestock grazing or are otherwise undesirable on range lands. These include: (1) poisonous plants, (2) plants of low forage value which replace good forage species, (3) plants with spines or thorns or dense brushy growth habits which cause mechanical injury, increase losses from disease or predators, snag wool, or complicate the handling or movement of livestock, and (4) plants which provide inadequate soil protection, or increase fire hazard. Studies of control of undesirable plants are closely related to studies of artificial reseeding to good forage plants. Often the reduction of competition from low value plants is prerequisite to reseeding, and conversely reseeding is often required to provide a protective cover on range lands after noxious plants have been removed.

With few exceptions, such as Halogeton and Klamath weed the important noxious range plants are native species. They constitute problems largely because they have greatly increased in abundance since the time of settlement and occupance of the range country by white men. We do not fully understand the disturbances to the established ecological balance which were responsible for increased in undesirable plants. The reduction in vigor and stand of good forage grasses, changes in the physical characteristics of the soils, increased seed dissemination by grazing animals, and reduction in the frequency and extent of range fires are doubtless important factors. Locally, unwise cultivation followed by abandonment has opened the site to mass invasion by a variety of aggressive undesirable species. But by and large, the changes involved are obviously less drastic and more subtle than those resulting from continued cultivation, since the weeds of cultivated lands are abundant only locally on range lands.

Much of the early research of the Forest Service in this field was directed at control of plants poisonous to livestock. It was found that small colonies of poisonous larkspur, death camas, and water hemlock on high mountain rangelands could be hand grubbed or sprayed with inorganic herbicides at costs that were economically justified, and many range units in Utah and other Western States were made more valuable by this practice.

Losses to woolgrowers, from Orange Sneezeweed, which amounted to more than $150,000 annually in Colorado alone have been reduced as the result of development of grazing management systems that would limit consumption of this poisonous plant. More recent tests show that control of this plant by use of 2,4-D is also feasible under some conditions.

Probably of far more significance than the poisonous plants, however, in reducing the productiveness of western range lands, are those species which are simply unpalatable or of low forage value and which occupy sites sometimes to the virtual exclusion of desirable species, thus reducing forage production by 50 percent or more. The bulk of the species now receiving attention from Forest Service research belong in this category. Many are woody plants that in general are not being investigated by other agencies.

Big sagebrush - a species which incidentally is closely related to sand sagebrush of the southern plains, but quite distinct as far as control methods are concerned -- covers some 90 million acres in the Intermountain West. Studies have shown that many sagebrush ranges can be greatly improved by planned burning and regulated grazing. Big sagebrush can be removed from other ranges mechanically, usually by disk plowing, and when followed by reseeding to desirable grasses the cost is liquidated in from 7 to 10 years by the value of increased forage alone. Tests of the possibilities of big sagebrush control by 2,4-D and other herbicides have been conducted in cooperation with several of the states. These tests, although promising, so far have been erratic and inconclusive.

Mesquite constitutes a serious problem on more than 60 million acres of range land in the Southwest. Excellent kills of the tree form of mesquite can be obtained by application of diesel oil or sodium arsenite to the base of the individual trees. These methods are economically justified and are in practical use under some conditions. The serious consequences of mesquite invasion and extensive areas of relatively low producing land involved, however, make the development of cheaper more easily applied mass methods particularly urgent. Empirical tests have not provided them. Accordingly, studies of the basic ecology and physiology of mesquite as a step toward development of control methods was begun about 2 years ago as an RMA project under the leadership of the Forest Service, and in cooperation with the University of Arizona. These studies have already provided some worthwhile practical information. These studies have shown that mesquite is susceptible to the hormone-type herbicides, but that limited absorption and movement within the plant of these materials when applied as a foliage spray has so far obstructed the development of practical mass control methods.

Before some of the more desirable range lands of the West can be restored to their full productivity, several species of juniper which have increased and invaded them will need to be controlled. Grubbing, and the application of sodium arsenite are effective methods. Burning or chopping is also effective on the non-sprouting species; but fully economical control must rest on development of methods that can be extensively applied over wide areas. So far the application of selective herbicides has been entirely ineffective and it appears that the hope for practical control of juniper in the immediate future lies in chaining, cabling, or other cheap mechanical methods. Cooperative studies with action agencies are underway to determine effectiveness and costs of methods so far developed and to increase their efficiency.

Other noxious range plants that have received the attention of Forest Service research workers in the West can be given only passing mention. Thus methods that can be used under limited conditions for control of burroweed and snakeweed have been developed in the Southwest. Promising leads are being obtained for control of cholla and pricklypear cactus. Cheatgrass can be reduced enough by seasonal burning or plowing to permit reseeding good perennial grass on many areas. Cheaper, more widely usable and more reliable methods are needed for control of these plants and some research is continuing on all of them. Greatly intensified study of control methods for the host of shrubby species represented by the "California chaparral" is now possible as the result of a newly initiated RMA-Forest Service project at the University of California and California Division of Forestry.

Although the foregoing review indicates that the Forest Service has been studying methods of control of many species of noxious range plants, it should be noted that most of this work has been only exploratory in nature. Practical, effective, and economical methods of control have been devised in some cases, and these have served as a basis for action programs. Even so, more efficient means are desired, and for many species application of known methods can be economically justified only in very limited situations.

The present research program approaches adequacy only in the case of one form of mesquite in Arizona. This has been accomplished by narrowly limiting the field of this research and passing over other species for which control information is sorely needed. Methods for control of several species of Juniper are urgently needed. Many species are receiving inadequate research attention and some important species including blackbrush, creosotebush and tarbush are now being investigated. From the work that has been done, it appears that each species of noxious range plant may present a distinct control problem, and that development of a good method for one species may be quite meaningless for control of a closely related species. Also a method that is fully satisfactory under one set of conditions may be physically, biologically or economically unsuitable in another situation.

As experience in noxious plant control on range lands accummulates, it becomes increasingly clear that there is no easy or simple method for dealing with most species. Two distinct problems are invariably involved. First, how to reduce or control the existing stands, and secondly, how to prevent reinvasion of controlled areas and further spread into areas not yet occupied. Initial efforts in research aimed at control might well be more or less empirical trials of promising herbicides applied at different seasons and by different methods. If these do not show promise some fundamental studies of the life processes and growth requirements, as related to control methods, may be necessary. Basic studies aimed at understanding the ecology of the plant or how it grows and reproduces under various environmental conditions may be required to clarify why it has become a problem and help prevent further spread. A knowledge of how the plant lives may provide the key to discovering how it can best be killed. For example, better understanding of the physiological processes of absorption and translocation of materials within the plant will provide a sounder base for the use of herbicides.

Marked improvements have been made in mechanical eradication equipment during the past few years and mechanical methods will doubtless continue to have an important, perhaps an increasingly important, place in many noxious plant control programs on range land. Since research funds cannot be adequate for purchase and operation of heavy equipment used, cooperative investigations with action agencies are desirable. Research technicians, based on their knowledge of plants and soils, can often suggest improvements in heavy equipment and its use, and provide an unbiased evaluation of results as the mechanical methods develop. When the need for special equipment for shrub control is clearly defined, help in its development can be obtained from skilled equipment engineers in the Forest Service. It was in this way that the brush-land plow for removal of big sagebrush without excessive equipment breakage even on rocky lands was developed.

The need to step up research leading to the early development of economical, effective methods for control of undesirable plants on extensive areas of range land is clearly recognized by the Forest Service. Progressive stockmen and many state and federal land administering agencies are awake to the far-reaching implications of noxious plant increase and invasion and are pressing for answers from research. In some cases methods that are admittedly unsatisfactory, even as stop-gap measures, and that are much too expensive are being used. To meet the urgent need for knowledge the best efforts of all who are in a position to help will be needed to develop a coordinated comprehensive research program for the West.

MR. BALCOM: The Forest Service's actual program of weed control on range lands will be presented by Mr. Herbert E. Schwan from this beautiful convention city. Mr. Schwan is Range Conservationist of the Division of Range Management, Region 2 - - Mr. Schwan:

MR. SCHWAN: Along the research program, I would like to discuss briefly some of the problems. In the National Forests there are about 200 million acres of which 180 million acres are under Federal ownership. We have some of the roughest country in God's out-of doors. The forests are managed on the basis of multiple uses - that is, when you have five major land users, we try to integrate those. Here in this region we have about 100 million acres.

In order to consider the problem of control of certain plants on National Forests, a breakdown can be made according to two of the major land uses - forest management and range management. In forest management, or the growing of trees, the following five categories of plant control cover most of the problems:

1. The control of weeds at forest tree nurseries.

2. The control of ribes (gooseberries and currants) for control of blister rust in white pine areas.

3. Control of brush in connection with tree planting in the field.

4. Control of weed tree species or undesirable individuals to improve the forest stand.

5. Control of vegetation on firebreaks.

On range lands, the following are the main problems:

1. Control of plants poisonous to range livestock.

2. Control of plats that lower the value of the range.

3. Control of undesirable plants prior to range seeding.

4. Control of noxious farm weeds which occur on National Forest ranges.

For convenience, these nine categories might be considered in three groups. The first group includes control of weeds in nurseries and the control of farm weeds. In these cases the problems are quite similar to those encountered by the agriculturist faced with weed control on crop lands. There is little question concerning the need for, and desirability of, control. Methods developed for crop lands may be modified for the particular problems. Of course, where farm weeds like whiteweed, cockleburs, or Canada thistle become established on National Forests, control problems frequently are complicated by vast areas of land, rugged topography and poor transportation facilities. Fortunately, infestations and the need for control are comparatively local.

In the second group I would place those rampant, introduced pests which may be very widespread and where the desirability of control is generally obvious. Included in this group are such things as Klamath weed, cheatgrass, and poison hemlock, and indirectly, the ribes, gooseberries and currants, which are the alternate hosts of the introduced

White Pine blister rust. Cheatgrass has several valuable attributes, but under National Forest conditions it often becomes a serious fire hazard and it would be desirable to have some cheap and practical means of controlling it over wide areas. The need for control in any one given locality would thus require careful study.

In the third and last group are native plants, part of the local flora, which may become undesirable from certain viewpoints and under certain conditions. In practically every case it is absolutely necessary to consider their present and future values as well as their undesirable attributes. Some examples are scrub timber, brush and defective trees which may take up space and interfere with timber production, but which also may have high values for wildlife food or shelter. A good example here in the west is big sagebrush. The foothill sagebrush lands have suffered severe depletion because of past abuse. Seeding has proved successful and a number of practical ways to eradicate sagebrush on a large scale have been developed. But sagebrush is one of the most important winter foods for deer on critical winter concentration areas throughout the west. Widespread and irresponsible sagebrush eradication, even locally, can have immediate disastrous effects on wildlife. On the other hand, carefully considered sagebrush eradication and seeding in valleys might ease livestock competition in the foothills and help the deer. Those plants which are undesirable when land is managed for a single use, may have high values under multiple use.

Some of these native plants may develop unforseen or unconsidered values. For instance alpine fir may come in following spruce logging in Colorado. At various times the control of non-merchantable alpine fir has been considered. The prevailing viewpoint now is that this tree has high values for watershed protection and eradication is undesirable. Many other examples could be cited. Western hemlock is another example. It was considered a weed tree 20 years ago, but has developed considerable value. Cost can sometimes be reduced by avoiding rather than controlling undesirable plants. Tree planting or grass seeding immediately following a fire may avoid competing vegetation. Similarly shifting from cattle to sheep grazing may reduce or eliminate losses from larkspur areas.

The poisonous range plants become problems only locally. For instance, a patch of lupine, where sheep are unloaded after a long rail haul, may cause disastrous losses. On the range, lupine is found on millions of acres and is a valuable livestock and wildlife forage plant, and is important in the cover. Losses are rare and control is very rarely considered. In fact, the reported livestock losses on all the National Forests from all poisonous plants in 1948 were only about 1/4 of 1% when permitted livestock and their offspring are considered. Losses may be severe locally where poisonous plants occur in local concentrations. Sneezeweed is a problem over wider areas, but it has been shown that loss can be materially reduced through good management, and no economically satisfactory and selective means of control has been developed.

No eradication of range plants should be undertaken unless the establishment of a satisfactory replacement cover is fully assured. This is necessary because of the absolute necessity for a good cover on steep watersheds.

Many of the plant problems on National Forests are caused by some type of land use or land management. In the vast majority of cases natural control is desirable. This can only be brought about by changing the form of use or management to encourage natural replacement. Where artificial control is used, it is generally costly and is usually a temporary palliative which may not bring about lasting results. For example, where excessive grazing has reduced valuable forage plants and has brought in undesirable ones, the first consideration is to change the use so as to reverse this trend. If this is impracticable and if it is considered desirable to eradicate the weed plants and reseed, it is still necessary to adjust the use so as to assume some permanence to the control and seeding.

We in National Forest administration depend on Research to tell us how weed problems may be avoided through proper land use, as well as how we can best control weedy vegetation in those places where artificial control is necessary. Control methods, of course, vary with the particular problems and include the use of chemicals, fire, oils, mechanical means as bulldozing, cutting, girdling, disking, biological control as use of insect enemies, and such hand methods as grubbing and pulling. The administrative man must decide if control is justified, the methods to use, and must then organize the ways and means of accomplishing it. Most of our native plant problems have developed through some form of land use; our first consideration then is to adjust that use so ecological control may be achieved.

To summarize, the administrative man has three types of weed problems.

1. The farm weed or nursery weed problem, where the necessity for control is not questioned.

2. The introduced weeds which are rampant and become widespread pests and where control is generally desirable wherever they are important and where practical methods are available; and

3. The native plants which become undesirable under some conditions and in some localities.

With respect to the last group he must carefully weigh their present and future values against their detrimental qualities. If he finds it necessary to control them, he must determine the cause for their increase. He must then decide if it is best to adjust land use and allow nature to do the controlling or if artificial control is fully justified. If the latter is indicated, he must consider the means and methods of accomplishing it. He must also assure himself that detrimental results of control are not excessive, that control will have some degree of permanence, and that a good cover is assured.

MR. BALCOM: The speaker for the Soil Conservation Service of the Department of Agriculture will be Mr. Edward G. Grest of Washington, D. C., who is Chief of that Service's Land Management Division, -- Mr. Grest:

MR. GREST: Ladies and Gentlemen of the Western Weed Conference --

Weed Control on Lands Administered by Soil Conservation Service --

Just as a reminder, let us mention that the Soil Conservation Service administers only 4,080,000 acres of land in the 11 Western States. More than 90% of that acreage is in the four Eastern of the 11 states and the remainder, or around 300,000 acres is in the State of Idaho, Oregon, Utah, California and Arizona in descending order. These lands are used almost exclusively for grazing purposes.

Our definition of a weed is about as follows: "A weed is any plant which is detrimental to the planned use of the land."

Since the planned use of the land we administer in the 11 Western states is grazing, any plant detrimental to satisfactory forage production and grazing use is considered a weed.

Based on this definition our field people estimate that there are between 800,000 and 900,000 acres that have herbaceous or woody weed plants in sufficient numbers or density to be considered as infested with weeds. If and when these weeds are supplanted by desirable grasses, this acreage will be more productive and, in most cases more fully protected from soil erosion.

Naturally, most of the weeds we find troublesome are those considered as range weeds, However, we do have some farm weeds on formerly cultivated land which has not as yet been restored to grass. In many cases these farm weeds are beneficial in providing cover for the land, thus reducing wind erosion hazards until such time as we can restore the land to grass.

Sagebrush is our biggest problem, comprising more than one-half of the weed-infested acreage. Cactus is next most prevalent being present on 104,000 acres. Wild sunflower and other farm weeds comprise nearly 100,000 acres. Snakeweed, rabbitbrush, and yucca are pests on about 40,000 acres each. Cheatgrass which undermany circumstances certainly must be classified as a weed, is still present on some of our areas; the acreage reported is around 30,000 but I believe this estimate is low. Many others are present, but the acreage and prevalence is minor.

The chief disadvantage of weeds on our land is the fact that most of them prevent or reduce the production of forage for livestock. Also, many of them furnish less protection to the soil from wind and water erosion than would a grass cover.

The farm weeds which infest some of the former croplands not yet restored to grass are, to a minor extent, sources of weed infestation for adjacent farm land. They also at times contribute to grasshopper damages. The farm weed problem on these former croplands is rapidly being eliminated by the restoration of these fields to grass by our grass seeding program, which is now progressing at the rate of about 30,000 acres a year in the 11 Western states.

Although poisonous weeds are present on many of our areas, they do not constitute a problem of significance and have not caused appreciable stock losses.

Cheatgrass has been considered a distinct fire hazard in the past but this hazard is becoming of less significance with major reduction in the acreage of this weed, which has resulted from improved management.

Our present weed eradication program largely consists of reseeding to grass the 100,000 acres of former cultivated fields, thus eliminating the farm type weeds and providing a more permanent and desirable cover for the land, much of which is subject to wind erosion. We are also doing some work, and hope to do much more, in eradicating sagebrush, rabbitbrush, and other woody plants from acreages adapted to grass and where there is a great need for increased forage for grazing by locally owner stock.

To establish grass on formerly cultivated land, no more work is done than is necessary to obtain a seed bed and reduce weed competition. After a stand is established, grazing is regulated so as to encourage grass development by permitting the grass plants to become and remain vigorous. In this way any remaining farm weeds are generally crowded out by the grass in a few years.

The eradication of sagebrush, rabbitbrush and other woody plants, presents a much more serious and costly problem. Burning, railing, plowing, and spraying with herbicides have all been used. The acreage covered has been negligible in comparison to the total acreage of infestation and the results have not been entirely satisfactory. In the first place, the initial cost of most of the methods is high in proportion to the value of the land and the resulting increase in grazing capacity. Also, the kill has not been satisfactory in all cases, thus requiring additional treatment, raising the cost still more. Re-infestation is quite common, introducing still another factor which must be dealt with.

We believe that the 170,000 acres of farm weeds, cheatgrass, and snakeweed, can be practically eliminated or kept under control on our ranges by proper range management. Proper management will also prevent or retard the invasion of many of the woody species, particularly if accompanied by spot eradication of new invaders. It is our first recommendation, therefore, that more emphasis be placed on proper range management as a means of controlling, eliminating, and preventing invasion of weeds in the grass-lands of the Western states. Under most conditions we have found it to be the cheapest and most satisfactory method available.

On the 660,000 acres infested with sagebrush, cactus, rabbitbrush and yucca, the Soil Conservation Service expects to continue eradication work on a small scale, using those methods that promise results at a reasonable cost. We feel that cheaper and more effective methods of eradicating such plants are urgently needed and recommended that research on this problem be intensified.

MR. BALCOM: Besides the Departments of the Interior and Agriculture, we have representatives of two other Departments which also have weed problems - the Departments of Army and of the Navy. I would like to introduce first, Mr. Walter V. Kell of Washington, D. C., Agronomist from the Office, Chief of Engineers, Department of Army -- Mr. Kell.

MR. KELL: My only responsibility, the chairman told me, was to say "hello" to all of you people..

MR. BALCOM: The speaker for the Department of the Army will be Mr. William E. Shatwell, Chief of the Ground Section Repairs and Utilities, of the Fifth Army, Headquarters in Chicago -- Mr. Shatwell:

MR. SHATWELL: Everyone seems to have their own definition of a weed here today and I am no different. We of the Fifth Army have our own definition of a weed which goes something like this -- Weeds are pestiferous plants and from the veiwpoint of maintaining military installation, all vegetative growth is considered pestiferous when found in areas where vegetation must be eradicated to maintain adequate fire guards, such as, around powder magazines or in areas where vegetation must be eradicated to reduce maintenance as on railroad ballast areas. Therefore, rather than to specifically state weed control, our problems evolve around vegative control and may be categorized as follows:

(1) Elimination of all vegetation to provide complete and positive fire breaks adjacent ammunition or critical materials storage areas, and to provide vegetative free areas where use requires, such as, railroad ballast areas, parking and open storage areas, etc.

(2) Elimination of undesirable vegetation in improved grounds or lawn areas, in drainage ways, training areas, rifle ranges, etc. - weed and brush control.

(3) Elimination of vegetation for compliance with Federal and State weed control laws - noxious weeds.

(4) Control of vegetation, where eradication would result in soil erosion, to minimize the potential vegetative fire hazards.

For conference purposes the following comments will be based mainly on those plants generally known as weeds.

<u>Estimate of Acres Infested with Weeds</u>: Actual data covering the acreage infested with weeds in the Fifth Army area is not available. However, using a typical storage installation, such as Pueblo Ordinance Depot where approximately 10% of the total acreage is infested with Russian thistle, as a basis for estimating, there would be approximately 64,000 acres in the 5th Army area infested with weeds. Generally speaking, infestations are not of a critical nature and gradually, with the aid of growth regulating chemicals, control is being accomplished.

Kinds of Troublesome Weeds: From the extent of estimated acreage infested with weeds in the 5th Army, it is evident that troublesome weeds native of given areas will be found. From the standpoint of military operations, the most troublesome weeds in the arid areas are:

Russian thistle - *Salsola pestifer*

Downy brome - *Bromus tectorum*

Lamb's Quarter - *Chenopodium Album*

Hoary Cress or Perennial Peppergrass - *Lepidium draba*

Field Bindweed - *Convolvulus arvensis*

all of the above weeds require control on military lands whether such lands are available for grazing (range) or cropping (farms) purposes or whether used solely for military purposes, such as, training areas, ammunition storage and manufacturing areas, etc. Of those lands used for ammunition storage, Russian thistle and Downy brome are considered the most troublesome.

Aside from effecting control of weeds to prevent infestation to lands adjacent to military reservations, vegetation must be controlled to minimize potential vegetative fire hazards.

At present the 5th Army vegetation control program is planned annually for all installations and consists of chemical control or soil sterilization where such control is economically feasible, control by mechanical methods such as mowing and hand eradication. In an effort to minimize expenditures of maintenance funds for vegetative control, every effort is being made to accomplish such control by grazing, either, by lease or by maintenance agreement where military activity will permit.

Russian thistle, Downy brome and noxious weeds are being controlled, insofar as available funds will permit, by one of the above methods.

Control of these weeds is considered of vital importance for the following reasons:

1. To eliminate vegetative fire hazards.

2. To prevent the spread of undesirable vegetation to adjacent properties.

3. To conform to recommendations of the U.S.D.A. Soil Conservation Service and manage public lands in conformance to standards recommended by U.S.D.A. for all lands.

At this time it is estimated that weeds are being controlled on approximately 50% of the total infested areas and each year acreage upon which weeds are being controlled is increasing.

Successful methods of Control:

1. Mechanical methods of control have been successful and will continue to be used though chemical control is being substituted for mechanical methods when this use will result in reduced maintenance costs.

2. The advent of 2, 4-D in its various formulations has resulted in tremendous gains in the war on weeds at military installations. For example, tumbleweed

or Russian thistle is now controlled in the early stages of growth by the application of an isopropyl ester of 2, 4-D. The salt formulations do not appear as effective on this plant. Generally speaking, 2, 4-D is fast becoming an essential item in the list of materials required for grounds maintenace at military installations.

3. Soil sterilants such as borax and borax chlorate compounds have been successfully used to establish vegetation control on railroads and on areas adjacent powder magazines. Borax, without the addition of chlorate, has not proven to be a complete soil sterilant and does not affect or tends to stimulate plants such as tumbleweed, quack grass and milkweed. Therefore, its use has not been satisfactory in areas where control of these plants is of major importance. Borax has been successfully used in humid areas and has resulted in improved maintenance standards that could not have been attained by hand mowing with the limited personnel available.

4. In areas where eradication of weedy vegetation is not desired because of the fact permanent grasses are weak and a kill of weeds would result in erosion problems and in areas where vegetation must be controlled but mechanical methods cannot be employed, excellent results have been obtained by chemical mowing with dinitro-ortho-secondary-butylphenol. This material is not selective but effects a top kill of vegetation and regrowth occurs though retarded from roots.

The repairs and utilities branch of the 5th Army Engineer Section is fundamentally a maintenance organization. However, because of the fact weed control problems arise that are peculiar to military installations and answers have not been readily available from research agencies, such as the problem of tumbleweed previously mentioned, experimental plots are established at installations where these problems exist. Currently, TCA, 2,4,5-T and borax chlorate compounds are in process of testing as follows:

1. 2,4,5-T data is now available thru research agencies and comparable results have been obtained through tests at military installations so that limited recommendations for its use can now be made.

2. Borax chlorate compounds proved exceptionally promising for one year soil sterilization purposes, and, where economically feasible, recommendations for this material can be made.

3. TCA is being tested at several installations, both as a soil sterilant and as a growth regulator. As a soil sterilant it appears at this time that the material will temporarily effect soil sterilization and will eradicate dense infestations of undesirable vegetation such as quack grass and Johnson grass, though available information is not adequate to warrant concrete recommendations. As a growth regulator, it also shows considerable promise but further tests must be made, or definite information obtained from research agencies, before wide scale use can be recommended.

In 1945 because of premature publicity by commercial concerns, the discovery of selective plant hormones was publicized by the United States Department of Agriculture. At that time, available information was not adequate to support the cure-all claims of commercial concerns for the new weed control chemicals and Department of Agriculture releases were justifiably cautious. Original advertising claims are still unsubstantiated. However, since 1945, the introduction of various chemical formulations of 2,4-D and other selective type herbicidal chemicals has lead to a highly specialized field of weed control. We have learned that these weed killing chemicals are not cure-alls but are a valuable aid to our maintenance problems of controlling and/or eradicating vegetative growth. Obviously, in a development this rapid, there have been many failures. In general, failures can be attributed to two basic reasons:

1. Inadequate basic information, pertinent to the use of chemicals, and

2. Inadequate equipment.

Inadequate basic information pertinent to the use of chemicals which lead to improper dosages and to failure to use herbicides at times when reaction would be most effective, is perhaps the major factor in unsuccessful use of weed control chemicals. This factor will be eliminated as results of successful experimentations are made available to individual operators.

In 1945 equipment used for the application of 2,4-D consisted of equipment previously on hand for applying insecticides and fungicides. Generally speaking, this equipment operated at high pressures, normally 100 lbs. or more, and at large volumes, 100-200 gallons per acre was required to obtain coverage, automatically limiting the efficient use of the chemical. It was a known fact that a very small quantity of the chemical was essential to effect desired vegetation control. This lead to the development of low pressure, law gallonage equipment, and today, satisfactory results have been obtained by airplane spraying with as little as 3 quarters per acre and grounds equipment has operated successfully at five gallons per acre. Obviously, effective coverage at such gallonages requires skilled operators which normally are not available at military installations. However, with unskilled men and by using improved type nozzles, effective spraying can be accomplished at 8 to 10 gallons per acre.

In order to minimize reasons for failure indicated above, it will be essential to establish a strong liason between research agencies and actual operators. Research men too often gain information without making it available, or, if made available, use a vocabulary and phraseology that is so highly technical the actual operator cannot comprehend. Sectional Weed Control conferences such as this conference have been held for the last three to twelve years and their programs have normally been so highly technical the actual value of research gained has been dwarfed to those in the field responsible for successful large scale application. At military installations coordination between research and actual field work is the responsibility of the Army Agronomist, but there are many types of operators having no liaison between research and field. Panel discussions such as this is sectionalized weed conferences is a most important step toward the dissemination of necessary information gained by the various research agencies and subsequently more successful vegetative control by chemical application will result.

The Department of the Navy has as its speaker on our panel Mr. W. D. Ellison, Soil Conservationist for the Bureau of Yards and Docks, Washington, D.C., -- Mr. Ellison:

MR. ELLISON: Ladies and Gentlemen: I came out here primarily to listen. I have a paper but I am not going to read it. I am just going to take two or three minutes to tell you about a couple of our problems.

Navy's participation in this conference is primarily for the purpose of learning about weed control. We do not intend to make a contribution to the technical literature. Navy lands in the 11 Western States participating in this conference, include 1.5 million acres that are owned, and some additional acreage that is used under permit or lease. These accommodate various activities such as airfields, radio stations, storage depots, and other.

The Bureau of Yards and Docks is the Department's technical agency on land problems. All of us of the Bureau are interested in keeping informed on important land problems, and in keeping the Department's various activities alerted to them.

We hope to obtain at this conference, answers to some of our troublesome problems. A brief summary of some of these problems in vegetative control includes seven items.

Before summarizing these, it should be mentioned that this is not a complete list, nor are the problems necessarily listed in the order of their importance.

(1) Some weed growths develop fire hazards; particularly during certain seasons of the year. In some instances these must be replaced with growths less hazardous, while in others all vegetal growths are to be permanently eliminated.

(2) Tall growing vines which climb antennae, obscure signal lights, and interfere with other operations must either be eliminated and replaced with low growing vegetations, or controlled in height.

(3) In one area we have the special problem of eliminating present, and controlling future growth of climax timber that reaches heights of more than 300 ft., on steep mountainsides comprising approximately 1500 acres. As this growth is eliminated, it must be replaced with vegetation which does not exceed about 10 feet. Even after the present trees are removed, the area will be infested with seed of these taller growing species, and there will be some seed spread from perimeter trees over most of the problem area. Much of this land is too steep to walk over, while carrying any hand tool that is heavier or more cumbersome than an ax. It would certainly simplify the problem to have selective sprays that would keep out tall growing trees, while permitting low-growing shrubs to survive.

(4) Since many of the annual weeds come and go throughout the year, they sometimes leave highly erodible soils exposed on very hazardous slopes. Control of this weed competition, to permit establishing more permanent types of vegetation is often desirable and even necessary for controlling soil erosion.

(5) To prevent some lands from becoming a source for seed of noxious and poisonous weeds is a problem with Navy, just as with other governmental agencies. Concerning this problem, we are interested in survey techniques, as well as procedures and programs which may make it possible to attack this problem on a broad basis.

(6) The usual problems of eliminating weeds from lawns and other turf areas are important to Navy.

(7) Navy's weed control jobs along roadways, fence lines, and ditch banks are similar to problems of other agencies.

In summary, Navy's weed problems, include (a) complete eradication of weed growths; (b) selective eradication; (c) control of infestation; and, (d) a great amount of work on height control. We face the usual problems of budget limitations, and to help us in placing first things first, we desire more information on the western weed problems.

The problems outlined above are small in terms of the whole problem of weed control. However, some of them are of outstanding importance to certain of Navy's operations. The Bureau of Yards and Docks does not have a research program in weed control work but looks to the agricultural agencies for information concerning methods of control.

The weed work now in progress on Navy lands is mostly limited to meeting the operational needs of the separate activities, and to clean-up work that is needed for improved grounds appearance. However, on two tracts of land now held in reserve under out-lease, the operators are required to bring noxious weeds under control and this provision is made a part of the lease under which Navy makes these lands available to private operators.

We have recognized that the cost of this weed control and in some of our leases for grazing where the land is infested with noxious weeds - we have made a reduction in levy in order that they might do some weed control work.

The Navy is deeply interested in the work of this conference and we appreciate the invitation for coming and we are looking forward to some general information coming out of this conference which will help in establishing a weed control policy.

Thank you.

MR. BALCOM: Many of you are connected with or near irrigation projects and we know that a large acreage of those projects are planted each year to beets. I just received information that we have a man with us today who can give us some information on rangeweeds as hosts of beetleaf hopper. This is extemporaneous and wasn't part of the program but if Mr. J. R. Douglas of the Bureau of Entomology would give us just a word or two about that subject, we would appreciate it very much.

MR. DOUGLAS: Ladies and Gentlemen: I realize it is getting late and getting later. A short time ago I prepared a brief regarding the problems of Land Use in Relation to the Beetleaf Hopper in Souther Idaho. 1/

The primary purpose of this paper is to emphasize at this time the importance of proper land use in comating the beet leafhopper (Circulifer tenellus (Bak.)) in southern Idaho. This subject was presented effectively by Piemeisel and Chamberlin 2/ in 1936. These authors stressed that this method "is based essentially on the idea that the proper use of lands now intermittently farmed or destructively grazed will hasten the natural replacement of the weed hosts by nonhosts, a process that takes place to a limited extent on these weedy areas even under present conditions. The problem is similar in all of the States west of the Rocky Mountains, hence the essentials of the control may be applied throughout these States." Extensive observations since 1936 have corroborated the principles advanced by the authors of the above-named bulletin.

The beet leafhopper, commonly referred to in the West as the "whitefly" is a tiny insect slightly more than one-eighth of an inch long and varying in color from gray to greenish yellow. It is a sunloving, dry-climate, insect whose distribution in North America is confined generally to the arid and semi-arid regions of the western United States and northern Mexico, where it is found breeding on many species of introduced weeds now generally established on nonagricultural and deteriorated range lands.

This insect feeds by sucking juices from its host plants and rarely becomes sufficiently numerous to cause any great direct damage by its feeding activities. It is, however, the carrier of the virus of curly top disease, one of the most destructive of all virus diseases affecting sugar beets, beans, tomatoes, spinach, Swiss chard, various species of the melon family, many ornamental flowering plants, and a large number of weeds. The virus of curly top survives the winter in both the beet leafhopper and its winter host plants. It is transmitted by the leafhopper from its host plants to other weed hosts and cultivated susceptible crops during the spring movement. Some of these crops in their seedling stage are very susceptible to the curly top disease and infected plants often die. The percentage of the spring-generation leafhoppers carrying the virus of curly top has varied appreciably from year to year, with a low of 4 percent in one year to a high of 73 percent in another.

1/ In cooperation with the Idaho Agricultural Experiment Station.

2/ Piemeisel, R. L., and J. C. Chamberlin. Land-improvement measures in relation to a possible control of the beet leafhopper and curly top. U. S. Dept. Agr. Cir. 416, 24pp., illus. 1936.

Young plants are usually more susceptible to injury by curly top than are older, well grown plants. In southern Idaho, the magnitude and time of the spring movement of the leafhopper from its wild host plant breeding areas into susceptible crops are important factors, therefore, in determining the extent of curly top epidemics, since in some years the spring movement coincides with the susceptible stage of beets and in other years with beans, which accounts for the sporadic injury to these crops.

In areas where curly top occurs as an epidemic, it has been the most destructive of all bean, beet, and tomato diseases. The development of varieties of sugar beets which are resistant to curly top has lessened the losses to this crop. There are no commercial varieties of tomatoes that are resistant to curly top, and practically a complete loss of this crop occurs in home gardens in southern Idaho during years of drastic curly top exposure. Most varieties of garden or snap beans are susceptible to curly top. The popular varieties of snap beans are the most susceptible. Southern Idaho produces approximately 80 percent of the national requirement of garden seed beans, since it is the last frontier where seed beans free from bacterial blight and other seed-borne diseases can be successfully grown.

Curly top not only causes large periodic losses to the sugar beet, bean, and tomato industries but actually limits very markedly the areas in which these and other susceptible crops can be successfully grown. The limitation is so severe that the growing of crops susceptible to curly top is rendered commercially impossible in many sections otherwise suitable.

In southern Idaho the beet leafhopper passes the winter in the adult stage. Females are fertilized in the fall and live until spring, but males die during the winter. Egg laying normally begins in March, and adults of the first, or spring, generation appear in May or June. This generation is produced on spring weed hosts, chiefly mustards. Under favorable conditions, the seeds of these weeds germinate in the fall, but occasionally additional germination occurs in the spring. The fall-germinated plants develop small rosettes of leaves, remain alive throughout the winter, and complete their growth the following spring. They mature and dry about the time the spring-generation leafhopper reaches the adult, or winged, stage, and when weather conditions are favorable for flight, the leafhoppers move to their summer hosts, the progress of which coincides with the maturation of the insect. They travel with the wind and infest practically all the host plants in their path. It is during this spring movement that cultivated crops are infested. The leafhoppers moving into the cultivated areas alight first in the fields nearest the spring breeding grounds and gradually move farther into the cultivated lands; consequently, beets, beans, tomatoes, and other susceptible crops situated nearest the breeding grounds are more heavily infested than those farther away and are, therefore, more seriously affected with the curly top disease transmitted by the leafhopper. Of the cultivated plants, beets are the only important breeding host. During the spring movement, this leafhopper will feed on beans, tomatoes, and other crops but will not reproduce on these plants.

Since the beet leafhopper does not hibernate during the winter but must feed when temperature permits activity, it requires a sequence of host plants. The principal plants on which this leafhopper over-winters and produces a spring generation in southern Idaho are several species of wild mustards, the most important being flixweed (Descurainia sophia (L.) Webb), green tansymustard (D. pinnata spp. filipes (A. Gray) Detling), perfoliate peppergrass (Lepidium perfoliatum L.), and tumblemustard (Sisymbrium altissimum L.). The summer weed hosts are Russian thistle (Salsola kali var. tenuifolia Tausch), smotherweed (Bassia hyssopifolia (Pall.) Kuntze), and the recently introduced halogeton (Halogeton glomeratus (Bieb.) C. A. Mey).

With the maturing and drying of the summer hosts in the early fall, the leafhoppers move to their winter hosts. If Russian-thistle and smotherweed dry before the winter hosts germinate, the leafhoppers may be forced to feed on sagebrush (Artemisia tridentata

Nutt.), rabbitbrush (Chrysothamnus spp.), or on almost any plant that is green at this time of the year until the winter hosts germinate. Of the important spring and summer weed hosts listed above, only green tansymustard, or sage mustard, is a native of the United States. The others are introduced plants that have become established on abandoned, waste, and deteriorated range lands. The misuse of the land by man created conditions favorable for the establishment of weeds over large areas, which became breeding grounds for the insect and reservoirs for the virus.

During World War I, the demand for agricultural products increased, prices soared, and sagebrush lands were cleared with a surge and scope unparalleled in history. Destruction of native vegetation occurred over large acreages in southern Idaho of both dry and irrigated farms. Prices of farm products declined, and dry seasons followed the signing of the Armistice. Low prices and successive crop failures, which were caused by a water shortage on the Salmon tract, on the Oakley project, and on the dry-farmed lands northwest of Minidoka and elsewhere resulted in the abandonment of large acreages. This abandonment of large acreages of cultivated lands, alien weeds became established on these lands. The establishment of mustards and Russian-thistle on such large acreages created conditions that were very favorable for the development of this leafhopper. During the spring movement millions of these insects were carried by the wind to sugar beet fields, and the curly top disease carried by them reduced the yields below a profitable crop. The sugar factory at Nampa, Idaho, was dismantled and moved to another place, only to be dismantled and moved again when it was found that the new area was subject to invasion by the insect.

The development of varieties of sugar beets resistant to curly top has made it profitable to grow beets again in areas of the western part of the United States that are affected by the beet leafhopper. However, even these resistant varieties are susceptible to curly top during the early stages of their growth. When a large spring movement of beet leafhoppers has coincided with the seedling stage of the plant, serious losses from curly top have occurred in Idaho and other states. For example, in 1941 a serious curly top epidemic occurred in southern Idaho, and the average yield of sugar beets in the affected areas, which included Castleford, Cedar, Gooding, Jerome, Richfield, Shoshone and Wendell, was reduced to 8.98 tons per acre, as compared with the 15 year average of 16.60 tons per acre for the Twin Falls district, comprising an estimated loss of 7.62 tons per acre.

Range fires on the Snake River plains in southern Idaho and eastern Oregon destroy nonhost plants of the beet leafhopper on thousands of acres of grazing lands each season. The Bureau of Land Management reported over 1,200,000 acres of range lands burned over in southern Idaho in 1941, practically all of which were on the Snake River plains. Observations of the writer indicte that range fires generally have their origin where downy chess (Bromus tectorum L.), an introduced annual grass, forms the plant cover or has entered deteriorated sagebrush areas to such an extent that it will carry fires. When downy chess matures and dries in the early summer, it becomes highly inflammable. During the fire season, it is the greatest range-fire hazard in the Intermountain Region, as it will burn like tinder. If this annual grass is burned under favorable conditions, it may reseed itself and again form the cover, but under unfavorable conditions, such as wind erosion and trampling by livestock, mustards (principally tumblemustard) and Russian-thistle may appear. The process from mustards and Russian-thistle to downy chess and then back to these weeds may continue in an endless cycle.

The successive weedy plant covers on abandoned fields in southern Idaho are as follows: First, Russian-thistle; second, mustards, either flixweed or tumblemustard; and third, downy chess. On burned-sagebrush areas, tumblemustard is generally first and then downy chess, but with disturbance either Russian-thistle appears or the ground may become bare. Sometimes the beet leafhopper goes from mustards to downy chess. Mixed stands of Russian-thistle and mustards are the most important combinations of weed hosts for leafhopper reproduction, since the leafhoppers can overwinter their spring and summer generations in the same area.

Until 1945 the extensive Russian-thistle areas, such as Hollister-Rogerson, Oakley, and Minidoka-Kimama, located on abandoned farm lands that were privately owned. However, after abandonment many of these farms reverted to public ownership. These areas were located south and northeast of the large irrigated districts, and since the prevailing winds are from the west and the beet leafhopper moves with the wind, the direction of the leafhopper movement in the spring was opposite from the cultivated lands. Russian-thistle on these areas has been greatly reduced during recent years by its replacement with downy chess. During the period 1945-1949 important Russian-thistle acreages developed in the Glenns Ferry-King Hill and Bliss-Tuttle areas on range lands that were originally covered with sage, but which were burned during recent years. Tumblemustard, a spring weed host, is growing intermixed with the Russian-thistle over a considerable proportion of this acreage. These areas lie to the west of the irrigated lands of south-central Idaho, and are strategically situated from the standpoints of abundant leafhopper production and movement in the direction of prevailing winds to susceptible crops grown in those lands. The soil is sand, which is favorable for the overwintering and early spring reproduction of the leafhopper. The winters are milder and the springs are warmer than in the Twin Falls area.

These important Russian-thistle areas are located on range lands that are largely federal - and state-owned, as shown in table 1.

Table 1

Ownership of lands infested with Russian-thistle in Elmore, Gooding, and Owyhee Counties, Idaho, during the summer of 1949

Area	Federal	State	Private	Total
	Acres	Acres	Acres	Acres
Glenns Ferry	21,881	1,950	3,000	26,831
Hammett	5,926	100	1,040	7,066
Indian Cove	17,111	1,100	3,280	21,491
King Hill	12,844	640	500	13,984
Tuttle-Bliss	4,236	1,340	3,822	9,398
Total	61,998	5,130	11,642	78,770
Percent	78.7	6.5	14.8	----

The information given in this table was obtained in cooperation with the Bureau of Land Management, U. S. Department of the Interior; Owyhee District Office, Boise, Idaho; and the Shoshone District Office, Shoshone, Idaho. Table 1 shows the ownership of lands which were infested with Russian-thistle during the summer of 1949 in Elmore, Gooding, and Owyhee Counties in Idaho. This table also shows the total acreage to be 78,770 acres, of which 61,998 acres, or 78.7 percent, are owned by the Federal Government and 5,130 acres, or 6.5 percent, by the State of Idaho.

To illustrate the importance of these weed areas in the current beet leafhopper problem, it may be stated that during September 1949 Russian-thistle occupied an average of 54 percent of each acre examined in the King Hill-Glenns Ferry area, and that the Russian-thistle plants were infested by an average of 57 beet leafhoppers per square foot of land surface occupied. On this basis, there were approximately 1,340,779 beet leafhoppers per acre, or an estimated total of nearly 55 billion of these insects infesting the 40,815 acres comprising the combined King Hill-Glenns Ferry areas shown in the table.

Chemical control of the beet leafhopper and curly top on cultivated susceptible crops has not proved practical, as continuous infection of the crops occurs by reinfestation during the susceptible period. Therefore, other methods for a feasible control have been developed. First, the major host plants of this insect have been determined, and methods for their replacement by nonhost perennial grasses have been studied. The replacement of weed hosts by perennial grasses that are not breeding hosts of the beet leafhopper may best be accomplished by reseeding the abandoned and burned areas, or if native perennial grasses are still present, protection against grazing will accomplish the same purpose. Since these perennial grasses remain green until late in the season, they do not constitute a fire hazard when compared with downy chess.

The second method is the chemical control of the beet leafhopper in weed-host areas that contribute large populations to the cultivated areas. This is a continuing program designed to keep the beet leafhopper populations below injurious numbers. This program would decrease as the weed-host areas decreased and new ones were prevented by range management. The control of annual weeds on idle and waste lands in and adjoining cultivated areas is the most difficult phase of range management, because of constant grazing and trampling by livestock and misuse by man. In such areas chemical control would be the most practicable.

MR. BALCOM: You have just heard representatives from the 10 agencies who administer the major portion of Federal lands in the 11 Western States. It has been pointed out that there is a great diversity of weed problems scattered over 400 million acres of land. Many of these problems concern plants which under some conditions are weeds and under others useful vegetation. In some instances plants not ordinarily called weeds must be controlled for securing better land use or other reasons.

An important factor which must be considered by Federal agencies is that after weeds have been eliminated from an area, they must be replaced with desirable species of plants or reinfestation will occur and the control results will have been lost. It can be seen that the total problem is very great and it cannot be solved in a short period. Then too, weed control work can be accomplished only as funds are made available. I think almost everyone of the speakers here have mentioned funds and I hope that you do realize that where there are shortcomings in weed control programs on Federal lands, it is principally due to the lack of funds.

Our speakers have shown that, except for a few agencies which have highly specialized problems of plant control, little research is conducted and that most of the weed control methods are adapted from the findings of others, principally the Bureau of Plant Industry, Soils and Agricultural Engineering, and State Experiment Stations. The research work accomplished by these organizations has been greatly appreciated, and as more comprehensive programs are planned their assistance will be in even greater demand in helping to develop more economical and effective methods of weed control.

Another point which has been emphasized by several members of our panel is the need for an efficient method of obtaining weed control research information. Many suggestions have been made as to how this may be accomplished but most are agreed that it would be very useful to have a central clearing house for disseminating information on tried and approved methods. There is no doubt that the availability of such a source for obtaining reliable recommendations would help reduce the cost of weed control by Federal agencies as well as stimulate the initiation of more comprehensive programs.

The programs of actual weed control on public lands which you have just heard discussed, certainly show that there is no lack of an appreciation of the problems. Perhaps much more control work is being accomplished in the field than you realized before these presentations were made. It is of considerable significance also to learn that personnel of Federal agencies desire to cooperate with local and other organizations interested in weed control.

When it is considered that weed infestations are scattered over millions of acres of public land, and that in many instances no feasible control methods have been developed, it can be seen that a good start has been made. Perhaps most encouraging is the fact that plans are being formulated by Government agencies to initiate more comprehensive programs as soon as funds are available, and economical methods have been found for large scale field control.

Speaking on behalf of the panel, it is sincerely hoped that you have gained a better understanding of weed control problems on Federal lands, the programs being conducted, and plans for future activities. We want to again thank you for this opportunity of discussing these subjects with you. We also appreciate the opportunity of being here to learn from others on your program, new developments in weed control which will be of value in helping solve our problems.

This conference has done much toward helping develop a more coordinated program of weed control in the 11 Western states and we want to continue working with you - particularly with Mr. Burges' Coordinating Committee - and to receive the aid you can give us. We wish you every success in your present meetings.

TUESDAY, JANUARY 31

The meeting was held in the City Auditorium Annex where industrial and educational exhibits were displayed.

Rodney H. Tucker, Extension Agronomist, Fort Collins, Colorado, was chairman of the morning session.

After making some introductory remarks he introduced Arthur Gieser, Chief Pilot, Division of Grasshopper Control, Bureau of Entomology and Plant Quarantine, USDA, Denver, who presented the following paper.

THE USE OF AIRCRAFT IN APPLICATION OF AGRICULTURAL CHEMICALS

The use of aircraft equipped with distributing apparatus is increasing every year. Through experiments conducted with seeding of burned-over forests and range lands, rice seeding, fertilizing of crop lands, spreading of grasshopper baits, the development of weed killers, and the highly concentrated insecticides we have today, aircraft are now working up to nine months of each year in some parts of the country. There has been a sudden increase in the use of aircraft since World War II, resulting in a great variety of distributing apparatuses that have been developed by individuals fleet operators, small companies, and by some large establishments. It is not my intention to recommend or condemn any of the various types of equipment, but rather to give you our impressions of what we have found to be more satisfactory, and I hope you will accept my suggestions that way.

Since this is a weed control meeting, I will not discuss aircraft alterations, hoppers, agitators, gear boxes, gates, or spreaders. Should there be anyone in the audience that may be interested in any of these subjects, I would be most happy to try answering any questions he might have following this discussion. If the questions may be too involved or may take up too much time and you would care to visit us at our shops at Stapleton, Field, we will give you all the assistance we can.

Tanks

In areas where operators have occasion to distribute solid materials as well as liquids, the general trend is to install dust hoppers that are liquid tight. Operators who use 24ST metals space their rivets 3/4 of an inch apart and apply Zinc Chromate paste to the seams, others who use half-hard aluminum weld all seams, and those who use galvanized tin, solder all seams. By making a hopper liquid tight it can also be used as a tank for liquids by removing the spreader and gate and bolting a plate to the bottom of the throat. By attaching a wind-driven pump, relief valve, and shut-off valve to this plate, they have an airplane that can be changed from a duster to a sprayer, or vice versa, in two to four hours. Another advantage of using the hopper for liquids is in cases where liquids may need agitation, paddles can be attached to the agitators.

If the airplane is to be used for liquid spraying only, it is better to install a tank rather than using a hopper. The tank should have a large filler neck so it may be speedily refilled and preferably designed with a large removable top for cleaning. It is especially important after spraying weed killers to thoroughly clean the entire system prior to spraying insecticides. The outlets should be designed so that the tank can be completely drained, either on the ground or in the air. Taking off with a fully loaded ship is sometimes hazardous and in the event of a motor failure, it is desirable that a provision be made for dumping the load, thereby perhaps saving the life of the pilot and the airplane.

Gravity vs. Pressure Systems

Tests have been conducted in rate of flow by gravity with a 75 gallon upright tank installed in an N3N. The rate of flow when the tank was full was 3 times the rate of flow with a low quantity, or a ratio of 3 to 1. This might be permissable with some insecticides, but it is my understanding that an overdose to this extent with some weed killers and some insecticides would probably do considerable damage.

Experiments conducted show that a pressure system is more dependable.

Pumping Systems

Two types of pumps commonly used are gear pumps and centrifugal pumps. Gear pumps furnish higher pressure, require fewer nozzles, and smaller tubing can be used, but gritty materials and residues wear out the gears and will soon cause failure of the unit. Centrifugal pumps provide lower pressure, require more nozzles and larger tubing, but they are not affected by grit and foreign material sometimes found in liquid insecticides. Centrifugal pumps are more satisfactory than gear pumps when it is known that the liquids may contain grit.

Many operators are attaching their pumps so that they may be engine driven, either directly or by belts. In these cases, larger pumps are usually used and by driving them with the engine, higher pressure and higher output are obtained.

The pumping system should have an adjustable by-pass valve installed, which will provide a means of regulating the pressure, the rate of flow, and which will prevent excessively high line pressure when the spray valve is closed in the event gear pumps are used, and will also provide a means of agitation for the liquids if needed. To prevent foaming, the return line from the valve should be below the surface of the liquid.

Spinner Discs and Brushes vs. Booms

To my knowledge, no one in the U. S. Department of Agriculture has tested the spinner brush system, but the Division of Gypsy Moth Control of that Department, Greenfield, Massachusetts, successfully used a spinner disc system to apply wettable powders to wooded areas before concentrate sprays were developed, and continued to use it to apply DDT until this past season. I have also flown an airplane equipped with a spinner disc system on numerous spray experiments on grasshopper control and tussock moth control, and it is reasonable to believe that the results of both systems should be very similar. Spinners are more practical than nozzles when liquids contain gummy substances or residues that gum up or plug nozzles. Unless the output was very light, the spinners could not be depended upon to obtain a uniform swath when the plane was flown close to the ground. Tests showed that at least 30 feet of elevation had to be maintained to obtain swath uniformity when applying average dosages, and it was necessary to increase altitudes as dosages were stepped up. Naturally anyone who sprays wants to fly as high as he can and still do a good job. With most insecticides this is permissable, but when spraying weeds, it is imperative that one fly as close to the ground as possible to reduce drift hazards. 2-4D has been known to drift and kill susceptible plants many miles away in a 5 m.p.h. wind.

Suspended boom installations, which usually extend from wingtip, and sometimes farther, give better control of particle size and better uniformity of swath at zero altitudes as well as high altitudes. There are some operators who prefer short booms that extend from the inside end of the aileron of one wing and pass underneath the belly of the aircraft to the inside end of the other aileron, and I have seen some booms suspended underneath the belly that were only 5 feet long. Some operators prefer to use nozzles, others prefer to cut slots into the boom, especially when they are applying very heavy dosages. The rate of flow or output with a boom installation is regulated by adding or subtracting nozzles, or when slots are used, a system that will vary the number of slots or their openings. In either case, whether using nozzles or slots, an adjustable by-pass valve is needed for final output adjustment. Short booms are better when spraying weed killers because it keeps most of the spray away from the wing-tip vortices. When spraying for weeds, it would be much safer to apply narrow swaths and keep as much spray away from the vortices as possible.

Uniformity of spray deposits in swath depends on several factors, including the number of outlets on the boom, the type of nozzles, their spacing, and relation of the airflow with the particular installation.

Provision should be made to eliminate drool and for this purpose shut-off valves or check valves at each cluster of nozzles are satisfactory.

Tubing

Tubing should be installed to avoid as many T's and elbows as possible since such installations reduce pressure. All hose used for flexible connections should be chemically resistant to avoid deterioration caused by certain insecticides, fungicides, etc. Particles from such deterioration can cause considerable trouble by plugging the nozzles and the system. The tubing should be designed so that it can be completely drained and cleaned after using weed killers.

The pressure loss in a system varies directly as to the rate of flow and inversely as the 4th power of the diameter of the tubing. This means that if the discharge rate is doubled, pressure loss is doubled, or that if the size of the tubing is cut in half, the pressure loss is increased 16 times.

Particle Size

Particle sizes are measured in microns. Some frequently used examples of drop sizes in microns are as follows:

Sea fog	5	microns	in	diameter
Cloud	33	"	"	"
Mist	100	"	"	"
Drizzle	200	"	"	"
Light rain	500	"	"	"

When comparing various size droplets they must be considered by volume, as a globe. On this basis, if one compares 100-micron particles with 500-micron particles, the ratio of difference is not 5 to 1, but rather 125 to 1. Another comparison, when applying liquids at the rate of 1 gallon per acres, a 500-micron deposit will deposit 9 drops per square inch; a 100-micron deposit will deposit 1164 drops per square inch, or a comparative ratio of 129 to 1. Carrying it further, a 5-micron deposit will deposit 9,186,000 drops per square inch.

The following factors will control particle size, and although some are interrelated, all must be considered. They are:

1. The viscosity of the material
2. Rate of flow
3. Type of nozzle or orifice
4. Position of nozzle
5. Speed of the aircraft
6. Altitude of the aircraft

The reason we must consider particle sizes, and this is very important when applying weed killers, is because the difference in drift of the various size droplets. As an example, for droplets of water in still air:

A 5-micron	diameter	drop	will	fall	10 ft. in 1.1 hours
A 100-micron	"	"	"	"	10 ft. in .18 minutes
A 500-micron	"	"	"	"	10 ft. in 1.6 seconds

For further comparison:

A 5-micron	drop,	when	dropped	10 ft. in a 3mph	wind	will	drift 3.4 miles
A 33-micron	"	"	"	10 ft. in a 3mph	"	"	" 400 ft.
A 100-micron	"	"	"	10 ft. in a 3mph	"	"	" 48 ft.
A 500-micron	"	"	"	10 ft. in a 3mph	"	"	" 7 ft.

There are three factors which act on any material once it leaves the airplane. They are (1) gravity, (2) wind, and (3) convectional air currents. Eighty-five degree temperature when the sun is high usually causes convectional air currents such that little benefit will result from either dusting or spraying under this condition. Because drifting chemicals can cause serious damage to nearby crops, wind and convectional currents must be constantly considered when applying chemicals.

Determining Effective Swath Width

When spraying liquids, a common procedure is to use a dye in fuel oil and catching the spray on glass plates. In this way the particle sizes can be checked as well as the uniformity of swath. When dyes are not available, glass plates that have been smoked or sooted with an acetylene torch can be used. There are some cases where paper has been used, but this is not too satisfactory because it is difficult to find the kind that will not allow the droplets to enlarge themselves when soaking into it, and particle sizes thus cannot be accurately determined.

It will be necessary to discount the feather edges or the glass plates that have light deposits on them. If it will be remembered to never stretch the effective swath width, the outcome of the job will always be better.

Determining Rate of Flow or Output

One of the first questions that usually arise after an installation is completed is how many nozzles are needed to provide the proper rate of flow. There are two methods of finding the answer to this question. In using either method, the number of nozzles and their spacing must first be estimated. By one method of calibration it is necessary to find a small field of known acreage, load the airplane with the proper amount of material to treat it with the proper dosage, spread the material over the area and readjust the equipment accordingly.

A second method is one that I use and prefer. It is a simple formula that can be applied to any material, whether solid or liquid. The formula is: An airplane traveling 100 mph and treating a strip 100 feet wide will treat 20.2 acres per minute. The speed and the effective swath width of the airplane are always known. Remembering this formula will enable one to calculate the acres per minute quickly and easily in each instance. For example, suppose an airplane is flying 70 mph and treating a 60 foot swath or strip. Seventy mph is 0.7 of 100 mph and 60 is 0.6 of 100 feet. 0.7 x 0.6 = .42 x 20.2 = 8.48 acres per minute. It must be remembered to multiply the number of acres per minute by the number of pounds or gallons per acre desired, which in turn will give the necessary flow in pounds or gallons per minute desired. Using this formula, a known amount of material can be loaded into the airplane, the length of time it flows can be checked, and the equipment can be readjusted accordingly.

Once the rate of flow or output necessary for the individual job has been determined and operations have begun, it is always advisable to doublecheck the number of pounds or gallons applied to the number of acres covered. This may correct an error in the pilot's judgment of the swath width when flaggers are not used.

Flying Procedures

It is of the greatest importance to identify the field to be treated since application of some chemicals on the wrong plant can cause disastrous results. The use of flagmen at the ends of the field is recommended to make certain that even coverage is obtained, especially in areas that do not have row crops or other features that can be used as markers.

Air strips should be located as near the area to be treated as possible to reduce round-trip flying distances. Operators could do more work in less time, even by carrying restricted loads, if they could operate from small strips near the area rather than ferry heavy loads long distances. Arrangements should be made with the farmers to provide landing strips on their property, since their loss of a few acres from cultivation could easily be repaid to them by operators being able to work more economically by eliminating long ferry flights.

Helicopters

I have been asked to make some comments on the use of helicopters for the application of chemicals. I am not too familiar with their operation and haven't seen one dust or spray since May in 1948 when I had the privilege of attending the International Demonstrations of air and ground equipment at Beltsville, Maryland.

I would list their greatest advantage as being the force or pressure with

Which they can apply the chemicals to the plants -- a force impossible to obtain with a convential airplane, especially in cases where it is necessary to cover under surfaces of leaves or to penetrate dense growths. Other advantages are: (1) They are ver maneuverable. (2) Their ability to hover, fly sideways, backwards, or forward at speeds varying from zero to 90 miles per hour makes them ideal for working small plots that are surrounded by obstructions, or fields that have many obstructions in them. (3) They need only a 50-foot circle to land and take off. Spaces this size are usually available adjacent to most fields to be treated and therefore would eliminate long ferry flights.

Their disadvantages are: (1) The initial cost is very high when compared with a conventional airplane. (2) Maintenance costs are considerably higher than maintenance for conventional airplanes. (3) Loading is restricted because their weight and balance is critical. (4) Helicopter pay loads are about 1/2 of the pay loads of conventional airplanes with the same horsepower. (5) It is questionable whether a helicopter could compete with ground equipment when working small plots that they are best suited for.

References

Brooks, F. A. 1947. The Drifting of Poisonous Dusts Applied by Airplanes. Agricultural Engineering. June.

Potts, S. F. 1946. Particle Size of Insecticides and Its Relation to Application, Distribution, and Deposit. Journal of Economic Entomology. 39:716-720.

F. L. Timmons, Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils and Agricultural Engineering, United States Department of Agriculture, was chairman of the afternoon session and presented the following program:

Factors Affecting the Absorption and Translocation of Herbicides in Mesquite (Prosopis juliflora) 1/

by

Dale W. Young and C. E. Fisher 2/

Introduction

Mesquite control is a major problem facing the livestock industry in the Southwest. Mesquite is a thorny, woody shrub or tree that infests 75 million acres of valuable range and pastureland in the southwestern United States. It competes with grasses and other valuable plants for sunlight, moisture, and plant food. Mesquite also acts as a serious barrier to the handling of cattle on the ranges.

In grazing studies at Spur, Texas, there was 43% more beef produced in the fourth year from cleared land than from comparable mesquite infested range. The grass cover

1/ Cooperative investigations between the Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U.S.D.A., and the Texas Agricultural Experiment Station.

2/ Assistant Agronomist, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, Spur, Texas, and Associate Agronomist, Texas Agricultural Experiment Station, Spur, Texas, respectively.

improved in composition and density when the competition from mesquite was removed. Mesquite clearing in New Mexico has increased grass production as much as two and one-half times.

Distribution of Mesquite

Mesquite belongs to the Mimosa family, and it is distributed in warm, mostly dry climates of the United States, Central America, West Indies, Africa, Persia, India, Chile, Hawaii, and other countries of similar climates.

Mesquite occurs in Texas, New Mexico, Arizona, and to a limited extent in Oklahoma and California. There are 2 commercially important species and 3 varieties of mesquite, namely: honey mesquite (Prosopis juliflora glandulosa), velvet mesquite (P. juliflora velutina), and western honey mesquite (P. juliflora torreyana). The other species is (P. strombulifera), a root sprouting mesquite that was introduced into the United States as an ornamental or forage plant, that is at present out of control.

Description of Mesquite

Mesquite forms a medium-sized tree in its optimum range of growth, but at its northern limits, it is usually a bush with many stems from 10 to 15 feet high. This variation in growth habit is influenced by soil, moisture, climate, and mechanical injury.

Mesquite has an extensive root system. An eleven month old mesquite seedling growing under ideal conditions at Spur, Texas, was dug from the soil and found to have a 17 foot horizontal spread of lateral roots, with tap roots extending vertically 7 feet into the soil. The top growth was 34 inches high. Another mesquite root was caught by a lister and 42 feet of lateral root was pulled to the surface. The lateral roots are usually less than 12 inches underground which enables the mesquite to compete effectively with grasses.

No sprouts are produced from lateral roots. Sprouts arise only from dormant buds which occur in a zone on the trunk extending from 3 to 12 inches below the soil surface. Once above the ground growth is injured by fire, frost, chemicals or other means, these buds are capable of sprouting and developing a bushlike growth out of a once single stemmed tree.

Causes for the Large Amount of Mesquite

Mesquite produces beans or seeds that are relished by livestock, rodents, and other animals. Tests show that 54%, 45%, and 12%, respectively, of the seed ingested by steers, horses, and sheep, and 50% of the seed ingested by coyotes and rabbits, pass through the animals' digestive tracts in a viable condition. As many as 4 mesquite beans have been found in one rabbit pellet.

Key plants probably were introduced into new areas by the early trail drives of cattle, or by herds of roving buffalo. Now the rapid transportation of cattle, along with the fencing and watering of the ranges, have brought about the serious infestation that we have.

Value of Mesquite Control

Facilitates handling of livestock

The rancher feels that the greatest value of mesquite control is in enabling him to handle his stock more easily. Johnny Stevens, manager of the Matador ranch at

Matador, Texas states that just knocking down his mesquite by chaining enabled his men to "work the cattle" in one pasture in less than one day's time, where on previous years it has taken from 10 days to 2 weeks to "work the cattle" and even then they always missed some.

Lonny Bates, a prominent rancher in Webb County, Texas, said that mesquite has cost him at least 400 calves in 1949 alone. The calves died of worms because the mesquite prevented him from rounding up and treating the calves. Similar difficulties prevail in the treatment of cattle with DDT for the control of horn flies. One of the greatest reasons that foot and mouth disease is feared in Texas is that the ranchers would be unable to round up their cattle for the repeated vaccinations.

At Spur two cowboys went into a 20 acre brush pasture to round up three steers for weighing, and after 3 hours they came out with one steer still missing. Multiply this by the vast acreage of mesquite infested range and you can see the difficulty of handling cattle in the brush country.

Mesquite Control

To date there has been no generally accepted economical method of clearing mesquite on range land. Some practices work well in some local areas, but generally the cost has been too high for range land.

Grubbing mesquite by hand or with large machines is feasible if one plans to grow cultivated crops. Grubbing usually costs the price of the land, destroys the grass cover to a serious extent, and makes a good seed bed for the ever present mesquite beans and weed seeds.

Poisoning with sodium arsenic is effective but costly, as well as being hazardous to men and livestock.

Kerosening, or use of light, cheap oils, is effective on porous soils with single trunked trees, but it is generally too costly and time consuming. It is impractical for controlling dense, brushy mesquite.

Cabling, or chaining, which consists of dragging a huge cable or chain in a loop between two crawler type tractors, is effective on large trees, but smaller trees and brush are just knocked down or bent over. Chaining smaller trees is a temporary measure. On this type of growth the mesquite, after 2 or 3 years, is generally worse than before it was treated.

Airplane Applications

At Spur, Texas, chemicals have received considerable attention, especially on the use of growth regulating chemicals for control of mesquite.

In 1949 we obtained 90% top kills and 25% root kills by applying 2/3 of a pound of 2,4,5-T ester in 5 gallons of a 20% oil emulsion, or applying certain mixtures of 2,4-D and 2,4,5-T in 5 gallons of oil per acre.

Greater amounts of 2,4,5-T, 2,4-D, or mixtures of 2,4-D and 2,4,5-T have not increased the percentage kill. In our tests 2,4,5-T was more effective when applied in an oil emulsion than in either a water or oil solution. Emulsions with greater amounts of oil appear to be more effective than those with smaller amounts of oil.

Of many mixtures of 2,4-D and 2,4,5-T, only two appeared equally as effective or more effective than the equivalent amount of 2,4,5-T applied alone. These were: (1) 1 part 2,4,5-T and 2 parts 2,4-D as the butoxy ethanol esters, and (2) 1 part

2,4,5-T and 1 part 2,4-D as activated butyl esters.

Formulations of 2,4-D either as esters, amines, or salts were ineffective when applied at varying rates in oils, emulsions or in water.

Treatments made at different seasons of the year indicate that most effective results may be obtained when the mesquite is treated just after it reaches full foliage in the spring of the year. In addition to controlling mesquite, spraying in the spring controls the growth of sunflowers, annual broomweeds, Russian thistles, and many other range weeds.

The successful airplane applications were made by using a plane that applied the herbicide in large droplets and under no pressure. We were not able to obtain any root kill of mesquite, or as much top kill, when we used a plane that applied the herbicide in smaller droplets and under high pressure. The small droplets appeared to give greater coverage of the leaf surface, and caused the death of the leaves before the material was able to translocate to the stems, while the larger droplets just covered part of the leaf and left part of it alive and greater translocation of herbicides was obtained. Larger droplets were better able to penetrate through the brush and fall on the lower leaves and stems of plants and drift was decreased considerably when large droplets and no pressure was used.

Spraying with Ground Equipment

With ground equipment, water solutions of the 2,4,5-T ester were superior to oil solutions or oil emulsions when plants were treated during active growing conditions. With treatments in late summer or in the dormant stage, oil solutions of 2,4,5-T are effective whereas water solutions are not. A spray solution must thoroughly wet the plant to be effective in the dormant stage. This fact limits the use of the airplane to the active growth stage.

Sprout growth, 4 feet high, responds similarly to mature trees. As in the airplane sprays, 2,4-D is not effective on mesquite except as used with 2,4,5-T in the before-mentioned brush killers.

Basal Application

On areas where airplane application of herbicides is not practical, effective control of mesquite may be obtained by thoroughly wetting the bark of the lower 12 inches of the tree at the ground level with a .5% solution of the 2,4,5-T ester in oil. One gallon of solution will treat 30 to 40 trees, depending upon the size of the trees, thickness of the bark, and the type of growth. Season of treatment does not appear to greatly affect the results of this operation.

Cut Surface Application

Highly effective kills of mesquite may also be obtained by cutting the mesquite off and spraying the stumps with a .5% solution of 2,4,5-T ester in oil. Large trees have also been killed by painting the freshly cut sap wood with the amine of 2,4-D at a concentration of 4 pounds per gallon. These treatments are effective at any time of the year.

While our results this year are very promising, we feel further research is needed before we can recommend a treatment to the rancher. We suggest that he use our results as a guide for his own experimentation.

While many of the trees that are not killed with proper airplane application are greatly inhibited, further research is needed to find ways to increase the percentage of root kills.

A chemical to be effective on mesquite must be able to be absorbed by the plant and be translocated in the plant to the underground buds in toxic amounts.

At Spur we have tried to determine the factors affecting the absorption and translocation of herbicides in mesquite. To do this we have devised the tip immersion and shield tests.

Tip Immersion Test

The tip immersion test is a rapid method of testing the translocation of herbicides when a constant supply of herbicide is made available for absorption by the plant. The tip immersion test consists of immersing the tip of a branch into a jar of herbicide for a period of 1 to 24 hours, and noting translocation of the herbicide by the effect on the plant tissue. Various formulations of herbicides have been tested on mesquite throughout the year and checked against stage of growth of the plant, type of chemical, temperature, humidity, wind velocity, and soil moisture.

From a detailed study it was shown that under the conditions used:

1. Translocation of herbicides is influenced mainly by the stage of growth of the plant. Translocation occurred anytime that the leaves of the tree were in a growing condition. In our area some translocation took place from April to September, with the maximum in May, June, and July, but with no translocation in October or November.

2. Temperatures above 80° with the accompanying low humidity, or moderate temperatures with high humidity, favor translocation.

3. An oil emulsion of the amines of 2,4,-D and 2,4,5-T translocates more readily than do oil emulsions of the esters of 2,4-D or 2,4,5-T. Emulsions of the esters and amines of 2,4-D and 2,4,5-T translocate more readily than do aqueous solutions of the amines or oil solutions of the esters. In general, a small amount of oil, 10% to 20%, appears to increase translocation, while a larger amount decreases translocation. Of over 20 oils tested, none are outstanding.

4. The addition of a wetting agent to the amine of 2,4-D increased translocation equally as well as the addition of an emulsifiable oil.

5. Solutions of chlorosol A, TCA, and ammate translocate readily in mesquite.

6. A combination of the ester and amine of 2,4-D was very readily translocated in mesquite.

7. The amines were translocated over a longer period of time than were the esters.

Shield Test

The shield test is a rapid method of testing the absorption and translocation of herbicides in a plant. This test consists in spraying the exposed branch of a plant under controlled conditions of application and noting translocation of the herbicide by its effect on the plant tissue of the shielded or untreated part of the plant. If a solution of herbicide is absorbed and translocated in the shield test the same results should be expected in spraying an entire tree. The results of the shield test can be read one month after treatment, whereas a wait of an entire year is necessary when the whole tree is treated.

Various formulations of herbicides have been applied in the above manner throughout the year, and then checked against stage of growth of the plant, type of chemical, temperature, humidity, wind velocity, and soil moisture.

From the detailed study, it appears that under the conditions used:

1. The stage of growth of the mesquite is the factor most limiting the absorption and translocation of herbicides. Absorption and translocation of herbicides took place from the spring growth stage until mid-summer, with no translocation in the late summer or fall. In our area we had no absorption or translocation of herbicides after August 15.

2. Absorption and translocation of herbicides were greatest during periods when the temperature was over 80°. A high temperature was not important, just a sustained temperature of over 80°. More absorption and translocation occurred on June 27 than any other day. This day had 16 hours of over 80° temperatures, and only 3 hours of humidity over 80%.

3. In the absence of high temperatures, absorption and translocation are favored by moderately high temperatures and high humidity.

4. A solution of the 2,4,5-T ester in water was absorbed and translocated more consistently than were the other herbicides tested.

5. The ester of 2,4,5-T in oil was absorbed and translocated to a limited extent, while the ester of 2,4-D in oil was not absorbed or translocated when applied to foliage.

6. Solutions of TCA and chlorosol A were not absorbed and translocated in the plant.

7. Of the many oils tested as carriers, low phytotoxic oils appear to be superior to high phytotoxic oils.

8. In limited tests, the addition of Goodrite VL 600, or Nugreen, increased the absorption and translocation of the 2,4-D amine.

9. A combination of the ester and amine of 2,4-D, a combination of the esters of 2,4-D and 2,4,5-T in oil, and the 2,4,5-T amine in water warrant further study.

Summary

1. Mesquite control is a major problem facing the livestock industry in the Southwestern United States.

2. It is present on 75 million acres of grazing land in the United States.

3. Mesquite is normally a medium-sized tree, but it may grow as a bush, depending on soil, climate, and mechanical injuries.

4. The seeds are spread by grazing animals and by many rodents.

5. Mesquite control enables ranchers to see and handle their livestock more easily, and it has also substantially increased the grass production of the land.

6. Mechanical control methods and the use of kerosene and arsenite are effective on localized areas, but are too costly for effective control.

7. Growth regulating chemicals appear to offer the most promising control, but more information is needed concerning their most effective use.

8. A chemical to be effective on mesquite must be able to be absorbed by the plant and be translocated below the soil line, where it can kill or severely injure the dormant buds.

9. The tip immersion and shield tests are effective methods of measuring the translocation and absorption of herbicides in plants.

10. Absorption and translocation are affected mainly by the stage of growth of the plant, the chemical used, the duration of temperature above 80° immediately after treatment, and the period of humidity above 80% when the temperature is moderate.

11. The 2,4,5-T ester in water is absorbed and translocated more consistently than any herbicide tested.

12. The amines of 2,4-D and 2,4,5-T are translocated over a longer period of time than are the esters.

Table I. The effect of various factors on the translocation of herbicides as determined by the tip immersion test.

Date	Stage of Growth	Hours of temperature above 80°F	Hours of relative humidity above 80%	Evaporation from a free water surface	Rainfall 30 days preceding test	Number of tests	Average inches translocated
5/9	First leaves and blossoms	0	13	.100	4.74	20	63
5/19	Full leaf	4	13	.185	6.07	23	66
6/14	" " Beans	3	11	.244	6.57	10	18
6/27	" "	16	3	.342	4.63	20	66
7/15	" " New Blossoms	8	10	.230	1.42	26	48
7/28	" " " "	8	11	.212	1.70	17	36
8/24	" "	7	5	.236	4.00	15	12
9/7	" "	5	9	.235	3.98	16	43
9/20	Leaves dropping	7	11	.079	3.63	20	16
10/6	" "	0	7	.216	2.91	17	8

Significant at .01 level.
Difference necessary for significance 7.0

Table 2. The effect of various factors on the absorption and translocation of herbicides in mesquite as measured by the shield test.

Date	Stage of Growth	Hours of temperature above 80° F	Hours of relative humidity above 80%	Evaporation from a free water surface	Rainfall 30 days preceding test	Number of tests	Average inches translocated
5/19	Full leaf	4	13	.185	6.07	46	4
6/14	" " Beans	3	11	.244	6.57	30	3
6/27	" "	16	3	.342	4.63	30	9
7/15	" " New Blossoms	8	10	.230	1.42	69	4
7/28	" " " "	8	11	.212	1.70	34	3

Significant at .01 level
Difference necessary for significance 1.0

There is a correlation of .94 between the hours of temperature above 80° F and the distance translocated.

There is a negative correlation of .68 between the hours of relative humidity above 80% and the distance translocated.

Brush Control in the Rocky Mountain West

By

D. F. Hervey, Colorado A. & M.

From the range managers viewpoint, brush may be highly desired in some cases and a nuisance in others. It is important, therefore, that we talk not just of eradication brush but rather in terms of brush-land management. In so doing, we consider the over-all picture of the land resources and the demands on these resource by various users.

First, let us look at the location of the brush ranges of the West, particularly sage brush ranges. Big sage brush (Artemisia tridentata) occurs in the western half of Colorado and in adjoining portions of Wyoming and Utah. There are even greater areas in the Intermountain region. This discussion will be limited to the Central Rocky Mountain region, however. The lower elevation sage brush areas are largely desert-like with precipitation generally less than 11 inches annually. These sage-brush ranges are grazed by sheep during the winter months. Brush land management in the lower sage brush zone should favor certain species of brush in order that sufficient feed be available to sheep when snow is on the ground. Brush removal is NOT recommended, but rather, the use of livestock operations designed to favor continuance of black sage, winter fat, and Indian rice grass. The best approach seems to be a system devised by Selar Hutchings of the Intermountain Forest and Range Experiment Station. He proposes a rotation system of grazing that will keep sheep off some pastures during the month of April when plant growth is getting underway. This is an indirect control of big sagebrush and other undesirable species. The grazing plan aims to favor the desired grass and brush species, thus holding at a minimum further spread of big sagebrush. Eradication programs are not being recommended because of the difficulty in revegetating cleared areas and because of the need for brush for winter grazing.

The middle elevation sagebrush ranges, such as those in Middle Park, North Park, Gunnison and Moffat counties contain areas on which eradication is desirable and feasible, and other areas on which eradication is not recommended. Precipitation is generally sufficient to allow for successful seeding or regeneration of cleared areas. However, many large blocks of sagebrush range in this zone are grazed not only in the spring and fall by sheep or cattle, but also during the winter by migratory deer herds. The complexity of the management problem thus encountered leads us to the conclusion that wholesale eradication is not desired. When it will benefit the user, sagebrush should be eradicated and replaced by better range forage. For example, a rancher using sagebrush ranges as lambing grounds would likely find poor feed and difficulty in caring for ewes and lambs in the brush. His problem could easily be solved by clearing the necessary acreage of sagebrush and seeding it to an early growing grass. Likewise, eradication and reseeding of cattle or sheep ranges in areas where there is competition with these deer herds would aid by increasing the grazing capacity and reducing the competition. It is assumed that eradication will take place on a relatively small percentage of the total sagebrush area, confined principally to the more productive sites, and thus leave sufficient brush for both game and domestic livestock.

In the middle elevation zone, several methods of eradication are adapted. Controlled burning is the cheapest. It gives a high percentage kill and leaves a seed bed ready for drilling. Burning is restricted to those areas which have sufficient vegetation to carry a good fire. In Colorado, such areas are largely restricted to the northwestern portion of the state.

Here are a few hints on burning:

1. Prepare adequate fire lanes, at least 75 feet wide, around the area to be burned

2. Burn only when the vegetation is dry, the day is hot with low humidity, and a moderate steady wind is blowing

3. Prior to burning, notify the sheriff and any firelookout as to the time and location of the proposed burning

4. Ignite as large a front as possible, using weed burners or the like

5. Have a stand-by crew prepared to fight any run-away fires

6. Reseed as soon as possible after burning.

Various types of plows and disks have been used with considerable success. Machinery is the safest means of eradication. It is rather costly but it gives a fairly high percentage kill to sagebrush. One-way type of plows and disks have been commonly used. Seeding may be done at the time of plowing if accomplished in the spring or fall.

Experimental use of herbicides to control big sagebrush has been tried, with somewhat variable results being obtained. Both the Colorado A. & M. Experiment Station and the Rocky Mountain Forest and Range Experiment Station undertook rather intensive testing of herbicides on big sagebrush during the 1949 growing season. Preliminary examination of the plots was made in September. Final examination will be made this summer. Judging from similar tests made in 1948, trends noted in the fall following application hold true in the final examination the next summer. With this assumption, we can say that our preliminary examination shows the following trends on the 1949 test plots:

1. Big sagebrush is not more than moderately susceptible to 2,4-D or a mixture of 2,4-D and 2,4,5-T at rates of 1/2, 1 or 2 pounds per acre.

2. Applications of these chemicals made in May or early June give much better results than later applications.

3. There was no appreciable difference in results obtained when carrier - on an acre basis - consisted of 3 gallons of diesel, an emulsion of 1 gallon of diesel in 4 gallons of water, 5 gallons of water, 10 gallons of water, 25 gallons of water, or 50 gallons of water. This would indicate that 3 gallons of diesel or 5 gallons of water could be used to spray an acre of sagebrush in a satisfactory manner, thus making possible airplane application.

4. At least one pound of either 2,4-D or the mixture per acre is required to give a satisfactory kill of big sagebrush, although under optimum conditions as little as 1/2 pound per acre may be good results. Since we do not yet know what optimum conditions are - at least in exact terms - recommendations would favor use of 1 to 2 pounds per acre.

5. Although tests made in 1946 gave as high as 86% kill of big sagebrush plants, the 1949 tests probably will not give over 60% kills with one-pound of 2,4-D per acre. However, of the remaining 40% of the unkilled plants, most of the foliage has been removed, and past experience indicates that these individual branches will remain defoliated. For this reason, a total effect on all plants within the plots was estimated, and on this basis as high as 90% of the sagebrush foliage has been removed.

6. The ester form of 2,4-D gave better results than the amine or sodium salt.

7. Combined results would indicate that 2,4,5-T is more effective than 2,4-D, but definite recommendations on this will have to await the final field examination of the plots.

The variability in experimental results causes us to hesitate to make definite recommendations at this time. It would be well, however, for those who have or can rent equipment, to make small scale tests using the above information. In this manner you can determine how these herbicides work in your area. If you obtain reasonable success, you can enlarge operations another year.

It appears that spraying should be limited to: 1. Areas that have a fair understory of desirable forage grasses and weeds. 2. "Islands" of sagebrush not killed by a burn, but which would furnish a source of seed to regenerate sagebrush on the burned areas. 3. "Islands" of sagebrush not easily plowed, but within a larger plowed area. It must be kept in mind that brush killed by herbicides will remain standing for some time. For this reason, drilling grass seed can not accompany spraying operations.

Higher elevation sagebrush ranges are characterized by an undercover of grasses and weeds. These areas are best treated by merely reducing the sagebrush to give the grass and weeds less competition and to make the forage more available to livestock. Railing is often well adapted here. When perfected, herbicidal control will be well adapted to this zone. Railing may result in sagebrush kills up to 65% and increasing forage production by as much as 50%. No figures are yet available on forage increases of sprayed areas in big sagebrush, but observations indicate that there is not the great increase obtained when sand sage is sprayed with 2,4-D. The effect of the release from competition from big sagebrush apparently takes a little longer than the release from sand sage competition. Because of the susceptibility of many weeds to 2,4-D and 2,4,5-T, spraying may not be desirable in these higher elevation sagebrush areas when they are grazed by sheep. In such cases, railing would be the preferred method of sagebrush control.

It is apparent, then, that brush-land management requires the consideration of the climate and forage producing capabilities of the area, the time of grazing and kind of grazing animals using it, the amount and kind of forage present on the range, and the characteristics of various eradication methods which might be used in any control or improvement program. At present, mechanical control measures are most widely adapted, burning next, and chemical control, at least for big sagebrush, limited in its adaptability and not yet perfected.

Introductory Remarks To Control of Aquatic Weeds

by

W. T. Moran, U. S. Bureau of Reclamation
Denver, Colorado

My only function in offering you these introductory remarks, at least as I see it, is to present three of my younger hard-working colleagues of the Bureau of Plant Industry, Soils and Agricultural Engineering, Department of Agriculture. Most of you are aware of the fact that the Bureau of Plant Industry and the Bureau of Reclamation have been embarked on a joint weed control research project during the past 4 years. The three Bureau of Plant Industry representatives shown on your program will discuss in detail their field findings as particularly related to the control of submersed and emergent weeds in irrigation facilities during the past year at their respective stations. In order to afford you an orientation on the matter of aquatic weed control, there will be presented to you a very brief film which we have recently prepared showing pictorially field application and laboratory phase work in chemical control methods. This film requires about 10 minutes and will give many of you who are not too familiar with the field of aquatic weed control a good background for the discussions which follow in turn by Jesse Hodgson of the Meridian, Idaho station, Vick Bruns of the Prosser, Washington station; and Fred Arle of the Phoenix, Arizona station.

I am going to call on John Shaw, Reclamation Engineer, to show the film and explain the high points. Mr. Shaw, who many of you know personally, is a member of my staff and has been directly in charge of the weed control research program here in Denver since its inception.

(Followed by 10 minute film on laboratory investigations and field applications of aquatic weed chemical control methods.)

Control of Emergent Aquatic Weeds 1/

by

J. M. Hodgson 2/

Emergent waterweeds found in slow flowing canals, drains, and around storage reservoirs present a very formidable problem of control to irrigation project operators. Most waterweeds of this type are known to be flagrant wasters of valuable irrigation water. For instance, one acre of cattails (*Typha* spp) and Tules (*Scirpus* spp) have been reported by the Bureau of Reclamation (1) to absorb and evaporate 8 or more acre feet of water in one year.

Emergent waterweeds, as referred to in this report are those plants which normally start growth and must grow at least a part of their life cycles in water. The leaves, flowers, and other portions of the plant are usually above water. Only a few of the more common emergent aquatic weeds, which are troublesome on irrigation systems and on which reports of control tests were available, will be included in this discussion.

Several people working on weed control problems were called on for assistance in making this report. A list of those contributing information used in this report, with accompanying references in the test, is attached. Their cooperation is very much appreciated.

Cattail

Infestations of cattail are undoubtedly the most serious problem of emergent aquatic weeds found in irrigation systems. In fact this plant has resisted chemical control treatments so persistently that it is considered by some to be the number one unsolved weed control problem on irrigation projects. Although more investigation is now being directed toward control of cattails than any of the other emergent waterweeds we do not yet have any effective, economic control for them.

2,4-D treatments made by several investigators have given negative results. V. F. Bruns (3) reports that applications of 6 pounds per acre of 2,4-D in the ester form were generally ineffective. TCA treatments at 109 and 163 pounds per acre were also considered ineffective for permanent control. Although there was some reduction in original heavy stands from some of the highest rates of treatment, the results did not justify the costs of the chemicals and operations.

L. D. Wirth (9) stated that cattails have resisted control treatments consisting of a combination spray of 320 pounds of ammate and 1.8 pounds of 2,4-D per acre, also that 2,4,5-T at 750 and 1125 ppm did not give any noticable control of heavy infestations of cattail.

A. B. West, Bureau of Reclamation (8), reported cattails to be a very troublesome weed throughout Region 3 and states that it is necessary periodically to undertake costly dragline cleaning operations to keep water channels in effective operation.

1/ Cooperative investigations in weed control with the Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture, and the Ada County Weed Control Division, Meridian, Idaho, and the Idaho Agricultural Experiment Station.

2/ Assistant Agronomist, U. S. Department of Agriculture.

He states that suppression of cattails is obtained with 3 pounds of 2,4-D acid in the form of an ester, or 4 pounds in the form of an amine salt combined with 10 to 15 gallons of oil and enough water to make 150 gallons of spray per acre.

Bowser (2) states that one spraying of cattails (Typha latifolia) with 4.23 pounds of 2,4-D acid as the ethyl ester in 350 gallons of liquid per acre resulted in 50 per cent kill of plants growing in water and 80 per cent reduction in density of those above the water line. Retreatment was made at the same rate per acre 5 weeks later, after burning the debris resulting from the first treatment. Field counts revealed 85 per cent reduction in cattail density five months after the treatments were started. He reports that ester forms of 2,4-D are more effective than 2,4,5-T preparations or any combinations of sodium or ammonium salts of 2,4-D.

Combination of 2,4-D with various materials such as ammate, kerosene or tributylphosphate, which aid in penetrating the waxy cuticule of cattails, generally improved results. E. W. Surber (5) stated that a 5 per cent solution of 2,4-D in tributylphosphate and kerosene gave effective control of cattail.

Applications of the amine salt of 2,4-D in combination with ammonium sulfamate (4) gave quite satisfactory control of cattail in one test. Two pounds of 2,4-D and 40 or 80 pounds of ammate were combined and applied in 80 gallons of water per acre. The treatments were made just prior to emergency of the fruiting stalk. These treatments gave complete control of cattails for the remainder of the season and less than 30 per cent regrowth occured the following year. These treatments were made on a cattail infestation which did not stand in water continuously. A short time after treatment the water was drained from the ditch for a few days. This may have influenced the results of these treatments. Others have often observed and reported better results from chemical treatments when cattails and other emergent waterweeds were not standing in water continuously.

Applications of ethyl ester of 2,4-D at 2 pounds per acre resulted in good control of cattails in this test. Less than 20 per cent regrowth occured the following season. STCA and ATCA at 218 pounds per acre caused 50 per cent reduction of stand as recorded the following season.

Most reports specified the esters of 2,4-D to be much more effective than other formulations on cattail. Generally, 3 pounds of acid or more per acre were the most effective treatments.

Applications of 2,4-D on cattails at different stages of growth were reported most effective when made just prior to heading, or emergence of the fruiting heads, and until female parts of the cattail head reached full size.

Control of cattails by mechanical means seems to have promise in some situations. Uhler, 1944 (7) reported that cutting cattails at the ideal time gave the most effective and economical control of cattails. He stated that the first cutting was accomplished when the staminate male flowers had matured and the female portions of the cattail heads were nearly developed. The second cutting was made 4 to 6 weeks later. Nearly complete control of cattails was frequently obtained from two such treatments. He found that this method of cutting was more effective than five cuttings made periodically and beginning earlier in the same season when root reserves of the cattail plants were at a higher level.

A method of drowning cattails is outlined in the recent bulletin on "Control of Weeds on Irrigation Systems" published by the Bureau of Reclamation (1). The cattails are cut beneath the water surface as near to the ground as possible necessitating new shoots to grow through as much water as possible to reach the surface. The number of cuttings required depends on the depth of the water and stage of plant growth when cutting is started. Care must be exercised so that leaves of the plants are not exposed above the surface between cuttings as the diffusion of air into rizhomes may cause previous work to be lost. Mr. E. T. Oborn, in testing this method in the greenhouse, found this method to be unsuccessful. Crafts (10) reports that cattails and tules have been killed by treating with a water emulsion of Benoclor 3C the same day that they were cut. The plants should be cut below the water line and just above the soil surface, before applying the water emulsion of Benoclor 3C. Treatment must be made during spring or early summer while weed growth is still rapid.

Results of a cattail root reserve study now in progress by F. L. Timmons (6) indicates that the carbohydrate reserve is lowest just as cattail heads reach full size. One season results of spray treatments on various stages of growth indicate that 2,4-D applied at this stage of growth to be very promising. E. T. Oborn is also studying the carbohydrate reserves of cattails. Results of this work may provide some very worthwhile results.

Water Smartweed (Polygonium spp)

Some of the polygonium species are found as emergent waterweeds interferring in operation of irrigation systems.

A rather serious infestation of one of these species of emergent waterweed is rapidly spreading on the North Platte Project.

L. D. Wirth (9) of the Bureau of Reclamation reported that water smartweed was controlled very effectively where it had been cut over previous to an application of aromatic solvent to control submersed waterweeds. The water smartweed was cut by hand a week previous to the solvent treatment. Aromatic solvent at the rate of 5.2 gallons per cubic foot per second was injected into the water in a 7 minute period. About 4 weeks later 95 percent of the smartweed had disappeared.

Chemical treatments tested to control swamp smartweed (Polygonium coccineum) in Idaho (4) showed 2,4,5,T, 2,4-D and 2,4-D in oil at rates of 1 to 3 pounds of acid per acre when applied in late summer on this weed were ineffective.

Tules (Scirpus spp)

Tules are an emergent type of waterweed which occur in many of the situations that cattails do. However, tules are not as entensive on irrigation systems. Information concerning control of these plants seems quite limited. E. W. Surber (5) indicated that a 1 per cent solution of 2,4-D in tributylphosphate and kerosene at 20 to 200 gallon per acre gave effective control of tules. Three to four sprayings with aromatic oil in a season have also been reported to eliminate tules.

Watercress (Nasturtium spp)

Watercress is also difficult to control and is found mostly in slow flowing drainage systems. 2,4-D treatments have been effective in killing the emergent foilage but did not seem to effect the plant below the water. Some success has been reported by combining 2,4-D foilage treatments with aromatic solvent applications in the water about the same time.

There are many more emergent aquatic weeds which cannot be discussed in this limited report. It is very evident that these plants are a major control problem in operation of irrigation systems. Present means of control are generally quite ineffective and costly.

Reference List:

1. Annonomous. Control of weeds on irrigation systems, bulletin 1949 Bureau of Reclamation, U.S. Department of Interior, Washington, D. C.

2. Bowser, C. Cattail control, report April 1949, Region 3, Bureau of Reclamation, U. S. Department of Interior.

3. Bruns, V. F. Annual Reports, 1947, 1948, 1949, Division of Cereal Crops and Diseases, BPISAE, U.S.D.A., Irrigation Experiment Station, Prosser, Washington.

4. Hodgson, J. M. Annual Report, 1948, 1949, Division of Cereal Crops and Diseases, BPISAE, U.S.D.A., Weed Experiment Station, Meridian, Idaho.

5. Surber, Eugene Control of Aquatic plants in ponds and lakes, July 1949, Fishery leaflet 344, Fish and Wildlife Service, U.S. Department of Interior.

6. Timmons, F. L. Annual Report 1949, Division of Cereal Crops and Diseases, BPISAE, U.S.D.A., Utah Agricultural Experiment Station, Logan, Utah.

7. Uhler, F. M. Control of undesirable plants in waterfowl habitats. Trans, Ninth N. American Wildlife Conference, 1944. P295-303.

8. West, A. B. Correspondence, Regional supervisor, Branch of Operation and Maintenance Region #3, Bureau of Reclamation, U.S. Department of Interior, Boulder City, Nevada.

9. Wirth, L. D. Correspondence, Water smartweed test, Bureau of Reclamation, U.S. Department of Interior, Casper, Wyoming.

10. Crafts, A. S. Control of Aquatic and Ditchbank Weeds, Calif. Agric. Extension Service. Circular 158. Oct. 1949.

SUBMERSED AQUATIC WEED CONTROL IN IRRIGATION CHANNELS

V. F. Bruns 1/

The serious problems created by various kinds of weeds growing on ditchbanks in irrigation channels are well known to most people concerned with water distribution and drainage systems. Yet, the enormity of the problem and the terrific toll extracted each year by these weeds are difficult to visualize, even for the most interested observers.

Agronomist Robert B. Balcom, Bureau of Reclamation, Washington, D. C., recently published on a survey conducted by the Bureau of Reclamation in 1947 and 1948. This survey revealed that irrigation water losses due to aquatic and ditchbank weeds in the seventeen western states are an estimated 1,272,480 acre-feet annually, with a gross value of nearly $25,500,000.

For convenience in conducting and reporting weed control investigations, aquatic weeds have been placed in three major groups: (1) submersed, (2) emergent, and (3) floating. Submersed plants, to which this discussion shall be limited, may be rooted in the bottom and sides of water channels, or free-floating under the water surface.

1/ United States Department of Agriculture, Agricultural Research Administration, Bureau of Plant Industry, Soils and Agricultural Engineering, Division of Cereal Crops and Diseases and Washington Agricultural Experiment Stations, cooperating

Some species may bloom above the water or have some floating leaves but otherwise be submersed.

Chaining, an old method of aquatic weed control, has been used on many projects. Two chaining operations, or more, a season usually have been required to sufficiently control submersed aquatic weeds. Each operation has necessitated travelling up and down a channel with equipment a number of times, depending on conditions of weed growth and other factors. A crew using hand methods or a drag-line must catch and remove weed growth released by the chain to prevent clogging of structures downstream. This method has been considered expensive, especially on small laterals. However, chaining has been continued on large main canals and drains because of the limiting costs of chemical treatments and the added advantage of controlling such emergent and ditchbank weeds as cattails and tules.

Draining water and drying the channels has been another method of submersed aquatic weed control. This method usually has required at least 5 days two or three times a season, and has been done during a period when water was needed for crop lands. Although effective in channels that could be quickly and thoroughly drained, this method has proved unsatisfactory in many instances and very unpopular with water users.

Copper sulphate and chlorinated compounds have been used in the past to control submersed aquatics chemically. Copper sulphate at relatively light concentrations has been effective on free-floating mosses, or algae, but not generally satisfactory on plants rooted in the channels.

The advent of aromatic solvents has greatly increased the efficiency of chemical control methods, especially from the standpoint of costs. Through the cooperative efforts of federal, state, and local agencies, about fifty different irrigation channels were treated with aromatic solvents on an experimental basis in Washington, Idaho and Arizona during 1949. At the same time, thousands of gallons of these materials were used on a field scale throughout the West by the Bureau of Reclamation and private irrigation districts.

Information gained through questionaires and other means, indicated that aromatic solvents have been generally effective against submersed aquatic weeds and popular with the users. Treatments considered thoroughly effective have cleared the channels of clogging weed growth and permitted unimpeded water flow. One potent treatment per season has frequently sufficed as far as water delivery has been concerned, except in areas with year around or long periods of irrigation. Since aromatic solvents have not been purported to damage the embeded root systems of submersed aquatics seriously, some regrowth from these sources has been expected. The necessity for retreatments has depended on the time and effectiveness or original treatments, amount and rapidity of regrowth, length of season, turbidity of the water, and other factors.

Sufficient information has not been made available to determine a definite superiority of one commercial product over another. However, Type A solvents (boiling point range 278-420° F.) generally have given somewhat better results than Type B solvents (boiling point range 275-360° F.). Although the oil-soluble petroleum sulfonates (mahogany soaps) used as emulsifying agents have given generally satisfactory results for distance ranging from 1/3 to 2 miles per treatment, emulsifiers have been more consistent than the solvent products. The development of newer type emulsifiers has led to satisfactory treatments of channels, with larger capacities, for distances ranging from 5 to 10 miles in some regions.

The recommended rate for applying aromatic solvents during the past year was 300 parts per million (4.05 gals. aromatic solvent per cubic foot per second of water flow) introduced into the stream over a 30-minute period. Most reports indicated that higher concentrations (400-600 ppm for 30 minutes) were more effective, especially on such stubborn species as the sago, giant sago, and Richardson's pondweeds. A report from Arizona showed that one treatment at 1200 ppm for 30 minutes was not entirely satisfactory, and that treatments usually were effective for only .3 to .4 mile. The high salt concentration of the waters of this and similar areas has been suspected of rendering aromatic solvent treatments comparatively less effective. Incidentally, the addition of salts has been used industrially for cracking certain emulsifying films for a number of years.

Booster applications at various concentrations have been made from ½ to 2 miles below the initial stations, depending on the holding capacities of the emulsions and lengths of channels treated. This has been necessary to maintain the desired killing concentration of the solvent blankets. Because of the time involved and high costs of labor, some users have favored "initial shots" at strategic points along the channels rather than waiting for the "blanket" in order to make "booster shots".

The best time to apply aromatic solvents for the control of various species of submersed aquatic weeds has not been determined definitely. However, optimum results have been obtained by treatments made when weed growth was beginning to interfere with the water flow noticeably, and before the weeds reached the water surface. Frequently, this is near the bud stage. Although effective on weed growth, treatment very early in the season often has permitted rapid regrowth. Moreover, some users have started treatments no sooner than was absolutely necessary, generally depending upon the number of channels or miles to be treated, in order to take advantage of rising water temperatures which apparently have influenced the effectiveness of the chemicals.

Sago and giant sago pondweeds have been reported to be among those most difficult to control with aromatic solvents. Richardson's and American pondweeds have also been somewhat resistant to solvent treatments because of their heavy stems. White water-crowfoot, or white buttercup, and species of algae were among the most susceptible.

The practice of cutting the water flow during treatments has been followed extensively. This seemed justifiable since less chemical was required to build up a desired concentration. However, experience has proved that cutting the water flow too much may result in the massing and compacting of weed growth, especially along the sides of the channels near the water surface. Aromatic solvents have been most effective when sufficient water was present to permit free movement of individual plants in a surrounding medium of treated water.

Thorough dispersion of the chemical in the water before it comes into contact with weed growth has been of utmost importance. Aromatic solvents are lighter than water. Unless completely dispersed, these emulsions do not extend to the bottom of the channel and tend to rise to the surface and bread more rapidly. The introduction of chemicals immediately above a weir or other structure, with a considerable drop and turbulent pool, has promoted adequate dispersion. In the absence of such structures, compressed air booms attached to large compressor units and placed in the water immediately below the spray boom have provided chemical dipersion. An advantage in mixing the aromatic solvents with water prior to introductions has also been reported. This has been accomplished without the handling of additional liquid by using two-fluid nozzles, or by introducing the aromatic solvents under pressure into the bell of a centrifugal pump discharging water directly into the channel.

All types of spraying units, ranging from ½-inch gear pumps with small spray booms to large orchard sprayers with orchard guns, have been used successfully for introducing aromatic solvents. Although various types of nozzles at pressures ranging from 50 to 100 psi have given good results, dispersion and stability of emulsions has been increased occasionally by the use of small orifice nozzles and high pressures. Since aromatic solvents are inflammable, frequent and thorough checking of spray units for leaks has reduced the fire hazard. Hose, gaskets, washers, and grease that are resistant to aromatic solvents have been necessary parts of the equipment.

The capacities of channels successfully treated during 1949 ranged from 1 to 150 cubic feet per second. Although sometimes difficult to obtain, an accurate measurement of water flow in a channel has been highly important in attaining the desired chemical concentration over a period of time. Irregular channels frequently have dead water pockets that dilute the chemicals. Furthermore, irregularities in channels and linear velocities of water flow have been reported to increase the distance the emulsion is carried, but they decrease the effectiveness on plant growth. Slow moving streams are reported to have an opposite effect.

Since each water channel presents an individual problem, a hard and fast rule for determining the best control method has not been possible. Important considerations have been the availability and cost of aromatic solvents, which varied considerably during 1949. Prices in the Pacific northwest ranged from $0.33 to $0.85 per gallon for solvents, and $0.94 to $7.50 per gallon for emulsifiers. Ready-mix or emulsified materals were obtained for $0.55 to $1.10 per gallon. Competition appeared to be the main factor in governing prices in different localities, although shipping costs had some effect. Several irrigation projects have treated small laterals at over-all costs ranging from $10 to $16 per mile, as compared with $80 to $200 per season for previous hand cleaning methods. However, as the capacity of the channels and price of materials increased the cost of chemical treatments approached that of other cleaning methods.

Not all aromatic solvent treatments for aquatic weed control were completely successful during the past season. Additional research and more practical trial runs are needed to determine the most efficient use of these materials. However, rapid progress has been made and the practical use of aromatic solvents has given a high percentage of satisfactory results during the past season. A general resume of reports indicated that far greater quantities of aromatic solvents will be used for aquatic weed control during 1950 than were used in 1949, unless costs of materials prohibit it.

THE EFFECT OF AROMATIC SOLVENTS AND OTHER AQUATIC HERBICIDES ON CROP PLANTS AND ANIMALS

H. Fred Arle 1/

Since the effectiveness of aromatic solvents for controlling many varieties of submersed aquatic weeds was first discovered in 1947 by technicians of the Bureau of Reclamation and the Bureau of Plant Industry, there has been much concern regarding the possibility of crop injury by treated irrigation water. In the past, precautionary measures have been advised. Whenever possible, turnout gates, located immediately below the point of application were closed and treated water was either wasted or allowed to flow a considerable distance before being used for irrigated crops. Such measures allowed the emulsion to break, and the eventual disappearance of solvent through evaporation. The Bureau of Plant Industry has undertaken experiments to test the toxicity of the aromatic solvents on crop plants. These have included greenhouse and field tests during the past two years. Although the results are still not conclusive in all cases, there is considerable evidence that crop plants are not damaged by concentrations required for weed control in irrigation waters.

1/ United States Department of Agriculture, Agricultural Research Administration, Bureau of Plant Industry, Soils and Agricultural Engineering, Division of Weed Investigations and University of Arizona Agricultural Experiment Station, Cooperating.

The first crop tolerance tests was a series of applications made to potted plants by V. F. Bruns at Prosser, Washington. The effects of various concentrations of solvent on lettuce, lima beans, orchard grass and Ladino clover was observed. Each treatment in this study consisted of the addition of 150 ml. treated water to the plants.

The first of successive applications were made to lettuce plants which averaged 5 inches in height. Five retreatments were made during the following 17 days. The concentrations of solvent naptha applied were 10, 80, 160, 320 and 1280 ppm. The four lowest concentrations caused no evident injury other than a slight wilting of the lower leaves. After the fifth application at 1280 ppm. the leaves became pale and somewhat decumbent and the final application resulted in rapid plant deterioration. Examination of the roots showed that they had been almost completely destroyed.

Six consecutive treatments of lima beans, the first of which was applied when the plants averaged 13 inches in height, produced no apparent injury to foliage or roots at concentrations up to 320 ppm. At treatments of 500 ppm. and above, damage to roots systems was observed, with the extent of injury proportional to the concentration.

Orchard grass was more resistant than any of the other plants under treatment. Eight applications ranging from 40 to 2000 ppm. during a period of 18 days resulted in no evident injury to either the above ground portions or root systems. Ladino clover appeared to be more susceptible to solvent treatments than did lettuce, lima beans and orchard grass. After 8 consecutive treatments, a trace of injury was observed at 100 ppm. However, injury to clover could not be evaluated until after 5 treatments at 200 ppm. After 8 applications to this same concentration, an average of 50% damage to root systems was recorded. Ladino clover injury was characterized by reddening and weakening of the stems, yellowing and shriveling of the leaves and general stunting of plant growth.

J. M. Hodgson initiated field plot trials at Meridian, Idaho in 1948 and continued these experiments in 1949. The conditions under which a field crop might be subjected to treated irrigation water were simulated as nearly as possible. The treated water was either flooded across plots or passed through irrigation furrows with the excess effluent passing off at the lower end.

During the 1948 season, various concentrations of aromatic solvent were applied to spring wheat, potatoes and sweet corn. Concentrations ranging from 600-2200 ppm. were applied to wheat for 30 minutes while it was in the booting to heading stage. A 20% decrease in yield was obtained with the highest concentration but no adverse effects were observed at 600 and 1200 ppm.

Aromatic solvent did not cause any reduction in yield or reduce the table quality of Netted Gem potatoes when treated by row irrigation for one hour at 185, 550 and 1000 ppm.

Similar concentrations of treated water were used on sweet corn and no reduction in the table quality of roasting ears was detected. Yield data were not obtained because several stray cattle voluntarily assisted with the harvest. In 1949, the treatments were repeated on potatoes and sweet corn and sugar beets and beans were added to the test. Solvent concentrations of 400, 800 and 1200 ppm. were maintained for a period of 30 minutes in each application. The resulting yields did not indicate injury by any of the treatments, in fact, the yield of sweet corn and stover was slightly higher on treated than untreated plots.

Crop tolerance tests were started at Phoenix, Arizona in 1949. Water containing 400 and 800 ppm. aromatic solvent was applied to alfalfa, cotton and milo. In this test all plots were completely bordered and none of the treated water was allowed to flow off the plot. Each irrigation was carried on for 40 minutes, during which time the equivalent of 3 acre inches water was introduced. Water stood on the plots from 1-2 hours after irrigation had stopped. The odor of solvent was easily detected in the soil for 2-3 days following treatment. Treated water used for the first irrigation following crop emergence caused some injury and killed a small percentage of the plants. Alfalfa seedlings that were completely submerged by the treated water were killed to the ground. Most, however, developed new shoots from the root collar and resumed normal growth. Later applications to alfalfa had no injurious effect other than damaging the lower leaves which were suspended in treated water.

Seedlings of cotton and milo that were completely or nearly completely submerged died within several days following treatment. Later applications had no apparent effect on growth although in the case of milo there was a trend toward reduced yields from applications made prior to the heading stage. Applications after the milo had headed did not effect the yield adversely.

In one case reported from Washington, in which irrigation water treated at 300 ppm. passed through a sprinkler system in an alfalfa field, a noticeable burning of alfalfa leaves resulted. The damage, however, was temporary and the alfalfa recovered very rapidly. The presence of solvent in water applied through a sprinkler system will cause acute toxicity to the foliar parts. Treated water should be avoided when a crop is to be sprinkled.

Several years ago the University of Arizona conducted several experiments with Benoclor 3C. This compound sometimes has been used for killing weeds in irrigation canals.

In the first experiment pots were filled with soil and sown to wheat. Six weeks after germination, the plants were watered with Benoclor solutions ranging from 10-500 ppm. None of these concentrations injured the wheat. One week after Benoclor applications, soil samples were taken from each pot for a micro population count. These counts showed a reduction in both molds and bacteria but the reduction was no greater from 500 ppm. than from 10 ppm. Also it was noted that the colony counts still were very high in soil treated at 500 ppm. In another experiment, only one concentration, 500 ppm., was used and treatments were made at various stages of growth. When this concentration was added at planting time there was no germination. Plants treated one week after emergence died in 6 days. Later treatments, up to but not including the 6 week old plants showed some degree of injury.

A third experiment was conducted to determine the residual effects of Benoclor. Pots used in the previous experiment were planted to corn. The corn germinated in every pot including one that had been treated only 9 days before the corn was planted. The corn in this pot grew as well as did the check, while the growth of corn in pots treated at an earlier date was even more rapid.

It is fortunate that the aromatic solvents and Benochlor are toxic to fish and fish food animals, usually at concentrations lower than is required for weed control. There is a theory that while solvents may be directly toxic to fish, the greatest injury is due to cutting off the oxygen supply. Crayfish, polywogs, bugs and even mosquito larvae are also killed. Solvents were used successfully in 1948 on the Belle Fourche Project in South Dakota and by the Imperial Irrigation District in California to kill Crayfish.

No reports of injury to livestock or poultry have been received. Because of the sprong odor and disagreeable taste, it appears unlikely that animals would drink strong treated water even when thirsty.

WEDNESDAY, FEBRUARY 1

PROGRAM OF THE RESEARCH SECTION

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

Chairman

THE PHYSIOLOGY OF WEED CONTROL

Prepared by Dr. A. S. Crafts
Presented by Mr. W. A. Harvey

Physiology treats the application of chemical and physical principles in the study of life processes. Since the origin, the maintenance and the cessation of life are basically physiological, weed control is obviously applied plant physiology. And the action of herbicides involves physiological processes fundamental to the survival of the species involved.

My title today is very inclusive. However, because most of you are familiar with the broader aspects of weed control by cropping and cultural methods I will confine my talk to four phases of chemical control that are developing rapidly at the present time. These are:

(1) Absorption of herbicides,

(2) Selectivity of herbicides,

(3) Translocation of herbicides, and

(4) Mechanisms of herbicidal action.

Absorption

In order to understand the mechanics of absorption by plant cells it is necessary to consider the nature of the substances being absorbed, the nature of the medium in which they are carried and the properties of the plant tissues themselves. I will start by contrasting the properties of the two common carriers of herbicides, water and oils.

Water is a very unusual liquid. Being so common we take it for granted although chemically it is unlike most other liquids. Being composed of hydrogen, a strongly electropositive element and oxygen, one of the most electronegative, water is extremely stable. In addition to their normal valence attractions hydrogen has a secondary valence of plus one while oxygen has a secondary valence of minus two. Because of these residual valences water molecules have strong forces of attraction for each other; the liquid is strongly coordinated and tends at low temperatures to assume a lattice structure.

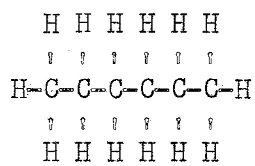
Because the electrical charges on the water molecule are separated from each other, each molecule has a plus and a minus end. The molecules are polar. Thus water is not actually H_2O or even H–O–H but has a structure = $O\langle^{H^+}_{H^+}$. We might compare it to a small magnet with positive and negative poles.

When the molecules spin they set up strong electrical force fields; the liquid has a high dielectric constant; it tends to saturate the electrical field between the ions of polar compounds such as the common water soluble salts. This lessens the attractive forces between the ions and they wander from their fixed positions in the crystal; in other words they go into solution. For this reason water is an excellent solvent for polar substances, common salts that dissociate in solution. Because of their strong coordination bonding forces, water molecules hydrate most ions, and many molecules containing the electronegative elements fluorine, oxygen, nitrogen, chlorine and sulfur. Some of these elements are contained in practically all herbicides.

Turning to oils, these are of four general types:

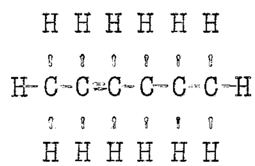
(1) aliphatic or saturated chain compounds having carbon atoms arranged in straight or branched chains as:

Normal hexane



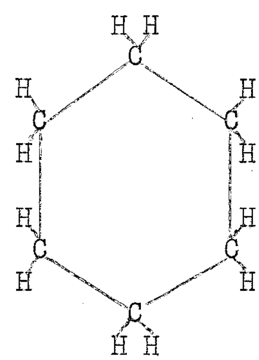
(2) Olefinic chain compounds containing double bonds between carbon atoms (unsaturated) as:

Hexene



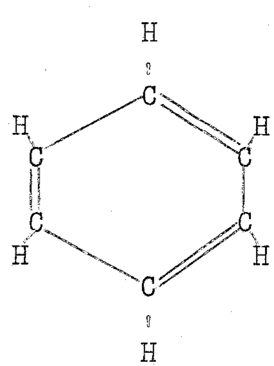
(3) Saturated ring structures termed naphthenic, as;

Cyclohexane



(4) Unsaturated ring structures termed aromatic, as:

Benzene



All of the carbon atoms mentioned have hydrogen atoms attached to them and the compounds are termed hydrocarbons. Most oil molecules are symmetrical and hence nonpolar. Oils have low dielectric constants and low surface tensions. They are mostly less dense than water; their internal structure shows random assortment of chains or rings as contrasted with the quasi-lattice structure of water. Table 1 shows some of the physical properties of water and a few oily compounds.

Properties	Water	Methane	Hexane	Benzene
Mol. Wt.	18	16	86	78
Density	1.00	.001	.66	.88
Boiling point	100°	-164°	68.7°	80.4°
Melting point	0°	-184°	-95.5	5.4°
Surface tension	75.6	—	20.5	31.6
Dielectric const.	81	—	1.8	1.0

Solutions are homogeneous mixtures of different ionic or molecular species. Ionizing compounds dissolve readily in water because their strong force fields are saturated by the polar water molecules; non-ionizing compounds dissolve because the mutual attractions between their electro-negative elements and the electro-positive hydrogen of water constitute bonding forces resulting in strong hydration. Examples of ionizing herbicidal compounds are sodium arsenite, sodium chlorate, sodium borate, ammonium thiocyanate, ammonium sulfamate, sodium pentachlorophenate, the salts of 2,4-D and of trichloroacetic acid. Non-ionizing solutes are sugar, glycerine, alcohol, polyethylene glycol (carbowax) and other cosolvents and sequestering agents of organic composition.

Oils are good solvents for oily compounds. For instance the four types of oils mentioned above all dissolve readily in each other. Furthermore many undissociated compounds of non-polar character dissolve in oils; such compounds are benzenes, phenols, and weak organic acids. Herbicidal compounds of this type are chlorinated benzenes, aromatic solvents of the xylene type, pentachlorophenol, dinitro substituted phenols, dichlorophenoxy acetic acid and maleic hydrazide. The more polar of these compounds dissolve best in the more polar types of oils, that is the unsaturated types.

Emulsions are mixtures of immiscible liquids; oil and water for example. Since almost any two liquids differ in density, such mixtures tend to separate into distinct layers if they are not agitated constantly. Emulsion stabilizers are compounds having molecules that are polar at one end and non-polar at the other. When added to emulsions those molecules arrange themselves at the interfaces between the immiscible phases. For example when a petroleum sodium sulfonate stabilizer such as Oronite wetting agent is added to an oil-water emulsion, the petroleum ends of the stabilizer molecules dissolve in the oil droplets and the sodium sulfonate (polar) ends dissolve in the water. The oil droplets assume like electrical charges and hence repel each other; this keeps them apart, they do not coalesce, hence the emulsion is stable.

Breaking the oil droplets up into extremely fine particles further stabilizes the emulsion because these very fine particles are constantly agitated by Brownian movement, the kinetic agitation of the molecules. Homogenization does this. The virtues of an emulsion stabilizer in an oil emulsion herbicide are two-fold. The very properties that orient the molecules so that they stabilize the oil-water interface also reduce the interfacial tension and make the water more oil-like. For this reason the stabilized emulsion spreads readily over the waxy surface of the foliage, covering the weeds completely and creeping to a limited extent down into the crowns. This is a favorable distribution for a contact type of herbicide and in such sprays a stabilizer is of great value.

Plant surfaces are of two different types. The absorbing surfaces of the roots, adapted to the function of absorbing water and mineral nutrients are composed of highly distinct hydrated, partially dissociated pectic substances. These substances are polar in nature and they are compatible with the polar compounds that the plant requires from its soil environment. To be readily absorbed from the soil by roots herbicides applied to the soil should be in the form of dissociable salts or as compounds that will hydrolyse in the soil. The common soil sterilants are of this type.

The remainder of the plant is covered with a protective layer specialized to prevent rapid loss of water. This is particularly true of the larger stems and roots; leaves have small openings (stomata) by which CO_2 absorption and loss of water vapor may take place under a certain degree of control. The remainder of their surfaces are covered with cuticle that restricts but may not entirely prevent loss of water vapor.

Most herbicidal sprays are applied to the leaves of weeds and in order to be absorbed into the living tissues they must penetrate the cuticle. This is a waxy coating, non-polar in nature, with a residual negative by electrostatic charge. Negative ions in solution are repelled by the cuticle; positive ions are attracted and held on the surface. Highly polar molecules dissolve with difficulty in the cuticle and hence are not readily absorbed. Undissociated compounds of non-polar character (oil-like) dissolve and pass through readily. This is the reason that undissociated substituted phenol and phenoxy acetic acid molecules are more effective than their corresponding ions; that esters of such acids are more effective than salts.

To summarize the problems of absorption, if a weed killer is to be presented to the plants through the soil for absorption by roots it should be in a water-soluble and hence in a polar form. Colematic, arsenic trioxide, or 2,4-D acid are not exceptions, being highly toxic they are applied as compounds of low solubility simply to prolong their release to the plants. They enter the plants in ionized form after slow dissolution as hydrolysis in the soil. The toxic vapors of CS_2 chloropicrin and DD are not exceptions; they are all somewhat soluble in water; there is evidence that they also enter the older roots through the non-polar periderm layer.

Selectivity

I will treat the various types of selectivity briefly trying to relate each to known characteristics of the solutions used and the plants to which they are applied.

1. Differential wetting.

Because the leaves of cereala, flax, peas, young alfalfa, onions and a number of other crop plants are highly cutinized and often corrugated or irregular on the surface, highly polar liquids such as water solutions or herbicidal salts fail to wet them whereas certain weeds are readily wet. For best results the spray should be coarse with ample velocity; the crop plants should not be wet with dew.

2. Morphological selectivity.

Plants of mustard, radish, fiddleneck and other weeds have their growing or meristematic tissues at the tips or in their leaf axils. These can be hit by a spray. In contrast, grass plants grow from meristems located at or below the soil surface and protected by the bases of all the lower leaves. To kill grasses you need a spray of low surface tension, such as an oil that will creep and penetrate down into the crown, and kill the meristematic tissues.

3. Selective spray placement.

Because grass plants and most mature broadleafed plants have their basal stem tissues protected by surrounding leaves or bark it is possible to spray low in the crop with a general-contact herbicide and kill all young weeds including grasses. Many herbicides can be used selectively this way. Examples are salts of the substituted phenols, fortified oil emulsions, straight oils, 2,4-D, TCA, maleic hydrazide, etc. Crops are corn, sugar cane, onions, cotton, flax, alfalfa and other field crops when planted in rows. This method is very useful for controlling weeds in row crops being raised for seed.

4. Biochemical selectivity.

If young barley and carrot plants are sprayed with a light aliphatic oil neither will die, if about 30 percent of a xylene type aromatic oil is included in the spray the barley will die and the carrots remain unharmed; if pure xylene is used both plants die. If these same true species are sprayed with 10 ppm of 2,4-D amine in water the carrots may twist and curl but neither plant will die. If 1000 ppm is used the carrots will die and the barley will be unharmed. If 10,000 ppm are used both species will die. These are examples of biochemical selectivity; this effect is relative with respect to concentration of the toxicant and depends upon the susceptibility of the plants involved. Because weeds and crop plants growing together constitute a mixed population of varying susceptibility to chemicals it seems possible that eventually selective herbicides for every common crop situation may be discovered. Biochemical selectivity is the most reliable type because it is less subject to dosage, concentration, and environmental variables.

5. Selective soil sterilization.

Because plants exhibit varying susceptibility to toxicants applied through the soil, herbicides may be used to control weeds in growing crops. An example is the use of 2,4-D salts as pre-emergence treatments in corn, sugar cane, milo, and similar crops. Even grass seedlings have been controlled by such practice. The principal drawback is the uncertainty of rains in many regions; with no rainfall the treatment fails and with too much the chemical is leached away resulting in poor results.

6. Life habit - annuals vs. perennials.

Selective control of annual weeds in perennial crops is often feasible if the application can be made while the crop is dormant or just after a harvest. Examples are the use of the fortified oil emulsion spray to kill winter annual grasses such as foxtail, rip-gut and annual blue grass in dormant alfalfa during the late winter. Certain broad-leafed annuals such as mustards, radish, shepherd's purse and fiddleneck may also be eliminated. The same treatment may be made during the crop season by applying the spray just after removing a crop. This is most feasible where the alfalfa is removed green for dehydration.

In all work with selective sprays it should be remembered that selectivity is relative. For example, 2,4-D at 250 ppm may be used to kill Ribes species in the forest; no harm is done to conifers and many other brushy species. At 500-750 ppm, 2,4-D will kill mustard out of flax; and at 1000-2000 ppm it will control fiddleneck in barley and lilies in rice. At excessive concentration 2,4-D will injure any plant and in every situation there are definite limits of concentration between which it is safe to work. This rule applies to other selective herbicides as well and in all situations where selective sprays are used the operator must know and keep within these limits if he is to have success with the chemical.

Translocation.

Work with the hormone indole acetic acid, with 2,4-D and a number of other herbicides has proved that when these chemicals are applied in water-soluble form to the roots of plants they are absorbed and translocated through the stems to the leaves in the transpiration stream. If the concentration is adequate and the supply is maintained toxic chemicals so used will kill the plants. Sodium arsenite, sodium chlorate, ammonium thiocyanate, ammonium sulfamate and a host of other herbicides will move through plants in this way and accumulate in the tops resulting in speedy death.

Furthermore, if tops of plants are immersed in solutions of these toxic chemicals, the toxicant will be absorbed and translocated through the xylem from the immersed shoots down into roots and across interconnecting roots into other shoots. This is the basis for the jar method, used to kill wild morning glory in strawberry patches, and employed by the California State Department of Agriculture in their fight against camel thorn.

If phosphates, sugars, indole actic acid or 2,4-D compounds are sprayed on the leaves of plants that are moving food materials from the leaves into the roots, these chemicals may migrate across the mesophyl into the phloem and translocate into the roots along with the foods. A good many experiments indicate that such movement in the phloem is determined by the flow of the food materials in solution and not by a gradient of the applied material. For example such movement from starch filled leaves will take place in the dark but from depleted leaves, light and presumably photosynthesis is required. Varying the amount of 2,4-D applied had very little effect on the rate of movement in bean plants but the degree of bending of the stem was closely correlated with dosage.

There is limited evidence that certain compounds undergo polar transport in plant tissues. Sugars traversing the mesophyl may be concentrated in the phloem; indole acetic acid will move downward in the oat coleoptile whereas a gradient 1000 fold greater is required to induce crosswise movement; 2,4-D applied to many plants accumulates in cambium and apical meristems when it kills the cells whereas surrounding parenchyma survives.

There is also evidence for another type of polar movement, one determined by physical forces of the environment. For example indole acetic acid is influenced by light to move to the shaded side of the oat coleoptile causing bending toward the light. Auxin in lodged grain stems is influenced by the gravitational field to accumulate at the lower side causing upward bending. And 2,4-D applied to wild morning glory moves downward through the tap root but may not penetrate more than an inch or so into laterals, in spite of the fact that food is moving into the laterals to supply their needs in growth and storage. Such polar movement of 2,4-D explains many of the responses one finds where the material is used under varying conditions in the field.

The transport of 2,4-D and similar substances in the plant depends upon many factors. Movement through the cuticle and intervening mesophyl into the phloem is a relatively slow process; after the chemical enters the phloem, experiments indicate that movement is quite rapid. As mentioned above it seems to be related to food movement rather than to any mechanism depending upon the 2,4-D gradient.

Response to hormone-like herbicides depends not alone on the absorption and translocation but also upon the condition of the receiving tissues; meristems respond whereas mature parenchyma does not; young roots may be killed while old roots survive. In considering field results with 2,4-D formulations some of the results are explainable on the basis of the conditions mentioned above. Field results indicate that 2,4-D esters are two or three times as toxic as the salts when used as contact herbicides on mustards in grain or on lilies in rice. However, as translocated herbicides on deep-rooted perennials there may be little or no difference between them. On the other hand the suspended 2,4-D acid applied in an emulsion containing just enough non-toxic oil to hold the particles on the leaves has proved superior in a number of instances. Perhaps the ester penetrates the leaves so rapidly that injury to the mesophyl and phloem prevents the required translocation. The slower moving salt would, under these conditions, move in subtoxic amounts into the roots where accumulation in the meristematic regions would result in ultimate injury. The suspended acid might be absorbed and moved even more slowly, at least during the first few hours, resulting in an even greater accumulation in the roots. That the initial toxicity of the spray inhibits translocation is indicated by early experiments where 2,4-D in aromatic oil and in dinitro fortified oil failed to kill roots of cattails where translocation was essential. The same 2,4-D dosage applied above killed the roots of many of the plants.

Mechanism of toxicity

Problems of herbicidal toxicity are complex because many chemicals are used having various phytotoxic properties. Among the classical materials arsenic, borax, and chlorate are used in relatively large quantities; arsenic is a protein precipitant; boron causes chlorosis and death through nutritional disturbance; and chlorate, antagonizing nitrate, causes chlorosis and nutritional deficiency. As sprays they are required at rates of several pounds per acre; through the soil several hundred pounds may be necessary.

Toxicity of oils seems related to two properties, the size of the molecules, as this determines volatility, and hence exposure time, and the degree of unsaturation. Saturated (aliphatic and naphthenic) hydrocarbons are relatively low in toxicity; olefinic and aromatic hydrocarbons are more toxic.

Starting with a series of aromatic hydrocarbons, toxicity is found to increase with increasing numbers of straight alkyl substitutions; for example the series benzene, toluene, xylene, cumene exhibits such properties. These non-polar substitutions render the benzene more oil-like and probably enhance its penetration through the cuticle.

In contrast polar substitutions also increase toxicity; phenol is more toxic than benzene, and chlorine substitutions increase toxicity of phenol up to the penta form. Nitro groups also increase phenol toxicity. Various polar and non-polar groups may be placed on the phenol molecule to produce such a compound as dinitroortho, secondary butyl phenol, the most toxic, non-hormone molecule in common use as a herbicide. In this case increase in molecular weight gives a molecule that will not volatilize; exposure time is prolonged. Non-polar groups such as the butyl chain make the molecule oil-like; it readily penetrates the cuticle. And the polar intro groups render it very reactive, it destroys the protoplasm when present only in minute amounts.

Of great interest is the toxic nature of the herbicides that act in small amounts; the dinitro compounds I.P.C., maleic hydrazide, 2,4-D, etc. Apparently these compounds work through enzyme systems in plants, disturbing growth and metabolism and eventually killing the tissues.

If introduced directly into the stomach of a sheep dinitro compounds bring about a rapid rise in temperature resulting in death. The same amount of chemical sprayed upon green vegetation and fed to the animal causes no disturbance. Evidently these very reactive compounds are altered during their contact with plant cells in such a way that they no longer cause their typical response in the animal. Possibly their role is to uncouple the processes responsible for normal energy transfer in cells resulting in a rapid and destructive dissipation of the stored reserves.

I.P.C. is the isopropyl ester of phenyl carbamic acid. Urethane, the ethyl ester of carbamic acid is an antipyretic and an inhibitor of photosynthesis. Other esters of carbamic acid are known to have sedative and hypnotic properties. It is interesting that IPC should have growth inhibiting properties, particularly on roots, and that it should be specific for certain grasses.

Maleic hydrazide has a heterocyclic ring structure with four carbons and two nitrogens in the ring; it has two double bonded oxygens that should be fairly reactive. Maleic hydrazide is a strong growth inhibitor; on sugar beets, cotton, and tomato it causes malformation of leaves; on tomato and flax axillary buds are induced to expand. On young tomato plants concentrations of 0.2% and above cause antho-cyanin pigmentation and stunting resembling curly-top infection. On older tomatoes shoots both terminal and axillary have symptoms resembling shoe-string virus. On grasses growth is inhibited; old leaves turn yellow and die. At sublethal concentrations grass plants are stunted, tillering is stimulated and maturity delayed.

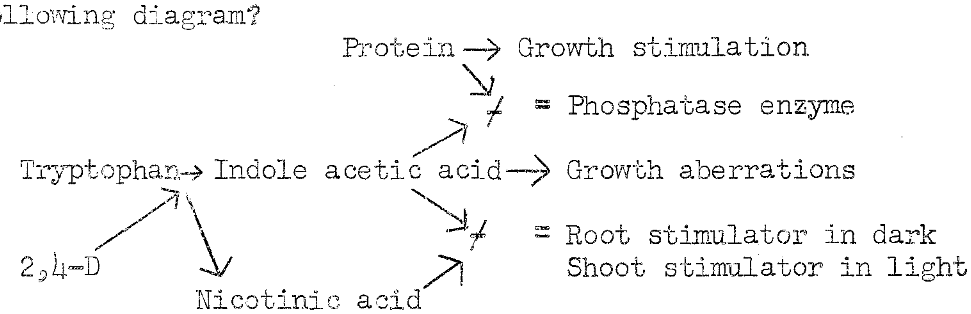
Much speculation as to the mechanism of toxicity attends the herbicidal use of 2,4-D. Van Overbeck has proposed that because 2,4-D resembles auxin it is absorbed into leaves where it may combine with protein to form an auxin-like enzyme capable of splitting high-energy phosphates into inorganic phosphate with release of energy. As this occurs there is increased respiration, hydrolysis of starch and a general depletion of food reserves. Olsen working at Davis has found a reciprocal relation between root growth and phosphatase activity with increasing 2,4-D concentration in the medium.

Paatela has proposed that 2,4-D supplements the natural auxin in plants. As a result normal plants treated with 2,4-D develop an excess which proves toxic whereas weak or shaded plants acquire a more normal supply and hence are stimulated.

Considering the physiological responses of both stimulation and repression of growth depending on concentration and the great array of morphological responses observed it seems that these theories of 2,4-D toxicity are too simple.

Bonner and Wildman have suggested that tryptophane may undergo two fundamental transformations, one to a protein, the other through indole pyruvic acid to indole acetic acid. If 2,4-D could be shown to affect the equilibrium between tryptophane and these two products a broader interpretation presents itself. If protein is favored, stimulation of growth might result whereas, increase in auxin might cause the variety of morphological aberrations observed.

Galston has recently pointed out a third product that might come from tryptophane, namely, nicotinic acid. He shows that nicotinic acid and indole acetic acid in the dark favor root initiation while in the light they favor shoot growth. Could it be possible that the two above schemes could be combined into a more complete picture as indicated by the following diagram?



If, 2,4-D should affect the above transformations, increase in protein might explain the growth stimulation of cotton shoots, grape tendrils, and many seedlings found in the light and that of root growth in the dark. Increase in indole acetic acid might bring about the morphological aberrations so commonly observed in 2,4-D treated plants. And in proper combination indole acetic acid plus nicotinic acid might stimulate root initiation and growth, as observed on treated plants. On the other hand a favorable combination of protein and indole acetic acid might result in increased phosphatase which in turn would account for depletion of stored food. Such a combination might explain the stimulation found from low application of 2,4-D, the translocation, accumulation in and death of meristems from intermediate dosage, and the immediate contact killing and restricted translocation resulting from heavy application of the readily absorbed esters.

Soil Sterilants for Perennial Weed Control

C. I. Seely, Agronomist
Idaho Agricultural Experiment Station

Soil sterilants as used in this report are restricted to those chemicals which when added to the soil make it unsuitable for the growth of the weed concerned. They may be applied either as a spray or dry but their major action is through the soil. The period of soil sterility produced varies from a few days or weeks to a number of years, depending upon the material, the soil, climatic conditions, and the weed species involved. Some sterilants are used for annual weed control, some for perennial weed control and others for the control of all vegetation. Relatively short period sterilants are normally used on agricultural lands and long period sterilants on non-agricultural land. Since the cost of these materials is usually high their use is normally limited to small areas where absolute eradication in a short period of time is desired for protective purposes. Soil sterilants have a definite place in any well organized weed control program and in many areas their use is being and should be materially expanded.

Many chemicals have been used as soil sterilants and a number are still in wide use in the Western states. Among the latter are sodium chlorate, carbon bisulfide, and borax. Most chemicals if applied to the soil in sufficient quantities produce soil sterility and hence the choice of sterilant is largely determined by costs and the suitability of the material to the job at hand. At lower rates most soil sterilants exhibit some selectivity and this partially determines the choice of sterilant.

A number of compounds which appear to be suitable for soil sterilization purposes have been inadequately tested to be certain of their possible place in weed control programs. In the following tabulation an attempt has been made to list the various soil sterilants in use with their general uses and limitations (other than costs) and also to call attention to a few compounds which inadequate tests have indicated may have merit in some lines of work. These compounds are indicated by question marks on rates, etc. in the table. Many factors determine the efficiency of any soil sterilant and hence definite rates for large areas are impossible. Dates of application vary widely with climatic conditions, and climatic conditions at least partially determine uses. As a consequence, the tabulation does not give specific rates, etc. but attempts to give the range over which they are normally used. Many of these materials are commercially available in many forms and where this occurs the rates are given in equivalents of either the toxic ingredient or a common form.

The following tabulation is not a complete list of soil sterilants, it is more a selected list since a number of compounds in limited use have been ommitted, either because of minor use or lack of available information. A few may have been ommitted through oversight.

In the use of soil sterilants, specific recommendations should be obtained from your own experiment station or extension service. This list should in no way be considered as a recommendation either for the use of the materials mentioned or the rates and dates of application; it is merely given as a guide to some of the materials that could be used for soil sterilization.

Table 1. A Summary of the Characteristics and Uses of Soil Sterilants in Perennial Weed Control

Material	Period of Sterility	Use[1]	Rate	Hazards	Normal season of application	Major Factors Determining Effectiveness	Normally Used for Control of following Perennial Weeds
Sodium chloride	Long	A & SRP	1/4-1 lb. sq. ft.	None	Spring & Fall	Soil type & rainfall	Seldom used. Kills Klammath weed, Tansey, & similar weeds.
Arsenic	Long	A & SRP	3-6 lbs. As_2O_3 equiv. sq. rd.	Poison	Fall, winter & spring	Soil type & species	Seldom used. Kills Klammath weed, Tansey, & simiiar weeds.
Borax	Medium	A & SRP	1-3 lbs., Boron equiv. sq. rd.	None	Fall*, winter & spring	Species & soils	Klammath weed, Tansey, & similar weeds. Occasionally used on leafy spurge & dogbane.
Sodium chlorate	Medium	DRP	2-6 lbs. sodium chlorate equiv. sq. rd.	Fire & Poison	Fall*, winter & early spring	Soil, rainfall & species	Most perennial weeds. Erratic on white top, camel thorn, & perennial groundcherry
Sodium chlorate plus borax	Medium	A SRP & DRP	Depends upon ratio, 1:3 is 3-12 lbs. sq. rd.	Fire variable with mixture	Fall*, winter & spring*	Soil, rainfall & species	Seldom used on perennials but can be used on most.
Ammonium sulfamate	Short	SRP	2-5 lbs. sq. rd.	Slightly corrosive	Winter & spring*	Rainfall, soils & species	Most frequently used on brush but can be used on Klammath weed, Tansey, quackgrass, & similar weeds.
Ammonium thiocyanate	Short	SRP	? 1-6 lbs sq. rd.	Corrosive	Winter & spring*	Rainfall, soil, & species	Inadequately tested but may be good for quackgrass & other shallow rooted grasses particularly, & for Klammath weed, Tansey, etc.
Carbon bisulfide	Short	DRP	1 1/2 - 3 gals sq. rd.	Fire & Poison	Spring, summer* & fall	Soil, moisture, temp. & species	Generally good on all deep rooted perennials
Prochlors	Short	SRP & DRP	? 40-100 lbs. per acre	Slightly corrosive	Spring, summer* & fall	? Soil type & species	Inadequately tested, good on those tested including quackgrass, Canada thistle, bindweed
Methyl Bromide	Short	SRP	? 200-400 lbs. per acre	?	? Spring & summer*	? Soil type, moisture, temp, species	Inadequately tested. Used primarily for killing weedseeds.

1. A = annual, SRP = shallow rooted perennials, and DRP = deep rooted perennials.

* Season most generally used

CONTROL OF PERENNIAL WEEDS BY CULTURAL METHODS
ALONE AND COMBINED WITH CHEMICAL TREATMENTS 1/

D. C. Tingey and F. L. Timmons 2/

The only reason we know that might account for our being selected to prepare the obituary for the cultural methods of controlling perennial weeds is that both of us have been active in the development of those methods. In order to determine just how dead an issue cultural methods of weed control really are, we prepared and sent out a questionnaire to 18 weed research workers in 13 states. Replies were received from 15 men in 8 Western and 2 Great Plain States. We were not surprised when the reports indicated that the patients -- clean cultivation and competitive cropping -- are still alive and may recover, although several amputations and transfusions may be necessary. A list of the research men who submitted reports is given at the end of this paper.

The reports showed that clean cultivation is still the only economical method of eradicating perennial grasses on cultivated land, and that clean cultivation, together with competitive cropping, must be used to supplement spraying with 2,4-D in order to obtain eradication or satisfactory control of Canada thistle, Russian knapweed, and white horsenettle on cultivated land. On the other hand, long periods of clean cultivation extending over a full cropping season or more is now definitely a relic of the past in controlling most perennial weeds, except on dryland areas where summer fallow is a normal practice.

Ten research workers reported on the control of wild morning glory. All were in general agreement that this weed can be eradicated in 2-4 years, usually 2 years, by clean cultivation at intervals of 8-12 days after each emergence, or every 14-21 days. Most of them stated that farmers in general have not had as good results as those in experiments, probably due to irregular and less effective cultivation operations. Clean cultivation alone is not being used to any extent on morning glory anywhere at the present time. The chief reasons are soil erosion losses, high costs, and loss of 2 or more crops during the cultivation period.

Competitive or smother crops in combination with intensive cultivation were reported as effective methods of eradicating morning glory over periods of 3 or 4 to as many as 8 years. While the use of competitive crops corrected most of the disadvantages of clean cultivation and the method became quite popular in some areas, it is now used very little except in dryland areas of Idaho and Kansas where summer fallow for small grains is a common rotation practice. The reason is that spraying with 2,4-D is an easy and inexpensive way of reducing the growth and stand of morning glory to a point where it does not interfere with crop production. Not one of the investigators obtained complete eradication with 2,4-D and cropping alone in periods as long as 4 years.

The majority of those reporting (4 out of 6) stated that spraying with 2,4-D did not reduce the number of subsequent cultivations necessary to eradicate morning glory. On the other hand, the opinion was 4 to 2 that a short period of intensive cultivation terminating a month or six weeks before spraying with 2,4-D definitely or slightly improved results. All of the men reported that grass competition appeared to increase the effectiveness of 2,4-D and the majority favored applying 2,4-D on morning glory in

1/ Professor of Agronomy, Utah Agricultural Experiment Station, and the Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture.

2/ Professor of Agronomy, Utah Agricultural Experiment Station, and senior Agronomist, U. S. Bureau of Plant Industry, Soils, and Agricultural Engineering, Division of Weed Investigations, respectively.

a growing grass, grain or corn crop rather than applying it between crops. However, spraying with 2,4-D in the spring before plowing and planting a sorghum crop, in summer before planting winter wheat, or in fall followed by seeding spring small grain were reported to give better results in some dryland winter wheat areas.

Summarizing the opinions of control of morning glory, spraying once a year with 2,4-D apparently is a satisfactory substitute for all cultivation except those operations necessary to control other weeds, conserve moisture, and prepare a seedbed. Intensive cultivation is necessary to complete eradication, but most weed workers and farmers are satisfied with control. Perhaps the fact that morning glory seed remains viable in the soil a generation or more as a constant hazard of reinfestation is largely responsible for the lack of hope for complete eradication.

Eight reports received on control of whitetop revealed a situation somewhat similar to that for morning glory. However, there were some important differences. Whitetop is killed somewhat more easily by intensive cultivation. Cultivating every 3 to 4 weeks gave complete eradication in $1\frac{1}{2}$ to 2 years, except on dryland areas in Montana, where dormancy of whitetop in summer extended the eradication to 3 or 4 years. The method was used very extensively until the last few years, but is now used very little anywhere, possibly for the same reason it is not used on Morning glory.

Methods most commonly used on whitetop consist of spraying in early spring, either in perennial grass of winter grain crop, or before plowing and planting to corn or a spring small grain crop. In some irrigated areas farmers prefer to wait and spray in the corn crop. Some investigators report applying a second 2,4-D spray in fall after small grain harvest or in perennial grass. Two men reported that spraying with 2,4-D in or before a grass or small grain crop had eradicated whitetop in 2 or 3 years, while two others stated that eradication had not been completed in two years. Three investigators reported that grass competition increased the effectiveness of 2,4-D on whitetop. One reported that it made no difference.

A common practice among farmers in some irrigated areas is to plow whitetop infested land deep early in the spring, work down immediately, and plant small grain, corn, potatoes, or sugar beets. After this set back, the whitetop caused little trouble in the crop. The practice will eventually eradicate whitetop if followed judiciously, but as commonly used it constitutes a method of living with the weed more profitably. Perhaps spraying with 2,4-D a week or two before plowing in the spring would improve the method and eliminate the whitetop more quickly. Some work has been done along that line, but the point has not been definitely established.

Seven reports received on Canada thistle revealed that this weed is rather easily eradicated in one or two years by intensive cultivation at intervals of 14 to 21 days. However, the method is being used very little on irrigated land. It is widely used on dryland areas in Northern Idaho, and to some extent in Montana. Alternate fallow and wheat was reported to be effective on Canada thistle, and is used to some extent in grain growing areas of Idaho and South Dakota. The most common method the last few years on irrigated land and on some dryland areas has been to spray with 2,4-D in a small grain crop or corn early in the summer, and if possible, a second time late in the season. Results in general have not been satisfactory.

All investigators were agreed that 2,4-D is more effective on Canada thistle growing in competition with perennial grass than on thistle on cultivated or non-crop land. The beneficial effect of grass competition in improving results with 2,4-D was much more definite with Canada thistle than with morning glory or white top. Most of those reporting recommended spraying Canada thistle in an irrigated pasture with 2,4-D in both spring and fall.

Two research workers found that spraying with 2,4-D reduced the number of subsequent cultivations necessary to eradicate Canada thistle, and that a short period of cultivation before spraying with 2,4-D improved results. A third investigator reported negatively on both points.

Only five reports were received on the control of Russian knapweed. All of these agreed that knapweed is somewhat harder to kill by cultivation than Canada thistle or whitetop, but eradication was accomplished in 2 to 3 years by cultivating at intervals of 14 to 21 days. Clean cultivation is being used very little by farmers at present, largely because most knapweed infestations are in small scattered patches or in orchards where intensive cultivation practice is difficult to carry out.

Two men reported experience with attempting to control knapweed by 2,4-D in combination with competitive cropping. In both cases the knapweed was growing in competition with perennial grasses. Two applications of 2,4-D per year reduced considerably, but did not eliminate the knapweed in 3 years in one case and 4 years in the other.

Two reports from Kansas on dogbane stated that that weed had been eradicated in 3 years by intensive cultivation at intervals of 21 to 28 days. One investigator in Arizona reported that white horsenettle was not eradicated in 2 years by cultivations at intervals of 7 to 14 days, but the weed was eradicated in 3 years by growing winter oats and cotton with intensive cultivation between crops and also in cotton. Another report from Arizona stated that nut grass (Cyperus sp.) had been eradicated in 3 years by shallow cultivation every 7 days and had been eliminated in 3 or more years by growing winter small grains and sorghum smother crops in rotation with intensive cultivation between crops. These methods are not being used to any extent at the present time on either weed. No reports were received on results with chemical treatment in combination with cropping or cultivation in the control of dogbane, white horsenettle, nut grass, or other perennial weeds not previously mentioned.

Two investigators in Montana and Oregon reported that quackgrass had been eradicated in one year or slightly more by cultivating every 6-10 days. Three research workers in Arizona and Kansas have found that Johnson grass can be killed in one year by cultivating every 14 days or even at longer intervals of 21 to 28 days. An effective and common practice in Arizona for control of Johnson grass is early plowing each year followed by intensive cultivation before and after cotton is planted. Several investigators reported that a cultivation just before or soon after treating quackgrass with TCA definitely increased the kill. However, the economy of the use of TCA on cultivated land is questionable. One investigator reported that only one cultivation following treatment with Pro-chlor was necessary to eliminate quackgrass, and that this method had possibilities economically on land capable of producing high value crops such as mint. At the present time we have no effective and economical chemical substitute for intensive fallow in the eradication of perennial grasses from cultivated land.

To summarize the present situation, it appears that during the past several years since the advent of 2,4-D, farmers and weed control workers have rather generally abandoned all use of intensive cultivation and cropping systems planned primarily for weed control on weeds that could be controlled temporarily with 2,4-D. During this period of high prices for agricultural products, the emphasis has been on keeping every possible acre producing cash crops. Fortunately, 2,4-D provided a relatively inexpensive means of temporary control for many of the broadleaved weeds. Most farmers and many weed workers have held fast to the hope that 2,4-D would actually prove the miracle worker it was first advertised and publicized to be. However, it is becoming more and more apparent that 2,4-D cannot be depended upon to consistently eradicate any of the creeping perennial weeds, even with repeated applications over a period of 3 to 4 years. To accomplish eradication, 2,4-d probably will have to be fitted into a combination program along with carefully planned cropping systems, and in some cases with periods of intensive cultivation. Several investigators have obtained promising results from experiments with such combination methods.

The inevitable lower support prices for wheat, cotton, potatoes and other surplus crops, and the acreage restrictions on such crops, probably will stimulate a renewed interest in actual eradication of perennial weeds from tillable land. Of course, eradication of morning glory and its accompanying seedling problem appears to be a long lasting and almost hopeless task. Once morning glory has been permitted to infest an area, the control and final elimination of old plants and recurrent crops of seedlings will require either spraying that infested land with 2,4-D once every year or two, or following closely a specifically planned program of crop rotation and cultivation for a generation or more. However, with Canada thistle, Russian knapweed, and whitetop, which do not present the longtime seedling problem, complete eradication of these weeds in a few years is an entirely practical objective, and probably more economical in the long run than continued use of temporary control measures.

Several of the weed research men who submitted reports suggested that under a program of restricted acreage of surplus crops, it might be advisable to seed all land infested with broadleaved perennial weeds to adapted perennial grasses or grass mixtures, and spray with 2,4-D once or twice a year until the weeds were eliminated. Where infested land is left in cultivated crop, present information suggests the advisability of using short periods of clean cultivation between crops selected for their ability to compete with the particular weed. The consensus is that no one method is adequate for satisfactory elimination or control of any of the perennial weeds in all situations. Rather, combinations of chemical and cultural methods that will keep the weed constantly at a disadvantage and enable the crop to provide more effective competition should be sought to the end that the weed may eventually be eliminated with the least possible expense.

Investigators who submitted reports on experimental results on the control of perennial weeds by cultural methods

1. Bohmont, Dale W., Wyoming Agricultural Experiment Station, Laramie, Wyo.
2. Bruns, V. F., Bureau of Plant Industry, Soils, and Agricultural Engineering, Irrigation Experiment Station, Prosser, Washington.
3. Cords, H. P., Arizona Agricultural Experiment Station, Tucson, Arizona. (Reported on investigations carried on by R. S. Hawkins, C. H. Davie, and T. J. Smith).
4. Erickson, L. C., Idaho Agricultural Experiment Station, Moscow, Idaho.
5. Freed, Virgil H., Oregon Agricultural Experiment Station, Corvallis, Ore.
6. Hodgson, Jesse M., Bureau of Plant Industry, Soils, and Agricultural Engineering, Meridian, Idaho.
7. Krall, J. L., Montana Agricultural Experiment Station Substation, Moccasin, Montana.
8. Phillips, Wm. M., Bureau of Plant Industry, Soils, and Agricultural Engineering, Fort Hays Experiment Station, Hays, Kansas.
9. Rasmussen, L. W., Washington Agricultural Experiment Station, Pullman, Washington.
10. Seely, C. I., Idaho Agricultural Experiment Station, Moscow, Idaho.
11. Stahler, L. M., Bureau of Plant Industry, Soils, and Agricultural Engineering, South Dakota Agricultural Experiment Station, Brookings, South Dakota.
12. Thornton, B. J., Colorado Agricultural Experiment Station, Fort Collins, Colorado.
13. Timmons, F. L., Bureau of Plant Industry, Soils, and Agricultural Engineering, Utah Agricultural Experiment Station, Logan, Utah.
14. Tingey, D. C., Utah Agricultural Experiment Station, Logan, Utah.
15. Warden, R. L., Montana Agricultural Experiment Station, Bozeman, Montana.

USE OF GROWTH-REGULATING COMPOUNDS IN CONTROLLING PERENNIAL WEEDS

* Bruce J. Thornton and Dale W. Bohmont

In gathering the information for this paper two Series of Questionnaires were prepared. Series I had to do with the treatment and control of specific weeds and Series II had to do with the general aspects of the use of growth-regulating compounds in weed control. These questionnaires were sent out to all Federal, State, County, and Industrial investigators known to be doing research on the control of perennial weeds in the 11 western states. Quite a number of these individuals reported that they had not been working on their respective problems long enough to permit their attempting to answer the questions. At the same time it is certain that many who could have contributed valuable information did not receive questionnaires, although every effort was made to make the list as inclusive as possible. Replies were received from all 11 states and one report was received from the neighboring state of Texas.

The response may be tabulated as follows:

Number of states involved	11
Number of states responding	11 (plus one report received from Texas)

Number of individuals receiving questionnaires	75
Number of individuals returning questionnaires	30

Number of individuals reporting from each state:
Arizona 3, California 7, Colorado 3, Idaho 1, (representing 2 individuals), Montana 4, Nevada 1, New Mexico 1, Oregon 2, Texas 1, Utah 2, Washington 2, Wyoming 1.

In summarizing the data offered by the questionnaires it is recognized that the questions were not always as definite or as complete as they should have been and that the questionnaires may be subject to criticism from several other angles. However, they represent an honest effort to assemble as much information as possible on the subjects involved.

Part I

Summary of the information contained in replies to the Series I Questionnaires dealing with the use of growth-regulating compounds in controlling individual species of perennial weeds.

Dale W. Bohmont
Wyoming Agricultural Experiment Station

The control of perennial weeds both herbaceous and woody has long constituted one of the major problems of the western states. Although much progress has been made in the development of materials and methods for the control of plants of this type in the past few years, many questions remain unanswered. The following is an effort to summarize the research results obtained from the use of growth-regulating compounds in attempting to control perennial weeds in the western United States as reported in the Series I Questionnaires which were sent to representatives of Federal, State, and commercial agencies known to be engaged in such weed control research. The interest in the subject is evidenced by the fact that 95 questionnaires were returned by 30 investigators who reported on 59 different species, involving 43 genera

* Colorado Agricultural Experiment Station and Wyoming Agricultural Experiement Station, respectively.

of perennial weeds. A summary of the findings reported has been set up in table form and is included as a part of this report. This table lists the weeds reported on with their botanical names and gives information on materials, stage of plant growth, time of year of treatment, rate of application, frequency of treatment, carrier used, percentage of growth reduction obtained, and the state from which each is reported.

In discussing the use of growth-regulating compounds in the control of perennial weeds, it is virtually impossible to generalize on such a heterogenous groups of plants growing under such a wide range of conditions as are represented in these reports. To facilitate this discussion, the weeds under consideration have been divided into two groups: (1) Perennial weeds of cultivated land, and (2) Perennial weeds of range and pasture land.

Perennial Weeds of Cultivated Land

The largest number of reports were received on individual weeds which normally infest crop land. The reports indicate that such weeds as Canada thistle, Russian knapweed, whitetop, and field bindweed are receiving the most attention by research investigators. It is generally recognized that perennial farm weeds which normally infest cropping areas constitute a problem which takes several years to control. Although several of the reports indicate a 99 plus per cent kill on certain species of this type of weed, there is no instance where complete eradication is reported. An interesting phase of these reports relates to the soil moisture conditions at the time of treatment and the practice of irrigating to produce optimum soil moisture conditions. Of the investigations which have incorporated this method of producing optimum conditions, there is general agreement that irrigating one week before or one week after treatment has increased the per cent of control.

The reports also emphasize that one of the most effective methods of controlling leafy spurge, as well as other weeds previously mentioned, is through a combination of crop competition and selective spraying. The most effective competitive crop is reported to be perennial grass pasture followed by spring grain.

The ester and the amine formulations of 2,4-D were consistently used at the same rates: however, there was not complete agreement on their comparative effectiveness. The general opinion appears to be that they are usually of equal effectiveness on herbaceous perennials when applied on an acid equivalent basis.

Satisfying results have been obtained by applying 2,4-D on fall growth of the various perennial weeds, but, in general the results were very erratic. The investigators indicate this may depend upon optimum moisture conditions.

Although 2,4,5-T was used in various experiments, its effectiveness did not exceed that of the 2,4-D formulations on herbaceous farm weeds.

Perennial Weeds of Range and Pasture Lands

Much research has been conducted on the control of range and pasture perennials, both woody and herbaceous, during the past year. In addition to the search for effective materials and concentrations, investigators are also faced with the economics of controlling undesired plants on relatively cheap land. For example, it is generally agreed that the economic control of brush and oak stumps in the Sierra Nevada foothills cannot exceed a cost of $10.00 per acre and, therefore, all research which has been conducted has considered this maximum cost. Likewise, the control of burroweed in Arizona is considered uneconomical if the total cost exceeds $3.00 per acre.

One of the most important points brought out by all of the reports on the control of woody plants is that successful control can be obtained only through thorough foliage application when the material is applied during the growing season. This necessitates the application of large volumes of herbicide carrier. The volume used on woody plants ranged from 80 to 500 gallons of water or oil-water emulsion per acre depending upon the density of foliage and the size of the plants being treated. The use of oil alone as a carrier ranged from 2 to 20 gallons per acre. There were several investigators who used wetting agents; however, a two per cent oil-water emulsion was the most common mixture used in applying the various herbicides on woody plants. Although several of the research workers reported the application of herbicides at the dormant stage, most of the material was applied when the plants were actively growing and fully leaved. This was usually during the spring of the year.

A satisfactory control of willows with 2,4-D was obtained by the application of eight pounds acid equivalent during the dormant period. Black willow trees 40 to 60 feet tall were killed by boring holes around the base at six inch intervals and inserting a teaspoon of undiluted ester of 2,4-D. The foliage application on willows likewise has been effective at 1,000 to 1,500 ppm, if care is taken to obtain complete foliage coverage. The reaction on gooseberry (Ribes) has been determined for 11 species. Seven species were found susceptible to 2,4,5-T at three pounds per acre while four species were controlled with one and one-half pounds of 2,4-D acid equivalent per acre.

Many species of sage (Salvia) and sagebrush (Artemisia) have been treated this past year with effective results. The concentrations ranged from one to four pounds of 2,4-D acid equivalent. The reports indicate that an important factor is the moisture condition at the time of treatment. Effective control has been obtained by either ground or air application. On several species of Salvia, 2,4,5-T was found to be effective when the plants were resistant to 2,4-D.

An important phase of range improvement in the western states is the control of poisonous plants. Such plants as sneezweed, larkspur, death camas and klamath weed can be effectively controlled by repeated applications of 2,4-D; however, here again the economic feasibility of control enters the picture and further investigations are necessary.

It is interesting to note the thoroughness of research being undertaken in the control of perennial weeds. Although the type of plant habitat varied greatly, the majority of the investigators were able to discuss all the questions which pertained to their problem and thus make this report possible. It is hoped that these data, which have been summarized through the cooperative efforts of the various investigators, will be of assistance in further research on the many unsolved weed problems.

Part II

Summary of the information contained in replies to the Series II Questionnaire dealing with the general aspects of the use of the growth-regulating compounds in controlling perennial weeds.

Bruce J. Thornton
Colorado Agricultural Experiment Station

It will be noted that although thirty individuals answered the Series I Questionnaire, only twenty-seven returned the Series II. In presenting this material the writer is taking the liberty to supplement some of the data with information based on own investigations.

1. (a) How long after treatment has residual effect in soil been noted?

No report - 11; 15 days - 1; 4 weeks - 2; 2 months - 3; 1-4 months - 1; 6 months - 2; 6 months to 1 year - 1; 12 months - 2; 18 months - 1; 2 years - 1; 3 weeks if soil is moist and 5 months if soil is dry - 1.

(b) Has it been noted the following year?

No report - 5; Yes - 8; No - 14.

(c) Does rainfall or irrigation reduce the effect?

No report - 8; Yes - 18; No - 1.

(d) Does plowing plowing reduce the effect?

No report - 16; Yes - 11; No - 0.

The writer found that under favorable soil moisture conditions, plowing before planting greatly reduced the residual effect. Pinto beans made a normal growth when planted following plowing one week after the application of 2,4-D while those planted four weeks after treatment without plowing showed marked residual effects.

It is recognized that the length of the residual period is influenced by many factors resulting in a wide range of answers as evidenced above. However, the evidence in general supports the concepts that the residual effect of 2,4-D is reduced by rainfall, by irrigation, by high temperatures, and by plowing and that it remains longer on heavy soils than on light soils. In planting crops following the application of 2,4-D these factors should be given full consideration, and, if possible, only tolerant crops should be planted and the planting should be delayed as long as conditions will warrant.

2. How soon after treatment may weeds be disturbed without reducing the effectiveness of treatment?

(a) By mowing?

No report - 11; 3 days - 2; 1 week - 2; 1 to 2 weeks - 1; 2 weeks - 2; 2 to 3 weeks - 1; 3 weeks - 3; 1 month - 1; 1 to 2 months - 2; 6 months - 2.

(b) By cultivating?

No report - 15; 1 week - 3; 10 days - 1; 2 weeks - 1; 2 to 3 weeks - 1; 3 weeks - 1; 3 to 4 weeks - 1; 1 month - 1; 1 to 2 months - 1; 2 months - 2.

(c) By plowing?

No report - 16; 1 week - 1; 2 weeks - 3; 3 to 4 weeks - 1; 1 month - 2; 1 to 2 months - 1; 2 months - 2.

In three tests on bindweed and one on silver-leaf poverty weed, conducted in Colorado, there appeared to be no reducing of the effectiveness when disturbed by plowing after 3 days. However, on the basis of the replies received, it appears that until more evidence is available treated areas should not be disturbed for two weeks and perhaps the longer the better, although there is indication that a much shorter time may be permissable.

2. (a) Do you consider the esters more volatile than the salts of these compounds?

No report - 6; Yes - 21; No - 0.

(b) Have you found any difference in the effectiveness of the different forms of the esters?

No report - 8; Yes - 8; No - 11.

(c) Have you found any differences in the effectiveness of the different forms of amine salts?

No report - 8; Yes - 5; No - 14.

(d) Have you found any difference in the effectiveness of the different commercial forms of the same growth-regulating compound?

No report - 9; Yes - 7; No - 11.

These answers indicate general agreement that the esters, within the alkyl group, are more volatile than the amine salts, one of the physiologists pointing out that, chemically, the salts are not volatile. It was also pointed out that drift is not necessarily a function of volatility and that it is very possible that the greater injury by esters to susceptible plants resulting from drift may not be due so much to the volatility factor as to the greater effect of the esters in micro-quantities as compared to the amines. The point is important only as it bears upon the question as to whether esters of less volatility will be sufficiently different in their action in this respect to justify their commercial development.

Those that expressed an opinion as to whether there was a difference in the effectiveness of the different esters were rather evenly divided, although somewhat favoring the negative. The same was true relative to the different commercial formulations of the same compound. There was a much stronger agreement that there was no difference in the effectiveness of the different amine salt formulations. In general it appears that the differences under consideration are not sufficiently marked to be consistantly apparent under a wide range of conditions so far as perennial weeds are concerned. One investigator, in reporting a difference in the effectiveness of the different esters, emphasized that the toxicity progressed to some extent from the lighter to the heavier molecular forms.

4. Do you agree that the amine salts of 2,4-D act more slowly than the esters, but are equally effective in the end?

No report - 4; Yes - 12; No - 11.

The answers here again were evenly divided. Several in the affirmative indicated the esters to be twice as effective as the amines, other stated the difference to be evident only on hard to kill weeds or when treated under adverse conditions, and others indicated the differences to be inconsistant. One answer indicated the amine salt to be more effective at times.

The writer has several tests which indicate that, on an acid equivalent basis within the usual range of rates of application, twice as much amine as ester is required to produce equivalent results, as based on a single year's application. However, in tests continued for five years on Canada thistle and Russian knapweed the differences between chemicals, including the sodium salt, and between rates (2, 3 and 4 pounds of acid equivalent per acre) tended to disappear, they being of doubtful significance after the third treatment which resulted in 99% reduction of the thistle and 93% reduction of the knapweed.

5. (a) Have you had opportunity to determine whether any of the new esters of lower volatility are less dangerous to adjacent susceptible plants than the more volatile forms?

No report - 2; Yes - 5; No - 20.

(b) Do you have any preliminary results indicating the effectiveness of any of the compounds referred to in the above question?

No report - 3; Yes - 5; No - 19.

In the few affirmative answers received it was pointed out, as mentioned under 3.(d), that, although the volatility was reduced, the danger from drift remained. The preliminary data on the effectiveness of these materials indicated them to be no better on ribes, a little better on some brush and apparently some better on woolly-leaved poverty weed. However, the available information is too limited to warrant more than passing notice.

6. Have you noted any difference in effectiveness of treatment as related to time of day of application and if so which time of treatment appears most effective?

No report - 7; Yes - 6; No - 12

The best times for treatment were reported as follows:

Morning - 2; Morning and evening - 2; Afternoon and evening - 2.

One investigator reported sunlight a factor and others indicated no consistency. It was also suggested that mid-day was a poor time to treat because of high temperature. No agreement indicated.

7. (a) Have you noted a wide variation in results from treatments made on different infestations of the same weed under what appear to be almost identical conditions?

No report - 1; Yes - 22; No - 4.

One investigator emphasized the point that these differences were not limited to different infestations but occurred in replications in the same infestation.

(b) Could this be due to factors not now recognized as influencing results and if so could you suggest some of them?

No report - 7; Yes - 20; No - 0.

The following factors were suggested as possibly influencing the action of 2,4-D on treated plants: (1) Physiological condition, (2) Genetic or clonal differences, (3) Cytoplasmic differentiation, (4) Organic acids in the plant, (5) soil fertility or unrecognized chemical constituents in soil or plants, (6) Root mass as effected by age of plants, by proximity of water table, or by proximity of gravel or impervious layers and, finally, (7) the inter-relationship or inter-action of a number of factors.

8. Do you think much reliance should be placed on one season's results and if not what do you recommend?

No report - 0; Yes - 6; No - 21.

The majority of those that replied "yes" to this question qualified their answers with some such statement as "if sufficiently replicated under a wide enough range of conditions".

The negative replies indicated two years as a minimum but most of them favored three or more years, involving as many different situations and conditions as possible.

9. Additional remarks, comments or suggestions:

Apparently those who responded to the questionnaire were pretty well exhausted by the time they got to this question as there were no additional comments.

Resume

The various reports indicated the residual effects of 2,4-D to be noted in the soil for periods varying from 15 days to one year. This great range in observations may be expected in view of the many factors which influence the length of time the material may remain in the soil. However, it was generally agreed that plowing or otherwise disturbing the soil, rainfall or irrigation, and high temperatures tended to dissipate the 2,4-D and that it remained longer in heavy clay soils than in light or sandy soils.

There was little agreement as to how soon treated plants may be disturbed after treatment without decreasing the effectiveness of the treatment but it appears that until more evidence is available at least two weeks should be allowed.

Although there seemed to be no question but that the esters in common use are much more volatile than the amine salts, there was considerable doubt indicated as to whether the volatility is entirely responsible for the greater damage to susceptible plants resulting from the use of these esters as compared to the amine salts.

The majority of the investigators reported no differences to be observed in the effectiveness of the different esters, in the effectiveness of the different amine salts, or in the effectiveness of different commercial formulations of the same growth-regulating compound. Those that reported differences to have been observed did not elaborate on their findings. It is probable that such differences as may exist in these categories are not too pronounced and are far outweighed by other factors.

The investigators were about equally divided as to whether the esters are more effective than the amine salts. However, only one person reported the amine salt to be superior to the esters while several reported the esters to be much more effective, or equally effective in smaller amounts, and especially on hard to kill weeds or under adverse circumstances. The results of one worker indicated any existing differences to be less apparent in tests carried over a period of several years.

Not enough work had been done on the new esters of reduced volatility to warrant any attempt to evaluate them.

Few observations were reported as to the effect of the time of day of treatment and they were not in agreement.

It was unanimously agreed that the action of the growth-regulating compounds is influenced by factors not now generally recognized and several such possible factors were suggested.

It was similarly emphasized that several years data are necessary before very much reliance can be placed on results.

The information received appears to support the following generalizations:

1. The growth-regulating compounds continue to offer great possibilities in effecting the control of perennial weeds, including both herbaceous and woody types.

2. The condition of the plant at the time of treatment as influenced by its age and environmental conditions, particularly with respect to available soil moisture, has far more bearing upon the results obtained than the type of growth-regulating material used, the rate of application (within reasonable limits), or other recognized factors normally involved.

3. The effective use of the growth-regulating compounds in controlling perennial weeds under arid, dry-land conditions poses a far more difficult problem than under conditions of higher rainfall and greater humidity or where irrigation is practiced.

4. Control, even of the most resistant or tolerant weeds, appears to be a distinct possibility, but only through persistent and continued effort combined with sound cultural practices.

In the overall picture the questionnaires evidenced the remarkable progress that has been made in the use of the growth-regulating herbicides. At the same time they indicated how much remains to be learned about the action of these materials as related to their most effective use and how great the need is for continued endeavor in both field and basic or fundamental research.

Common and Scientific Name	Formulation and amount per acre	Most effective Stage of Growth	Time of Year for Treatment	% Reduction Maximum	% Reduction Minimum	Number Treatments per yr	Carrier	Classification	Location or State
Alder Alnus sp.	3-5# E 2,4-D*	Full Leaf	Late Spring Early Summer	95	60	1	Water	Susceptible	Washington
Arrow Weed Sagittaria sp.	3-5# E or A- 2,4-D	Early to late bloom	Late Spring to Early Fall	100	---	2	Water	Intermediate	Arizona
Artichoke Thistle Cynara cardunculus	1½-2# E, A & S	Rosette	Spring	99/	50	1	Water	Very Susceptible	California
Austrian Field Cress Rorippa austriaca	1½# A 2,4-D	Pre-bud	Spring	100	90	1	Water	Very Susceptible	California
Big Sage Brush Artemisia tridentata	1-4# E 2,4-D	Bud to Early Bloom	Spring	85	50	1	Water	Intermediate	Colorado Wyoming
Blackberry Rubus sp.	1½-3# E 2,4-5-T	Bud to Full Growth	Late Spring Summer	99/	50	1	Water & 1-5% Oil	Intermediate	Oregon, California Washington
Black Sage Salvia mellifera	1½-3# E & A- 2,4-D 2,4,5-T	Full Leaf	Spring	95/	---	1	Water	Intermediate	California
Blue Oak Quercus douglasii	1½# E- 2,4,5-T	Early Bloom	Spring	50	---	Every 2nd yr.	Oil	Resistant	California
Burroweed Aplopappus tennuisectus	E-2,4,5-T E- 2,4-D (5000 PPM)	Active Growth	Spring or Early Summer	80	35	---	Oil only	Intermediate	Arizona
California Coastal Sage (1)-Artemisia Californica	1½-3# A or E 2,4-D	Full Leaf	Spring	95/	50	---	---	Susceptible	California
California Toyon Photinia Californica	1½# E 2,4-D or 2,4,5-T	Undetermined	Undetermined	---	---	1	Oil or Water	Resistant	California
Canada Thistle Cirsium arvenese	1½-4# E & A-2,4-D	Prebud to Early Bloom	Spring and Fall	99	30	1	Water	Intermediate	Idaho Mont. Ore., Color. Utah, Wash. Wyoming

* E=Ester, A=Amine, S=Salt

(1) 2,4,5-T not superior on A. Californica

Common and Scientific Name	Formulation and amount per acre	Most effective Stage of Growth	Time of Year for Treatment	% Reduction Maxi-mum	% Reduction Mini-mum	Number Treat-ments per yr.	Carrier	Classifi-cation	Location or State
Death Camas Zygadenus gramineous	2-3# E 2,4-D	Pre-bud	Spring	70	20	1	Water	Resist-ant	Wyoming
Field bindweed Convolvulus arvensis	1-3# E & A 2,4-D	Early bloom	Spring and Fall	95	50	2 per year	Water	Suscep-tible	Calif., Kans., Mont., Wyo., Uta Wash., Idaho, N. M. & Colo.
Gaura sp. Odorata (1) villosa coccinea sinuata	2-2½# E, A & S 2,4-D	Pre-bud	Spring	95	50	1	Water	Suscep-tible	California
Hazel Corylus sp.	3-5# E 2,4-D	Full leaf	Late Spring Early Summer	95	60	1	Water	Suscep-tible	Washington
Klamath Weed Hypericum perforatum	1-1/4 1½# E. 2,4-D 2-3# A 2,4-D 1½-2# E. 2,4,5-T	Pre-bud	Spring	100	95	1	Water & Spreader	Suscep-tible	California
Larkspur Delphinium (1) geyeri	1-3# E 2,4-D E 2,4,5-T	Bud to bloom	Spring	70	40	1	Water	Resist-ant	Wyoming
Leafy Spurge Euphorbia Esula	2-6# E & A 2,4-D	Prebud to Early bloom	Summer & Fall	80	20	1 or 2 per yr.	Water	Resist-ant	Montana Colorado
Locoweed Oxytropis sp.	1-2# E & A 2.4-D	Bloom	Spring to Early Summer	99/	50	1	Water	Suscep-tible	Wyoming
Milk Vetch Astragalus sp.	1-2# E & A 2,4-D	Bloom	Spring to Early Summer	99/	70	1	Water	Very Suscep-tible	Wyoming

(1) Rank of decreased susceptibility as listed

Common and Scientific Name	Formulation and amount per acre	Most effective Stage of Growth	Time of Year for Treatment	% Reduction Maxi-mum	% Reduction Mini-mum	Number Treat-ments per yr	Carrier	Classifi-cation	Location or State
Orange sneezeweed Helenium hoopesii	4# E & A 2,4-D	Bud	Spring	95	80	1	Water or oil	Inter-mediate	Colorado
Perennial Ground Cherry-Physalis sp.	1-4# E 2,4,5-T	Probably Early bloom	---	70	30	1	Water	Resist-ant	Idaho
Perennial Sow Thistle Sonchus arvensis	2# E & A 2,4-D	Bud Stage	Spring	90	30	1	Water or oil	Inter-mediate	Montana Wyoming
Poverty weed Iva axillaris	2-4# E & A- 2,4-D	Early bloom & Fall rosette	Spring and Fall	95	25	1	Water	Inter-mediate	Colorado
Purple Sage Salvia leucophylla	1½-3# E & A- 2,4-D	Full leaf	Spring	95/	---	1	Water	Inter-mediate	California
Ribes sp. petiolare nevadense roezlii bracteosum	1½# A & S 2,4-D	Early bloom until fruit is half grown	Late spring to Early Summer	95/	50	Every 2 years	Water and Tergi-tol	Suscep-tible	California
Ribes sp. lacustre montigenum viscosissimum inerme binominatum triste cereum	3# E 2,4,5-T	Early to Late Bloom	Late Spring to Late Summer	90	70	Every 2 years	Water and oil	Suscep-tible	California
Russian knapweed Centaurea repens	2-4# E, A & S 2,4-D	Bud to Bloom	Late Spring	99/	0	2	Water and Oil	Resist-ant	Idaho, Nev., Ore., Calif. Wyoming

Common and Scientific Name	Formulation and amount per acre	Most effective Stage of Growth	Time of Year for Treatment	% Reduction Maxi-mum	% Reduction Mini-mum	Number Treat-ments per yr	Carrier	Classifi-cation	Location or State
Salt Cedar Tamarix gallica	2-5# S, E & A 2,4-D	Early to Late Bloom	Spring to Fall	90	40	2 per year	Water	Resist-ant	Arizona Texas
Scotch Broom Cytisus sp.	3-5# E 2,4-D	Full Leaf	Late Spring to Early Summer	95	60	1	Water	Inter-mediate	Washington
Velvet Mesquite Prosopis juliflora velutina	E 2,4,5 T E 2,4 D (2000-5000 PPM)	Full Leaf	Spring	20	0	-	Oil or Oil and Water	Resist-ant	Arizona
Wedgeleaf ceanothus Ceanothus cuneatus	1½# E 2,4,5 T	Early Bloom	Spring	100	85	Every 3 yrs.	Oil	Inter-mediate	California
Western Ragweed Ambrosia psilostachya	2# E 2,4 D	Pre-bud	Spring	95	--	1	Water 2% Oil	Suscep-tible	California
White Franseria Franseria discolor	1-2# E & A 2,4 D	Early Bloom	Spring or Fall	95	50	1	Water	Suscep-tible	Colorado Wyoming
White Horse Nettle Solanum elaeagnifolium	3/4-4# E 2,4 D	Full Bloom	Late Spring	100	--	1 or 2 per yr.	Water	Suscep-tible	California
White malva Sida hederacea	2-3# A, E & S 2,4-D	Pre-bud	Spring and Fall	80	--	2 per year	Water & 2% Oil	Inter-mediate	California
White Sage Salvia apiana	1½-3# E & A 2,4 D & 2,4,5 T	Full leaf	Spring	95/	--	1	Water	Inter-mediate	California
Whitetop Lepidium draba	1½-4# E A, & S 2,4-D	Bud to full Rosette	Spring or Fall	95	20	2	Water & Oil	Inter-mediate	Mont., Ore. Idaho, Utah, Calif., Wash. Nev., & Wyo.
Wild Garlic and Onion-Allium sp	1# E 2,4-D	Pre-bud	Spring	98.5	--	1	Water & 5% oil	Mother bulb suscep-tible	Oregon

Common and Scientific Name	Formulation and amount per acre	Most effective Stage of Growth	Time of year for Treatment	% Reduction Maximum	% Reduction Minimum	Number Treatments per yr.	Carrier	Classification	Location or State
Wild Rose Rosa sp.	1-3# 2,4-D & 2,4,5-T (1000 PPM)	Late Bloom	Late Spring	90	30	1	Water	Susceptible 2,4,5-T Resistant 2,4-D	Utah
Willow* Salix exigua bebbiana nigra lasiolepis**	E. 2,4-D (1000-1500 PPM) (Foliage Spray) 8# 2,4-D per acre (Dormant spray only)	Full leafed or Fall (Dormant)	Spring or Late Fall	95	50	1	Water or Oil	Susceptible to Intermediate	Utah Texas Montana Washington
Woolly Pod Milkweed Asclepias eriocarpa	1/3-2/3# E. 2,4-D	Early Bloom	Summer	99/	---	1	Water and 1% Oil	Susceptible	California

* 2,4-D Salt at 1# per acre with oil or Dreft as spreader used in Texas

** 2/3# per acre in 160 gallons water reported to give eradication in two years in Washington

WEED QUESTIONNAIRE LIST

Bohmont, Dale	Agricultural Experiment Station, University of Wyoming Laramie, Wyoming
Bruns, V. F.	Bureau of Plant Industry, Irrigation Experiment Station, Prosser, Washington
Buck, W. L.	Irrigation Manager Bureau of Indian Affairs, Lower Colorado River Indian Agency, Parker, Arizona
Burge, Lee M.	State Department of Agriculture, P.O.Box 1027, Reno, Nevada
Cordua, W. J.	Farm Advisor, Visalia, California
Doran, Clyde	Rocky Mountain Forest & Range Experiment Station, United States Department of Agriculture, Fort Collins, Colorado
Erickson, Lambert	Department of Agronomy, University of Idaho, Moscow, Idaho
Freed, V. H.	Agronomy Department, Oregon State College, Corvallis, Oregon
Glover, L. C.	Shell Oil Co., Modesto, California
Harris, L. E.	Chipman Chemical Company, 2800 N.W. St. Helens Road, Portland, Oregon
Harvy, Don	Grazing & Range Management Department, Colorado A & M, Fort Collins, Colorado
Johnson, E.	District Supervisor California Seed Laboratory, Los Angeles, California
Krall, J. L.	Central Montana Branch, Station, Moccasin, Montana
Leiper, T. E.	Land Use Specialist, Upper Missouri District, Great Falls, Montana
Loomis, George L.	Land Use Specialist, Fairfield, Montana
Lowry, O. J.	Conservationist, Bureau of Reclamation, Box 536, Carlsbad, New Mexico
Meridian Weed Experiment Station, Meridian, Idaho	
Offord, H. R.	Bureau of Entomology and Plant Quarantine, 26 Giannini Hall, University of California, Berkeley, California
Price, Raymond	Director, Southwest Forest & Range Experiment Station, Tucson, Arizona
Pryor, M. R.	California Department of Agriculture, Sacramento, California
Rasmussen, Dr. L. W.	Department of Agronomy, Washington State College, Pullman, Washington
Resch, W. F.	Bureau of Reclamation, El Paso, Texas
Seely, C. I.	Department of Agronomy, University of Idaho, Moscow, Idaho
Swezey, A. W.	Dow Chemical Company, P.O. Box 245, Seal Beach, California
Thompson, A. N.	Bureau of Reclamation, Amarillo, Texas
Thornton, Bruce	Seed Laboratory, Colorado State College, Fort Collins, Colorado
Timmons, F. L.	Department of Agronomy, Utah Agriculture Experiment Station, Logan, Utah
Tingey, D. C.	Department of Agronomy, Utah State College, Logan, Utah
Warden, R. L.	Agronomy Department, Montana State College, Bozeman, Montana
Westgate, W. A.	Standard Agricultural Chemicals Inc., Forum Bldg., Sacramento, California
Wright, W. H.	Agricultural Commissioner, Riverside, California

CONTROL OF ANNUAL WEEDS IN SMALL GRAIN BY THE USE OF SELECTIVE HERBICIDES

Robert L. Warden
Assistant in Agronomy and Extension Weed Specialist
Montana State College

The data included in this paper was obtained by means of a questionnaire sent to workers in all states of the conference. Other material referred to has originated in the North Central Conference area, including Central Canada. Returns from the questionnaire indicate that the use of selective herbicides for the control of annual weeds in small grains is now an important established practice wherever small grains are grown. The use of selective herbicides has proven to be a very desirable practice and has increased returns to the farmer in almost all cases. It must be emphasized however, that selective herbicides are tools of the good farmer and can in no way be recommended to the exclusion of good farming practices.

This paper considers primarily the post-emergence use of 2,4-D derivatives since this herbicide is the one that is being used almost exclusively in areas where grain is the primary crop.

The dinitro materials are used primarily on flax and grain crops which have an under-crop of seedling legumes and in areas near crops highly sensitive to 2,4-D. The dinitro materials continue to have a place in selective weed control. Comparing dinitro materials with 2,4-D for weed control in cereals, there are several advantages in favor of 2,4-D. These are:

1. 2,4-D will control weeds satisfactorily under a greater variety of conditions.

2. 2,4-D can be applied in much smaller volumes of carrier per acre. This difference is a major consideration for large area dryland treating, where water may have to be hauled several miles.

3. The basic cost of 2,4-D to the farmer is generally somewhat less than for the dinitro materials.

The extent of use of 2,4-D in terms of cereal acreage treated for the western area is recorded in Table I.

Rates of 2,4-D recommended over the conference area for selective weed control in grain crops ranges from .25 to 2.0 pounds acid equivalent per acre (Table I.), dependent upon several factors which will be considered later. The majority of the states are recommending the use of both the amine and ester formulations, although several do not recommend the esters for selective work. Many reports have shown that the ester materials have given better weed control at comparable rates than have the amines.

Table I. DATA ON USE OF 2,4-D, FORMULATIONS AND RATES RECOMMENDED AND METHODS OF APPLICATION

	Acres Treated Selectively	Percent of Total Small Grain Acreage	Formulations & Rates Recommended		Methods of Application		
			Amine	Ester	Dust	Ground Spray	Air Spray
Arizona	No estimate	—	.25-.50	NR*	0	100	0
Calif.	1,500,000		.50-.75	.25-.50	0	50	50
Colorado	926,000	50	.50-1.0	.25-.50	0	25	75
Idaho	200,000	15	.5-2.0	NR	3	92	5
Montana	2,000,000	35	.3-.75	.3-.75	2	90	8
Nevada	25,000	50	.5-1.0	.5-.75	0	20	80
Oregon	350,000	40	.50-1.00	.34-.75	13	20	67
Utah	No estimate	—	1.5-2.0	1.0-2.0	0	100	0
Washington	No estimate	—	.50-.75	.33-.75	0	40	60
Wyoming	No estimate	—	.25-.75	.25-.75	No estimate		

* NR - not recommended

It is a well known fact that very large differences in tolerance to 2,4-D exist within and between weed species. (See Table II) Such differences are of vital concern to everybody working on the control of annual weeds. These affect the rate of 2,4-D required to do a particular job since too high or too low rates will either not do a satisfactory job of killing weeds or permit the crop to go essentially unharmed.

What are the reasons for the differential plant responses? With a constant rate of 2,4-D applied under standardized conditions these partially established differences in reaction require consideration. The most important of these differences existing in a plant population growing over a wide area and similarly treated with 2,4-D appear to be:

1. Stage of weed growth.
2. Weed species.
3. Environmental conditions.

Stage of plant growth is an important factor in the degree of control which can be obtained at one particular rate of 2,4-D or is an indicator of the rate of 2,4-D required. Weeds are usually in their most susceptible stages during early growth. Tolerance to 2,4-D increases as the plant approaches maturity. For certain annual species, at least, it appears that there is a very sharp increase in tolerance about the time the first seeds are formed. In the writer's experience this has been particularly true of lamb's-quarters and red root pigweed.

There are large differences in tolerance to 2,4-D between the various annual weed species occuring throughout the area. This varies from almost complete tolerance of the annual weedy grasses to broadleaved weeds which succumb when exposed to a label taken from a can of 2,4-D. Some of the most susceptible annuals have been controlled very satisfactorily by rates lower than .10 lbs. 2,4-D acid equivalent per acre.

Environmental conditions affecting the growth of the weeds are very important in control operations. Under favorable conditions certain weeds normally classed as susceptible, may be quite highly resistant. Of the various environmental conditions encountered, soil moisture, as it effects the growth of the plants, is one of the most important. Under optimum soil moisture conditions where the plant is developing rapidly, susceptibility to 2,4-D is high.

Temperatures before, during and after treatment with 2,4-D are tied in with plant response. It is probable that high temperatures adversely affecting growth rate will reduce the effectiveness of the treatments. There appears to be some question regarding the relatively high susceptibility of weeds treated under optimum temperatures for growth, immediately after a cool damp spell. Some observations have indicated that weeds are more susceptible under this condition than at any other temperature combination. Frost apparently increases tolerance to 2,4-D regardless of whether the foliage is killed or not. Low non-freezing temperatures during and after treatment slow down reaction time and accentuate differences in formulations. Some other environmental conditions affecting response for various reasons are wind, humidity, soil nutrient levels and rainfall.

Table II. CLASSIFICATION OF ANNUAL WEEDS COMMONLY OCCURING IN THE WESTERN AREA ACCORDING TO THEIR REACTION TO 2,4-D UNDER AVERAGE CONDITIONS

Susceptible*	States**	Intermediate	States	Resistant	States
Brassia(early)	6	Atriplex spp.	4	Annual grasses	2,3,5
Black Mustard	2,3,4	Brassia(late)	6	Buffalo bur	3
Buckwheat	6	Blue Mustard	9	Corn Cockle	4
Capsella spp.	7	Fiddleneck	7,9	Cow Cockle	3,4
Cocklebur	1,2,3	Goosefoot spp.	3	Dodder	6
Fanweed	2,3,4,6,7	Knotweed(late)	3	Henbit	8
Hare's Ear Mustard	5,7	Kochia	3,5	Nightshade spp.	3,4
Knotweed(early)	3	Lamb's Quarters	2,3,4,5,7	Penn. Smartweed	3
Kochia (early)	3,10	Pheasant eye	8	Sunflower(late)	4,6
Lamb's Quarters	3,5,10	Pigweed spp.	2,4,5,7	White Cockle	4
Lepidium(annual) spp.)	4,7	Prickly Lettuce	2,3,4,6,9	Wild Buckwheat	5
Pigweed(early)	3	Romeria poppy	8		
Prickly Lettuce	3	Russian Thistle	2,3,4,5,7,9		
Ragweed	3	Sheperds Purse	2,3		
Rough Pigweed (early)		Smartweed	3		
Russian Thistle	3,10	Sunflower	3,4,5		
Sunflower (early)	1,3,6	Tansy Mustard	5,8		
Sweetclover	5,6	Tumbling Mustard	8		
Tumbling Mustard	2,3,4,5,9,10				
Wild Mustard	1,2,3,4,5,7,9,10				
Wild Radish	2,7				
Wild Rutabaga	9				

*Classification is based on the following rates of 2,4-D:
Susceptible - .25-.75 lbs. acid equiv. per acre
Intermediate- .75 - 1.50 lbs. acid equiv. per acre
Resistant - 1.50 & above lbs. acid equiv. per acre

**Number refer to states reporting the classifications.
1, Arizona; 2, Calif.; 3, Colorado; 4, Idaho; 5, Montana; 6, Nevada; 7, Oregon; 8, Utah; 9, Washington; 10, Wyoming.

One of the major questions which has faced research workers since the advent of herbicides which control weeds selectively has been the response of undesirable weedy species which are not controlled by the herbicide. In Montana at the present time, it appears that several grass weeds have increased greatly in the very few years that 2,4-D has been extensively used on a commercial basis. Such an increase in grass weeds has no doubt been brought about by several factors. Two of these are:

1. Reduced competition from broadleaved weeds so that more seed was produced, and
2. Producers have been growing grain and treating with 2,4-D instead of using other control methods.

The first factor is probably the most important in that this is occurring in areas whose economy is based on grain production. It appears that an occasional spring crop in winter wheat areas will reduce winter annual gross populations effectively because of short seed longevity. Spring germinating annual grass weeds are increasing in importance in many areas. Wild oats appear to be on the increase in some areas where grain has been grown continuously for the past several years. In all the annual grasses in small grains constitute a very definite problem which I believe will increase in importance in the next few years.

The volumes of carriers or diluents which are generally used over the area for 2,4-D application by ground sprayers usually ranges from a minimum of about 5 gallons per acre to as high as 50 or 60 gallons. For ground spraying operations water is used almost universally as the carrier.

In aerial operations, the fact that fuel oils have been applied at rates as low as 2 quarts per acre and has thus reduced the cost of application considerably, has led to the general use of oils. Several states are recommending the use of oils by aerial applicators while other states are not recommending their use.

Dr. L. M. Stahler's report at the 1949 North Central Weed Conference indicated that aerial application in the Great Plains area was responsible for the treatment of about 20 percent of the treated acreage. Several western states have reported that aerial operators treated a considerably higher portion of the state's acreage. For instance, Colorado reported that almost 700,000 acres were treated by air, which is 75% of the total acreage treated in the state.

Crop response to 2,4-D or any selective herbicide, must be considered before any selective weed control can be undertaken. The crop must be affected to a considerably smaller degree than the weeds involved for selective spraying to be satisfactory. Several of the important considerations on the crop side are considered below.

The stage of growth of the crop when 2,4-D is used is a major consideration since crop responses vary greatly in accordance with the stage of growth at treatment time. For cereals, recommendations are not to treat with 2,4-D until the crop has entered the stooling or tillering stage which normally occurs about the time the crop has reached the five to eight inch stage of growth. Treatment is generally considered safe from stooling to the time the crop reaches the boot stage. Spraying in the boot stage has often resulted in considerable yield damage due primarily to flower sterility. Treating cereals after the bloom stage is termed pre-harvest treatment and appears to be a relatively safe stage. The primary value of this treatment is to knock down green weeds so that they do not interfere with harvesting operations. Observations made in several states in 1949 indicated that under certain conditions, pre-harvest treatment may result in some stem breakage.

The use of oils as carriers for 2,4-D appears to be somewhat less desirable than water. Some foliage burning apparently largely due to poor distribution by the applicator has been noted over much of the conference area. In Montana, it appears that some sterility has resulted from the use of fuel oils as diluents for 2,4-D applied at the proper growth stage to hard red spring wheat growing under good moisture conditions.

Oregon and Idaho reported that preliminary comparisons of oil and water as carriers resulted in less favorable yield responses for the oil carriers. Is this due to the reduced selectivity of 2,4-D applied in low volumes as reported by Erickson and Seely of Idaho, or to an increased toxicity to the cereals as a result of increased surface wetting? Reduced selectivity or increased wetting would result in a larger amount of 2,4-D absorbed into the tissues of cereal crops. The oil itself because of phytotoxic constituents or its distruptive influence on normal plant functions may also influence the response of cereals to selective treatments with 2,4-D.

Differential varietal responses were recorded by Utah, Idaho, Wyoming, and Montana. The results reported were obtained from preliminary work and must not be considered to be the final word since differential varietal response in cereals appears to be very complex. Of the factors involved, environmental conditions affecting varieties and the adaptability of the variety to the particular area where the test was run are to be considered.

Utah reported that Federation and Baart white wheats appeared to be less tolerant than Dicklow and Lemhi. Idaho reported four classes of tolerance in barley. Ranging from the most tolerant to the least, the varieties belonging to each class are listed:

Class I; Hannchen; II, Lico; III, Velvon, Trebi, Frontier and Gem; IV, Glacier, Atlas and Atlas 46. Erickson has reported that Hannchen in Class I has shown favorable growth responses which have resulted in yield increases for this variety. Wyoming has reported Yogo winter wheat to be more susceptible at maturity than two other hard red winter varieties, Cheyenne and Nebred. Montana results reported by J. L. Krall have indicated that Yogo is less susceptible to head malformations and resultant shattering than Karmont, Newturk or Wasatch when treatment is applied at an early growth stage.

Protein content in wheat, as affected by 2,4-D treatment, appears to be fairly definite in that some increase can usually be expected although in most cases this is too small to be of much value in increasing protein premiums. In some cases where a low protein is desired, increased protein due to 2,4-D is not desirable. The relationship of protein to yield is not clearly established. In some tests protein increases were accompanied by decreased yields while in other cases yields were not affected.

It seems logical to assume that the response of cereal crops to 2,4-D under varying environmental conditions will be much the same as that of the weeds, in that crops growing under optimum conditions would be affected to a greater extent than would crops growing under less favorable conditions. There is not much direct evidence to date concerning this point, but some work in Montana on spring wheat in which a comparison was made between two soil moisture levels, indicates that a greater yield decrease may be expected where moisture conditions are more nearly optimum.

A SUMMARY ON THE CONTROL OF ANNUAL WEEDS IN POTATOES AND BEANS WITH SELECTIVE HERBICIDES IN THE WESTERN REGION

Lambert C. Erickson
Idaho Agricultural Experiment Station

Research data on the control of annual weeds in beans and potatoes with selective herbicides is meager in this Western Region. From over 40 requests for information mailed to research workers within the Region only 4 presented any data on current work.

Beans and potatoes are not minor crops in this Western Region. We produce over 30 million tons of snap beans, over 8 million bags of dry beans, and about 90 million bushels of potatoes annually. These production figures compare favorably and in some instances exceed those of any other region. These figures indicate the size of these commodity fields which are practically unexploited with reference to chemical weed control.

It is certain that much more work has been done than was reported for this regional summary. There is reluctance on the part of workers to report negative results. This is unfortunate in many respects because negative data supported by data on prevailing ecological conditions are actually more valuable than positive control or production results not supported by such data.

Herbicidal treatments primarily for the control of annual weeds in beans and potatoes fall into 3 recognized categories based upon the stage or condition of the crop at the time of treatment. These are: (1) post-emergence, (2) pre-emergence and (3) pre-planting. It seems necessary to add a fourth category termed "pre-soil-preparation." The latter system has been used for the control of perennial weeds in these crops.

I. POST-EMERGENCE CHEMICAL WEED CONTROL IN POTATOES

Beans and potatoes as crops are generally recognized as sensitive to most herbicides applied as post-emergence treatments. But some workers have successfully controlled weeds in potatoes with post-emergence treatments of 2,4-D and other herbicides, especially in the eastern states and in a few instances in the north central area. However, in most instances injury to the potatoes has been so severe that the practice is discouraged, and this is especially true in our western area. One of the reasons for this difference is the supersensitivity of our popular potato varieties.

On the contrary Fultz and others of Colorado have used small amounts of 2,4-D and other growth regulators to improve both color and quality of potato tubers.

Seely of Idaho used 2,4-D as a post-emergence spray for annual weed control in potatoes in 1946 and 1947. In these experiments he failed to get satisfactory weed control and furthermore obtained abnormal plants and reduced yields in the succeeding year from these original treated stocks. There appeared to be a carry-over of the growth regulator in the tubers from one season to the next.

Tingey of Utah describes as follows his results on post-emergence weed control in potatoes for the 3 year period 1947-49 inclusive.

"In 1947, the Bliss variety was treated with 2,4-D at 4 stages of growth and at rates of ½, 1, and 2 pounds of 2,4-D per acre with 6 different 2,4-D products. Land on which the potatoes were grown was not infested with morning-glory. Data from this experiment showed no reduction in yield or quality with either kind or rate of 2,4-D used."

In 1948 these experiments were continued in an area infested with bindweed.

"Yields were rather low because of the heavy soil, which is undesirable for potatoes, and of low fertility. Where morning-glory was kept out by cultivating and hoeing, Bliss yielded 141 bushels of marketable potatoes, Cobbler 92, and Russetts 112 bushels. Where morning-glory was allowed to grow, the acre yields were 97, 74, and 66 bushels, respectively. On a relative basis as compared with the cultivated and hoed plots, the yield of Bliss was 69, Cobbler 80, and Russetts 59 percent. These data show how much injury morning-glory may cause if it is not controlled.

Plots treated with 2,4-D when compared with those cultivated and hoed yielded Bliss 73, Cobbler 65, and Russetts 54 percent for the sodium salt of 2,4-D; for the ethyl ester or 2,4-D the corresponding values were 67, 76, and 40 percent. From these data it appears that Russetts are injured more by morning-glory competition and by 2,4-D treatments than either Bliss or Cobblers. Yields of marketable tubers were less affected than total yield by the 2,4-D treatments. With the sodium salt of 2,4-D the acre yields were about the same for the different rates of application, but with the ethyl ester, the 2 pound rates yielded about 30 percent less than the 1/2 pound rate. The reason for these different results in the 2 years is not easily explained, but is typical of results frequently encountered in using 2,4-D. Since, however, definite injury has occurred on potatoes farmers should be cautioned in its use for general weed control in this crop."

In 1949 the experiments were repeated again. One series of plots was located on Canada thistle infested land and in another case in a sow thistle infestation. The triethanolamine of 2,4-D and ethyl ester of 2,4,5-T were used.

Tingey's conclusions are as follows: "We received much less injury on the vines in the 1949 than in the 1948 treatments. However, there was a marked reduction in yield where the 2,4-D's were used, and where 2,4,5-T was used we got practically nothing by way of yield. From my experience to date, which involves only post-emergence treatments. I would not think it advisable to use either the 2,4-D's or 2,4,5-T for weed control in potatoes."

Rex Blodget, in charge of research, Idaho Potato Growers, Inc., reported better results with reference to weed control in 1948 but concluded: "Indications are that even rates of 2,4-D as low as 1/4 pound (which will not kill many weeds) will adversely effect the quality and yield of Russet Burbank potatoes when applied to the growing crop."

In summarizing the post-emergence work on weed control in potatoes for the Western Region it must be concluded that this practice is not desirable and that we must develop other practices, methods, or chemicals if we are to succeed in controlling annual or perennial weeds in potatoes with herbicides.

Post-Emergence Chemical Weed Control in Beans

Very little research work has been done in this field, but according to data submitted by A. W. Swenzy, Dow Chemical Company, some success has been obtained in controlling broad-leaved weeds with post-emergence sprays in beans with ammonium DNOSBP, near Salinas, California.

Some bean injury resulted from these treatments but no data on yield were reported. In these same tests 6 to 10 pounds of sodium TCA per acre produced definite injury to beans at all stages but did not control watergrass. Mr. Swenzy emphasizes that they as yet are not recommending any of the treatments with which they have had moderate success to date. Instead he indicates that these are merely early experimental results that need greater supporting data.

II. PRE-EMERGENCE WEED CONTROL IN BEANS

Three summaries of work on pre-emergence weed control treatments in beans were submitted.

Experiments conducted at Huntington Beach, California, on lima beans revealed that rates of NH_4DNOSBP varying from 2.5 to 7.5 (lbs.) gallons per acre in 100 to 500 gallons of water applied 24 hours after planting gave satisfactory control of broad-leaved weeds but very poor control of annual grasses. Rates of 10 to 30 pounds of 95% PCP sodium salt in 100 to 500 gallons of water were slightly less effective than the above treatments for the control of either the broad-leaved or grass type weeds. No apparent effect was noticed on growth or germination of the beans. No harvest data was reported.

Another study reported by A. W. Swenzy, conducted at Twin Falls, Idaho, using DNOSBP and sodium PCP revealed that the ammonium salt of DNOSBP at rates of 4 to 6 (lbs.) gallons in 80 gallons of water gave complete control of all annual weeds for a period of 25 days following treatment. No injury to the beans could be noticed. This treatment was applied 5 days after planting and 19 days following soil preparation. No final yield data was reported.

The Montana Agricultural Experiment Station supplied the following abstract.

The effect of pre-emergence herbicides on weed control, stands and yields of snap beans. Cockrum, E. E. and Warden, R. L. Tendergreen snap beans were planted in a four replication randomized test on June 14, at Bozeman, Montana, in a dry soil (Huffine silt loam) and sprinkler irrigated with one acre inch. Also rains totaling 1.67 inches fell before the herbicide could be applied on June 23. An additional .84 inches precipitation fell after application of the herbicides and before bean emergence was complete. The herbicides used, rate per acre and percent weeds (red root pigweed, lambsquarter and wild mustard) remaining are listed for each chemical as follows: Exp. Herb. #1, 2.5 lbs., 33%; NIX, 15 lbs., 40%; NIX, 30 lbs., 18% Na PCP, 20 lbs., Na salt basis, 6%; Na PCP, 40 lbs., Na salt basis, 3%; and Na 2,4-D 1 lb, acid equiv., 23%. As soon as weed emergence readings were taken, weeds in all plots were controlled mechanically so that differential herbicidal effects could be measured. There were no statistically significant stand or yield differences in this test. The NIX treatments appeared to stimulate early growth as was evidenced by greater leaf size and plant height. These differences were still visible at picking time. Yields from each of the NIX treatments averaged about 25% above the check but because of the large experimental error, differences were not significant. Sodium pentachlorophenate at the high rate appeared to produce early injury (leaf chlorosis and necrosis) but plants recovered and yielded essentially the same as the check. The low rate of Na PCP did not produce a marked amount of early injury. The 2,4-D and the Exp. Herb. #1 did not depress yields but did produce early formative effects. The Na PCP rates were outstanding in control of weeds. Cooked samples from each of the treatments showed no appreciable differences in flavor and quality. (Contribution of Montana Agricultural Experiment Station).

Pre-emergence Weed Control in Potatoes

Many studies have been conducted on pre-emergence weed control in potatoes with 2,4-D throughout the nation and some of the reasons for success and failure are beginning to clarify. A limited discussion of these factors will be given later.

Only one study for 1949 on this phase was submitted for this report. Cockrum and Warden of Montana report that in their experiments 2 pounds of 2,4-D per acre were required to obtain reasonably good control of annual weeds for a period of 6 to 8 weeks. This rate produced practically no formative effects on the tops, and the tubers of the Netted Gem potatoes were normal in all respects. Unfortunately, due to variable plant stands throughout no reliable yield data could be obtained.

III. RESEARCH STUDIES ON PRE-PLANTING TREATMENTS FOR WEED CONTROL IN BEANS AND POTATOES

In 1948 a series of studies were initiated in the vicinity of Twin Falls, Idaho to determine the influence and importance of some of the factors which had been responsible for producing conflicting results under otherwise apparently comparable chemical treatments and management practices. The study was so designed that through a sequence of years treatment and management practices could be modified in the hope that definite recommendations could ultimately be made.

The work in 1948 was designed to determine:

(1) How long 2,4-D toxicity would persist in this soil type (Portneuf Silt Loam) under irrigated and non-irrigated conditions.
(2) How different crops would respond to equal 2,4-D treatment rates.
(3) How annual weeds would respond.
(4) Whether the salt and ester forms would vary significantly in their performance and persistence.

Two sets of treatments of 0, 2, and 4 pounds 2,4-D per acre were made, replicated 3 times, the first set on May 5, and the second on June 24. Five crops were planted, replicated 4 times, and at 15 day intervals for a period of 45 days.

Results from these 1948 tests revealed that: (1) sterility did not decrease over a 45 day period in non-irrigated plots (0.18 inch rainfall), (2) residual toxicity began to decrease in 2 to 3 weeks following irrigation, (3) the salt and ester forms did not vary significantly in their toxicity or persistence, (4) time and temperature in the absence of supplementary moisture were not significant factors in the decomposition of 2,4-D over a 45 day period, and (5) 4 pound rates were significantly more toxic and persisted longer than the 2 pound rates.

The crop and weed data obtained, averaged for the 2 and 4 pound rates, revealed that these 2,4-D treatments caused:

(a) An average reduction of 68**% in bean stand.
(b) An average reduction of 10% in potato stand.
(c) An average reduction of 83** and 89**% in annual weed stand in beans and potatoes respectively.

Yield results did not follow the pattern set by the effects of the treatments upon plant stand. Yield data revealed that:

(a) Dry bean yields were reduced only 9%.
(b) Potato yields were reduced 28**%.
(c) Treatments delayed bean maturity 2 weeks.
(d) Treatments caused an additional 22**% reduction of first grade potatoes by weight.

** Highly significant.

IV. PRE-SOIL-PREPARATION WEED CONTROL TREATMENTS IN BEANS AND POTATOES

Both pre-and post-emergence treatments with 2,4-D or other herbicides for annual weed control may eventually find a definite place in the production of various horticultural crops. This will occur only when the factors underlying their success are understood.

Present pre- or post-emergence treatments are of little value for the control of perennial weeds. Therefore, other methods must be developed to meet this problem.

The practice of pre-soil-preparation 2,4-D treatments in Idaho began as a result of farmer demands. They requested spring treatments on fields infested with perennial weeds, and these fields would later be prepared and planted to beans or potatoes. The first work of this type was done by D. K. Hendry, Weed Supervisor in Jerome County, Idaho in 1947. Both weed control and crop yields appeared good at the end of the 1947 season. As a result of this work in 1947, several hundred acres were so treated and cropped in 1948, and over a thousand acres in 1949. The latter acreage extended into several counties. Results have been good in general but not consistent especially with reference to yield.

Under the present system the weed infestations are left or even encouraged to rapid growth in early spring. When the growth approximates 1 foot the infestations are sprayed usually at a rate of 4 pounds 2,4-D per acre. After a lapse of 2 weeks these areas are plowed to a depth of 6 to 8 inches. The seedbed may be prepared and planted immediately, or another lapse of 1 to 2 weeks may be allowed before planting. In some instances these areas are irrigated during the interval between plowing and planting.

Research Studies on Pre-soil-Preparation Treatments for Weed Control in Beans and Potatoes.

With the information gained from the 1948 pre-planting weed control treatments, the studies were continued in 1949 to determine how residual toxicity to these crops might be reduced by various management practices. An adjacent area of the same field used in 1948 was used for the 1949 studies.

The objective in 1949 was to determine to what extent the following variations in management would influence residual toxicity: (1) irrigation and other super-imposed treatments followed by planting, (2) no irrigation until after planting.

The area was divided into 2 blocks. Both areas were treated with triethanol amine salt 2,4-D at 4 pounds per acre, except for the non-treated checks within the respective blocks. Only 1 variable was introduced between the 2 blocks; Block A being irrigated 1 week following the treatment while Block B was not irrigated until after planting.

Following the 2,4-D application on May 4 the following treatments were super-imposed upon the treated areas. On May 9 Block A was irrigated. On May 18, strips 1 rod wide each within both Block A and B were disced, fertilized, and plowed, respectively. The fertilized strips received 120 pounds of ammonium sulfate per acre. The plowing was at an 8 inch depth. Thus, there were five treated strips within each block: (a) non-treated check, (b) treated check, (c)treated and disced, (d) treated and fertilized, and (e) treated and plowed. All crops were planted on May 21 and irrigated on May 22. Thereafter the plots were irrigated as required for crop production.

Certified seed stocks of Bliss Triumph and Netted Gem potatoes, and U. I. No. 123 beans were used in these studies. The 1949 crop stand and yield, and annual weed control results are given in Tables 1, 2, and 3.

Table 1.—Influence of 4 pounds 2,4-D per acre plus 3 superimposed management practices upon the stand and yield of beans as compared to the non-treated checks; and the effects of irrigation between the 2,4-D treatments and planting.

Treatment	Plant stand - Aug. per yard of row (2,4-D) (beans*)	Plant stand - Aug. per yard of row (clean) (beans)	Yield - Aug. lbs. dry beans per rod of row (2,4-D) (beans*)	Yield - Aug. lbs. dry beans per rod of row (clean) (beans)
Plots irrigated 12 days before planting				
Non-treated checks	12.3	19.5	1.43	1.51
2,4-D treated checks	3.0	6.0	.97[d]	1.10[d]
2,4-D treated and disced	7.7	13.0	.98	1.22
2,4-D treated and fertilized	4.7	7.0	.93[d]	1.35[d]
2,4-D treated and plowed	9.0	13.3	1.02	1.52
Plots not irrigated before planting				
Non-treated checks	13.3	18.7	1.85	1.83
2,4-D treated checks	0.4	0.4	0.18[d]	0.17[d]
2,4-D treated and disced	0.5	0.7	0.33[d]	0.42[d]
2,4-D treated and fertilized	0.7	0.6	0.33[d]	0.35[d]
2,4-D treated and plowed	6.7	8.0	1.00	1.17

* Beans grown in 2,4-D treated plots in 1948.

[d] Maturity delayed 2 weeks.

Beans, The data in Table 1 shows: (1) that irrigating during the interval between the 2,4-D treatment and planting reduced the residual toxicity to beans, (2) that discing or fertilizing did not significantly improve either stand or yield while plowing improved both. Plowing following the 2,4-D treatment would, therefore, appear to be a desirable practice for bean production whether or not irrigation follows treatment. Furthermore, there was no visible delay in maturity in the 2,4-D treated and plowed plots.

Table 2.—Influence of 4 pounds 2,4-D per acre, plus 3 superimposed management practices upon the stand and yield of potatoes as compared to the non-treated checks; and the effects of irrigation between the 2,4-D treatments and planting.

Treatment	Plant stand - Aug. per yard of row (Triumph)	Plant stand - Aug. per yard of row (Gem)	Yield - Aug. lbs. potatoes per rod of row (Triumph)	Yield - Aug. lbs. potatoes per rod of row (Gem)
Plots irrigated 12 days before planting				
Non-treated checks	2.8	3.0	12.9	20.0
Treated checks	3.0	2.8	14.4	16.8
Treated ≠ disced	2.8	2.3	12.1	16.6
Treated ≠ ammonium sulfate	3.0	2.5	13.8	18.8
Treated ≠ plowed	2.8	2.3	12.4	14.5
Plots not irrigated before planting				
Non-treated checks	2.8	3.0	12.4	21.0
Treated checks	2.3	2.3	11.3	16.3
Treated ≠ disced	2.7	2.5	9.6	13.8
Treated ≠ ammonium sulfate	2.7	2.5	11.8	15.5
Treated ≠ plowed	2.7	2.7	10.6	14.3

Potatoes. Table 2 illustrates that potatoes did not respond to the superimposed treatments; discing, fertilizing, or plowing in the same manner as beans. According to the data it is desirable to irrigate following the 2,4-D treatment and prior to planting, but plowing prior to planting should be discouraged.

Reductions in yield of Netted Gems due to the 2,4-D treatments were quite comparable to the results obtained in 1947. The Bliss Triumph potatoes, however, survived without any significant reductions in yield. In no instance did the treatments reduce market quality so severely as they did in 1947.

Table 3.-- Influence of 4 pounds 2,4-D per acre plus 3 superimposed management practices upon emergence and survival of annual weeds 22 days after planting as compared to the non-treated checks; and effects of irrigation between treating and planting.

Treatments	Weed stand in beans - Aug. No. per 148 sq. ft.	Weed stand in potatoes Aug. No. per 148 sq. ft.
	Irrigated 12 days before planting	
Non-treated check	53	67
2,4-D treated check	2	6
2,4-D treated and disced	0	1
2,4-D treated and fertilized	1	5
2,4-D treated and plowed	35	6
	Not irrigated before planting	
Non-treated check	241	126
2,4-D treated check	11	5
2,4-D treated and disced	11	2
2,4-D treated and fertilized	9	2
2,4-D treated and plowed	91	22

Weeds. Control of annual weeds was essentially equal for the treatments; 2,4-D alone, 2,4-D and discing, and 2,4-D and fertilizer. Control was approximately 96% as an average for both blocks. The block not irrigated prior to planting showed an insignificant advantage. However, any such slight advantages in weed control must be disregarded in view of the detrimental effects upon crop yield.

It must be recalled that these experiments on pre-soil-preparation, although designed for the control of perennial weeds, have thus far been conducted on land free of perennial weeds. The studies to date have been for the purpose of determining residual 2,4-D soil toxicity to crops. With the information gained on the influence of various factors and management practices the experiments will be moved to fields infested with perennial weeds for continuation in 1949. Results in variance from those obtained to date may be anticipated when perennial weeds become an additional factor.

Conclusions

Results with chemical pre-planting, and pre - or post-emergence weed control treatments have been erratic and will continue to be so until more fundamental information is obtained upon the factors which influence toxicity and its duration. Some factors which influence especially residual toxicity are: (1) total soil moisture and distribution, (2) soil type, texture, structure, and chemical composition, (3) type and activity of soil micro-organisms, (4) species and variety of weeds and crops, (5) temperature and time under the prevailing ecological conditions, (6) size of weed or crop seed, (7) depth of planting, (8) amount and type of chemical and how applied. When the reactions and inter-actions of these and other factors are understood and accounted for, greater success will be had and more uniform results will be obtained.

Since factors like the above determine the success or failure of a treatment with respect to weed control and crop yield, it is not difficult to realize that results will vary between and within areas. Uniformity in resluts between areas are therefore the exception rather than the rule. The inter-actions of the total factors under a given environment must be considered and the weed control and cropping practices modified accordingly.

The following factors are of importance in reducing 2,4-D toxicity to crops, and are sufficiently uniform to justify inclusion here: (1) adequate soil surface moisture speeds 2,4-D decomposition by dilution, percolation, leaching, and by creating a media conducive to microbial activity: (2) coarse soils leach more readily while high organic or colloidal soils have higher 2,4-D adsorptive capacities (3) soil micro-organisms are responsible for removal or deactivation of the major portion of 2,4-D; (4) time and temperature are of little practical significance in deactivating 2,4-D in dry soils. Arid conditions are, therefore, conducive to prolonged sterility; (5) within many plant families large seeds tend to be more tolerant to 2,4-D than small seeds; (6) seeds of the same crop deep planted will frequently escape with less injury than those shallow planted; (7) the degree and duration of soil toxicity or sterility is usually directly related to the rate of application.

Control of Annual Weeds in Orchards and Vineyards

W. W. Robbins
Department of Botany
University of California
Davis

In irrigated sections, weeds in orchards and vineyards may seriously compete for water. Therefore, control of weeds becomes an important factor in orchard management. Another reason for the control of weeds in these crops is the elimination of host plants of fungi and insects. And, also, in order to facilitate harvest, it may be desirable or necessary to eliminate weed growth. If water is not a limiting factor, and pests harbored by weeds are not serious, and harvesting is not interferred with, there may be some advantage in allowing weeds to grow in the orchard or vineyard and in utilizing them as a green manure.

The two common methods of weed control in orchards and vineyards are tillage and the use of chemicals. The latter is relatively new. The most notable example of chemical control of weeds in tree plantings is in citrus groves of southern California. In some of these, nontillage was started 25 or 30 years ago and has been continued with satisfactory results. At the present, over 50,000 acres of citrus plantings in California have eliminated tillage in citrus soil management, substituting therefor, chemical weed control. This involves slightly more than 15% of the total citrus acreage. The acreage under nontillage is increasing year by year. moreover, olive growers are taking up the practice, and in several counties tests in deciduous orchards are under way. And, a large percentage of the avocado orchards now practice nontillage.

The experiences in citrus show that cultivation may have injurious effects; root destruction, and the formation of an impervious soil layer. As a matter of fact, nontillage results in gradual improvement of soil structure and increased rate of water penetration. Moreover, on sloping land, the erosion problem is not serious in those planting under nontillage, because absorption of water is rapid, and there is little loose soil on the surface. And, too, handling of fruit is made easier, rodent control has diminished, and snails have disappeared.

In those plantings where nontillage has been given a fair trial over a series of years, there is no evidence that yields have been improved. However, there has been no decrease in yield quality, and no injurious effects on the soil by repeated applications of the herbicides employed. Cost studies have been extensive, and have been compared with those of tillage. The general conclusions concerning costs are as follows: (quoting from Johnston and Sullivan in California Agr. Ext. Service Circular 150, Eliminating Tillage in Citrus Soil Management)

> "It would appear from these studies that the nontillage system would cost about one third more the first two years, the same the third year, and 50 per cent less after the third year than conventional tillage. The proportions would be greater in orchards with heavy soils and dense weed growth, and less on light gravelly soils with few weeds and light rainfall. In view of the high cost the first two or three years, the grower - before adopting the nontillage system - should be reasonably sure that he will have facilities and materials necessary to continue it over a period of years."

The material used in citrus orchards are as follows: (a) orchard heater oil, straight or diluted with water; (b) diesel oil, straight or fortified with sulfur, or dinitros, or chlorinated phenols, and oil water emulsions; (c) 2,4-D where broad-leaved perennials constitute a portion of the weed flora. Much 2,4-D has been applied in the citrus orchards of California, and with due precaution to minimize drift, no injury to trees has resulted. Lemons are more susceptible than oranges.

Equipment employed is highly variable, and much of it is constructed on the property. Booms are usually shielded in order to lift low-hanging branches, and reduce drift. The number of applications in a heavily infested orchard is between 4 and 8 the first year, and from 1 to 2, after three or four years. The amount of material per application will vary from 40 to 100 gallons.

The use of general contact herbicides in vineyards is becoming a fairly common practice. As a rule, the chemicals are applied in the rows and around the main stems, where the cultivator does not reach. There is no injury to the main stems if they are three or more years old. The treatment may be applied any time prior to elongation and leafing out of the canes. In the San Juaquin Valley, puncture vine and certain grasses are the most undesirable weeds. 2,4-D is to be avoided in and about a vineyard.

The growers of deciduous orchards have shown some interest in nontillage, and the use of herbicides. There are several fairly large scale tests under way in California. Thus far, no injury to trees or soil has been experienced. The main interest is one of relative costs. We have used in a limited way both general contact herbicides, and 2,4-D in deciduous orchards to control the weeds that cluster about the bases of trees and are usually removed with a hoe. And along fence lines surrounding all types of orchards, and of vineyards, there is increasing use of herbicides.

Definitely, orchardists and vineyardists are demonstrating a keener interest in and understanding of the problems of weed control, and are anxious to keep informed as to new developments.

The following are abstracts of papers which were presented at the research section meeting:

RECENT RESULTS OF BASIC PHYSIOLOGICAL STUDIES OF MESQUITE IN THE SOUTHWEST

Byron O. Blair
Southwestern Forest and Range Experiment Station
Tucson, Arizona

Investigation of basic physiological processes in velvet mesquito (Prosopis velutina) as related to the development of practical methods for controlling this shrub on range lands were started by the Southwestern Forest and Range Experiment Station in 1948 under the BMA. A number of studies dealing with the absorption, movement, and toxic effect of organic and inorganic herbicides have been initiated.

Pertinent findings to date: Aqueous solutions of the sodium salt of 2,4-D and the free acid of 2,4,5-T at 0.3 percent concentration were injected in the absence of air into the stem of mature mesquite trees at four different stages of growth. Movement of these herbicides was restricted to xylem tissue. Movement upqard was much greater than downward, with downward movement being greatest during December and least during April. Lateral movement was confined to tissue immediately adjacent to the injection part. Volume of solution intake on a given date was inversely correlated with relative humidity. Intake was lowest in April, greater in July and August, and maximum in December.

A comparison was made of the growth inhibiting effect of low concentrations of the free acid of 2,4-D and 2,4,5-T (1, 2, 5, and 10 p.p.m.) on mesquite seeds and 24-hour-old seedlings. On seeds, growth suppression ranged from approximately 60 percent at 1 p.p.m. to 100 percent at 10 p.p.m. with no consistent difference between the 2,4-D and 2,4,5-T. On 24-hour-old seedlings, suppression ranged from 61 percent at 1 p.p.m. to 99 percent at 10 p.p.m., with the 2,4,5-T producing greater suppression than the 2,4-D at all concentrations above 1 p.p.m. Both hormones caused abnormal thickening of the root-stem transition zones. Inhibition of mesquite seeds and suppression of growth of young seedlings indicates that mesquite as an organism is not resistant to low concentrations of 2,4-D and 2,4,5-T.

Foliage spray applications were made on isolated segments of mesquite seedlings and mature trees at 2- to 4- week intervals during the period April to November 1949. Movement of both the isopropyl ester and amine salt of 2,4,5-T below the point of application was very limited in the case of the seedlings and did not occur on the mature trees. On seedlings, downward movement appeared to decrease as the leaves matured, with the lethal effect varying from 40 percent in April to 0 in August. The ester produced rapid toxic effect, causing death of the treated tissue within 5 days. The amine salt required two weeks to produce an equivalent toxic effect. This difference in rate of action of the amine and ester was also observed on mature trees.

An amine salt of 2,4,5-T was introduced hypodermically and applied topically to the base of freshly cut mesquite stumps to determine the concentration required to prevent sprouting when this herbicide is brought in direct contact with the dominant stem buds. Aqueous solutions of 2,4,5-T injected into the cambium at the bud zone produced 32, 90, and 96 percent suppression at 1, 10, and 20 thousand ppm. Paintbrush application of 2,4,5-T to the bark in the form of a slurry, produced 59, 93, and 100 percent suppression of sprouting at these same concentrations.

Shale Oil As A Herbicide: Dale W. Bohmont, Agronomy Department, University of Wyoming, Laramie, Wyoming.

A series of experiments were conducted to determine the effect of shale oil on plant growth and development. Materials of the naptha, kerosene and gas-oil fractions of shale oil were further subdivided on the basis of their impurities into raw shale oil, tar acids, tar bases and shale oil with all impurities removed (neutral shale oil). Thus a total of 12 materials were applied as an oil-water emulsion at concentrations ranging from 1 to 50 percent to determine their relative phytotoxicity. Bean and Tomato plants were used as indicators of the oil toxicity. Undiluted oil was applied to carrots and parsnips to determine the crop tolerance at rates ranging from 50 to 100 gallons per acre. All treatments were replicated, randomized and were conducted under greenhouse conditions and repeated under field conditions during the summer of 1949. Toxicity and other effects of the various shale oil materials were determined by periodic injury readings and actual floral counts. The naptha fraction caused acute plant injury while the kerosene and gas-oil fractions produced chronic injury. Raw shale oil was the most toxic and neutral shale oil the least injurious to plant growth. Very little difference was observed between the tar acids and tar bases in relation to comparative plant injury. The 10 percent naphtha emulsion equaled the toxicity of the 5 percent kerosene and the 1 percent gas-oil fractions. All shale oil treatments which were not lethal to the plant resulted in an abundant production of both axillary and adventitious buds on tomato and bean plants. These floral buds eventually developed into normal flowers and fruit. The 1 to 5 percent naphtha fraction was the most stimulative. All shale oil fractions proved toxic to carrots and parsnips at rates of 50 and 100 gallons per acre. However, plants receiving naphtha treatments completely recovered within 24 days after the application.

Field trials using 2,4-D, 2,4,5-T and combinations applied during the dormant season for control of willows. C. C. Butler, Regional Land Use Specialist, Bureau of Reclamation, Billings, Montana.

Field trials to determine effectiveness of spraying, willows during the dormant season were started in the fall of 1948.. In field trials near Billings, Montana, treatments were applied to willows (Salix interior var. pedicillata (Andress)) five or six years old standing 4 to 5 feet high, and willows approximately 25 years old standing 12 to 15 feet high. Applications were made in November and April. Material used for the November application was 2,4-D only and for the April application 2,4-D, 2,4,5-T and a combination of 1 1/3 pounds of 2,4-D acid plus 2/3 of a pound of 2,4,5-T acid. All materials were mixed with diesel oil at a concentration of 4,000 ppm and applied in amounts approximating 10 pounds of acid equivalent per acre. Mixtures were applied to standing willows, stubs cut 6 inches above the ground, willows with bark bruised on one side and willows with bark bruised on two sides. Observations during the 1949 growing season showed no regrowth on any canes or stubs regardless of the chemical used, size of willows or time of treatment. All plots showed some regrowth from lateral root stocks. November applications of 2,4-D produced slightly better root stocks control than April applications. Stub treatment gave slightly better control than on standing willows. 2,4-D gave better control than 2,4,5-T and the combination of 2,4-D - 2,4,5-T was more effective than 2,4,5-T. Regrowth from lateral root stocks on standling willows was estimated to be 4 percent for 2,4-D applied in November, 10 percent for 2,4-D applied in April, 15 percent for the combination of 2,4-D - 2,4,5-T applied in April, and 30 percent for 2,4,5-T applied in April. Regrowth from lateral root stocks from cut stubs was estimated to be 3 percent for 2,4-D applied in November, 10 percent for 2,4-D applied in April, 25 percent for 2,4,5-T applied in April, and 30 percent for the combination 2,4-D - 2,4,5-T applied in April. Results were much less effective at other locations in Region 6 where the spray mixture used had an acid equivalent ranging from 2 to 5 pounds per acre.
(Contributed by the U. S. Department of the Interior, Bureau of Reclamation, Region 6, Billings, Montana, cooperating with Montana State College, Bozeman, Montana).

A study of the feasibility of using a helicopter for spraying willows on irrigation systems. C. C. Butler, Regional Land Use Specialist, Bureau of Reclamation, Billings, Montana.

A study to determine the feasibility of using a helicopter to spray willows on irrigation systems was initiated on the Milk River Project near Malta, Montana during the summer of 1948. Spray mixtures were calculated on the basis of two pounds of 2,4-D acid per acre using from 2.5 to 28 gallons of solution per acre. Where the willows were relatively thin and not more than about 8 feet tall, little or no regrowth appeared regardless of the gallons of solution used. On other areas regrowth ranged up to 50 or 55 percent. The study was repeated during the summer of 1949 applying 2,4-D at rates of 2,4, and 8 pounds of acid per acre, 2,4,5,-T and 2,4-D - 2,4,5-T combined at 2,4, and 6 pounds of acid per acre mixed with 5, 10, and 20 gallons of water per acre. The spray nozzles were calibrated prior to flying to produce drop sizes, the majority of which were in excess of 500 microns in diameter. Nozzles to produce this drop size with 40 pounds pressure were .116 of an inch in diameter. The relatively large drop size combined with the helicopter rotor down blast caused the spray to go almost straight down when the wind velocity did not exceed 10 to 12 miles per hour and the speed of the helicopter not more than 20 miles per hour. Observations at the end of the growing season indicated that the spray had been well controlled as there was very little evidence of drift, only traces of regrowth had appeared, and all treatments appeared to be equally effective regardless of chemical used or rate of application. Final results of the effects of the 1949 spraying will not be known until the summer of 1950. (Contributed by the U. S. Department of the Interior, Bureau of Reclamation, Region 6, Billings, Montana, in cooperation with Montana State College, Bozeman, Montana)

Response of peas to pre-emergence treatments with Exp. Herb. #1 and NIX. Cockrum, E. E. and Warden, R. L., Montana Agricultural Experiment Station, Bozeman, Montana. Thomas Dexton peas were planted in rows in a four replication randomized test on June 14, 1949 in a dry soil (Huffine silt loam). A one inch irrigation by sprinkler was applied the day after planting. Rain to the extent of 1.67 inches fell before the herbicides could be applied on June 23. An additional .84 inches fell before emergence of the peas was complete on June 26. Exp. Herb. #1 was applied at the rate of 2.5 pounds per acre and NIX at 15 and 30 pounds per acre. Weeds present were red root pigweed, lambsquarter and wild mustard. Weeds emerging on the Exp. Herb. #1 plots were 24 percent of the check, NIX at 15 pounds allowed 21 percent of the weeds to develop while NIX at 30 pounds suppressed all but 9 percent. As soon as weed emergence readings were taken, weeds in all plots were controlled mechanically so that differential herbicidal effects could be measured. The NIX treatments yielded significantly more than the Exp. Herb. #1 treatment and yielded 7 percent more than the check although the difference was not significant. There were no significant differences in pea stands. The NIX plots appeared to have a more vigorous vegetative growth and a larger number of pods than did the check or Exp. Herb. #1 plots. Cooked samples from each of the treatments showed no appreciable difference in flavor or quality.

The effects of Exp. Herb. #1 and NIX on pre-emergence weed control, stands and yields of carrots and garden beets. Cockrum, E. E. and Warden, R. L., Montana Agricultural Experiment Station, Bozeman, Montana.

Tendersweet carrots and Perfected Detroit beets were planted in a three replication randomized test on June 15 in a dry soil (Huffine silt loam). A one inch irrigation was applied by sprinkler after planting. Rain to the extent of 1.67 inches fell before the herbicides could be applied on June 23. An additional 1.33 inches precipitation fell before emergence of either crop was complete. Beet emergence began on June 25 and emergence was complete on June 27. Carrot emergence was complete on July 1. Chemicals used in this test were Exp. Herb. #1 at 2.5 and 4.0 pounds per acre and NIX at 15 and 30 pounds per acre. Weed populations (red root pigweed, lambsquarter and wild mustard) were reduced to 28 and 5 percent respectively by the two rates of Exp. Herb. #1, and 12 and 1 percent respectively by the two rates of NIX. As soon as emergence readings were taken, weeds in all plots were controlled mechanically so that differential herbicidal effects could be measured. Beet stands and yields were reduced significantly by both rates of Exp. Herb. #1 while NIX at the 30 pound rate reduced stands but not yields. The 15 pound rate of NIX was not significantly different from the check in either stand or yield. Carrot emergence was completely inhibited by the 4 pound rate of Exp. Herb. #1, and reduced to 14 percent of the check by the 2.5 pound rate, which resulted in a marked reduction in yield. The 30 pound rate of NIX reduced the stand and yield of carrots, but differences were not significant, whereas the 15 pound rate of NIX improved the stand and yield but the differences were not large enough to be significant. The Exp. Herb. #1 treatments produced forked carrots and beets, while NIX treatments produced normal carrots and beets.

Post emergence weed control in onions with Aero Cyanate, NIX and Exp. Herb. #1. Cockrum, E. E. and Warden, R. L., Montana Agricultural Experiment Station, Bozeman, Montana.

Mountain Danvers onions were transplanted on May 24 and sprayed with herbicides on June 23. Because a series of rains (1.67 in.) delayed treatments about a week beyond the ideal stage, the weeds (red root pigweed, lamb's quarter and mustard) were from one to four inches in height at the time of application. The onions were about ten inches in height. The herbicide used, rate per acre in 50 gal. water, and percent of weeds remaining are listed for each chemical as follows: Aero Cyanate, 10 lbs., 78%; Aero Cyanate, 20 lbs., 23%; NIX, 15 lbs., 33%; NIX, 30 lbs, 25%; Exp. Herb. #1, 2.5 lbs., 100%; Exp. Herb. #1, 4.0 lbs., 90%. Rains totaling 1.33 in. fell within four days following application, of which .08 in. fell at about 8:30 p.m. following application in afternoon. The onions did not appear to be injured by the low rate of Aero Cyanate but the 20 lb. rate produced a slight burning. NIX at the 15 lb. rate caused slight burning and the 30 lb. rate produced somewhat more burning immediately after application. Both rates of Exp. Herb. #1 caused no visible injury. As soon as data on chemical weed control was taken, weeds in all plots were controlled mechanically so that differential herbicidal effects could be measured. There were no significant differences in yield due to using any of the herbicides.

The effects of Exp. Herb. #1 and NIX on pre-emergence weed control, stands and yields of radishes, spinach and lettuce. Cockrum, E. E. and Warden, R. L., Montana Agricultural Experiment Station, Bozeman, Montana.

Cavalier radish, Northland spinach and Great Lakes lettuce were seeded in a four replication randomized test on June 15. The plan called for transplanted head lettuce, but since plants were not available, it was decided to direct seed. A one inch irrigation was applied by sprinkler the day of planting. Rains totaling 1.67 inches delayed application of the herbicides until June 23. By this time about 25% of the radishes and 15% of the lettuce had emerged. The spinach started to emerge the following day. An additional .84 inches of rain fell before emergence was complete on June 26. Exp. Herb. #1 was applied at rates of 2.5 and 4 pounds per acre and NIX at 15 and 30 pounds per acre. Weeds emerging (red root pigweed, lambsquarter and mustard) on the 2.5 lb. rate of Exp. Herb. #1 plots were 25% of the check and the 4.0 lb. rate 13%. NIX at 15 lbs. allowed 5% of the weeds to develop and the 30 lb. rate suppressed all but 3%. As soon as weed emergence readings were taken, weeds in all plots were controlled mechanically so that differential herbicidal effects could be measured. Both rates of Exp. Herb. #1 severely reduced radish stands, yields and quality. NIX at the high rate significantly reduced stands and yields. While the 15 lb. rate of NIX milled most of the radishes emerging before treatment, those emerging later were uninjured and had no abnormalities. Spinach stands and yields were significantly reduced by both rates of Exp. Herb. #1, as well as the high rate of NIX. However, the 15 lb. rate of NIX gave the same stand as the check and the yield was slightly higher. Stands and yields from the direct seeded lettuce were markedly reduced by all treatments. (Contribution of the Montana Agricultural Experiment Station).

A cumulative fluorescent chemical found in certain plants treated with 2,4-D identified as scopolotin (6-methoxy 7-hydorxy 1:2 benzo-pyrone) Jess Fults and Milton Johnson, Department of Botany and Plant Pathology, Colorado A & M College, Ft. Collins, Colorado.

During the summer of 1946, a series of tobacco plants which had been treated with the sodium salt of 2,4-D and which were exhibiting typical symptoms were examined under an ultraviolet light. The stems, nodes, veins and roots fluoresced a brilliant bluish-white - many times brighter than untreated controls. Since that date this peculiar reaction has been investigated in considerable detail. Through a lengthy series of isolations and purifications a crystalline product has been obtained and a number of its physical properties determined. Paper chromatographic data (RF values) pH fluorescence curves, and absorption spectra in the ultraviolet of the unknown and of several pure compounds indicate that the compound is probably scopoletin or 6-mothexy-7-hydroxy-1:2 benzo-pyrone. This compound is a derivative of 1:2 benzo-pyrone or coumarin the agent responsible for the odor of sweet clover and which has recently been shown to inhibit germination and root growth in plants and to cause formative effects identical to those of 2,4-D and its derivatives.

Scopolotin appears definitely to be a normal metabolite in castor beans, tobacco, dandelion and bindweed. Treatment of these plants with herbicidal dosages of 2,4-D and its derivatives causes at least a doubling in the amount of scopolotin present. Data for bindweed and tobacco are presented in detail. It is suggested that the action of the scopolotin may be to counteract the action of the natural hetorcauxin in cell elongation at low concentrations and to accentuate it at high concentrations. Thus accounting in part for the abnormal growth followed by death of plants treated with high concentration of 2,4-D and its derivations.

Herbicidal Control of Big Sagebrush: Donald F. Hervey, Assistant Conservationist, Colorado A & M College, Ft. Collins, Colorado.

Big sagebrush (*Artemisia tridentata*), a woody shrub, is considered to be a noxious range plant under certain situations. Herbicidal control has recently been investigated as one means of controlling sage brush.

Small-plot tests made in 1946 indicated the importance of applying 2,4-D early in the growing season. The tests also indicated that one to two pounds of actual 2,4-D per acre would give satisfactory kills (80% - 90%). The butyl ester was the most effective formulation.

Other investigators reported variable success with 2,4-D on big sagebrush. When airplane application of 2,4-D was tried in northwestern Colorado during June, 1948, only poor results were obtained. It was then decided that small-plot tests should again be tried to test several variables. These tests were made on May 15, June 1, June 15, and July 1, 1949. Although only preliminary observations are available as yet, the data appears to substantiate results of the 1946 trials in that:

(1) One pound of actual 2,4-D in the butyl ester form applied June 1 (7,000 feet elevation - northwestern Colorado) Produced good kills, and superior to those produced by other forms of 2,4-D.

(2) Herbicides were much less effective when applied July 1 than when applied earlier (May 15 - June 15).

In addition, the 1949 trials indicate that:

(1) Good results can be obtained by use of 5 gallons of water or an emulsion of 4 gallons of water with one gallon of diesel oil per acre as a carrier for the herbicide.

(2) When only water is used as a carrier, an emulsifier should be added to act as a wetting agent.

(3) Since mixtures of 2,4-D with 2,4,5-T produced slightly better results than did 2,4-D alone, it is believed that 2,4,5-T is superior to 2,4-D in control of big sagebrush.

Because trends in the data were not always consistent, it is believed that variables other than those isolated were in operation. Perhaps basic research with these herbicides will bring these other variables to light.

The Electrovator As A Method of Controlling Perennial Noxious Weeds: 1/ Jesse M. Hodgson Assistant Agronomist, U. S. Department of Agriculture.

The Electrovator, a unique patented device developed as a weapon for weed control, is designed to distribute a charge of electricity into plant foliage as it is pulled over the weed infestation. The effect of electrical treatments with this machine on the perennial noxious weeds, white top (Papidium draba), Canada thistle (Cirsium arvense), and field bindweed (Convolvulous arvensis) was studied.

White top was not effectively controlled with four or five successive treatments with this electric weed killing machine.

Field bindweed and Canada thistle also survived as many as six of these electrical treatments in one season with only slight reduction of the infestations.

The electrovator treatments were not sufficiently effective on perennial weeds and requirements for the best results are too exacting and costly for the method to be practical in controlling these weeds.

(1) Cooperative investigations in weed control with the Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils and Agricultural Eningeering, Agricultural Research Administration, U.S. Department of Agriculture, and the Ada County Weed Control Division, Meridian, Idaho, and the Idaho Agricultural Experiment Station.

Results of Recent Investigations in the Control of Ribes with 2,4-D and 2,4,5-T: H. R. Offord, V. D. Moss, and C. R. Quick, Division of Plant Disease Control, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, Berkley, Calif.

Effective Treatments and Formulations. Principal conclusions from the 1948-49 investigations on the chemical control of Ribes in the Western States are: (1) 2,4,5-T is toxic to R. acerifolium, R. Binominatum, R. inerme, R. Lacustre, R. laxiflorum, R. montigenum, R. setosum, and R. viscosissimum-species that could not be killed economically with 2,4-D. (2) With conventional high volume equipment and aqueous 2,4,5-T spray is effective on the Ribes just named when it contains 3000 p.p.m. acid equivalent of the ester plus 10,000 p.p.m. summer oil emulsion. (3) In sprayers equipped with atomizing nozzles for a low volume work, 2-3% of the 2,4,5-T ester either in Diesel oil or in water containing 2-3% summer oil emulsion effectively kills these same Ribes. (4) For equivalent amounts of total acid the combination of 2,4,5-T and 2,4-D in several different proportions is not as effective on the above Ribes as the straight 2,4,5-T. (5) For mid-summer work on R. roezli 2,4-D sprays containing the sodium salt (500 P.P.M. acid equivalent) plus 10,000 p.p.m. light-medium summer oil emulsion plus 400 p.p.m. sticker-spreader are superior to the 2,4-D esters or salts without the oil and sticker-spreader. (6) A satisfactory bush kill is obtained by spraying the basal stems (with or without scarification) of R. nevadense and R. cereum with Diesel oil or weedkiller oil, containing 50,000 p.p.m. acid equivalent of the ester of 2,4-D or 2,4,5-T. Plants approaching dormancy are killed as readily by the basal stem treatment as are those in active growth stage.

Results of Helicopter Tests. In August 1949, fourteen months after spraying Ribes and associated brush with 2,4-D by helicopter, a 10% sample of the 16 plots on the Sierra National Forest, Calif., showed: Most effective formulation, ester in Diesel oil; intermediate, aqueous ammonium salt plus summer oil emulsion plus a sticker-spreader, and aqueous ester plus a sticker-spreader; least effective, aqueous amine. On the plot treated with the isopropyl ester of 2,4-D in Diesel oil (33.4 ounces acid in 5 gallons of oil per acre) 86% of the R. roezli and 96% of the R. nevadense were dead. Increased volume of spray compensated for decreased dosage of the 2,4-D. Ten gallons of oil (or the same volume of water containing 1-2% oil emulsion) and 1½ pounds 2,4-D per acre seemed an effective and practical dosage for the initial spraying operation. Ribes kill varied greatly on different parts of a single plot where rough terrain, tall trees or snags had forced the helicopter to change the pre-scribed flight line and to fly 40 feet or more above the brush. On the Coeur d'Alene National Forest, Idaho, June 22-25, 1949, a Bell 47-D helicopter was used to spray R. lacustre, R. viscosissimum, and associated brush with 2,4,5-T ester. Dosage rates of 1, 2, and 3 pounds of acid (2,4,5-T) in 5 and 10 gallons of Diesel oil, and in water containing 1% summer oil emulsion, were used in treating 12 plots. Elevations of the plots varied between 4,000 and 4,600 feet. September inspection showed that the 2,4,5-T water-oil emulsion formulation appeared to be as toxic to Ribes and brush as the 2,4,5-T straight oil and was less injurious to conifers. Idaho and California tests clearly showed the importance of spraying alternate strips from opposing directions and allowing at least 10% overlap.

The Effect of Selective Sprays for the Control of Annual Weeds in Grass Seedings, L. W. Rasmussen and Don Douglas, Washington Agricultural Experiment Station and Soil Conservation Service, Regional Nursery Cooperating, Pullman, Washington.

Six grass species were seeded May 25, 1948 on a relatively uniform slope at the Soil Conservation Nursery. Three 12 inch rows 20 feet long of each species were seeded in each plot, thus the plots were 18 by 20 feet in size. The sprays used were 2,4-D sodium salt and 2,4-D ester at 1/4, 1/2, and 1 pound per acre each and dinitro selective (Sinox D) at 2,4, and 6 pounds per acre at a volume of 120 gal. per acre. Sprays were applied at 3 times, first set when the earliest grass species reached the 3 to 4 leaf stage, second set one week later, and third set one week later than the second. The predominant weed species was tumbling pigweed (Amaranthus graecizans) and at the time of the first spray was succulent and had two to four leaves. At the time of the second and third sprays the weeds had hardened noticeably because of the hot dry weather.

The dinitro at the two higher rates and at the first application time gave complete kills of the weeds. The high rates of the 2,4-D compounds also gave complete kills, but were slower acting than the dinitro. At the second and third application times the dinitro and the 2,4-D salt were completely ineffective, but the heavy rate of 2,4-D ester gave good control at the second time and held the weeds in check at the third time.

Two grass species, smooth brome and slender wheat, were harvested August 18, 1948. The heaviest yields were on plots treated at the first stage with dinitro at 4 and 6 pounds and 2,4-D ester at 1 pound, corresponding to the plots on which the best control of weeds were obtained.

In 1949 no spraying was done but forage and seed yields of all six species were obtained. The seed and forage yields were highest on the plots sprayed at the first stage, indicating the beneficial effects of early weed control. The increase in yield for the first spray time was significant, $P = < 0.01$. The chemicals and the rates did not cause any significant difference in the yield of forage or seed.

Effect of time of day of application of 2,4-D in controlling Canada thistle. Bruce J. Thornton, Colorado Agricultural Experiment Station, Ft. Collins, Colorado.

In a randomized block test, a heavy stand of Canada Thistle, growing in irrigated pasture, was treated with two formulations of 2,4-D at three rates of parent acid and at three times of day, each treatment being replicated three times. The return growth the year following treatment indicated no significant difference between effects of the two different formulations or the rates of application. However, the difference in the reduction of the Canada thistle as affected by the time of day of application was highly significant, the morning treatments being superior to the noon treatments and the noon treatments being superior to the evening treatments.

Direct comparison of the effect of an ester and an amine salt of 2,4-D in the ratio of 2 to 1 in controlling whiteweed (Lopidium draba). Bruce J. Thornton and L. G. Kauts, Colorado Agricultural Experiment Station, Ft. Collins, Colorado.

In a randomized block test, whiteweed, growing, luxuriously on noncultivated land was treated with an ester of 2,4-D at the rates of $\frac{1}{4}$#, $\frac{1}{2}$#, 1# and 2# of parent acid per acre and with an amine salt of 2,4-D at twice these rates or with $\frac{1}{2}$#, 1#, 2# and 4# of parent acid per acre. The applications were made with water at the rates of 10, 20 and 40 gallons per acre. Treatments were made in spring and fall and each test was replicated three times. The return growth the following year indicated the ester form of 2,4-D, in each of the rates applied, to be fully as effective as twice the respective amount of 2,4-D in the form of the amine salt. With both formulations there was an increase in effectiveness with increase in the rate of parent acid applied. The combined spring and fall treatments were much more effective than the spring treatment alone. There was no difference indicated in the effectiveness of the chemicals as influenced by the different amounts of water used.

Control of quackgrass in established alfalfa with TCA and chlorate. F. L. Timmons and D. C. Tingev. Contribution from Bureau of Plant Industry, Soils, and Agricultural Engineering, U.S.D.A. and the Utah Agricultural Experiment Station, Logan, Utah.

Sodium and ammonium salts of trichloroacetate (TCA) were applied as spray treatments to quackgrass Oct. 16, 1948 at 3/4, 1, 1$\frac{1}{2}$, and 2 lbs. per sq. rd., and sodium chlorate was broadcast dry at 2 and 4 lbs. per sq. rd. New treatments were started April 1 and June 21, 1949 comparing sodium TCA at 3/4, 1, and 1$\frac{1}{2}$ lbs. per sq. rd. and sodium chlorate at 4 lbs. per sq. rd. in each case. The experiment was located in a sub-irrigated field of established alfalfa that had become infested with quackgrass. All treatments were replicated six times with plots arranged at random.

Since none of the treatments gave complete eradication of quackgrass, retreatments were applied three times in 1949 (Apr. 28, June 21, and Oct. 1) on the plots treated originally Oct. 16, 1948. Retreatments were made June 21 and Oct. 1 on plots originally treated Apr. 1, 1949, and were made Oct. 1, on plots originally treated June 21, 1949. The amount of chemical used in retreatments was based upon the amount of quackgrass regrowth present.

The original TCA treatments temporarily reduced the quackgrass stand 70 to 100% in all cases, with the heavier rates giving the greatest reduction. However, recovery was rapid and by September 27, 1949 the average stand of quackgrass ranged from 27 to 73% for original treatments made Oct. 16, 1948 and April 1, 1949, despite retreatments made in 1949 bringing the total amount of TCA applied up to 2 to 3 lbs. or more per square rod in all cases.

Sodium chlorate reduced the stand of quackgrass much more than did TCA, and there was little recovery during the season. The stand on chlorate treated plots Sept. 27, 1949 averaged 5 to 22% with 4 lbs. per sq. rd. applied October 16, 1948 giving best results.

Alfalfa was killed almost 100% by both the light and heavy chlorate treatments made October 16, 1948, and was reduced more than 90% by the heavy applications made April 1 and June 21, 1949. Alfalfa was severely stunted for 2 or 3 months by all TCA treatments made in fall or early spring, but was not reduced in stand and gradually recovered toward normal color and vigor. The TCA treatments made June 21, immediately after the first crop of hay had been removed, caused very little detrimental effect on growth of alfalfa. Yields of alfalfa hay from the second cutting August 2 and the third cutting Sept. 20 were determined for all plots. The yields were quite variable, and showed no consistent or significant increase or decrease for TCA treatment as compared with untreated quackgrass infested check plots. No harvestable alfalfa was produced on the chlorate treated plots.

This experiment will be continued.

Control of annual weeds in sweet corn by pre-emergence treatment with 2,4-D and TCA
F. L. Timmons. Contribution from Bureau of Plant Industry, Soil, and Agricultural Engineering, U.S.D.A., cooperating with the Utah Agricultural Experiment Station., Logan, Utah.

Sodium salt and micronized pure acid formulations of 2,4-D were compared at rates of 1, 1½, 2, and 2½ pounds (acid equivalent) per acre in spray applications made 5 days after planting and just before emergence of sweet corn (Golden Hybrid 2439). Combinations of sodium TCA and the sodium salt of 2,4-D tested included TCA at rates of 1½, 2, 2½, and 3 pounds with 2 pounds of 2,4-D per acre, and 2,4-D at the rates of 1, 1½, 2, and 2½ pounds with 2 pounds for TCA per acre. The chemical treatments were compared with hoed and unhoed controls and all treatments were replicated 4 times in randomized blocks on cultivated and non-cultivated series of plots. Just before planting the sweet corn, annual weed seeds, including mustards, redroot pigweed, (*Amaranthus retroflexus*) and green foxtail grass *Setaria viridis* were broadcast at the rate of 80 pounds per acre to insure a uniformly heavy stand of both broadleaved and grass type weeds.

The chemical treatments reduced the early season population of broadleaved weeds 65 to 95% and of weedy grasses 45 to 80%. The reduction in weeds tended to increase with rate of chemical. Micronized 2,4-D acid was definitely more effective than the sodium salt of 2,4-D at equivalent rates (acid equivalent basis), especially on broadleaved weeds. The combinations of TCA and 2,4-D were only slightly more effective in reducing the stand of either woody grasses or broadleaved weeds than the same rates of 2,4-D used alone. The TCA did, however, appear to reduce the size and vigor of surviving grasses while 2,4-D did not. Very few weeds emerged later in the season on chemically treated plots that were not cultivated. On the cultivated series after two cultivations the population of broadleaved weeds was reduced 60 to 95% and the stand of weedy grasses was reduced 35 to 90% by the chemical treatments, as compared with untreated cultivated check plots.

None of the chemical treatments had a significant effect upon the number of sweet corn plants per 10 feet of row. However, the number of stalks was increased 12 to 40% by all treatments except the sodium salt of 2,4-D alone, as compared with untreated hoed checks. The increase in number of stalks due to chemical treatment was consistently greater on the cultivated series and was somewhat greater for combinations of TCA and 2,4-D than for 2,4-D alone. The number of stalks for unhoed untreated check treatments averaged about 70% as much as for hoed untreated check treatments, and only 50 to 60% as much as for the various chemical treatments.

Most of the chemical treatments increased the number of sweet corn ears up to as much as 30% in the cultivated series, as compared to the hoed check treatment, but produced no increases and even slight decreases for low rate treatments on the uncultivated series. The number of ears for unhoed check treatments was only about 25% as much as for the chemical treatments on the uncultivated series, and about 70% as much on the cultivated series. The average weight per ear showed the same trends as number of ears, but the difference between treatments were much smaller.

The average yields of ears on the uncultivated series ranged from 4.0 to 6.9 tons per acre fresh weight for the different chemical treatments, as compared to 6.4 tons for the untreated hoed check and 1.0 ton for the untreated check that was not hoed. Yields for the combination TCA and 2,4-D treatments and the higher rates of micronized 2,4-D acid averaged about the same as, or slightly less than, for the untreated hoed check, but were considerably less for the lower rates of 2,4-D which gave less effective weed control. The average yields of ears on the cultivated series ranged from 6.0 to 8.4 tons per acre for the chemical treatments as compared to 6.0 tons for the untreated hoed checks and 4.8 tons for the untreated checks in which the weeds were not hoed from the rows. Ear yields averaged .8 ton per acre more for micronized 2,4-D acid and 1.0 ton more for combination treatments of TCA and the sodium salt of 2,4-D than for the sodium salt of 2,4-D alone. The average ear yield for all chemical treatments was 5.7 tons per acre on the non-cultivated series, and 7.2 tons on the cultivated series, giving an advantage of 1.5 tons for cultivation on chemically treated plots, an average gain of 1.2 tons for chemical treatments as compared to cultivation and hoeing alone, and a gain of 2.4 tons for chemical treatment over cultivation without hoeing the weeds from the row.

The yields of dry forage showed similar trends to yields of ears in all cases, and the differences between treatments were proportionately about the same.

WEDNESDAY AFTERNOON

President Whitman, Presiding

STATE ORGANIZATION FOR WEED CONTROL

T. F. Yost
State Weed Supervisor
Topeka, Kansas

It has been my pleasure to attend several of your conference meetings in past years including the first here in Denver in 1938 as well as those held at Salt Lake City and at Reno in later years. I have always enjoyed the excellent quality of your meetings. Your conference is to be congratulated for the high type of research workers in your area and for the excellent regulatory programs which exist in your states. I especially desire to congratulate your conference for the close relationship and friendly harmonious feeling which I have observed between the research workers and the regulatory officials in charge of state weed control and eradication programs. May I further congratulate you for the excellent assistance which you are receiving from the federal level in weed research work. In this connection, May I further say that if you are in the slightest degree disappointed with Tim or Vic, won't you just drop me a gentle hint so I may invite them to return home from whence they came. We were sorry to lose them and would be happy to welcome them back to our conference area and especially to Kansas. Should these workers appear a bit strange, unaccustomed or a little lonesome at their work in your area, may I suggest that you just give them a little more time and tolerance, and I can assure you that with your scenic mountain landscapes, your wonderful irrigated farms, vineyards and orchards and with your fine people they cannot help but adjust themselves to their new conditions and surroundings so that they will enjoy and be enjoyed which I am sure is already true. I feel sure that these men, as well as you and your area are benefited by our loss.

Your program committee has asked me to discuss the subject of "State Organization for Weed Control." May I say that this is one of the reasons why we came to your conference hoping that we might make some contacts and pick up some new ideas that would be helpful in improving our own state weed program.

In Kansas our program is 12 years old. The ideas that I may express in this paper will be based on the observations we have made in visiting and studying other state programs and more especially in studying and trying to improve our own state program during these past years. As you already well know, there are no two states that have like or even very similar state programs.

It would probably be impossible to discuss this subject without also discussing the legal angles of a good state weed law. It would seem almost impossible to set up a statewide noxious weed program without some kind of law to give support and direction to such a program. There would be some difficult problems that could not be hurdled without legal provisions. So in my discussion I will frequently make reference to legal provisions.

May I say that a state weed program should be divided so that the state agricultural extension service would be responsible for the treatment and control of the common weeds which involves only a program of education and that of action where the landowner or farmer does all the control and eradication work. This part of the program should include all of the common or easy to kill weeds. Those weeds classed as noxious and which are really hard to kill should be included on a special list and their treatment, control and eradication undertaken by a special set-up and program backed up by a State law which should set forth all of the conditions under which such a program should be organized and should operate.

Some of the important features that must be covered by such a law should receive some consideration here. First of all, a state agency should be designated to have charge of the program and be responsible for enforcement of the law as far as local officials are concerned. It, of course, goes without saying that a state office should be properly financed and adequately staffed with competent help. The law should provide for a state weed set-up and should provide for a state appropriation to support the set-up on the state level. Most, if not all, of the regulatory weed programs are properly placed with the State Department of Agriculture.

In most, but not all, cases a Division of Noxious Weeds is created and a division head is put in charge. In some states the weed division head consults with the State Secretary, Director or Commissioner of Agriculture and proceeds from there, whereas in other states there is a state weed or advisory board which adopts policies in steering the program on the state level. There might be some disagreement of opinion as to which would be the better plan. A state weed board if properly organized could be helpful by representing such agencies as the Extension Service, the Experiment Station as well as Crop Improvement Associations, Horticultural Societies, State Grain Inspection Departments and possibly other agencies which could be helpful in assisting to build a stronger and more effective weed program. Each individual on such a board should represent an important agricultural agency in the state, and his representation on the board should lend the active support of his agency. I can see where such a board would be very helpful, providing it was not necessary to consult them on all occasions concerning methods or procedure which could be more expeditiously decided by consulting the directly superior official such as the top regulatory official of the department.

Another important matter on the state level is the question of the number and kinds of weeds that should be designated as noxious. In our state the belief has prevailed that the number of weeds designated as noxious should be held to only a few of the most important weeds which are a threat to the welfare of the state's agriculture. If this is the case, only a state agency should have the power of declaring weeds as noxious. This plan will lead to uniformity whereas a plan of local option will lead to long lists of noxious weeds in certain counties some of the species frequently may be added by individuals of influence or pressure groups. In this way some weeds of relative unimportance are added which tends to weaken the effort directed against the truly bad species. It is my personal opinion that the weeds included on the noxious list should consist mainly of the deep-rooted perennials which have the habit of lateral spread. There might in some rare cases be just cause for adding certain other species which would not fall under this description.

The state noxious weed set-up should have sufficient and qualified personnel so that the local or action set-up can be given plenty of assistance in planning their program, and in carrying out their activities in such a way so as to accomplish two things, first, uniformity of action and procedure between the various counties, and two, tosecure satisfactory results and progress. There should be frequent contacts between the state workers and local agency workers and with definite responsibilities by the local program to the state agency.

With a properly organized state office adequately financed and properly staffed, we can now consider how the local program should function. First, let us consider the size or scope of the local action unit. In most states the county is considered the best unit of action. In some states where weed district set-ups are organized, local units sometimes are much smaller. In our opinion, the county is in most cases the best size of unit on which to organize and function.

Agreed that the county is probably the best unit as a basis for action who should be designated as the officials in charge of the overall county weed program. A good state weed law should make this point clear. Should existing county officials who are elected along party lines be designated to act in this capacity or should the people be requested to elect their own county weed board. Kansas is an example where existing county officials are used, and Nebraska is an example where the people elect their own county weed board. I do not propose to say which is the better plan. No doubt there are good arrangements in favor of both. In Kansas we have found our plan highly satisfactory in most but not all counties, and I feel certain the same could be said of the other plan. Probably the worst that could be said of using regularly elected party officials is that partisan politics might frequently be a deciding factor to the disadvantage of the weed program. With us we have found this to be true but very little and usually exists only for a short period. It is sometimes said that regularly elected officials are too economy minded and would therefore employ cheap and inefficient help and hold other costs to the bone. As a general thing we have not found this to be true but rather believe that where this is the case it is due to a lack of full appreciation for a well-conducted and properly financed program.

Let us now consider the management or supervision of the local program. It is our opinion that the local set-up responsible for the action program should have a weed manager, commissioner or supervisor in charge. Unless this is the case little can be accomplished. For the purpose of this discussion I will mention such official as a supervisor although one of the other designations might be more desirable in your state. The ideal plan is to have a county supervisor work on a full time 12 months basis. This, however, might depend and be governed by the seriousness of the noxious weed condition existing in the county. This is the actual situation in some of our counties. It might also be considered that the county supervisor might be given other duties in such counties such as insect or other pest control activities. This, I believe, is the case in some of your states. However, if the weed situation is widespread or of a serious nature in the county, he should be designated as a full time worker on weeds only. This we have in about 65 of the 105 counties in our state. Probably one-half of the remaining counties should maintain full time supervisors whereas the other half would not be justified unless other pest work would be added to his duties.

If a local program is to be both sound and logical it must cover both ends of the noxious weed problem which consists of measures to eradicate existing infestations and likewise to make every effort to prevent, to control or at least to reduce the natural and normal methods whereby the seeds of noxious weeds move from place to place. It is our conviction that it is fully as important to control the spread of noxious weeds as it is to institute eradication measures. With us this has consisted of controlling or regulating the sale of infested livestock feed materials, screenings, nursery stock and cleaning of harvesting and threshing machinery and equipment.

Having considered the size and scope of the local program, let us now consider the actual eradication work to be done by the supervisor and by the land-owner himself. Concerning the supervisor of the county weed program what should be his qualifications. With no fear of insult or contradiction, I would say that a Ph.D is wholly unnecessary if not undesirable and the same might be said of a masters degree. By this I do not mean to infer that a strong back and a weak mind are the essential qualifications. A good supervisor of a county weed program should not be considered to hold a white collar job. The essential qualifications are willingness and ability to learn readily by reading, observation and by doing, good judgment and horse sense, ability to make good contacts and get along well with farmers and above all willingness to work hard. Ability to keep good records and made reports is desirable. A good mechanic may be considered important, a knowledge of chemistry, botany and soils is much to be desired but not altogether necessary. Much of the necessary technical information can be acquired by interest and diligent application to the problem at hand.

Having a qualified supervisor on the job in charge of the county weed program we are now ready to start taking information to the farmers and start actually killing some weeds (about time we got around to that.) In light to medium infested counties, it is my thought that this might be pretty much of a one-man program but possibly using some help during the heavy season.

Let us now consider some of the problems with reference to the organization of a local county program. Should the program be entirely educational and the landowners and public agencies do all their own eradication work or should there be some cooperation between the landowners and the county weed set-up? Should railroads, highways, cities and other agencies be expected to do their own weed eradication work? I say that would be fine if they would give the necessary and desired cooperation. If I had the power and authority to revise our law and program, I would put all eradication activities on highways, railroads, in cities and other similar places, but not including farm land, under the supervision and responsibility of the county weed supervisor. All such agencies should pay the cost of treatment and eradication. In this way there would be no difficulty in trying to secure action from unwilling cooperators. Thus all such eradication work would come under one county set-up instead of having separate programs in charge of different officials for each of the various agencies mentioned.

That phase of the program dealing with the eradication of noxious weeds on farms should also be under the supervision and direction of the county weed supervisor.

Now comes the question as to whether the farmer should be wholly responsible for all treatment and eradication activities on his farm. Should the farmer be entrusted with such dangerous chemicals as sodium chlorate; and further, is the intelligent use of 2,4-D and other weed killers, too complicated for the average farmer? In our state we have had a chance to try both methods. The intelligent use of sodium chlorate is a careful and accurate procedure as well as dangerous. Farmers using the material frequently have poor results and the same is true with 2,4-D and other weed killer chemicals. In our state we have favored the plan where the county weed supervisor does most if not all of the handling and use of sodium chlorate as well as borax compounds. With us, the county taxing unit pays one-half the cost of the chemical which may be a good cause for expert supervision, in the safe and efficient use and handling of such materials. In many cases the farmer would not be justified in purchasing special equipment such as mechanical dry spreaders which could seldom if ever be used for other purposes.

In the case of using 2,4-D for treating large areas of noxious weeds, it is my opinion that the farmer should be prepared to help himself. In addition the county weed set-up should also own and operate one or more weed sprayer outfits in order to help the program along. The farmer should be expected to pay for such services on an actual cost basis.

There might be some difference of opinion concerning the question of furnishing a source of approved chemicals for use in such a program. It would seem that such materials as needed in a compulsory program, should be purchased by the county weed-set-up at the lowest possible cost and resell such materials to farmers at actual cost in order to encourage farmers as an additional inducement toward cooperation. And further to furnish a dependable supply of high quality and sometimes scarce materials that cannot be stocked by local dealers. In our state the county taxing unit furnishes state approved chemicals at half price when used in a state approved manner. I am not suggesting that chemicals should be resold at a reduced figure to farmers. However, we do feel that this has made it somewhat easier to secure cooperation. It might also be justified on the grounds that noxious weeds are a public menace and therefore the public should help share the cost.

As I stated before there are two important ends to the noxious weed situation: The eradication phase and the prevention of spread phase. Both ends of the program should be worked simultaneously in each county. Every effort should be made to reduce the spread of noxious weed seeds through the sale and exchange of farm seeds. In most states this is being well done through the operation of a state pure seed law. In our state another source of spread is through livestock feed materials including both feed grains and hay. Probably 90 per cent of the oats and barley raised is utilized as livestock feed and almost 100 per cent of the rough feeds produced are fed to livestock. Probably more seeds of bad weeds are spread through livestock feeds than through field seeds. It should be unlawful to sell livestock feed materials which are infested with the seeds of noxious weeds, and such feed materials when offered for sale should be checked by the local agency in charge of eradication activities. It should also be unlawful for anyone to move harvesting or threshing machines and possibly other equipment from an infested field without first cleaning such machines free of noxious weed seeds. In like manner nursery stock or garden plants should be unsalable if grown on infested land. The movement of infested soil or sod should be checked and supervised.

Running a successful county weed program will need to employ every good method of approach. The successful supervisor must be intelligent and wide awake to the value of various methods as: newspaper publicity, circular letters, meetings, exhibits at meetings and fairs as well as farm visits and personal contacts.

If the Kansas program has attained any degree of success it would be due to a number of facts some of which I desire to list as follows:

1. A state agency in full charge of the overall program in all counties.

2. Adequate and qualified personnel on state level to keep in touch with county programs and give assistance in program planning, inspection tours, annual weed tax budgets, holding county-wide weed schools and giving instructions and suggestions to county workers when necessary. In addition two series of district educational meetings for county workers and a state-wide weed conference for all are held each year.

3. Appointment of county weed supervisor must be approved by state regulatory officia

4. State agency has power to adopt rules, regulations and official methods of eradication which counties must follow in their program.

5. State agency has organized and supervises a cooperative plan of purchasing state-approved chemicals in pooled car shipments direct from the manufacturer to counties.

6. All county programs throughout the state are set up and function on a uniform plan. All counties make about the same price charge for chemicals and for services. Supervisors in each county are doing about the same kind of work at all times throughout the year.

7. Noxious weeds may be designated only by legislative action. At the present time only field bindweed, Russian knapweed and hoary cress have been declared as noxious, as well as Johnson grass in a few counties.

8. All counties are required to employ a supervisor of which 65 counties work on a full time year around basis.

9. Counties are required to adequately finance county weed programs. For 1950 counties have set up tax budgets aggregating $920,000 and an additional $200,000 for township and city weed work.

10. County weed supervisors have charge of eradication work on highways, railroads, in cities and on other public land. This procedure gives excellent cooperation to joining landowners who desire to initiate eradication measures.

11. County supervisor cooperates with farmers by actually applying sodium chlorate for small patch treatment.

12. Counties are required to furnish state-approved weed killer chemicals to farmers at one-half actual cost.

13. County supervisor can and does cooperate with farmers in spraying large areas of noxious weeds with 2,4-D where farmer agrees to follow state-approved cropping plan.

14. County supervisor does most of his work on the basis of personal contacts and by farm visits to inspect noxious weeds in field and make recommendations based on observation and actual field conditions.

15. County supervisor is responsible to work on prevention of spread phase of program.

16. County supervisors are required to make monthly and annual reports of their activities to state office on forms supplied by state.

In closing, may I say that we appreciate the invitation and opportunity to attend your most excellent conference here at Denver. I desire to bring each of you greetings and good wishes from the North Central Conference which was instigated and largely patterned after your organization. I desire to extend a personal invitation to each of you to attend our next conference at Milwaukee in December of this year. Our last conference at Sioux Falls was glad to have Bruce Thornton, Dr. Crafts and several commercial representatives from your area in attendance. We certainly missed Walter Ball and some of your other faithful workers.

INSTRUCTION IN WEEDS AND WEED CONTROL IN ELEVEN WESTERN STATES AND HAWAII

W. W. Robbins
Botany Division, College of Agriculture
University of California, Davis

It is apparent that there has been an increasing interest in weed control, and recognition of the importance of weeds in agricultural production. High labor costs have stimulated the mechanization of agriculture, and chemical weed control is one phase of this mechanization trend. Naturally, there has arisen a demand for weed research, and, concurrently, a realization that an effort needs be made to organize and strengthen instruction in weeds and weed control in our agricultural colleges and secondary schools.

At the request of your President, the Education Committee of the Western Weed Control Conference conducted a survey, and herewith presents its report. Brief questionnaires were sent to the Agricultural Colleges in the eleven Western states, and to Hawaii; also to such offices in the various states that could give us information from the field of vocational agriculture. Responses were prompt, rather complete, and in general very gratifying.

Eight of the Agricultural Colleges offer special undergraduate courses in their curricula. Data pertaining to these courses are shown in Table I, and discussed further on.

Field and laboratory exercises vary considerably. California stresses field and laboratory work, including identification of approximately 100 weed species, chiefly in the field; methods of weed distribution; vegetative and reproductive characteristics; demonstrations of mechanical equipment including spray equipment; preparation and application of spray solutions; observation in field of spray applications with ground equipment and airplane; visit to State Seed Laboratory; field trips to observe weed infestations under a variety of conditions.

Idaho emphasizes field and laboratory exercises, including weed identification and control methods. It offers a special course on weed and weed seed identification.

Montana offers no laboratory exercises, but makes observations of the results of control methods mostly on experimental plots; about 20 per cent of the course is devoted to weed identification; weed seed identification is given in a separate course.

Nevada's laboratory exercises include identification of weeds and weed seeds, green house studies of responses of weeds to chemicals and competition; the field exercises involve use of hand and power spray equipment, and practice in weed identification; minor emphasis on weed seed identification.

Oregon reports six field exercises devoted to establishment of plots, taking of readings, and observation of results on established plots. Laboratory exercises include weed identification, chemistry and properties of herbicides, and methodology.

Utah has about 4 field exercises during the quarter, collecting and identifying weeds and weed seeds; laboratory exercises include further study of weeds and seeds.

Washington reports laboratory exercises, emphasizing weed and weed seed identification, but no field exercises.

Wyoming's field exercises involve a study of range weeds, those of irrigation canals, and miscellaneous problems; the laboratory exercises include greenhouse experiments with chemicals, these being conducted by all students.

In addition to undergraduate courses in Weeds and Weed Control, the states of California, Colorado, Oregon, Utah, Washington, and Wyoming report graduate students working on problems directly or indirectly related to weed control.

At the secondary level of agricultural education, we have reports from Arizona, California, Idaho, Oregon, Utah and Washington.

Arizona reports that in Agriculture 1 (first year) 4 days out of 175 for the year includes losses caused by weeds, identification and characteristics of common weeds, how weeds spread, and control methods. In Agriculture III (third year), instruction in weeds involves identification and control practices including actual work in the field; these exercises take up 6 days out of 175 for the year. There is a state contest on weed identification.

In California most Smith-Hughes schools include exercises on weeds and control methods. Emphasis on particular phases varies with the locality. Main interest is in weed control by chemicals. Some schools possess spray equipment and give field demonstrations. Nearly all emphasize identification of local weeds. No special courses are given, but weed control is given attention in the study of different crops. One Regional Supervisor states that of the 26 schools under his supervision, all of them spend from a week to ten days each year on various phases of weed control. Another Regional Supervisor who administers 22 Smith-Hughes schools, states that their study of weeds is incorporated in their detailed instruction of agricultural enterprises. Also, in the same area there are 17 Institution-on-Farm Agricultural Programs which spend a considerable time on the economic phases of weed control. They are using a mimeographed pamphlet entitled "Weed Control Lesson Plans for Teachers of Vocational Agriculture", prepared by the U. S. Bureau of Reclamation in cooperation with the Regional Director's Office.

From Idaho the report from the State Board of Vocational Education states that each local department of Agricultural Education teaches weed identification and control for from 10 to 15 days; and that more time is given to weeds than to the study of either plant diseases or insects.

Oregon reports that some instruction and study in regard to weeds and weed control makes up a portion of virtually every individual trainee's course in the Institutional on-Farm program. This includes weed identification, field trips, and control methods.

In Utah, each Vocational Agricultural Department gives some instruction on weeds, and fosters state weed identification contests.

The State Board of Vocational Education of Washington reports that most vocational schools engage in weed and weed seed identification contests, have field trips to observe plots and field applications of herbicides, and that in crop courses, there is emphasis of weed control methods.

From the foregoing brief abstracts of reports submitted, we may draw some pertinent conclusions:

1. There is a widespread, intelligent and growing interest in weed control, both at college and secondary school levels.

2. There is a trend toward the establishment of definite courses in weeds, rather than the incorporation of such instruction as merely a relatively insignificant part of other production courses.

3. Courses of instruction in weeds are graduating from the strictly identification stage to one which includes control methods based upon botany, chemistry, soils, crops and engineering.

4. There appears to be a need for upper division weed courses in agricultural colleges.

5. The number of graduate students working on problems definitely related to weeds is increasing.

6. The demand for young men with fundamental training in weed control coming from experiment stations, Extension Departments, educational institutions, State Department of Agriculture, commercial companies, large farm holdings, in fact, agricultural organizations of all sorts, is placing a responsibility upon our colleges, and we should be keenly aware of obligations and opportunities. The development of young men with such fundamental training will play a role in crop production on individual farms and will increase the scope and effectiveness of weed courses in secondary schools.

7. There is strong evidence that the day is not far off when research and instruction in weeds and weed control will have the recognition and status now enjoyed by research and instruction in entomology and plant pathology.

TABLE I. Instruction in Weeds and Weed Control in Agricultural Colleges
(Eleven Western States and Hawaii.)

State	Name of Course	Units Credit	Ave. Class Enrollment	Pre-requisites
Arizona	-	-	-	-
Calif.	(1) Weed Control (Bot. 51)	3	75	No
	(2) Weed Control (Bot. 107)	4	80	General Botany
Colorado	-	-	-	-
Hawaii	-	-	-	-
Idaho	Weed Control	3	30	Junior standing
Montana	Agron. 415	3	30	Farm crops, Gen. Bot. Syst. Bot. Or Chem.
N. Mexico	-	-	-	-
Nevada	Agron. 346	3	5	Org. Chem., Forage Crops, Tax. or Pl. Phys.
Oregon	Weed erad.	3	40	Gen'l.Bot., Sys. Bot., Pl. Phys.- Junior standing
Utah	Weeds	3	25	No
Wash.	(1) F.C. 5	3	25	One course in Bot.
	(2) F.C. 107	2	10	F.C. 5, Bot. 24 (Pl.Phys.)
Wyom.	Agron. 607	3	25	Agron. 301 A, B, C., Bot. 301 A, B, C.

REGULATORY PHASE OF WEED CONTROL

Walter S. Ball
California Department of Agriculture

Due to the rapid developments in the research phase of weed control it is only natural that certain mistakes will be made in the use of some of our herbicides. Unfortunately, as all of you know, 2,4-D is a very toxic herbicide and when it is permitted to drift from a weedy area to crop plants, obviously something is going to happen. It has been the hope of most of us, I am sure, that this would be corrected through education and better developments toward the application of 2,4-D compounds.

So far as California is concerned thousands of acres have been treated with 2,4-D and we have had our share of troubles along with Texas, Arkansas and Louisiana. Investigation of all known instances of crop damage has revealed that misuse of the material caused the trouble. Application was made at the wrong time of the year, during a period of high winds or under very high temperatures, all of which conditions we had hoped could be corrected to eliminate laws and rules and regulations. However, after several thousand acres of cotton were affected and hundreds of acres of our Today grape growing area were damaged, naturally the persons affected became somewhat alarmed about the continued use of the material in those areas, and the result was legislative action. The law was passed and approved by the Governor on July 27, 1949. This law in part is as follows:

"It is unlawful to use any form of 2,4-D or other herbicide which the director finds and determines, after hearing, to be injurious to crops......."

"The director after investigation and hearing shall adopt rules and regulations covering the use of 2,4-D and other herbicides which he finds and determines to be injurious to crops that are being grown in any area of the State. Such rules and regulations may prescribe the time when and the conditions under which such herbicides may be used in different areas of the State and may provide that such herbicides shall be used only under permit of the commissioner (agricultural commissioner) or under the direct supervision in certain areas or under certain conditions or in excess of certain quantities and concentrations ....."

The introduction of these regulations brought about hearings which definitely pointed out the place that 2,4-D had in our modern agriculture — probably one of the largest hearings ever to be held on any pest control measure by the Department of Agriculture. These rules and regulations as provided by the law made it necessary to set up given areas throughout the state and also provide how the material was to be used in these areas.

One section in the regulations on injurious herbicides provides as follows:

"The director finds and determines that herbicidal preparations containing 2,4-Dichlorophenoxyacetic acid (2,4-D), 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) or 2-methyl-4-chlorophenoxyacetic acid (MCP), or any compound thereof, hereinafter referred to as "injurious herbicides", are injurious to certain crops grown in various areas of the State, hereinafter referred to as "susceptible crops", to-wit: grapes; cotton; beans; peas; cowpeas, and other annual legumes; melons, cucumbers and other cucurbits; tomatoes, peppers and eggplant; lettuce and other annual garden vegetables; sinnias and other annual flowering ornamental plants; and many other plants and crops, particularly in the seedling stage and during periods of active growth". Hazardous areas are defined as well as legally outlining these areas throughout the State. The rules and regulations then set up time and conditions for use as follows:

"Injurious herbicides shall be used only at the time and under the conditions herein set forth. Said conditions are applicable to all uses of such herbicides, whether or not a permit is required, and are implied as a condition of each permit issued pursuant to these regulations.

(a) Packages of injurious herbicides shall not be opened or exposed, and opened containers or leaky containers or equipment in which injurious herbicides have been used, shall not be stored or handled, at any place where they are likely to contaminate fertilizing materials, planting seed, nursery stock, or plants for sale to or owned by another person, or pest control materials other than herbicides.

(b) Injurious herbicides or emptied containers thereof shall not be dumped or abandoned in or at any place where plants of value are likely to be injured by the vapor or by water flowing through or over the material, or where contaminated soil is likely to be transported or used in proximity to susceptible crops.

(c) Equipment used for injurious herbicides shall be cleaned so that no injurious residue remains before being used for any purpose whereby such residue might come in contact with suscepitble crops.

(d) Equipment for application of injurious herbicides by aircraft shall be leakproof, with nozzles equipped to prevent dribble.

(e) Unless expressly authorized by permit, no injurious herbicides shall be discharged from aircraft over any property, other than the property to be treated.

(f) No injurious herbicides in dust or aerosol form shall be applied except (1) by or under the direct supervision of the Director or a county agricultural commissioner, or (2) as a constituent in a fertilizer being applied solely to lawns.

(g) Unless expressly authorized by permit, no injurious herbicides in highly volatile form shall be applied within one mile of a susceptible crop, if by ground rig, or within ten miles by aircraft.

(h) Unless expressly authorized by permit no application of injurious herbicides shall be made when wind velocity exceeds ten miles per hour; nor at a height greater than ten feet when wind velocity exceeds five miles per hour.

(i) No injurious herbicides shall be used under any circumstances where injury is likely to result to plants of value on property other than the property to be treated, either through drift of the herbicide during application or through subsequent movement of vapor or contaminated dust in the wind; nor at any time when the form of the herbicide, the method of application, the condition of surrounding crops, weather conditions, or other circumstances present exceptional risk of injury to crops" and then sets up provisions for permits.

Other regulations which have been discussed from time to time for many years have recently been brought up to date in California and it appears that enforcement of these regulations is going to bring about a much better condition relative to seed screenings and cleanings. We feel these regulations are very important in that we are enforcing seed laws as well as setting up standards for certification of seed where it is necessary to clean all noxious weeds from the crop seeds before they can be sold to the public. Too little attention has been given to the screenings which have been cleaned from these crops and in many cases it is known that the screenings are used for feeding purposes without processing or are planted in certain areas of the state for cover crop purposes, which definitely defeats the objectives of forcing farmers and dealers of commercial crop seeds to clean the seed that is offered for sale

The following are excerpts from the revised rules and regulations pertaining to seed screenings and cleanings:

"Terms Defined. As used in these Regulations:

(a) "Screenings" mean seed screenings or cleanings from crop seeds, and is construed to include any product or material removed from crop seeds by any means whatsoever, except uncleaned or partially cleaned crop seeds consigned to a recleaning plant for further cleaning.

(b) "Process" means grinding or other treatment of screenings to render the seed of any pest incapable of reproduction.

(c) "Pest" means any form of vegetable life that is or is liable to be dangerous or detrimental to the agricultural industry of the State. (cf. Agr. Code Sec. 100)

(d) "Crop seed" means the seed or seed-like fruits of grain, beans, flax, beets, onion, or any other crop, whether or not intended for planting purposes. (cf. Agr. Code Sec. 100)

3801. Processing. The following processes are found to render the seed of any pest incapable of reproduction when applied to all portions of the screenings to be processed, in accordance with the specifications herein:

(a) Burning in an incinerator with sufficient draft to affect complete combustion

(b) Dumping in tidewater or in other locations designated by the commissioner in which the seed of any pest may be rendered incapable of reproduction by natural causes.

(c) Cooking not less than 20 minutes in boiling water or steam at a temperature not less than 212°F., or in dry heat at a temperature not less than 300°F.

(d) Decomposition by fermentation in a pit or silo or by putrefaction in a compost heap, under conditions whereby air is excluded and moisture is provided continuously until decomposition ceases.

(e) Pressure of sufficient force to burst the seed coat of all seeds subjected thereto.

(f) Chemical extraction which results in a change of form and composition

(g) Grinding by any means followed by sifting through bolting-cloth or screen of not more tha 1/64-inch mesh.

(h) Hammer-milling under the following conditions:

(1) That the screenings to be milled have first been screened to remove all components of a size smaller than the mesh of the screen to be used in the hammer-mill.

(2) That the hammer-mill screen and cylinder teeth are closely fitting and unbroken.

(3) That the cylinder is operated at a speed not less than 1500 r.p.m.

(4) That all conveyors of unprocessed screenings are tightly closed to prevent escape of seeds.

3802. Approved Processing Plants. (a) Any person operating a plant for processing screenings may apply to the commissioner for approval of such plant. Approval of a processing plant shall be conditioned upon a finding that the plant is equipped and operated to receive and handle screenings without risk of disseminating the seed of any pest, and to process such screenings in accordance with these Regulations, and upon any such other conditions as the Commissioner may reasonably impose.

(b) Approval may be withdrawn at any time upon determination by the Commisioner that the terms of approval are not complied with.

(c) The Commissioner shall list with the Director all plants for which approval has been granted, together with the conditions, if any, of such approval, and shall notify the Director of any approval withdrawn, and the reasons therefore. A list of approved processing plants shall be made available to all interested persons by the Director.

3803. Permits. (a) Applications for permits to move screenings for destruction or processing shall be made to the Commissioner of the county in which the screenings are located. No permit shall be issued for movement of screenings into another county except to processing plants approved by the Commissioner of the county of destination, as provided in Section 3802. A copy of each permit to move screenings into another county shall be mailed to the commissioner at destination".

Our time is limited, but I believe this will give you some idea of the problems which I think are general throughout the eleven western states where the regulatory phase of weed control is very important.

WEED CONTROL

Murray R. Pryor
Field Supervisor of Weed Control
California Department of Agriculture

California has just witnessed a great acceleration in weed control during the three years following World War II, in particular the first two. This sharp upward trend leveled off in 1949. Many requirements such as the demand for new equipment and increased man power have been satisfied. The most important phase of the present program is the manner of arriving at practical recommendations for weed control in the various localities of the State.

As a result of the mounting damage to susceptible agricultural crops throughout the State from the uncontrolled use of 2,4-D for spraying weeds the state legislature enacted a bill for the regulation of 2,4-D and other injurious herbicides. Following the enactment, regulations for the use of 2,4-D as a herbicide were adopted. Enforcement of these regulations by the State Department of Agriculture and the county departments of agriculture should go a long way to circumvent the further misuse of 2,4-D and similar materials.

Isopropyl-n-phenyl carbamate (IPC) has been used as a grass killer with success in California but the extended use has not been very great as most of the work has been experimental. The material is quite expensive and farmers are reluctant to increase their farming costs, unless assured beyond a reasonable doubt that by doing so a fair profit can be made. The inclination on their part at present is to cut costs; however, they have found in many situations that IPC is useful for the control of seedling grasses in Ladino clover and alfalfa seed fields.

Trichloroacetic acid (TCA) has been used experimentally for the control of watergrass in cotton and for the "spot treatment" of Johnson grass in fields and on ditchbanks. The chemical has promise as a grass killer, but its extensive use is not regarded to be likely in the near future on account of its high cost.

It is significant that more attention was given to treatment of broadleaved perennial weeds growing in cerals. The results of this work have been attended with considerable success. Of several reported cases of this kind in the State, an interesting one occurred where grain infested with hoary cross and perennial peppercress was sprayed at a dosage rate of 24 ounces of acid equivalent, sodium salt of 2,4-D, per acre with a surprisingly good kill and it is estimated that 75% of the infestation was eliminated.

In the biggest rice crop of California history 2,4-D played an important roll. Generally speaking the herbicide was wisely used and excellent results obtained. Dosage rates of 20 to 24 ounces of 2,4-D acid to the acre, usually in the amine form, were common rates. The higher dosage rates were necessary in the case of hard-to-kill weeds such as the sedges, bulrushes and seedling cattail. During the season it was well established that the addition of light summer emulsive spray oils in the spray solution increased the efficiency of 2,4-D in killing such plants as in the "hard-to-kill" group.

As far as known the first case of 2,4-D contaminated irrigation water injuring a crop is reported from Riverside County. In this instance the trouble developed when a 27-mile strip along the All-American Canal in Coachella Valley was treated with 2,4-D by aircraft for the control of tule. In a three-day operation 671.4 pounds of 2,4-D acid in the ester form was applied in 1713 gallons of solution, 556 of which was in kerosene. Application flights were made upstream or in the opposite direction of flow of water in the canal. Allegedly it had been recommended that the application be made downstream. At points 35 to 55 miles downstream cotton fields aggregating 800 acres were irrigated two days subsequent to the spray operation. Shortly afterwards much of the cotton in these fields manifested typical symptoms of 2,4-D injury. Reportedly the injury varied from light to heavy, the greatest injury to the cotton being found in the low areas of the fields.

United States Bureau of Reclamation continued its program to developing aromatic solvents in the control of submerged aquatic weeds in California and elsewhere. Their reports reveal that they have been successful in controlling the following weeds, namely: Potamogeton sp., (Sago pondweed), Zanichellia sp., (Horned pondweed), Najas sp. (Naiad etc.), Anacharis sp. (elodea), Ceratophyllum sp. (Coontail), and Chara spp. (algae).

Austrian Field Cress (Rorippa austriaca). Subsequent to the eradication for Austrian field cress which was inaugurated in the middle 1930's the infestation involved 25,000 or more acres of fertile meadow lands between Alturas and Likely in Modoc County. The reduction of these infestations in the last few years by various methods has been attended with a great deal of success. Among other things the use of 2,4-D has greatly hastened the eradication program. The infestation has been reduced to such a low level that field workers much search carefully to find solitary plants or small infestations arising from seedling growth. Much of the work now constitutes patrolling the area and searching out these small infestations.

Gorse (Ulex eurapeus), a leguminous plant somewhat similar in its appearnace to Scotch broom, is an adventive plant from the Old World and in California is found mainly in Mendocino County. Minor infestations have been reported from Del Norte, Humboldt, Marin and Alameda Counties.

The Biological Control Division of the University of California has been conducting starvation tests with various species of beetles for the control of the seed of this plant. The investigators have found in this work that the main difficulty lies in the fact that the adult beetles which are to be used for feeding and ovipostion tests are so short-lived that it is hard to obtain the host plants with seed pods in the proper stage for test. They have found that the plants normally flower and seed a month or more after the period of acticity of the beetle. Arrangements are being made to import adult beetles from New Zealand as well as Europe and it is felt that this will give a greater span of time to the test period. 1/

The biological control of Klamath weed in California with several species of Chrysolina beetle is showing great promise. According to J. K. Holloway and C. B. Huffaker of the Biological Control Divison of the University of California who have been closely associated with this report Klamath weed beetles are becoming well established throughout the Klamath weed counties. They note in their annual report for 1949 that a total of 127 releases of beetles in California have been made and 97% of these have successfully survived. The progress of the Klamath weed beetles at Blocksburg in Humboldt County has been striking and is best described in the words of these investigators: "The Blocksburg plot continues to show progress. The total destruction of the weed has been far beyond expectations. Not one living weed could be found in a solid stand of 5 acres, which was thoroughly searched by more than 100 people. Before the larval activity took place last winter, the Hypericum was so thick that all other vegetation in the area was negligible. The migration of the beetles to the surrounding areas has also been very satisfactory. During the period of adult activity following emergence last spring, adult C. gemellata were found more than four miles from the nearest emergence area. There was an enormous population of adults emerging in the central zone where food no longer existed. As a result the beetles resorted to flight in order to obtain food. This in part accounts for the large area over which eggs were encountered during October and November. In December it was difficult to find a plant on which there were no eggs or larva within a radius of six miles from the original release center. Beyond the six-mile zone traces of eggs and larva could be found up to eight miles away".

Plant ecology studies reveal that desirable grass species are following the Klamath weed in areas where it has been eradicated or controlled by the beetles.

Halogeton glomeratus, commonly spoken of as "Halogeton", is a new weed introduction in California, first being reported in 1946 from Lassen County. 2/

As far as know Halogeton is confined to the Amedee-Herlong-Cal Neva area in Lassen County. Reports from the NevadaState Department of Agriculture reveal Halogeton to be highly toxic to livestock. Heavy losses of sheep have been reported in that State. Inspection of the stomach contents of sheep involved in these losses revealed almost 100% Halogeton. Surveys by this Department and the Lassen County Department of Agriculture reveal the major part of the 4,157 acres of land infested in Lassen County to be within the confines of the Sierra Ordnance Depot at Herlong.

The first annual California Weed Conference was held at Governor's Hall, State Fairgrounds, Sacramento, February 16 and 17 with a total attendance of about 1,000 people. The program was devoted to discussion of research, regulation in weed control, education, and equipment. The meeting was enthustiastically acclaimed as being highly successful by the majority of those in attendance.

1/ Annual Progress Report 1949, Biological Control of Klamath and other weeds by J. K. Holloway and C. B. Huffaker.

2/ Halogeton Invades California by Margaret K. Bellue. The Bulletin, State Department of Agriculture, State of California, Volume 38, Jan-Feb-Mar. 1949 No. 1

IDAHO STATE REPORT

Eugene Whitman
Idaho Noxious Weed Association
Boise

Interest in weed control in Idaho has continued at a high level through 1949. Counties set up weed budgets of nearly $1,000,000.00. State weed funds were changed from a hand out proposition to use on state lands entirely. One fund is administered to cover all types of state lands without separate appropriations to each state department. County weed programs are locked to do all weed work on public lands including work on state, county, highway, district federal lands, canals, railroad and other rights-of-way. This method avoids duplication of equipment, personnel and administration.

With increases in Halogeton and spread to two new areas interest in weed control on federal lands in Idaho is practically at a fever heat. Action on such a program has been taken by the Idaho Noxious Weed Association, Idaho Association of County Commissioners and Clerks, Idaho Grange, Idaho Farm Bureau, Idaho Woolgrower's Association and joint groups of local grazing associations.

During the past year an Idaho Interagency Weed Committee was Organized including representatives of the Forest Service, Reclamation Service State Department of Agriculture, State Land Commissioner, Production and Marketing Administration, Idaho Noxious Weed Association, Bureau of Plant Industry and the University of Idaho Extension Service. Each agency representative was called on to explain what his group was doing or could do for weed control. By unanimous consent it was agreed to continue the group and invite additional agencies to attend future meetings.

Additional information has been developed from research programs, particularly in connection with weed control in crop rotations, water weed and ditch weed control. The contributions of the Bureau of Plant Industry Cooperative Weed Station at Meridian is of special note.

More recognition of their own responsibility in weed control has been evidenced by farmers. Approximately 1,000 new names were added to the list of those owning their own weed equipment. In several cases counties reported selling more materials to individual farmers than was applied by county equipment.

Results from the use of 2,4-D during the past year have been somewhat more disappointing than for most years. This may have been due to the dry season experienced. Low rates of application of 2,4-D (less than 1/2 lb. acid equivalent) in Power County on dry farm wheat fields failed to stop heavy seeding of several of the annuals. Several cases of severe damage to crops (particularly red clover) was noticed where the ester form of 2,4-D was used.

Several Idaho counties are now engaged in making complete surveys of their county lands by contacting each individual farmer and getting a record of weeds on his farm and discussing the follow up for control. This program is meeting with considerable success especially where it is in its second or third year. Several counties have taken advantage of the offer of the Union Pacific Railroad to carry on a more complete program by making a survey and setting up a complete program for weed control on railroad company property.

Idaho has several serious weed problems on which little progress has been made. These include: (1) research and control of weeds on federal lands including both poisonous and other noxious weed pests; (2) an adequate cheap chemical control for quack grass and other grasses; (3) more reliable materials for control of weeds both broadleaf and grasses in vegetables and other crops; (4) greater activity in both research and service to facilitate a greater interest in and volume of work for weed control.

NEVADA STATE REPORT

Lee Burge
State Department of Agriculture

The principal problems in the Nevada weed picture today are the creating of control districts, poison range plants, control of operators, education, and a general economy movement.

Education has not yet sufficiently sold the farmers on the value of control districts. Interest is there, the need is not denied, but execution, except on an individual basis, is slow.

Approximately 50% of the grain acreage in Nevada has been sprayed for control of both annual and perennial weeds. Except on Russian knapweed, economic success can be reported on all types of weeds seriously threatening our grain acreage.

Airplane operators now under control in Nevada, have cooperated well in most instances. Several incidents, however, have come to our attention involving out-of state operators sneaking a cross the state line to do spray work without proper registration. Need of uniform legislation for control of operators is here again indicated.

In the field of poisonous plants, we find an ever increasing population in meadows of such plants as hemlock, arrowgrass, larkspur and camas. On the range, larkspur and Halogeton, particularly the latter, have made more rapid spread than many of our people would have believed possible a few years ago. Cattle losses from Halogeton continue to crop up with the result that interest among stockmen has increased. Both cattle and sheepmen's associations have requested relief, with cattlemen being somewhat cautious in requesting an all-out program designed in any way to request excessive federal agency expenditures. On the other hand, there is a belief that control of all poisonous weeds could be handled on the public domain in such a manner as to concentrate on the heavy infestations, thereby cutting down possible losses. Another school of thought believes that reseeding of certain areas with desirable grasses would help. Caution in the case of Halogeton must be used in approaching this program. Any type of soil distrubance will make a perfect seed bed for Halogeton and should a poor grass stand result, Halogeton would immediately take over. A good grass planting ahead of Halogeton, or any management program that will prevent over-grazing appears at present to offer a better approach than attempting to seed grasses after Halogeton has become established.

Many Halogeton situations can be improved with proper planting of highway railroad, and underground telephone rights-of ways. In many instances we find transcontinental highways and railroads being sprayed with oils and 2,4-D for control of all plants along the right-of-way. This results in the destruction of such competitive plants as crested wheat and sweet clover. The immediate result is that if Halogeton seed is present, a perfect crop results, particularly following the universal practice of dragging the highway shoulders after they are sprayed.

Nevada sheep and cattlemen are anxiously awaiting the results of this conference with the hope that some sane and economically possible program can be developed to attack this most serious range problem of poisonous plants.

UTAH STATE REPORT
Ray Whiting
District Agricultural Inspector

The State Weed Eradication Law provides for a contractual agreement between the landowner, county, and the State, for the purpose of weed eradication. As a part of this agreement the State provides the supervision; the county the labor, equipment, and supplies; and the landowner the use of his land, labor, supplies, and a limited amount of equipment. The cooperative weed eradication program is now operating in all counties of the State.

County operations are planned by an organization in each county consisting of representatives of the Extension Service, the State Department of Agriculture, federal agricultural agencies, county commissioners, county planning boards, road supervisors, representatives of farm and livestock organizations, and any other interested in any phase of land management which includes weed control. These organizations are know as County Weed Committees.

Noxious weed control is the concern of many agencies, some having research responsibilities, some have educational responsibilities, and some having regulatory responsibilities. In order to utilize the services and training of all of the agencies, and build the strongest and most complete type of weed eradication program, the Agricultural Correlation Committee was brought into existance. This Committee consists of

Representative of the Soil Conservation Service
President of the Utah State Agricultural College
Chairman of the Board of Trustees of the USAC
Director and Assistant Director of the Agric. Extension Service
Director of the Utah Agricultural Experiment Station
Commissioners of the State Department of Agriculture
Farm Bureau President and Executive Secretary
Representative of the Production and Marketing Administration

All of these agencies direct their respective programs of weed control in harmony with the over-all program developed by the Agricultural Correlation Committee.

At the present time, the financial burden of weed eradication is carried by the individual property owners, the counties, and the State. The State Department of Agriculture furnishes chemicals and supervision for projects that are deemed necessary in order to prevent the spread of the weed menace over more than one county, for projects to eradicate weeds on marginal lands, and for infestations on water sheds which endanger the lands irrigated from such watersheds.

Surveys indicate that the policy has been shifting from one of a non-cropping weed control program to one in which cropping and chemical treatment are combined. Farmers are beginning to give more attention to the value of spraying cereal crops to remove weed competition and crop rotation is being utilized to reduce the costs of weed control. This practice has increased the number of farm type operated machines and approximately doubled the use of 2,4-D in Utah.

The use of Chlorates for weed eradication has not increased except on sheep and cattle ranges where such chemicals are used on isolated infestations of poisonous and other injurious weeds. Reports indicate the fact that other chemicals such as T.C.A., 2,4,5-T, ammate, and oils, have been used only to a limited extent.

Some interesting observations taken from experiences in weed control in Utah include:

A. Some feed companies have expressed a marked preference for spray treated grain.

B. One tractor operator who often sprayed weeds with 2,4-D became ill and the Doctor diagnosing the case declared the cause to be chemical poisoning.
C. Several reports indicate spray injury on corn and grain.
D. Damage by drift has been reported on alfalfa, beans, tomatoes, and fruit trees.

There are 29 weeds officially declared noxious by the State Board of Agriculture. The following list indicates the area and extent of infestation of some of these weeds which are more or less general throughout the State.

Morning Glory	(Convolvulus arvensis) This is found in every county of the state.
White Top	(Lepidium Draba) This is also found in every county of the state. Many areas are reporting remarkable cleanup with a cultural cropping and 2,4-D spray program.
Canada Thistle	(Cirsium arvense) Although limited to a few counties, it is reported very hard to eradicate with chemical spraying. Good results have been obtained from cultivation.
Puncture Vine	(Tribulus terrestris) This weed is rapidly spreading in many counties.
Burdock	(Arctium minus)
Cocklebur	(Zanthium spp.)
Quack Grass	(Agropyron repens) This is generally spread in small areas throughout the State.

The following noxious weeds present isolated problems in various section of the State.

Whorled milkweed	(Asclepias Galiodies)	Southern Section
Russian knapweed	(Centaurea Picris)	Northeastern
Professor Weed	(Galega Officinalis)	Northeastern
Roemeria poppy	(Roemeria refracta)	Northern
Leafy Spurge	(Euphorbia Esula)	Northern
Corisporah Tennela DC . .	(Tennela)	West Salt Lake
Bur Ragweed	(Franseria Discolor)	East Central Area

The following weeds have noxious characteristics and present problems, even though they are not on the official noxious weed list.

Halogeton	(Halogeton glomeratus)	Western Utah
Yellow Toadflax	(Linaria Vulgaris)	Ogden Valley

Summary:

The State Weed Eradication Program is in operation throughout the state supported by weed and seed laws. Appropriations are obtained by special tax levy and aided by property owners and State Department of Agriculture.

Cultivation and spraying is being combined with a selected crop rotation program which has replaced the old long term contracts of having infested land out of production for a number of years.

Notes of interest observed in the use of 2,4-D would include:

A. Marked preferences for spray treated grain by feed companies.
B. One case of chemical poisoning of spray operator.
C. Spray injury observed on grain and corn, alfalfa, beans, tomatoes and fruit trees.

More attention is also needed to control the following troublesome weeds: Halogeton, Whorled milkweed, Russian knapweed, Leafy Spurge, Bur Ragweed, Corisporah Tennela, Professor Weed, Yellow Toadflax and Roemeria Poppy.

W A S H I N G T O N   S T A T E   R E P O R T

Auburn L. Norris
State Weed Specialist

Annual progress in weed control is apparent and one of the best indications of this progress in the State of Washington is the large acreage on which some form of weed control is now practiced. It is seldom that one talks to a farmer today who professes no knowledge in this field. These are the encouraging results of a concerted action and education program which is paying off in dollars returned through more crop production for less cost.

In 1949 a survey of the weed infested lands of the State of Washington was made. There was reported 2,132,003 acres of noxious weeds infesting some portion of over 75% of the farms of the state. There are 37,930 acres reportedly abandoned because of noxious weeds.

In Washington we have a tremendous noxious weed problem on non-farm lands. Some of these lands are of such low valuation that the question is often brought out regarding whether any known control measures are economically feasible for use on these lands.

Persons in charge of highways, railroads, Bonneville Power Administration, The Bureau of Reclamation, The Forest Service and others responsible for public and quasi-public lands have cooperated well in weed control work. They have done remarkably well when it is considered that topography, climate, soil conditions and type of vegetation influence control measures to an extent that sometimes necessitates entirely different approaches to the problem in areas only relatively few miles apart. As the program continues and more experience in methods of weed control is gained by employees of these organizations, they are better able to evaluate both the problem and results obtained. This experience along with an intensive education program has materially aided in weed control and promoted better understanding of the farmer's weed problems by these groups.

On our range lands, St. Johnswort (hypericum perforatum L.) is probably the number one problem. Much of the land infested with this weed is of low value and on such steep hillsides that present known means of control are very costly. It is hoped that some of the several colonies of beetles turned loose within the state will survive and afford a means of controlling this pest.

In our coastal area, the problem of controlling Tansy Ragwort (Senecio Jacobaea) is similarly regarded as too costly consistent with land value where brush and bracken fern has already cut the grazing capacity to such an extent that the land has little value for pasture. It is probably true that the value of these lands is low but the infestation of weeds does not increase their value. Weeds spreading from these infestations to higher value lands and other low value property are also part of this problem. It may not be economical to put high priced chemicals on low value lands but some thought should be given to cost of weed control on these lands, versus increased value or increased income from this property plus value of the removal of the hazard to adjoining lands not now infested.

There is planned a State Weed Conference for March 3, 1950 at Spokane, Washington. This, it is hoped, will be the first annual conference. It is planned that this will afford an organization, through which coordination of plans and programs on weed control can be accomplished. In 1950, it is planned that more counties will be encouraged to form week areas by showing the farmers the need for cooperative action on their weed problems. More cooperation will be worked for between individual farmers and those who control public and quasi-public lands with regard to weed control. Closer cooperation between neighboring states and adjoining counties is also one of our aims. Watching for new weed pests and an effort to eradicate them before they become established will be practiced. New methods of weed control will be watched for; yet an all-out effort will be made to keep farmers from being "taken in" by advocates of new untried methods which will cost more than they are worth or cause damage which is not anticipated by the user.

WYOMING STATE REPORT

George B. Harston
Department of Agriculture
Powell

Weed control, through organized county efforts, continued to be predominant by spraying. Formulations of 2,4-D were the most popular sprays used.

There was an increased interest in the creation of "Weed and Pest Control Districts" to facilitate the fighting of weeds through organized effort. Some counties, particularly Sheridan County, are now making efforts to organize the entire county into one district. Much dissatisfaction has existed in counties where only a portion of the county is embraced in the district and taxes from the entire county assist in the weed control work within the district.

Since the last Western Weed Conference the State of Wyoming, Department of Agriculture, purchased a truck upon which was mounted spraying equipment which has proven very satisfactory in the control of weeds in counties where there is no organized district. Although this equipment is far from adequate in controlling weeds over such a large area, it has proven to be a valuable unit in demonstrating before counties and individuals.

No concerted effort has been made to obtain weed control, on a larger scale, on Federally owned land. This continues to be a problem of great concern to individuals and counties trying to conduct weed control work adjacent to such public land, which is frequently infested.

Following is the business session called to order by President Whitman.

REPORT OF THE TREASURER

February 1, 1950

Balance January 1, 1949		$ 1,028.14
Registrations — Bozeman meeting		1,025.25
Sale of copies of proceeding of Bozeman meeting		27.00
Dues of associate members		950.00
		$ 3,030.39
Expenses of Bozeman meeting:		
Banquet	$ 417.25	
Printing programs and cards	23.75	
Cost of registering	20.00	
Sign	1.75	
Stenographic services	30.00	
Mimeographing report of research committee	20.87	
Printing proceedings of Bozeman meeting	957.38	
Transportation of secretary to organization meeting at Kansas City, Missouri	120.15	
Expenses of secretary on Kansas City trip	69.01	
Rental of auditorium for Denver meeting	250.00	
Expenses of secretary to Northeastern Weed Control Conference at New York City	300.00	
	$ 2,210.16	$ 2,210.16
Balance February 1, 1950		$ 820.23

REPORTS OF COMMITTEES

Executive Committee Report
W. S. Ball, Secretary

The executive committee met with all members present. Chairman Whitman called the meeting to order.

The question of annual meetings was introduced for discussion. It was thought that with the State conferences meeting annually that the regional meeting could well serve its purpose if held biennially.

Robbins moved and Harris seconded to hold the Western Weed Conference biennially. The motion was carried.

State reports were discussed and this resulted in a motion by Thornton which was regularly seconded that the state reports be discontinued. Motion carried.

The committee discussed the next meeting place. Moved by Harris and seconded by Thornton that the next meeting be held in Reno, Nevada.

The secretary reported on the National Organization meeting in Kansas City, September 15, 1949. The committee did not approve of the organization committee's suggestion that the delegates be the president and past president of member conferences. It was suggested and unanimously agreed that delegates be selected by each conference. The name "Weed Control Advisory Board" was suggested for the national conference.

It was agreed that the secretary would attend the next national meeting.

It was recommended that the constitution be amended to read that the "Executive Committee shall set registration fees for each meeting", the objective being to make it possible for the committee on arrangements to cover annual expenses including publications of proceedings.

Vote for change of the consitution relative to fees was called and carried.

Discussion followed the report of the executive committee.

Biennial meetings were not approved by all members. The president called for a vote on this question. The conference voted to meet biennially.

Burge moved that the executive committee call a meeting of active committees annually -- seconded and carried.

Changing to biennial meetings required the amending of the by-laws. The President called for a vote amending the by-laws to provide for biennial meetings. Carried.

The question of state reports was discussed and the conference voted to continue state reports. If not read at regular meetings they were to be made a part of the record, the executive committee to decide disposition of state reports.

Other than the question on state reports the executive committee report was approved.

ORGANIZATION MEETING

Kansas City, Missouri

September 15, 1949

Representatives from each of the regional weed conferences and the Bureau of Plant Industry, Soils and Agricultural Engineering, United States Department of Agriculture, met at Kansas City, Missouri, on September 15, 1949, for the purpose of discussing the possibility of creating a national weed organization. Following is a report of the conference and the suggestions made relative to such an organization.

PURPOSE: To coordinate the activities of the member conferences on weed control problems of national scope.

REPRESENTATION: Each regional conference shall be presented by two delegates who shall constitute the officials of the national organization (the committee suggested the delegates be the immediate past president and the president of the member conferences.)

DUTIES: The officials shall be empowered to take action on any weed problem of national importance, either on their own initiative or by reference from the member conferences or other sources. This shall include the authority to request assistance of special committees, for example:

(1) Congress, governmental departments, Secretaries, Directors and Commissioners of Agriculture, Council of Interstate Governments, Insecticide and Chemical Association of the PMA, implement manufacturers, American Seed Trade, American Society of Agricultural Engineers, Civil Aeronautics Administration, farmer organizations and other organizations actively interested in weed control work.

(2) To institute negotiations for the establishment of a national weed publication.

(3) To cooperate with state and federal agencies and industries in the formulation and enforcement of weed and seed legislation and regulation.

(4) To encourage cooperation between regulatory, education and research agencies.

FINANCES: Until other sources of income are available each member conference shall bear the expense of its delegates to an annual official meeting of the association. (Attention is called to the possibility that the officials of the association might become a committee similar to the Insect Advisory Committee of the American Society of Economic Entomologists which is supported by direct appropriation from Congress).

REPORT OF THE REGULATORY AND COORDINATING COMMITTEE

Lee Burge, Chairman

Your committee has given considerable time to a large number of problems as outlined in our preliminary report. We believe, however, that the efforts of this conference could best be concentrated on a few of the very urgent or critical problems presently recognized as affecting the economy of the states represented.

We therefore urge careful consideration of the following:

Enactment of the model act relating to the custom application of insecticides, fungicides and herbicides, as suggested by the Council of State Governments.

Support of the present re-seeding of range lands now being carried on by certain Federal agencies. We believe that such re-seeding practices on rangeland represent a long time solution of many of the range weed control problems.

We wish to encourage states within the western area to place their seed law enforcement and other similar regulatory work in the hands of their state departments of agriculture. We believe that having the regulatory duties in the hands of seed analysts or colleges does not prove as satisfactory as when the department of agriculture is charged with these regulatory duties.

The enactment of uniform legislation or quarantines relative to the movement and inspection of custom operated farm equipment, capable of spreading noxious weed seeds.

There appears a need for a closer liaison between research workers and regulatory administrators. We recommend that regulatory officials be informed of research projects in the various states and that they be kept in closer touch with the progress of said research projects.

REPORT OF THE RESOLUTIONS COMMITTEE

W. L. Hendryx, Chairman

Poisonous and Noxious Weeds on Public Lands

WHEREAS, poinonous, noxious and troublesome weeds are a very serious problem and state and local governments are unable to adequately cope with this problem on public lands, and

WHEREAS, various federal bureaus have personnel and equipment, and some of these agencies have district offices and district supervisors as well as research personnel located in several of the western states doing research work on poisonous, noxious and troublesome weeds; and

WHEREAS, these agencies are qualified to make surveys of weed infested areas and recommend methods of eradication and control; and

WHEREAS, there has been serious loss of livestock on public lands attributed to poisonous weeds; and, farm crop damage from noxious weed infestations have resulted, creating a serious menace to profitable livestock and farming operations and affecting our entire agricultural economy.

THEREFORE, BE IT RESOLVED that the Western Weed Conference in convention assembled request the Secretary of the U. S. Department of Agriculture and the Secretary of the Department of the Interior to cooperate with federal, state and county governments and agencies for the control and eradication of all weeds that are a menace to livestock and farming, as outlined in the report of the Regulatory and Coordinating Committee, and that the Congress make sufficient funds available to be allocated on the basis of state and local participation.

BE IT FURTHER RESOLVED that a copy of this resolution be sent to the U. S. Secretary of Agriculture, the Secretary of the Department of the Interior, Bureau of the Budget and to all Congressmen from the eleven western states and to the Governors of each of these states.

RESOLUTION 1

FEDERAL-STATE COOPERATION ON CONTROL OF POISONOUS AND NOXIOUS WEEDS

WHEREAS, poisonous, noxious and troublesome weeds are a very serious problem and state and local governments are unable to adequately cope with this problem on public lands, and

WHEREAS, various federal bureaus have personnel and equipment, and some of these agencies have district offices and district supervisors as well as research personnel located in several of the western states doing research work on poisonous, noxious and troublesome weeds; and

WHEREAS, these agencies are qualified to make surveys of weed infested areas and recommend methods of eradication and control; and

WHEREAS, there has been serious loss of livestock on public lands attributed to poisonous weeds; and, farm crop damage resulted from noxious-weed infiltration from such public lands, creating a serious menace to profitable livestock and farming operations and affecting our entire agricultural economy; Now therefore be it

RESOLVED that the Western Weed Conference in convention assembled in Denver, Colorado, January 30 and 31 and February 1, 1950, request the Secretary of the United States Department of Agriculture and the Secretary of the Department of the Interior to co-operate with state and county governments, the several federal agencies and resident farmers for the control and eradication of all weeds that are a menace to livestock and farming, as outlined in the recommendations of the Regulatory and Coordinating Committee of this Conference and that the Congress make sufficient funds available to be allocated on the basis of state and local participation.

BE IT FURTHER RESOLVED that a copy of this resolution be sent to the United States Secretary of Agriculture, the Secretary of the Department of the Interior, Bureau of the Budget, and to all Congressmen from the eleven western states and to the Governors of each of these states.

APPROVED

RESOLUTION 2

Biological Control of Halogeton

WHEREAS, surveys show that a poisonous range weed known as *Halogeton glomeratus* has become a serious threat to the sheep and cattle industry in certain western states; and

WHEREAS, mechanical or chemical controls on large areas of low value lands are not deemed economically practical.

NOW, THEREFORE, BE IT RESOLVED that the Twelfth Annual Western Weed Conference request the Bureau of Entomology and Plant Quarantine, USDA, to take immediate steps to study the possibility of introducing insects capable of effecting biological control of this pest on our western ranges.

APPROVED

RESOLUTION 3

Survey of Noxious and Poisonous Weeds by Federal Agencies

WHEREAS, perennial noxious and certain poisonous weeds have made serious inroads on public lands in the western states, and

WHEREAS, Federal agencies charged with the administration of these lands have not studied the extent of these infestations.

THEREFORE, BE IT RESOLVED by this Twelfth Annual Western Weed Conference that the Bureau of Plant Industry of the United States Department of Agriculture be requested to develop a uniform method of surveys for use by the various Federal agencies in studying and mapping the perennial and annual poisonous weeds, and perennial noxious weeds now known to be present on the public lands of the eleven western states.

APPROVED

RESOLUTION 4

Mr. L. W. Kephart

WHEREAS, Mr. L. W. Kephart labored long and hard, faithfully and diligently for the welfare of agriculture; and

WHEREAS, this conference feels we have lost a very good friend of our program in his withdrawal from the services of the U. S. Department of Agriculture.

THEREFORE, BE IT RESOLVED, that the Twelfth Annual Western Weed Conference express our appreciation to Mr. Kephart for his long years of valuable services to the people of our land in his efforts to solve our weed problem.

BE IT FURTHER RESOLVED that this resolution be printed in our conference proceedings and copies be sent to Mr. Kephart and to the Chief of the Bureau of Plant Industry Soils and Agricultural Engineering.

APPROVED

* * * * * *

Following the approval of this resolution the secretary read the following letter:

Killigarth, Wokingham Rd.
Brachnell, Berks.
England
Jan. 8, 1950

Walter S. Ball, Sec.
Western Weed Conference
Sacramento, Calif.

Dear Walter:

As the newly self-appointed European Correspondents Association of the Western Weed Conference, we send you greetings of the Conference in Denver. We wish jointly that we could be present both to imbibe at the fountain of wisdom which we know will flow copeously and to keep fragrant the innumerable memories which each of us cherish of friendship among the members of the Conference.

We wish you every success. We know that the Conference in its position as oldest and most respected of weed gatherings, and we extend our best wishes.

In particular we invite the Conference to hold its next meeting in London - and wish we could endorse a check as evidence of good faith -- Should the Conference act favorably on this invitation we will be first on the dock at Southamptom to greet the delegates.

Sincerely,

L. W. Kephart
W. G. Templeman

* * * * * * * * * *

RESOLUTION 5

COMMENDING OFFICERS

WHEREAS, our officers for the past year, Mr. Eugene W. Whitman, President; Dr. W. W. Robbins, Vice-President and Walter S. Ball, Secretary-Treasurer, have spent a lot of time and effort in making this a successful convention.

THEREFORE, BE IT RESOLVED that we express our deepest appreciation and thanks to them and that this resolution become a part of this conference records.

APPROVED

RESOLUTION 6

COMMENDING ARRANGEMENTS COMMITTEE

WHEREAS, we have been so graciously entertained during the past three days by our hosts in the city of Denver, and

WHEREAS, the Colorado A & M College personnel and Mr. Bruce J. Thornton, and

Mr. Moran, a member of the College Staff and Chairman of general arrangements, have worked diligently to add to our comfort.

BE IT RESOLVED that our sincere appreciation be extended to them and to all others who assisted in making our convention not only pleasant but instructive.

BE IT FURTHER RESOLVED that this resolution be a part of this conference records.

APPROVED

REPORT OF THE NOMINATIONS COMMITTEE

D. C. Tingey, Chairman

W. W. Robbins, President

C. I. Seely, Vice-President

Walter S. Ball, Secretary-Treasurer

A motion from the floor that the name of the conference be changed to the original name "Western Weed Control Conference" was seconded and carried.

This required a vote for the amending of the constitution and by-laws relative to the conference name. The conference voted to amend the by-laws to change the name.

It was moved by Mason and seconded from the floor that Secretary Ball attend the 1951 meeting of the Southern Weed Control Conference as representative of the Western Weed Control Conference.

There being no further business President Whitman adjourned the 1950 Western Weed Control Conference.

Walter S. Ball
Secretary-Treasurer

* * * * * * * * * * * * * * * * *

REGISTRATION

ARIZONA

Arle, H. Fred	USDA-BPISAE, Phoenix
Canafax, Euel L.	Bureau of Reclamation, Yuma
Marsh, W. O.	Marsh Aviation Co. Inc., Phoenix
Neace, John F.	Marsh Aviation Co. Inc., Phoenix
Pearse, C. Kenneth	U. S. Forest Service, Tucson

CALIFORNIA

Ball, Walter S.	State Dept. of Agriculture, Sacramento
Baranek, Paul P.	Bureau of Reclamation Delta District, Stockton
Bellion, Clement E.	American Cyanamid Co., San Francisco
Bernard, Gould E.	Carbide and Carbon Chemicals Div., San Francisco
Bodine, Eddie W.	Shell Chemical Corp., San Francisco
Brady, F. W.	Brady & Holmes, Los Altos
Bronson, Art	Richfield Oil Corp., Los Angeles
Cox, Edwin W.	W. T. Cox Co., Santa Ana
Finney, Gerald M.	Bureau of Reclamation, Fresno
Graham, Cecil J.	U. S. Bureau of Reclamation, Sacramento
Greary, Jack	Hurst Industries Inc., San Jose
Harang, Edward A.	Spraying Systems Co. San Francisco
Harvey, William A.	University of California, Davis
Hughes, Wm. J.	Shell Chemical, Modesto
Hurst, Jack	Hurst Industry, San Jose
Kankright, Blaine J.	Soilserv Inc., Salinas
Lunsford, C. F.	Pittsburg Agr. Chem. Co., San Francisco
Medberry, C. J.	Pacific Coast Borax Co., Los Angeles
Quick, Clarence R.	U. S. Dept. of Agriculture, Berkeley
Raynor, R. N.	The Dow Chemical Co., San Francisco
Robbins, W. W.	University of California, Davis
Rooke, Lloyd	American Cyanamid Co., Los Angeles
Scull, Charles H.	California Spray Chemical Co., Richmond
Snyder, T. Joseph	Bureau of Land Management, San Francisco
Steinen, Otto	U. S. Rubber Co., Torrance
Strew, S. W.	Chipman Chemical Co., Palo Alto
Swezey, Arthur W.	Dow Chemical Co., Seal Beach
Watwood, Robert P.	Monsanto Chemical Co., San Francisco
Westgate, Warren A.	Standard Agricultural Chem. Co., Sacramento

CANADA

Foster, J. Roe	Experimental Station, Regina Sask.
Pavlychenko, Thomas K.	American Chemical Paint Co., Saskatoon, Sask.

COLORADO

Adams, James D.	Simpson & Company, Colo. Springs
Allred, A. Fullmer	C. D. Smith, Grand Junction
Albrecht, Paul H.	Albrechts Aerial Sprayers, Denver
Baillie, K. A.	County Commissioner, Garfield Co., Glennwood Spring
Bandy, Pascal Earl	Montezuma Co., Delores
Bardwell, C. M.	National Aluminate Co., Denver
Barnett, Charles	Hi Production Sprayers, Pueblo
Beattie, Victor C.	Skelley Oil Co., Denver
Beckett, Irving P.	Craig Land & Dev. Co., Craig
Bicking, Joe	Whitworth Supply Co., Denver
Brenker, A. H.	The Parker Co., Denver
Brown, W. G.	Production Marketing Adm., Proctor
Carter, E. C.	Longmont Flying Service, Longmont
Chandler, Robert Gray Jr.	The Orman Const. Fog Division, Pueblo
Ciborowski, S. T.	Denver Fire Clay Co., Denver
Cox, Harold D.	Tanners Inc., Cortez
Curry, John H.	Vest Aircraft Co., Denver
Dewey, Carl A.	C. D. Smith Co., Grand Junction
Dickson, F. W.	The Parker Co., Denver
Dockham, Charles K.	Swift & Company, Denver
Dunham, Charles K.	Swift & Company, Denver
Eggbert, H. W.	Skelley Oil Co., Denver
Farnham, Harry C.	Farnham-Morris Co., Denver
Farnham, L. Lawrence	Ft. Collins Flying Service, Ft. Collins
Fithian, Robert Warren	Co. Ext. Off., Weld Co., Greeley
Flock, Calvin E.	Farmers Union Marketing, Denver
Ford, R. E.	Extension Service, Ft. Collins
Fraser, Bert H.	Nat'l Park Service, Estes Park
Frix, Marcus A.	Thompson-Hayward Chem. Co., Denver
Fults, Jess H.	Color. A & M College Botany Dept, Ft. Collins
Gadd, J. C.	E. C. Stone Company, Denver
Gordon, Jack	Rocky Mountain Seed Co., Denver
Greewald, David	Co. Agt, Alamona
Gregory, Walter I.	County Agricultural Agent, Craig
Haldeman, Byron P.	Timmath
Hammon, A. J.	Irrigations Specialist, Colo. A & M, Ft. Collins
Harrison, Roy J.	National Aluminate Corp., Denver
Henderson, A. W.	Henderson's Crop Control, Watkins
Hervey, Donald F.	Colo. A & M College, Ft. Collins
Herzman, Carl W.	County Agricultural Agt., Denver
Higby, Charles S.	Greenland Land & Cattle Co., Greenland

Higby, Louis R.	Greenland Land & Cattle Co., Greenland
Hoar, Sherman S.	Ext. County Agent, Sterling
Hofmann, J. Stuart	Livestock, Montrose
Hopkins, Leon L.	County Agent, Center
Jasper, Frank P.	Colo. Fuel & Iron Corp., Denver
Jensvold, G. J.	Skelley Oil Co., Colorado Springs
Johnson, Glen A.	Fort Collins
Johnson, Milton R.	Colo. A & M. Botany Dept., Fort Collins
Kerbs, Paul Leo	Kerbs Spraying, Greeley
King, S. Jay	Farmers Union Mkr. Association, Denver
Knaus, Floyd M.	Thompson-Hayward Chemical Co., Denver
Koefoed, Don E.	Farmer, Wetmore
Kroeger, F. W.	Farmers Supply Co., Durango
Kroeger, J. R.	Farmers Supply Co., Durango
Lamb, J. Marvin	Loveland Flying Service, Loveland
Lough, A. Vance	County Agent, Glenwood Spgs.
Luna, Archie J.	L & R Sprayers, Julesburg
Lyndes, H. E.	General Chemical Div., Denver
McCampbell, Sam. C.	Selco Supply Co., Ft. Collins
McFall, Glenn W.	Valley Air Service, Grand Junction
McKeller, William H.	Am. Refrigerator Transit Co., Grand Junction
McMillan, C. W.	County Agent, Lajara
McNey, John W.	Elbert Co. Agent-Ext., Simla
MacLennan, Roderick Clark	Lincoln Co. Agent, Hugo
Maletic, John T.	Region 7-Bureau of Reclamation, Denver
Marlman, William A.	Valley Aviation, Las Animas
Martin, Donn S.	Gates Rubber Co., Denver
Marvin, Long	Farnham-Morris Co., Denver
Meyer, Donald Earl	Western Spray, Greeley
Milligan, Hien M.	Montezuma Co., Cortez
Mills, Paul J.	Geigy Co. Inc., Denver
Moran, Willis T.	U. S. Bureau of Reclamation, Denver
Morris, Roy	Farnham-Morris Co., Denver
Nelson, Russell Theodore	Greatwestern Sugar Co., Longmont
Neil, Don A.	Glenwood Springs
Oborn, Eugene T.	Bureau Plant Industry Soils & Agric., Denver
Olsen, Jack W.	The Parker Co., Denver
O'Malley, Thomas G.	Standard Oil Co., Denver
Orman, Fred B. Jr.	The Orman Cons't. Co., Foy Division, Pueblo
Orum, Clay A.	Denver
Pattison, E. P.	Holly Sugar Corp., Colo. Springs
Peacock, George A.	Agricultural Processing Industries, Denver
Powell, Carl H.	Colo. Extension, Delto
Prettyman, Norman S.	Genoa Aerial Sprayers, Genoa

Quinn, Louis F.	Farmers Aerial Sprayers, Denver
Rains, Jack	Chemical Corp. of Colo., Denver
Ramsey, G. A.	Thompson-Hayward Chem. Co., Denver
Raseman, M. H.	Chemical Corp. of Colo., Denver
Rhodes, Frank D.	Henderson Crop. Control, Watkins
Rice, David Gover	Colo. Cattleman's Association, Denver
Richards, Miles A.	Com. Sprayer, Delta
Richard, Max Earl	Denver
Rogers, Donald E. A.	Denver, Colo.
Rogers, R. E.	Agricultural Processing Ind., Denver
Romen, James C.	Romen Mene Co., Holly
Rouse, Ralph V.	Henrylyn Irrigation District, Hudson
Royd, Frank H.	C. S. William Co., Rocky Ford
Ryland, R. W.	Chemical Corp. of Colo., Denver
Schwan, H. E.	U. S. Forest Service, Denver
Scott, W. D.	County Commissioner, Rifle
Shaw, John M.	U.S.B. of R., Denver
Skyway Sprayers	Greeley
Smith, A. Dale	PMA, Sanford
Smith, W. D.	Denver Fire Clay Co., Denver
Steele, John Lee	Farmer, Genoa
Stewart, Howard F.	F & S Flying Service, Burlington
Stolte, Stanley H.	County Agent-Jefferson, Arrada
Story, Leland A.	Simplot Soil Builders of Greeley
Swingle, John W.	Swingle Tree Surgery Co., Denver
Taylor, Joseph A.	Skelley Oil Co., Denver
Thornton, Bruce J.	Colorado Experiment Station, Ft. Collins
Tucker, R. H.	Colo. A & M, Fort Collins
Vashus, Charles T.	Colo. Farm & Ranch Supply, Denver
Warner, Gale A.	Soil Conservation Service, Longmont
Wesley, W. Wall	Bud's Flying Service, Yuma
White, Bernard	Farm Bureau, Monte Vista, Colo.
Whitmore, Bruce G.	Extension Service, Las Animas
Whitworth, H. C.	Whitworth Supply Co., Denver
Williams, Donald White	Farmer, Rocky Ford
Williams, Richard Charles	C. S. Williams Co., Rocky Ford
Wilshusen, Arnold	County Agent, Ordway
Wilkins, Ed. L. Jr.	Rainbow Dusters. Inc., Las Animas
Woehlke, Fred C.	Albrecht Aerial Sprayers, Denver
Wonders, William J.	County Agent Rio Grande, Monte Vista
Yonge, P. K.	D & R GW RR, Denver
Ziemer, Paul	Genoa

HAWAII

Hanson, Noel S.	Experiment Station HSPA Oahu, T. H.

IDAHO

Adkins, Ernest D.	Co. Commissioner, Richfield
Ames, Robert E.	The Dow Chemical Co., Boise
Andrus, Reed S.	Bonneville County, Ucon
Boditz, Glenn L.	Co. Extension Agent, Burley
Boyle, W. Dean	Bureau of Reclamation, Boise
Cox, Y. A.	Ada County Weed Control, Meridian
Douglass, J. R.	Bureau of Ent. & Pl. Qur., Twin Falls
Edwards, Herbert M.	Valley County Extension Agent, Donnelly
Gault, Harry S.	Twin Falls Co., Twin Falls
Hall, Delane M.	Power County, American Falls
Hale, Edsel K.	Magic Valley Aircraft, Twin Falls
Hansen, A. C.	A. C. Hansen Co., Rexburg
Hendrix, W. L.	Co. Comm. Ada Co., Boise
Hodgson, Jesse M.	U. S. D. A. BPISAE, Meridan
Huey, D. L.	Gooding County, Gooding
Jensen, Leslie Frank	County Weed Supt., Caldwell
Jensen, Wilford L.	Madison Co. Supervisor, Rexburg
Johannesen, E. J.	Co. Ext. Agent, Emmett
Johansen, Keith A.	County Commissioner, Jerome
Kautz, Don	Weed Supervisor, Weiser
McBirney, H. L.	Rogers Agri. Sales & Service, Idaho Falls
McCollum, Joe D.	Simplot Soilbuilders, Twin Falls
Mason, W. L.	County Weed Supervisor, Lewiston
Mecham, Hypum M.	Jerome County Weed Supervisor, Jerome
Nef, Emil	County Com., Rexburg
Nyblad, Ralph T.	Simplot Soilbuilders, Caldwell
Robinson, Al	Jerome Co. Comm., Jerome
Rudd, Vena	Fremont Co. Weed Control, St. Anthony
Seely, Charles I.	University of Idaho, Moscow
Skinner, Kirt	Van Waters & Rogers Inc., Boise
Smith, M. B.	Bannock Co., Weed Super., Pocatello
Young, D. R.	County Comm., Twin Falls
Ward, John C.	Burley
Welch, Ralph D.	Weed Supervisor, Emmett
Whitman, Eugene W.	University of Idaho, Boise
Whornham, George	American Chemical Paint Com., Idaho Falls

ILLINOIS

Branson, Harold A.	Standard Oil Co., Chicago
Gibboney, James L.	National Aluminate Corp., Chicago
Shatwell, Wm. E.	Headquarters 5th Army, Chicago

IOWA

Elliott, Dale I.	Dr. Salsbury's Lab., Charles City

KANSAS

Armstrong, Robert	Armstrong Air Service, Inc., Scott City
Beydler, Glen W.	Kiowa
Bothe, Clarence W.	Santa Fe RR, Topeka
Hutchison, John L.	Kansas State Board of Agri., Paradise
Loeffler, Robert W.	Robert W. Loeffler & Co., Clifton
McCall, George L.	E. I. DuPont de Nemours, Manhattan
Moorehead, F. G.	Ida County Weed Commission, Ida Grove
Pickett, Lloyd E.	Dodge City Air Service, Dodge City
Pratt, Don E.	P-T Air Service Inc., Hays
Scott, Maynard W.	Kansas State Board of Agri., Topeka
Thompson, Bert T.	Thompson Oil Co., Syracuse
Yost, T. F.	Kansas State Board of Agri., Topeka
Zoller, C. L.	County Weed Supervisor, Phillipsburg

MARYLAND

Lovvorn, Roy L.	U. S. D. A., Beltsville
Minarik, Charles E.	Camp Detrick Chemical Corps, Frederick
Quisenberry, Karl S.	U. S. D. A., Beltsville

MICHIGAN

Smith, Hillard L.	Dow Chemical Co., Midland

MINNESOTA

Carlson, Arne E.	E. I. DuPont de Nemours Co., Minneapolis
Melander, L. W.	Bur. of Ent. & P. Q. USDA, Minneapolis
Sorenson, Eldon	Worthington
Wirth, J. F.	Hypro Engineering, Minneapolis

MISSOURI

Berrian, Roy M.	Pearson-Ferguson Chem. Co., Kansas City
Cherry, W. F.	Rohn & Hans Co., Kansas City
Edwards, W. H.	Accessories Mfg. Go., Kansas City
Hammett, Jack W.	Aero Chemical Industries Inc., Kansas City
Harrison, W. F.	DuPont Co., St. Louis
Nelson, Charles E.	DuPont Co., St. Louis
Ong, William A.	Aero Chemical Industries, Inc., Kansas City
Swishen, Elm M.	Rohm & Hoas Co., Kansas City
Zuhl, Herbert A.	Dow Chemical Co., Kansas City

MONTANA

Bolingbroke, D. T.	Bureau of Reclamation, Billings
Borges, H. Milton	U. S. F. W. S., Billings
Butler, Charles C.	Bureau of Reclamation, Billings
Byron, Clem	Montana Flour Mills, Great Falls
Hagen, Hal E.	H-C-L Equipment Inc., Billings
Lavin, Owen P.	Van Waters & Rogers, Inc., Billings
Mack, R. G.	Pacific Coast Borax Co., Bozeman
Warden, Robert L.	Mont. State College, Bozeman
Stieg, W. F.	Baker

NEBRASKA

Burg, Marlo	E & E Sprayer Co., Waverly
Chambers, R. H.	Pioneer Chemical Co. Inc., North Platte
Darland, D. F.	Pioneer Chemical Co. Inc., North Platte
Daubert, Fred E.	Bureau of Reclamation, Grand Island
Fitzpatrick, Wm. H.	Colo. Fog Service, Lincoln
Schlaphoff, Elmer & Fritz	E & E Sprayer Co., Waverly
Schmidt, W. J.	Scottsbluff

NEVADA

Bowser, Curtis W.	Bureau of Reclamation, Boulder City
Burge, Lee M.	Nevada State Dept., Reno

NEW JERSEY

Reade, Charles F.	Reade Mfg Co., Jersey City

NEW MEXICO

Allem, Price A.	Ravel Bros., Inc., Albuquerque
Davis, Gerald M.	Ravel Bros. Inc., Albuquerque
Goedeke, W. L.	Clovis Flying Service, Clovis
Jentgen, A. P.	Clovis Flying Service, Clovis
Lowry, Orland J.	Bureau of Reclamation, Carlsbad
Ribble, Ira E.	N. C. Ribble Co., Albuquerque
Sanders, Louis	Ravel Bros. Inc., Albuquerque
Spradlin, Raymon G.	Western Flying Service, Clovis
Willett, A. Edwin	Denver Fire Clay, Albuquerque

NEW YORK

Berggren, Fred H.	Oldbury Electro Chem. Co., New York
Edwards, John Paul	Hooker Electro Chem. Co., Niagara Falls
Elishewitz, H.	Entomologist, New York

NEW YORK

Ferguson, George R.	Geigy Company, Inc., N. Y. C.
Skaptason, J. B.	Pittsburg Agr. Chem. Co., New York

OHIO

Emminger, H. H.	F. E. Myers & Bro. Co., Ashland

OREGON

Bierman, Herman E.	Oregon State College, Corvallis
Cakin, Eugene A.	Bureau of Reclamation, Klamath Falls
Cummings, C. L. "Swede"	Pendleton Grain Growers Inc., Pendleton
Dierman, Herman E.	Corvallis
Eichmann, Robert D.	Stauffer Chemical Co., No. Portland
Harris, Lin E.	Chipman Chemical Co., Portland
McCambridge, J. R.	Chipman Chemical Co., Portland
Platt, Kenneth B.	U. S. Bureau of Land Management, Portland
Sime, Keith	Chipman Chemical Co. Inc., Portland
Starker, Chuck	Pacific Supply Corp., Portland

PENNSYLVANIA

Sherwood, Frank R.	American Chem. Paint Co., Ambler
Stone, E. C.	Pittsburg Agricultural Chem. Co., Pittsburgh

SOUTH DAKOTA

Ball, Walter F.	Dakota Aviation Co., Huron

TEXAS

Green, John F.	Stauffer Chem. Co., Houston
Koagler, John G.	Bureau of Reclamation, Amarillo
Mayfield, L. Grady	Denver Fire Clay Co., El Paso
Miller, Delmer M.	Plains Aero Sprayers, Amarillo
Young, Dale W.	BPISAE, Spur

UTAH

Anderson, J. Bryant	State of Utah, Salt Lake City
Blanchard, T. L.	State Dept. of Agri., Logan
Davis, Wynn L.	Utah State Dept. Agri., Brigham
Gunn, Horace J.	E. O. Muir Co., Salt Lake City
Holmes, F. A.	DuPont, Brigham City
Lyman, M. Hess	Co. Comm, Weber Co., Ogden
Regan, Morgan A.	Steve Regan Co., Salt Lake City
Smith, Elmer	Denver Fire Clay Co., Salt Lake City

UTAH

Stark, A.	Wasatch Chemical Co., Salt Lake City
Thatcher, Lavar W.	Wasatch Chemical Co., Salt Lake City
Timmons, F. Leonard	U. S. D. A. Bur. Plant Industry
Tingey, D. C.	Utah State Agr. College, Logan
Whiting, Ray	Utah State Dept. Agri., Ogden
Zipko, John M.	Duchesne County, Roosevelt

WASHINGTON

Bruns. V. F.	U. S. Dept. of Agriculture, Prosser
Hedlin, William Alan	American Cyanamid, La Connet
Hurford, Robert O.	Wash. S. & Coll. Extension, Yakima
Otis, Chet	Dow Chemical Co., Seattle
Rasmussen, Lowell W.	Wash. State College, Pullman
Watke, Phil A.	American Chemical Paint Co., Spokane

WASHINGTON D. C.

Balcom, Robert B.	Bureau of Reclamation, D. C.
Ellison, W. D.	Navy, D. C.
[illegible] William	Department of Interior, D. C.
Flory, Eran L.	Indian Bureau, D. C.
Grest, Edward G.	Soil Conservation Service, D. C.
Kell, Walter V.	OCE Dept. of Army, D. C.

WISCONSIN

Gerhardt, J. T.	Kupfer Products Inc., Madison
Shoup, F. H.	Kupfer Products Inc., Madison

WYOMING

Bohmont, Dale W.	Univ. of Wyoming, Laramie
Beaudoin, Howard S.	Deputy State Entomologist, Powell
Chisholm, F. A.	Agr. Ext. University of Wyo., Laramie
Edwards, Clyde R.	State Seed Laboratory, Laramie
Fales, Heard	Greybull
Griffin, Frank S.	Co. Pest Inspector, Lovell
Hamm, Adolph S.	State Dept. Agri., Cheyenne
Harston, George B.	State Entomologist, Powell
Hudson, Edwin T.	Dept. of Agriculture, Lander
Robb, Theodore R.	Wyo. Univ., Torrington
Swanson, John A.	Torrington Flying Service, Torrington
Thieman, Leonard Russel	Pest Inspector, Torrington
Trierweiler, B. H.	County Agent, Torrington
Wirth, Laurel D.	U. S. Bureau of Reclamation, Casper

OFFICERS
1950

President----------------EUGENE W. WHITMAN, Idaho Noxious Weed Association, Boise, Idaho

Vice-President-----------W. W. ROBBINS, Department of Botany, University of California, Davis, California

Secretary-Treasurer ----- WALTER S. BALL, State Department of Agriculture, Sacramento, California

OFFICERS
1951-1952

President----------------W. W. ROBBINS, Department of Botany, University of California, Davis, California

Vice-President----------- C. I. SEELY, Department of Agronomy, University of Idaho, Moscow, Idaho

Secretary-Treasurer------WALTER S. BALL, State Department of Agriculture, Sacramento, California