PROCEEDINGS

EIGHTH ANNUAL

California Weed Conference

FIFTEENTH WESTERN WEED CONTROL CONFERENCE

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FEBRUARY 15 — 17, 1956

JOINT MEETING

OF THE

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AND THE

EIGHTH CALIFORNIA WEED CONFERENCE

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February 15-17, 1955

Headquarters - Hotel Senator

Meetings - Governor's Hall, State Fairgrounds, Feb. 15-16

University Airport, Davis, Feb. 17

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REMARKS OF W. C. JACOBSEN, CALIFORNIA DIRECTOR OF AGRICULTURE, PRELIMINARY TO DELIVERY OF GOVERNOE KNIGHT'S PREPARED ADDRESS

W. C. Jacobsen
California Director of Agriculture
Sacramento, California

As many of you may have noted from news reports, our Governor, Goodwin J. Knight, has been recovering in New York City from an attack of influenza, and he cannot be with us today as originally planned. He sends his deepest regrets over his enforced absence.

Governor Knight has requested me to read to you the remarks he had planned to make here, and with your permission, I will do so.

The Governor's remarks are:

On behalf of the state government, we welcome to Sacramento the Western Weed Control Conference and the California Weed Conference.

We are here for the serious and important purpose of considering the weed control problem as it exists in the western states, and also to learn of the progress being made in the campaign to control the farmer's number one enemy.

Our State Department of Agriculture advises me that in the United States each year losses attributable to weeds and the cost of controlling them amount to about four billions of dollars.

In California alone losses from weeds and the cost of weed control will run not less than 200 million dollars each year.

California growers are progressive people; I am sure that they are constantly aware of the importance of weed control, and that they are really doing something about it. California has a most diverse character of soil and climate. It is a fact that almost any crop which can be grown anywhere can be grown in California; in fact, more than 220 crops are produced here commercially.

It is logical to assume that if commercial crops are responsive to such natural conditions, we can expect every kind of weed to be fully encouraged.

This situation also makes weed control a year-around problem calling for more than ordinarily aggressive action.

We recognize also that California has a unique facility for coping with this gigantic weed control problem. Not only do we have weed control experts at the state level, but we also have competent men in that field at the county level--the county agricultural commissioners.

These officers also inspect shipments of agricultural seed to be sure that new and injurious pest plants are not introduced. Through the watchfulness of these state and county officials, the detection of new weeds is helpful to early discovery and application of control measures.

In the past this survey program has turned up several major weed species in the incipient stage of their infestation. By finding them before they have spread, and by attacking them vigorously where they are, many of these new weeds have been stopped before becoming widespread.

Furthermore I recognize that similar action programs are characteristic of weed control activities in all our western states.

Another fortunate circumstance in the state government's concern with weeds is the liaison established for many years, and maintained throughout the years, among the research authorities of the College of Agriculture, the practical control officials of the State Department of Agriculture, and county officers.

Through this close relationship and harmonious endeavor, there results a correlated development of information that is most important in the whole broad attack on injurious weeds. This relationship is a splendid illustration of teamwork at its best.

And I am fully aware of the fact that with the advent of new chemical herbicides, much valuable research has been developed by the agricultural chemical industry itself.

With these few words I have endeavored to show that I recognize the importance of conferences such as these, and the important role you have in the welfare of our agriculture.

Please be assured of my continuing interest in your problem, and my willingness to be of assistance in any appropriate manner. I hope your conferences are most successful, and that sometime in the future you may return to California for another joint program.

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That is the Governor's message to you.

I would like to take this opportunity to give you a little historical background in weed control here in California. There are so many new people in this business now who are unaware of the travail and frustrations that some of us old timers went through to get a sound weed control program underway. Shortly after the turn of the century the only so-called illegal weeds in California were Scotch thistle, Russian thistle, Canadian thistle and Johnson grass. As knowledge of others progressed they were gradually added.

About 33 or 34 years ago it became our responsibility to head up the weed control enforcement work. Little had then been done in research. There were two or three formal papers from our State Experiment Station and these were mostly devoted to morning glory. Investigation had been going on elsewhere, but the findings from other states were not necessarily applicable to California conditions.

Since it had become our responsibility to develop some sort of a plan, how should it be undertaken? We figured it might best be done by selecting some more or less spectacular weed for which we seemed to have a satisfactory control procedure and capitalize on this. Puncture vine was selected. At that time there was a county agricultural commissioner, then called horticultural commissioner, in Kern County who enjoyed making speeches about puncture vine. He said, "the scientific name of this pest is Tribulus terrestris which means -- terrible tribulation all over the ground". Using remarks of that nature and advising on potential damage and good control he developed at least some sentiment against puncture vine.

Weed control methods as we know them today were purely embryonic. You could count on the fingers of one hand the chemicals that were available to us -- the arsenicals, carbon bisulphide, sulphuric acid, the petroleums and the sulphate salts of iron and copper, the last two being more or less selective in character.

Associated with us in the early Nineteen Twenties was Ethelbert Johnson, who many of you know, and he had developed the use of diesel oil, one of the petroleum compounds, on puncture vine -- so a really good start on our plan was possible. But we needed more than this so set about developing additional basic precepts to support our plan.

First of all we recognized that identification was an important problem. Could we get out a book that would let the people know what this and other serious weeds looked like? A preliminary book of that character was prepared in 1922 by Dr. Smiley of Occidental College assisted by some of our staff people who were available. Secondly, it was recognized that prevention of the introduction of more weed pests through foul planting seed was important and in 1921, a pure seed law was enacted which for the first time, together with the pest provisions in the then horticultural statutes, listed many more than the few of the weeds specified by law. Thirdly, we wanted to establish eradication programs, if possible, against incipient infestations or new and limited infestations of serious weeds and leaving the abatement provisions for the generally distributed weeds but selecting those where there was some chance of doing a good job against those weeds known then to be of major economic significance or which would become so. Fourthly, emphasis was placed upon the importance of weeds as intermediate or obligatory hosts of injurious insects or plant diseases of our expanding group of commercial crops. Fifth, we had to find some way to divest the regulatory people of what then appeared to be the responsibility of weed control research work and to place it where it actually belonged. Sixth, we should obtain the services of a specialist trained in weed control techniques and with a background to get the available information completely disseminated and correlate the activities of local officers in the counties. This was the framework of our plan.

About 1923 Professor W. W. Robbins came to Berkeley and Davis -- that was the beginning of the establishment of a remarkable research team in the field of weed control. His associates and students are still carrying on effectively. At that early date Dr. Robbins was to find out whether or not the Board of Regents of the University would give him an adequate budget to embark upon a real research program in weed control. Through him we sought a man qualified in the practical phases of weed control to assist in the regulatory features and to advise with county agricultural commissioners. You should realize this unique type of service in California where agricultural regulatory work is also at the county level. That makes possible the accomplishment of a good many jobs otherwise difficult if we had to rely solely upon a state staff. In many areas of plant industry type of work our state people serve advisorily and the county agricultural commissioners and their staffs carry through on enforcement.

Dr. Robbins suggested that we consult with Professor Durrell at Colorado Aggies who gave me three names from which Walter Ball was selected.

It had taken us four or five years to get our plan working but from the time Walt Ball came into the picture our department people and the county agricultural commissioners really have accomplished much more regulatory-wise in weed control than would have been possible without a man of his qualifications, caliber, and character.

From my remarks you will recognize that I represent what is clearly in the middle period of weed control progress. Our development was through a succession of slowly accomplished steps. Serious research had brought us the use of the chlorates, the borates, some of the cyanates, some of the dinitros, and then in the early 1940's 2,4-D and with that the explosion. From that point on those old timers of us that are still interested in punching weed control are sort of left behind because now the weed control is a highly specialized field of specialists within specialties. One virtually has to be a chemist to understand about 2,4-D and its relatives and most of the others that have come along from the research in the herbicide industry.

For a weed control conference twenty or so years ago a dozen or more was a good crowd as contrasted to the hundreds here today. In those days it was difficult even to utilize chemical herbicides whereas now we have regulatory provisions to inhibit or restrict the application of some of these new and complicated chemicals. Certainly real progress has been made.

In closing I just want to ennumerate a few dates particularly for some of the newer people interested in weed control work.

1872 was the first mention of noxious weeds in the statutes and these were Scotch or Canadian thistle and what plant actually was Scotch thistle I don't know.

In 1897 the general powers of the boards of supervisors included making provisions for the control of noxious weeds.

In 1903 Johnson grass, Scotch thistle, Canadian thistle and Russian thistle were mentioned. Probably if it had been known whether Johnson was a Swede, Dane or Norwegian to be consistent they would have called it Swedish or Danish or Norwegian grass because then all the weeds seemed to have some sort of foreign identification.

In 1907 the county boards of horticultural commissioners, which became our county agricultural commissioners, were charged with the duties of noxious weed control.

In 1919 it became the responsibility of the State Department of Agriculture to engage in weed pest suppression when the old Johnson grass law was included in those functions and agencies which became the Department as we now know it.

In 1921 the pure seed law, the weed free area act and a special listing of more weedy species than just Johnson grass, Canadian and Scotch thistles was made in the law to define which plants were noxious weeds. Even then it took a long, long time to find just what a noxious weed was but in 1929 we had some better clarification of that by the Legislature.

While I was enjoying the incidental responsibility of serving as Secretary of the Western Plant Quarantine Board from 1923 until 1931 I undertook the job of interesting the representatives of the eleven western states in the importance of weed control. Finally in 1929 it began to take hold when a special committee was formed. That committee grew and later became a full fledged group on its own. The result is the Western Weed Control Conference. It is fitting that I congratulate you on the outstanding progress you have made. To get back to dates again.

In 1933 when the agricultural code was developed by codifying the many agricultural laws the broad definition of a detrimental weed that we know to-day was included as one of the "pest" types -- "any form of plant life that is dangerous or detrimental to the agricultural industry of the state". This leaves it so that our regulatory officers must prove to the satisfaction of the court, if it comes to litigation, that a weed is in fact within the pest category.

A particular milestone achieved came in 1941, after five or six years of careful preparation, planning and budgeting, with the publication of a most complete book in "Weeds of California" by Robbins, Bellue and Ball. This filled a most important need just as Dr. Smiley's bulletin had twenty years earlier.

In closing let me read one statement that came out in 1936 from the College of Agriculture as Extension Circular #97, revised in 1940, which for a number of years was our Weed Control Bible: "No matter how well conceived and elaborately stated our regulatory measures, they cannot be fully and effectively administered unless public sentiment is in thorough accord with their application and enforcement". That is just as true today with all of our highly specialized control materials and techniques as it was in those days.

I wish you every success in your conference.

REMARKS CONCERNING THE PESTICIDE CHEMICALS AMENDMENT TO THE PURE FOOD, DRUG, AND COSMETIC LAW

W. W. Allen, President
The National Agricultural Chemicals Association

We in the chemical industry have been very much interested in the Pesticide Chemicals Amendment to the Pure Food, Drug, and Cosmetic Law. Most of us have felt, from the beginning, that this was a good thing; that while it did not change the basic requirements of the Law it would do what its framers intended; it would help very much to make it practical to carry out both the letter and the intent of Pure Food Laws.

I am sure you know what the law and this amendment provide. The intent of the Pure Food, Drug, and Cosmetic Law is quite clear. Foods, Drugs, and Cosmetics - we are concerned here primarily with food - must be pure. That is, a food must be correctly identified and it must not contain or carry anything which would be harmful or deleterious to the user. All of us eat food and I am sure all of us agree that this insistence on purity is not only desirable, it is necessary.

Farmers have been able to produce more and better crops at lower cost in the past decade or two by the use of pesticides which have increased greatly in number and effectiveness. The abundance of fresh vegetables, better quality meats, finer foods of all types which can be seen in our food stores, attest the success with which this has been done. From the producer's viewpoint, it has been important for him to tighten and improve his production practices in the economic climate of these times.

Thoughtful people have wondered whether our abundant foods might in some way be contaminated because of the wider use of these new chemical tools for farming. It is a reasonable thing to wonder, and for my part I am glad it has been brought out into the clear light of understanding. Nobody stands to gain by mystery, misunderstanding, and fear.

Representative Miller, who led the job of drafting the amendment which bears his name, is a physician, a doctor of medicine. As a man whose professional career has been dedicated to keeping people healthy and helping the unwell to regain their health, Dr. Miller has attempted to draw up a workable instrument to protect the public and at the same time make it possible for farmers to use modern chemical tools in producing the abundance we enjoy. And Dr. Miller has known, I am sure, as most of us have known, that the health of the nation is now better than it ever was before.

Turn to the statistics of the U. S. Public Health Service, the insurance companies, or any other source of reliable information. You will see that we are living longer, that we are healthier during those longer years, fewer babies die; many of the afflictions which men have feared are no longer dread killers but minor troubles.

Besides that, if you have a growing boy in your house, as we have at our house, you may have noticed that the younger generation are, in many cases, taller, broader-shouldered, and stronger than their parents, and very likely, better looking. The statistics don't tell about their looks, but it is a matter of record that our children are bigger, as well as healtheir, than their parents.

Much credit is due, of course, to better medical knowledge and medicines; but much credit is due, also to the fact that our food supply is better, human labor is not the man-killing thing it sometimes had to be in the past, and we have more conveniences and more leisure. In all this, I am convinced that our better food supply has been an important factor; and there is no doubt that agricultural chemicals have helped produce that better food supply.

Many thoughtful people have been grateful for this, but at the same time have thought it necessary to assure a food supply free from possible injurious or harmful materials.

The Miller amendment recognizes something that small boys and their mothers and professional toxicologists, have long agreed upon. Almost any substance is harmless to eat if you don't get too much of it. Most mothers of small boys growing up on farms are used to the idea that, at one time or another, their enterprising sons will eat a certain amount of dirt. In fact, there is an old saying in the farm country where I came from that "you should eat a peck of dirt before you die." Your life, so to speak, hadn't been complete without it.

And the professional student of toxicology recognizes that anything - sugar, salt, even water, in excessive amounts or improperly used, can be dangerous and harmful. Similarly, it might almost be said that any chemical material however deadly it may commonly be considered to be, can safely be eaten if the amounts are small enough. As an example I might cite the instance of one of the most deadly poisonous chemical substances known, sodium cyanide. There is universal agreement that this substance is one of the most powerful and quick-acting of chemical poisons. Almost everywhere the material is named or its use is discussed, there are warnings of its poison nature. Yet for many years this substance has been recognized in the U. S. Pharmacopoeia, and physicians have used it for many years as a medicine. In very small doses under a physician's care, it has had a useful place in medical practice.

With a background of that kind of understanding, The Pure Food, Drug, and Cosmetic Law has provided that where any material which might be harmful or deleterious appears or is likely to appear in or on food and certain other materials, due study shall be conducted and a tolerance level established, below which this material is not considered injurious. And in case of any question, Federal officials have interpreted it to be their responsibility to set exceedingly conservative and safe tolerance levels.

When this first became part of the established regulatory practice, it was provided that tolerances should be established upon the basis of data presented in public hearings. In theory the public hearings were a good, open way of doing business; but they soon proved to be prohibitively expensive, and instead of taking a few days or weeks, they began to run into years. The whole effort to protect the public was threatened for want of an expeditious means of setting tolerances.

The Miller amendment stems from a recognition that a pesticide, which is used only in production of a raw crop and is not an additive added to a food, comes in a somewhat different class from food additives or preservatives. Pesticide residues require somewhat different consideration. They differ in such factors as the amounts present, the kinds of material, the intent, and the factors such as weather and farming practices which affect the amount and nature of materials present. The amendment recognizes that these materials are necessary in good farming; yet it holds the traditional view - which is a sound one - that the health of the public must be protected.

In the case of pesticides, then - insecticides, fungicides, herbicides, and similar materials - the law now makes it possible for federal officials to establish allowable residue tolerances upon the basis of data they consider adequate. Such data may include state and Federal government laboratory tests and field reports; reports from reliable biochemical and toxicological laboratories; from physicians and other qualified observers. Pesticide manufacturers are held primarily responsible for furnishing this information.

Residue tolerances then become a factor in the establishment of recommended farm practices.

The purpose of the law is to make sure that raw agricultural products will be safe, as regards the possible presence of any pesticide residues.

That is a very brief statement of the Miller Bill and its effects. Now we in industry have been much interested, and at times concerned, for a certain side-effects of this law.

For one thing, I feel very sure that the tremendous publicity given to this whole matter has focussed attention as never before upon the vital job being done by chemical pesticides. We in the industry have watched our business grow, and we have recognized that many people did not know it was growing so solidly. Now, there is a broader public awareness of our industry, our profession, than ever before.

We are glad for this. It will help more farmers to benefit from using modern pesticidal materials. That in turn means more sales for industry, and I should be hypocritical indeed if I were not interested in that. It also means more importance, and recognition for the state and federal specialists under whose considered recommendations these materials are used.

You could summarize this side effect by saying that the Miller Bill and the publicity which has attended it have brought a degree of recognition to our industry which we never enjoyed before.

For another thing, I feel that there is a rising public confidence in our industry. In this regard I think that the public in general has always held our profession - our industry - in pretty good esteem.

The outcry of a few mistaken or self-seeking publicists has not essentially confused most people. But now the basis is being developed for a solid, intelligently based confidence which will make for better agriculture, better industry, and a professional relationship with the public better than ever before.

A third vital side effect is to focus attention upon the fact that many manufacturers have been conducting very important and costly research for many years. Some of the toxicological data recently brought to light were developed by industry research before representative Miller entered medical school.

Industry research is expensive, as anyone in any kind of research knows. Seldom does an industry make a profit of toxicological information. Its use is rather to protect customers and the public. Now these are reasonable and proper concerns of industry; but they are not directly profitable. We are now beginning to appreciate how heavily manufacturers have invested, over the years, in the health and safety of their customers and the public. We have their solid backlog of reliable data, now when we need such information, which gives us fair evaluations of many chemicals. Those firms whose research programs have been well considered and adequately supported have come to enjoy recognition for this which they have not always had.

Fourth, pesticide labels have won a due respect they have not always enjoyed in the past. I am sure you know that, our labels are now under closer scrutiny than ever, for highly detailed accuracy. Under this new pressure, some people are learning for the first time that manufacturers' labels are prepared with very great care and at far higher cost than the average user suspects. As label recommendations have come under official review, there is general recognition of something we in industry have known all along because we pay the bills; and that is, that a good label is hard to write; that it is hard to rewrite to make it better, and you can put a price tag of many dollars a word on most manufacturers' labels, simply to cover costs of writing. Research, which tells you what to write, and the printing of the label after it is written, cost extra, and sometimes very much extra.

The fifth side effect is, I am sure, temporary; and I can state it in one word. That word is confusion. If you have had responsibility for developing state or Federal recommendations for pesticide use, or if you have had similar responsibility for a manufacturer's label recommendations or sales literature, you have had experience with this. Sometimes we have not quite known what we could rely upon, which way we were going, or whether we are going at all. At close range this has been a sorely troublesome situation, and has given many a good man reason to go home after his day's work with his head a whirl of annoyance and uncertainty.

Most pesticide recommendations are issued in late winter or early spring. We in the industry believe - and hope - that this will be a spring to remember, as the only time we have had so many unresolved problems to face, and so much trouble dealing with them. If you are having a hard time, too, as some of you have assured me you are, we hope this is the first and only time we and you must face such a situation.

I have been asked, as a matter of practical administration, what you can do, those of you who are charged with developing recommendations, as a way of living with this new law until its terms are more clearly known. What can you recommend until you know what Food and Drug will permit?

Certainly nobody can offer to solve all your problems; but I can perhaps, give you some idea of what is being done, in some places, by some people.

First, I have long believed and now have the opinions of highly placed Federal officials to support me, that state, federal, and industry recommendations for pesticide use have been, in general, pretty sound all along. In today's closely managed agriculture, farmers do not generally use any more of a pesticide than they must, to protect their crop. Because they tend to keep costs at a minimum, they tend to keep residues at a minimum, too. Therefore, with some exceptions, we can pretty much continue to rely, at least for the immediate future, upon past recommendations. And I think when this whole business is finally cleared up, the new and wholly approved recommendations will not be very much different from the recommendations conscientious men have submitted in the past.

Close attention may be given to the time when a farmer applies a pesticide. Materials known to have persistent residues should usually be avoided on crops nearing harvest. Of course this is not a new idea; but it warrants a close second look this spring.

Some state colleges of agriculture have checked with Washington in regard to materials on which they wanted to issue recommendations, where the status of some materials was in any doubt; and have delayed issuing recommendations pending residue tolerance determinations and related matters. In this quandary, last year's recommendations have sometimes been followed, on a temporary basis.

And some state colleges have proceeded to issue the best recommendations they know, with the appended statement that these recommendations are valid only to the extent they conform with applicable federal regulations, if any. This last is admittedly not a very satisfactory answer. It leaves everybody in doubt and really protects no one.

Let me assure you that the Federal officials who are charged with administering this law, have no intention of making life difficult for conscientious state college people, extension specialists, experiment station staffs, or manufacturers. I know they are as fully cooperative as they can be.

A tremendous job is to be done, evaluating the many useful chemicals which are available, fixing the limits of their safe and effective use, and spreading that information where it is needed.

And that brings me to a matter in which many of you can be of tremendous help; and it is none too soon to begin.

I predict that in the future there will be far more trouble from misuse of pesticides by people who don't read the label, or don't read your published recommendations, than by all other classes of users combined. Under the terms of the new law, it will be more important than ever that pesticide users read and follow directions. Conscientious manufacturers put the very best recommendations they know, on their labels. Conscientious state and federal people publish the best recommendations they know. Yet all this work is for naught if the user fails to heed and follow those recommendations.

If there ever was any doubt about it, we can now be sure the day is past when the user of pesticides can afford to be indifferent or careless about exactly how he uses these materials and exactly what he uses them for.

One of the big future problems for which no present easy answer has been found, will be to educate users to intelligent compliance with recommendations. To do this we must make sure that county agents have the information they need. Most of them are already well aware of this problem. We must also see to it that our dealers and jobbers are aware of this problem. Vocational agriculture teachers, youth work leaders, -- the field broadens and we could mention agricultural editors and broadcasters, and any others who reach the farming public. All can help. If you are looking for a slogan for this spring, let me suggest it could be "Read the label and do what it says," or "Read the bulletin and do what it says." Until most pesticide users habitually do these things, no law will be complete enough, and no regulation wise enough to bring about the combination of safety and effectiveness which we all are seeking.

WEEDS -- WHERE THEY COME FROM AND WHAT THEY COST

H. Wolfe, Extension Weed Specialist
Washington State College
Pullman, Washington

It is a pleasure to be in California at this time for the Western Weed Control Conference. It doesn't make me too unhappy to be away from the snowy north country for a few days, and also coming to California at this time gives some of us a preview of our summer's work. What I plan to say will probably indicate that Washington certainly has a lot of work to do. It might even make Washington look like a Utopia for a weed man. However, I am almost certain that these conditions are not peculiar to Washington, but exist to a certain degree in all of the Western states.

Having had a chance to travel around over much of the Western area, I feel that Washington is in a pretty favorable position. As far as I'm concerned we have some of the finest weed research men in the West. We have an active regulatory branch which certainly is most cooperative with the research and educational phases of weed control. The representatives from commercial companies are not only cooperative, but as far as I'm concerned, the commercial companies can be proud to be represented by these men. Along with lots of good research we certainly need the help of a regulatory branch and representatives from industry.

Yet, we need more than what these three groups can offer. I feel we need some way to make ranchers and farmers half-way unhappy with themselves, with their neighbors. It isn't difficult to discuss with a group of farmers the latest research findings. I feel this is like always drawing to an inside straight since it becomes quite discouraging.

Along with the latest research findings we are striving not only to tell the farmers how to kill weeds, but to give them some reason why they should do so and some idea of where these weeds are coming from. I must admit that we do have a lot of our land infested with some of the serious weeds. We also have hundred and thousands of acres not infested with serious weeds, and we have more than a million acres of weed-free land coming under irrigation. I say it is weed-free, however, it is covered with sage brush and cheatgrass. Consequently, we are interested in pointing out more than research findings. I think I can probably best show you what I mean with a few slides.

Here is a sample of what appeared to be good clean red clover seed. One could pick it up, run it through his fingers and feel certain that it was good enough for planting purposes. Yet the purity analysis showed that it contained sweet clover, alsike clover, white clover, timothy, and alfalfa. Having these crops in red clover seed planted for pasture purposes probably isn't too bad. However, the purity analysis also showed that the sample contained 23,000 noxious weed seeds per pound. Rather than depending upon your eye and your guess as to whether the seed is good, always insist on seed that has a purity or analysis tag on it. This is important, as evidenced by a survey of non-certified crop seed that was sent to the W.S.C. seed laboratory.

Percentage of Primary and Secondary Noxious
Weed Seeds in Crop Seed Sent to the
W.S.C. Seed Laboratory

	per cent
Wheat	37
Alsike clover	83
Ladina clover	50
Sweet clover	72
Alfalfa	54
Red clover	80
White clover	75

Here's another example from our state seed laboratory in Yakima where alfalfa seed was tested during an 8-month period.

In an Eight-month Period 1316 non-certified Alfalfa Seed samples Were Tested at the State Seed Laboratory

582 samples contained one kind or more of the following weeds:

Canada thistle	White top
Russian knapweed	Wild morning glory
Plantain	Dodder
Dock	Charlock mustard
Fanweed	Yellow star-thistle
Sheep sorrel	Perennial ground cherry

We talk about pure seed, or at least planting the best seed that you can buy, and we in Washingron feel that our certified seed grown in Washington is good seed. Farmers planting that seed can depend upon its quality and its purity.

For the Same eight-month period, 442 Certified Alfalfa Seed Samples were Tested at the State Seed Laboratory

Twenty samples contained seeds of the following weeds:

Canada thistle	Dodder	Russian knapweed
Plantain	Dock	

Twelve of these samples couldn't be cleaned sufficiently to meet certified seed requirements and were rejected.

Most of you will say that a lot of those weed seeds can be cleaned from the crop seed, and I'll certainly agree with you. A lot of them can be cleaned. However, it certainly doesn't always happen. This past year a drill box survey was taken in one part of the state on oat seed that was actually being planted. From this drill box survey you can see that a lot of the seed that is planted isn't clean.

Oat Seed Taken in a Drill Box survey.
(Of the 107 samples collected, 43 could not be legally sold for seeding purposes in Washington.)

Noxious weeds	Number of Samples	Av. weed seeds per lb.
Quackgrass	36	82
Canada thistle	13	38
Leafy spurge	1	4
Plantain	30	205
Dock	14	23
Sheep sorrel	14	67
Charlock mustard	7	3
Fanweed	2	12

In addition, the 107 oat samples contained 62 different common weed species.

Another example of contaminated seed that was planted was found in Eastern Washington. Anytime there is a shortage of any particular crop seed, there is a better chance of planting contaminated crop seeds.

Weed seeds found in a sample of barley seed that was actually planted.

Kind	No. of weed seeds per bushel
Russian knapweed	6,624
Corn cockle	6,336
Fanweed	288
Cow cockle	1,152
Lamb's quarter	1,728
Wild oats	2.1%
Morning glory	6,624
Curly dock	288
Wild buckwheat	1,728
Cheatgrass	15,284
Mallow	288
Gromwell	5.3%

I mentioned that we believe our certified seed is the best seed that we can plant. However, there must be more precautions than just buying and planting certified seed. In Washington we can buy bulk certified cereal seed. One of our farmers had the right idea when he went to purchase certified wheat. He had taken his truck to one of our seed men and before the seed man would sell him the seed, he took a vacuum cleaner and cleaned out the bottom of the truck. That farmer had the right idea, but he was willing to load more than 100 bushels of clean certified wheat in a dirty truckbed.

Weed Seeds in 3½ lbs. of cracked peas, dirt, debris
Removed from a Truckbed just before loading
bulk certified wheat seed

Kind	Amount
Wild morning glory	118
Tarweed	826
Corn cockle	32,450
Buckwheat	826
Knotweed	326
Wild oats	2,450
Lamb's quarters	391,700
Canada thistle	590
Fanweed	165,700
Mustard	177
Dock	885
Madia tarweed	1,947
Pigweed	24,500
Dog fennel	33,984

You may wonder if the weeds we have in Washington are causing the farmers any loss of money. From the same cereal-producing areas we find that the cost of the weeds runs into the millions of dollars.

WEEDS

Cost Washington's wheat ranchers
an estimated $13,285,095 each year

Weeds reduced the yield of Washington's Dry Pea Crop
an estimated $2,135,000 in 1954

There certainly are many ways that weeds cost our farmers and ranchers. One of them that was most striking is the actual reduction in yields of wheat that we get from both annual and perennial weeds. Annual and perennial weeds, depending upon the extent of infestation, have been found to reduce wheat yields up to as much as 22 bushels per acre.

Enough Wheat Is Lost Each Year

BECAUSE OF WEEDS

To Bake 192,044,750 Loaves
of Bread

Another area where weeds are certainly costing our ranchers money is on our range land. Sixty to sixty-five per cent of our range land is in poor to fair condition because of sage brush and cheatgrass. At one time our range land produced typical bunch grass. Today, we have sage brush and cheatgrass over most of it, and five weeds are moving into these areas that will make our cheatgrass and sagebrush look like pretty good forage plants. These five weeds that are on the move are Medusa-head, Mediterranean sage, goatweed, diffuse knapweed and dalmation toadflax. This range situation is of real interest to us in Washington because.... Range and pasture weeds cost Washington farmers an estimated fifteen million dollars per year.

Another way that weeds are coming into Washington and are spreading is evidenced through screenings being sold for livestock feed. I doubt very much whether the screenings are being ground fine enough to take care of all of the weed seed viability. After checking one feed lot where they were feeding screenings, I'm quite certain that not all of the screenings are ground fine enough. Here are some examples from tests on screening sold for livestock feed that had not been ground:

These screenings were being sold for livestock feed

A ton of screenings would contain:	pounds
Wild oats	1,700
Fanweed and Lamb's quarters	60
Gromwell and Buckwheat	60
Cow cockle	20
Canada thistle	14
Dog fennel	10
China lettuce	1.8
Cracked peas	100

Fourteen pounds of Canada thistle is approximately 3,964,800 Canada thistle seeds.

Screenings are also being shipped in from Canada. In one carload that was checked, 40 per cent of the seed was weed seeds. To show you a few of the kinds of weeds that were found and approximate number of weed seeds in that one carload:

Refuse screenings shipped in from Canada for livestock feed

kind	number
Canada thistle	2,160,000
Quackgrass	2,160,000
Corn cockle	2,640,000
Lamb's quarters	45,360,000
Russian thistle	19,000,000
Knotweed	8,649,000
Wintercress	2,160,000
Wild oats	73,440,000
Barnyardgrass	2,160,000
Pigweed	10,800,000
Fanweed	2,160,000
Black mustard	2,160,000
Buckwheat	3,646,080,000
False flax	4,320,000

In Washington we have miles and miles of irrigation canals, laterals, rivers, streams, creeks, and in general we have lots of water. We feel reasonably certain that much of this water carries a lot of our weed seeds. Some of our research work at the Prosser Experiment Station has indicated that many of our more serious noxious weeds will remain viable in irrigation water regardless of winter and summer temperatures, for as much as four years. Consequently, it seems reasonable to assume that many of these weeds, when they get in irrigation water, will remain viable long enough to become established either along the banks or on somebody's farm. In one of our irrigation areas a pint of debris was collected from an irrigation canal. By weight 4 per cent of the material that was collected was weed seeds.

Weed seeds in one pint of debris collected from an irrigation ditch:

kind	amount
Wild morning glory	1
Barnyardgrass	53
Knotweed	408
Smartweed	96
Common milkweed	26
Quackgrass	4
Cheatgrass	7
Russian thistle	13
Water hemlock	1,509
Yellow foxtail	98
Wild buckwheat	50
Mallow	32
Bull thistle	10
Green toxtail	13

Another example that I probably shouldn't mention here is how Washington is getting weeds by purchasing plant materials from other states.

Nut Grass made the long migration
from California to Washington
in a few days as an unwanted hitchhiker in asparagus crowns

So far, the man that has purchased asparagus roots from California has already spent more than $500 in attempting to eradicate this nut grass, and hasn't yet succeeded. To show you some more of the costs, here are actual expenditures that take place each year:

Each year weed and brush control costs the following:

State, county and private roads	$405,300.00
Power companies	333,153.05
Government agencies	200,000.00
County Weed budgets	79,749.00
Railroads and public telephone companies	789,795.92
Total	$1,807,927.93

And here are some of the costs of weeds, and these are very conservative costs, in 13 of the crops that we raise in Washington:

Here are the yearly profits we could share
if desirable vegetation could replace weeds.

Cereals	$13,285,095
Dry peas	2,135,000

Range and pasture	15,000,000
Sugar beets	1,410,000
Strawberries	1,144,900
Green peas	943,256
Asparagus	210,362
Legume seed	745,000
Other seed crops	210,000
Sweet corn	578,100
Dry beans	390,000
Potatoes	90,000
Cranberries	65,800
From hay fever	1,300,000
Total	$37,507,513

If we could arrive at all the figures and all the costs of weeds, I'm certain that Washington is loosing more than $50 million each year because of weeds and brush.

By using materials like this and using our latest research, we have gotten our farmers and ranchers thoroughly disgusted with the weed situation. They are certainly talking about weeds. And many are doing something about them.

WEED CONTROL AND THE BUREAU OF LAND MANAGEMENT

Edward Woozley, Director
Bureau of Land Management
United States Department of the Interior

This is the first opportunity I have had to meet with the Western Weed Control Conference since I was State Land Commissioner for Idaho. I have wanted for some time to discuss with you the responsibilities and limitations of the Bureau of Land Management concerning weed control on the public domain.

Realizing the extensive knowledge and experience of this group, I have followed your activities with special interest.

We are not a research agency, but we are keenly conscious of the need for continuing research and we depend on you for newer, more practical weed control measures that can be readily adopted for use.

In this day, when the American farmers and ranchers are trying to cut costs, they must have practical ways to increase their net returns. One of the surest ways is to combat crop inhibitors and livestock killers.

One of the main reasons for my being here is that the public lands have the bulk of one of the most dangerous of these livestock killers--halogeton. This weed seems to thrive on the poorer lands that are in public ownership. But before discussing halogeton, I would like to give you a brief account of the overall job of the Bureau and the lands we administer.

As the Department of the Interior agency responsible for management of the public domain lands, BLM has exclusive jurisdiction of about 468-million acres of what is termed vacant and unappropriated lands in the United States and Alaska. Approximately 178-million acres lie in the Western United States and are mainly range lands. Most of these lands are in almost constant productive use. More than 12-million head of livestock graze on these lands each year, and they furnish considerable forage for more than a million head of big game animals, not counting other forms of wildlife.

Under provisions of the Taylor Grazing Act, we are authorized to classify these same lands, whenever someone thinks they can be put to a higher use in private ownership. We receive hundreds of applications, and when classification shows that public land is suited to a higher use, it becomes subject to disposal under the various public land laws.

We still receive quite a few homestead applications. Desert Land Act entries have increased in many States, and you have probably noted the increased interest in obtaining small tracts of five acres or less under the Small Tract Act.

The search for minerals in the public domain lands, particularly uranium, has created problems of multiple-land use in the past few years. One of the problems important to weed control is the damage to the range from prospecting and assessment work on mining claims. Torn up lands offer a better foothold for the spread of halogeton than the undisturbed range. This is undoubtedly contributing to the spread of halogeton in the face of control efforts.

The point I wish to emphasize is that the seemingly barren grazing lands are decidedly important to the year-around operations of two of our biggest industries--livestock and big game as well as to the all-important watersheds of the West.

I would like to say a word about the reorganization of the Bureau, particularly as it affects weed control. I feel that the decentralization of our activities during the past two years has definitely contributed to greater efficiency when it comes to weed control, as it has in many other ways. When I came into the Bureau in 1953, we were operating under seven regional offices with the district offices reporting directly to the regions. With reduction of the regional offices to four area offices and establishment of a State office in each of the 11 Western States, one in Washington for the Eastern States, and an operating office in Anchorage, Alaska, we have been able to increase our efficiency and improve our services to the public. Decentralization of most of our work in the field has now been accomplished and we find that where there is no district manager, such as is the case with Section 15 lands, the users no longer have to go to regional administrators to get action. They can take up matters with the State supervisor who is close at hand.

Our area offices are doing an important job of coordinating all State programs, in clarifying policy, and in bringing the best methods from one State into the programs of other States.

At the Washington level we have a full-time man assigned primarily to weed control. As you may know, he is Ernest Palmer, who is doing a good job in coordinating the Bureau's weed control activities where the funds originate.

Part of Mr. Palmer's time is required for the soil and moisture conservation and other range programs which tie in with weed control and eradication. Soil and moisture conservation work is a phase of our program that is primarily geared to erosion control and protecting our ranges from further damage.

We expect our district and State personnel to become thoroughly familiar with the public land problems of the State and work closely with the range users and other local, State, and Federal prople in properly managing the public lands.

I don't have to tell you people about the importance of weed control to the farmers or to the range users. Weed control on range and agricultural lands of the Nation cannot be overemphasized. We realize that the public lands are infested with undesirable plants such as mesquite, sage brush, rabbit brush, halogeton, medusa rye, and many other noxious or poisonous weeds. Control of such weeds is therefore recognized by BLM as a conservation and range improvement practice in the proper management of the lands under its jurisdiction. We are cooperating in every reasonable way with individuals, associations, counties, and States in carrying out a coordinated weed control program. Our aim, of course, is to make it as effective as possible with the least possible expenditure.

The Taylor Grazing Act, of 1934, provides broad authority for protecting the public lands against noxious and harmful weeds. The range improvement work carried out with range improvement funds indirectly helps to control weeds.

The National Soil Conservation Act of April 1935, and the provisions of Section 6, Government Reorganization Plan No. 4, authorized the Bureau to do weed control work in connection with its soil and moisture conservation program. It has been interpreted, however, that weed control can only be justified under this program when undesirable plants are replaced by more beneficial plants as erosion resistant plant cover.

The Halogeton Control Act of July 1952 is the only Act that gives the Bureau direct authority for a weed control program and this, of course, specifies halogeton only. Since inception of this program, the Bureau has made a conscientious effort to control halogeton with a four-phased program. We first make surveys for accurate information on halogeton location, density, size, direction of spread, rate of spread, and areas that are susceptible to invasion. We also look for other information needed to plan the most effective control measures.

Second, we seed infested and threatened ranges to hardy perennial grass that will crowd out halogeton, prevent spreading, and at the same time produce forage for livestock removed from infested areas that are unsuitable either for grazing use or reseeding.

Third, we attempt to control the isolated or spot-infested areas by chemical spraying. Eradication is the main purpose of this direct treatment, although along perimeter areas and avenues of spread, spraying is used to prevent seed production and reduce the rate of spread.

Fourth, in the drier and poorer soil areas of the Federal range where grass seedlings can't successfully be established, we are attempting to control halogeton by better range management. Here we find proper grazing use and forage development projects to be the best answer. The hardier range plants, which can tolerate poor conditions are improved to such a degree that halogeton will be crowded out. The methods used in this phase of the program are fences for controlled grazing, waterspreading and contour furrowing projects to catch and make better use of the available moisture, and proper grazing use.

Some of the results of our halogeton program can be tabulated.

We have seeded more than 400,000 acres for halogeton control, at the rate of about 80,000 acres a year.

In chemical control, we have treated about 83,000 acres since the program began in 1952, at an average rate of about 15,000 acres a year. Several small spot infestations have been eradicated, and we have materially reduced seed production and spread in perimeter areas.

In forage development programs, we have constructed more than 1,000 miles of protection fences and more than 87,000 acres have been included in forage development projects. In many of these areas native vegetation is definitely crowding out halogeton.

Chemical control, of course, has a definite place in the control of halogeton, but control of the large infestations must come about through improved range management, including soil and moisture conservation, range improvement practices, and so forth.

Good progress is being made in adjudicating the range and regulating the stocking of the range by domestic livestock and wildlife to its proper sustained-yield capacity.

Range improvement fees are used to build stock watering facilities, fences, roads, corrals, and other projects aimed at facilitating livestock management.

In Soil and Moisture Conservation, detailed planning and construction are carried out on a community watershed basis. We have divided the work into structural and land treatment practices. Structural practices include all types of dams, dikes, checks, terraces, water spreading and similar structures for retarding runoff and sedimentation. Land treatment practices include revegetation, brush control, deep tillage, contour furrows and other measures that restore and maintain an adequate plant cover to the soil.

Under the S. and M. C. program about 75,000 acres are seeded and watershed protection is applied to more than 1,000,000 acres each year.

So, looking at the whole picture, we are convinced that through proper use of the range, coupled with our range improvement program, Soil and Moisture Conservation program, and weed control programs, we will eventually restore the public land to its optimum grazing capacity. This means that weeds will have been controlled to the extent that they are an insignificant problem.

I shouldn't overlook the very important cooperation we are receiving from the range users. It is backed by dollars from their own pockets. Contributions from stockmen and others in the form of cash, materials, and labor have totaled nearly 40 percent of the total programmed expenditures.

I would like to point out that our public lands are important to the entire economy of the West. Although to some people they seem barren and unproductive compared to the more fertile agricultural land, they do provide either full or part-time range for something like 9,000,000 head of sheep and goats and 3,000,000 head of cattle and horses. They are also valuable as range for an estimated 1,000,000 head of big game animals in addition to other forms of wildlife. About 30,000 sheep and cattle operators are dependent upon the Federal range for economic year-around operations. Most of the western range livestock people could not have a rounded, efficient program for use of their private property if it were not tied to use of the public lands. The operators contribute to watershed protection which is important to downstream uses for irrigation, recreation, power production, and domestic water. The taxes they pay for Federal, State and local needs also reflect the coordinated use of these Federal lands. So that in addition to paying a reasonable fee for range improvement and use, and contributing to the protection and rebuilding of range land, the users are actually building an economy that extends far beyond the ranches and the lands around them. In fact, there is hardly a person in this country who does not receive some of the benefit in some way.

Although halogeton is our most serious public range weed problem, I know you are wondering about noxious and poisonous weeds other than halogeton. Certainly they are a problem too. We know that there are about one million acres infested with poisonous weeds other than halogeton in the public lands, and that there are another one and one-half million acres of noxious weeds. In some areas these weeds are not of sufficient density to cause any material damage. In other localized areas, however, these weeds are a serious problem to the use of the range and to adjacent agricultural lands.

We are certainly aware of this problem and will do whatever we can with funds available to meet it. In 1956 we asked Congress to allow us to use a limited portion of the halogeton monies, first, to cooperate with local county agents and county and State weed control groups in making a reliable survey of the more serious noxious and poisonous weeds on the public lands; second, to cooperate with the various research agencies of the Federal Government and the States in carrying out a research program to find the best ways to control these weeds; third, to cooperate in a limited way with State and local weed control organizations in controlling the more serious noxious and poisonous weeds where the efforts of these groups would be nullified if the Bureau did not participate.

The Congress approved this request but, as stated before, our funds will be very limited. However, I would like to point out that in our halogeton control program we have been doing work on intermingled and adjacent lands of other ownership in cooperation with the owners. In this way, we have been contributing to the over-all weed control program of the county and State.

Fortunately, most of the Western States have effective weed control laws, and local and State weed control groups are doing a good job in controlling the more serious weeds. We have asked our district and State BLM people to maintain a close relationship with these groups so that we will be prepared to cooperate in emergency cases.

I would like to congratulate the research and the control groups you represent. You certainly have BLM's moral support in the good work that is being done in the Western States on weeds. It has been a pleasure to meet with the Western Weed Control Conference and I want to thank you for the opportunity.

WEED CONTROL IN NEW ZEALAND

Dan Watkins, Ivon Watkins, Ltd.
New Plymouth, New Zealand

It is indeed a pleasure to be able to tell you something about new developments in weed control in New Zealand. Actually we have received and continue to receive from the United States much assistance on how to cope with our imported and unwelcome weed pests.

Mr. A. J. Healy, Botany Division of the Department of Scientific & Industrial Research, reported at New Zealand's Fifth Weed Control Conference on the accidental introduction of many weed plants which decided they liked our climate and other environmental conditions. California Poppy (Eschscholtzia californica, Californian, or should I say, Canada Thistle (Cirsium arvense), to name but two of our lease lend importations from your fine country, have both settled down to a regular routing plan of taking over where ever they can.

Our worst weed, if there is such a category, is perhaps Nassella Tussock (Nassella trichotoma) that apparently came in attached or clinging to wool or hair of imported Merino rams and has now established itself on some 368,610 acres of some of our better hill country (in the province of Canterbury) in the South Island of New Zealand.

Variegated Thistle (Silybum marianum), Winged Thistle (Carduus tenuiflorus) and the Buttercup (both Ranunculus repens and Ranunculus acer) are an annual problem in some of our best producing country while weeds, yes just weeds, in brassicas constitute the biggest unsolved weed control problem in New Zealand. Part, and a very important part, of our normal farm programme consists of growing Rape (Brassica napus), Chou Mollier (Brassica deracca), Soft Turnips (Brassica rapa) and Mangolds (Beta vulgaris) as supplementary feed for both cattle and sheep.

We also have some rather tough woody types, such as Gorse (Ulex europaeus) and Sweet Briar (Rosa rubigibosa) that infest some tens of thousands of acres and these are receiving special attention from our research workers.

However, I wish to deal more specifically with our methods of control and to give you some idea as to what we are doing in the way of independent applied research.

Nassella Tussock, to which I have already referred, has been sprayed successfully from the air using 50 lb. of TCA in 30-50 gallons (imperial) of water per acre in two successive treatments. Whilst perfect control has not been achieved, the authorities are reasonably satisfied with the 4,000 odd acres treated to date. Extensive research using Dalapon, CMU, DCMU and Amizol is under way and we hope that at least one of these compounds will provide a quicker and less costly answer to this problem.

In the southern part of the country an extensive rabbit problem prevailed and as the result of a very strenuous drive the rabbits have been almost wiped out. The result has been that the Sweet Briar which the rabbits keep in check is now taking over thousands of acres of good land in our high country. The best results to date have been with the polyethylene glycol esters of 2,4,5-T and with the butoxyethanol esters of 2,4,5-T. However, we are not completely satisfied and we are trying out Amizol which seems to be working well on the related Rubus species.

With weed control in our forage and root crops, Oktone has shown up best, although, under favourable conditions, TCA at 10-15 lb. to the acre is showing up reasonably well. We prefer Oktone as it works under the widest range of weather conditions, but even so very wet weather following application tends to allow a fresh crop of weeds to come away.

We have had some rather interesting results with Docks (Rumex spp.), a weed of our high producing dairy farm lands. The form of 2,4-D that works best on the adult plants is "PEG" 2,4-D (polyethylene glycol ester). Hundreds of trials have consistently shown "PEG" to be outstanding, yet every now and again we get complete failures which we just cannot blame on formulation, poor application or wrong timing. With seedling Docks, amine 2,4-D is best and MH-40 rivals Peg 2,4-D in effectiveness but tends to fail with plants in the adult stage.

So much for general comments. I believe you would be interested to know something of the New Zealand Government workers views on new chemicals so that you can compare their results with your own. Official work that has been undertaken during the past year has been summarized by Mr. L. J. Matthews of the Department of Agriculture as follows:-

"Gorse Control

To date, in our work, no material has proved as effective as straight 2,4,5-T. This word needs qualifying. The most promising alternatives have been your material CS-301. Preparations of 4-C and 2,4,5-TP have not proved very effective. The addition of ATA to MCP, 2,4-D, 2,4,5-T and 2,4,5-TP, 4-C and to CS-301 have not increased the herbicidal efficiency of these materials. In each case CS-301 was applied at 1 gallon per acre or 4 lb. of acid equivalent. This rate of application was less effective than an equivalent rate of 2,4,5-T. The other materials, such as 2,4,5-T, plus ATA, 2,4,5-TP, 4-C, etc., have shown no promise. On the whole, the kill from CS-301 has been less effective than equivalent rates of 2,4,5-T, that is, there has been a smaller proportion of end kill. The reporting has not been detailed enough to conclude whether or not the kill has been more rapid. All evidence shows that 100% complete foliage cover is still required with this material. Hence it is doubtful whether it translocates any better than 2,4,5-T.

Weed Control in Cruciferous Crops

If suitable weather conditions prevail, TCA at rates up to 30 lb. has given quite effective control of most of the weeds, except members of the Cruciferae. For instance, fat hen goes out at rates of over 20 lb. Members of the Polygonaceae go out at rates under 20 lb. The carbamates have not proved effective for Brassica weed control, simply because they have to be applied at rates up to 4 lb. to give effective weed control and at these rates severe brassica injury takes place. The most promising chemical is Oktone as it is a chemical that does not depend so much on climatic conditions for efficiency. Applied in a suitable carrier, Oktone has given excellent weed control in rape and chou moellier. If dry conditions prevail, good weed control is also obtained in turnips and swedes, but if wet conditions prevail these crops usually become infested with weeds at a later date. We have done little work on garden cruciferous crops. Oktone has been quite successful in both Islands. It is best used in conjunction with a stale seed bed, that is, allow the weeds to germinate, drill in the crop and then spray before crop emergence. In comparison, with TCA and IPC, Oktone, used in this way, has given total weed kill of all germinating seedlings present whereas TCA is required at rates over 20 lb. to kill fat hen and spurry. It is not effective against cruciferous weeds or clovers, and non-effective against flat weeds, etc. IPC, of course, controls a very small range of weeds. It is effective against grasses and spurry but does not control any of the other weeds. Of course, both TCA and IPC depend on suitable moisture conditions to be effective.

The above has been borne out in numerous trials on brassicas, onions and carrots where the three materials have been compared. Right throughout New Zealand last year, TCA and the carbamates, to a lesser extent, gave very poor weed control, simply because dry conditions prevailed.

Control of Barley Grass in Pastures

TCA at rates of 10 and 15 lb. applied in Autumn when the barley grass (Hordeum murinum) is germinating, or at rates up to 20 lb. in Spring when the barley grass has established, has given excellent control without damaging severely associated grass and clover species. The use of carbamates could only be recommended for nucleus areas under fence lines or on dry hill tops where clover persists due to hot ground temperatures. Because the carbamates have a very detrimental effect on species such as rye and cocksfoot, its use could not be recommended as a blanket application on high fertility pastures. The chemical that has shown the greatest promise to date is Dalapon. Even at rates of 1 lb. per acre, this material has given excellent barley grass control. Its action is quite slow so that the area could be oversown with desirable species that would gradually replace barley grass. It can also be applied in a minimum amount of water so that it could be applied by aerial means. At the rate used to kill barley grass, Dalapon has had no visible effect on either grasses or clovers. We have, of course, carried out other trial work where we have compared Dalapon for clover and grass tolerance. At rates up to 5 lb. Dalapon will seriously retard or kill all the main clover species and all the main grass species at rates up to 5 lb. per acre at the seedling stage of growth. Once established, rates of 10 lb. do not affect clover to any extent. Rates of 10 lb. would seriously retard most of the pasture grasses. Dalapon at 1 lb. has been applied at rates of 4-6 gallons of water per acre. It could possibly be applied in less water than this so that its use is quite practical from the air.

Gamma-butyric Acids

The work done with these materials supports the English findings that these materials are very selective towards clovers, peas and lucerne at rates approaching the 2 lb. level. The work also indicates that it is only the weeds that are fairly susceptible to MCP and 2,4-D that can be killed with Gamma-butyric acids. These materials will also have to be applied at rates higher than normal rate applications of MCP and 2,4-D. Our latest line of development is using the esters of the Gamma-butyric esters rather than the sodium and amine salt preparations. The main reason is that if clover damage is not a factor, then the esters are better preparations to apply than the water soluble materials. We have not done sufficient work to indicate whether the esters will be any more severe on clovers and other legumes than the salts. Personally, I do not think the degree of selectivity should be decreased because, if a plant has the property of breaking down the butyric acids into the acetic acids, then it should be effected either by salts and amines provided, of course, that penetration is not a factor.

Dalapon

This is an extremely promising chemical and in many cases will replace TCA. Unfortunately it is fairly toxic to clovers and to lucerne but to date it has given good control of species such as tall fescue, cocksfoot, etc., that have not been killed with TCA. Rates of 40 lb. to the acre of Dalapon have given excellent control of tall fescue but I have not the results of our latest trials.

2,4-DP and 2,4,5-TP

We have been trying to evaluate these chemicals in preliminary trials but to date they have shown no advantage over MCP, 2,4-D or 2,4,5-T. Furthermore, they are probably more toxic to clovers than the above materials.

ATA

The work to date shows that this chemical has not improved the efficiency of 2,4-D, MCP, or 2,4,5-T for the control of gorse, blackberry, sweet briar, etc. Because of its severe effect on clovers and grass it could not be used for pasture weed control. Further work is being done with this chemical in conjunction with Dalapon and TCA for the control of grass and as a temporary soil sterilant."

Our own findings will no doubt be also of interest and I will now endeavour to give you some idea of New Zealand's weed control problems and how we are going about trying to provide the answers.

Gorse, our big scale problem, has been under attack since 1947 when our company released the first 2,4,5-T formulation in New Zealand. Since then, tens of thousands of acres have been sprayed with generally first class results. Yet to date and after using over 300,000 gallons of 2,4,5-T formulation, only 5% of the known infestation of Gorse has been eradicated.

We have been working continually on this problem and last year laid down a 100 acre aerial trial using various formulations of 2,4,5-T and a new material, CS-301, which is a compound of trichlorinated alaphatic acids. The last mentioned is still experimental but has, in our trials, done even a little better than straight 2,4,5-T formulations over a wider range of seasonal conditions.

Although aerial spraying is quite commonplace in a number of areas on specific weeds, collectively there is much of interest in this most useful and relatively inexpensive aid to clearance of undesirable pasture weeds and, in some cases, brush weeds. The main aerial spraying programme over the last 2-3 seasons has been on the various species of thistle, variegated and winged thistles, comprising the majority of the sprayed areas.

The quantity of liquid required to the acre varies from about 1 gallon to the acre for insecticides to three times this quantity for the ideal results with hormones. If spraying is carried out under conditions of low convection, and this is highly important (i.e. from first light to 8 or 9 o'clock in the morning), a fine droplet size, which will fall readily in the cool air, will give good coverage and quantities as low as 1 gallon to the acre may be sufficient. In general, we recommend between 2 and 3 gallons to the acre of diesel oil in which is mixed 3/4 to 1 lb. of 2,4-D acid. Our Weedone Aero Concentrate, 2,4-D Non-Volatile, contains 7.2 lb. of acid per gallon and 1 pint of this material to the total mix required per acre will give very good control, a higher quantity of material being used as the thistle growth becomes more advanced. It is generally accepted that to spray weeds in flower is not good practice as, at this stage, they become very difficult to kill.

With oil based materials, such as Weedone Aera Concentrate, the effect of rain is usually to accelerate the kill. However, by this we do not suggest that spraying should be carried out in rain as it would quite possibly wash off the plant before it is absorbed, but rain an hour or two after spraying, or misty conditions before or after spraying, will certainly make the effects more severe.

Autumn, Winter and Spring treatments are carried out, all seasons being generally successful. Variable results are obtained, however, with late Spring season spraying and we would recommend most strongly that aerial spraying of thistles be undertaken between the period May/August and later than this period only in a reasonable season. Apart from the fact that results vary after this period, the plants are so advanced that they require a much higher rate of application to bring about their control and this, in turn, makes the job uneconomical.

A rough approximation of the areas of thistle sprayed in 1954-55 may be of interest:-

Poverty Bay	10,000 acres
Hawke's Bay	26,000 "
Wanganui/Rangitikei	16,000 - 18,000 acres
North Auckland	3,000 - 4,000 "

There is relatively little thistle spraying from the air in the South Island.

Costs per acre for application of 1 pint of Weedone Aera Concentrate in 3 gallons diesel oil per acre, inclusive of flying costs, are roughly 28/- ($3.90) per acre for a 1 pint application.

On the East Coast of the North Island, numerous other plants have been aerial sprayed, some specifically, and others in conjunction with the ordinary thistle programme. One of the most notable perhaps if Burr Clover (Medicago hispidus), a most undesirable plant which can be most successfully sprayed from the air with Weedone Aera Concentrate at a very economical rate.

Gorse

The value of being able to spray gorse from the air successfully will be apparent but we feel we are obliged to point out the difficulties involved in such a treatment even though we are endeavouring with extensive trial work to prove this treatment successful. It has been proved beyond doubt now that at least 2-3 lb. 2,4,5-T are required per acre to successfully control established gorse and also that to bring about this control, gorse plants must be sprayed to total coverage. To do this successfully from the ground, at least 100 gallons of spray solution are required per acre under optimum conditions. Our viewpoint is that with standard aircraft applying very low rates of water, in the vicinity of 8-10 gallons per acre, this is most impractical. However, with favourable conditions and good flying, good initial results have been obtained in North Canterbury and reports to date indicate that regrowth is far below that which was generally expected even by the most optimistic. As a result of this work, a number of farmers have agreed to have their properties sprayed from the air for gorse control at their own risk but we would emphasize at this stage that we cannot as yet recommend such treatment.

In order that we may have more specific or critical information on this problem, we have arranged for a trial block of roughly 100 acres to be sprayed in the Wanganui district using commercial, near-commercial and experimental formulations, in an endeavour to control gorse from the air.

By using a variety of materials and as high a liquid application per acre as is practical and by using a variety of conventional type aircraft, we hope that we will have some indication as to its practical solution. It has recently been established that 2,4,5-T translocation in gorse is almost negligible. Therefore this places more importance on the fact that for successful control of gorse, the plant must be sprayed to absolute coverage and it is difficult to see that this can be obtained from the air with a very limited quantity of total spray liquid per acre. It must also be borne in mind that a total browning of the top growth of the gorse is not indicative of a complete kill. In many instances, top growth kill can be obtained with a reasonable spraying and will remain as such for one or two seasons but because no root kill of any consequence has been obtained, regrowth can occur after this period.

Our engineers and field staff have been working on a new technique to apply moderately low volumes of water, that is about 30 gallons, compared with the normal 6-10 gallons that is used for most aerial spraying, and have this applied by a single pass of the aircraft. The effect, when using high capacity nozzles of our own design, is similar to a shower of rain and we have found that this "spray shower " gives excellent coverage. In our preliminary work we have found that one application, using this general method, is giving better results than three single passes each of 10 gallons. We are getting maximum retention of the spray liquid and as I have indicated, very encouraging results.

Lupin (Lupinus aboreus)

Large areas of lupin have been sprayed from the air in the sandhills south of Wanganui by one operator using 2-3 pints of Brushkiller '32' in 10 gallons of water. It would seem that a very high measure of control is possible. The past season't work over some 2,000 acres has shown that application is the greatest problem in control. Best control achieved has been obtained after flying between the bushes and not over them and we can expect the aerial operator will be forced into using heavier applications of water in order to reduce the flying risk and yet obtain coverage.

Broom (Cytisus spp.)

We are still not satisfied with our work for the control of broom from the air. With this particular weed, timing seems to be more essential than the material chosen and our best results come from sprayings during full flower or early pod formation using the mixed esters of 2,4-D and 2,4,5-T and as little as 15 gallons of water per acre.

Ragwort (Senecio jacobaea).

Much of our Ragwort-infested country is on land inaccessible to ground spraying equipment. Apart from this inaccessibility it is a constant source of spread to adjacent areas. If this plant could be successfully controlled from the air, it would make the task of eradication of this most undesirable weed much easier.

Two areas have been treated from the air, one in Hawke's Bay and one in the National Park area, using both oil and water as diluents and Aero Concentrate 2,4-D from 1-3 pints per acre. These areas have only been down a relatively short period and results are in no way complete but also in this case interim reports are most promising.

Without wishing to bother you with a mass of figures, I want to give you some idea of New Zealand's potential and how the country is being developed. Our country is, as you know, really dependent on its ability to produce and export sufficient primary products (meat, butter, cheese and wool) to maintain our standard of living. We have no real natural mineral resources and must export to pay for our imports of important materials, such as agricultural chemicals.

Whilst individual farmers in New Zealand have brought about a great increase in production in recent years, it is perhaps not generally realised to what extent the Government itself is engaged in farming operations, chiefly in the way of breaking in and grassing new land. This phase of Government activity is controlled by the Land & Survey Department and a report by the Minister of Lands, Mr. E. B. Corbett, published in July 1955 gives some very interesting information on the Department's operations. The following is a resume of the report which should be of interest:-

"The Department's land development programme since 1949 has, with the exception of one year, resulted in substantial increases in the area of land brought under cultivation each year. Since the year ended June 30th 1949, when 17,702 acres were broken in and grassed from unimproved country, the yearly break-in of completely unimproved country has nearly trebled. Some idea of the extent of the work could be gained from figures which showed that after the 17,702 acres broken in in 1948-49, there were 32,026 acres in 1949-50 with increases in later years as follows:-

1950-51	...	...	35,006
1951-52	...	...	45,835
1952-53	...	...	45,811
1953-54	...	...	46,855
1954-55	...	...	48,835

The target for 1955 was 50,000 acres. The Land Department was now working on 126 blocks of land throughout New Zealand totalling 690,000 acres. Approximately half was unimproved and the balance was in various stages of development. A yearly breaking-in of 50,000 acres means much in terms of increased production for New Zealand. This acreage will give from 180 to 200 farms on the basis of the present ratio of 20,000 acres for dairying and 30,000 acres for sheep. The addition of 50,000 acres each year to our productive capacity means a yearly increase of 1,250,000 lb. of butterfat, 50,000 lb. of wool, 50,000 lambs or their equivalent, and some 4,000 run cattle. All this would add 500,000 pounds each year to the gross revenue of the country. The Department's programme of development was on such a scale that each year 380,000 fence posts, 700 tons of wire, 500,000 feet of piping, 2,300,000 lb. of grass seed, 44,200 tons of lime and 36,000 tons of manure were required. This was used on land at all stages of development. The use of aerial techniques in developing land was becoming a big factor in the work of the Department. Their use for sowing pasture and topdressing was well known but, in addition, planes were used for rabbit poisoning, cattle spotting, dropping of materials and spraying for pest control. For the year ended June 30th last, 110,000 acres of land being developed by the Department were topdressed by air. A total of 8,800 acres were seeded. On the Molesworth-Marlborough block alone last year 300 tons of poisoned carrots were dropped."

The land development work in North Auckland is a good example of mechanical, ecological and chemical methods being combined to give an excellent end result. The fact that land is cleared from scrub and gorse and sown to pasture capable of carrying three ewes per acre or one cattle beast per acre from start to finish in three years speaks for itself. Briefly, the system at present in use after much trial and error experimentation is as follows:-

The land is broken in mechanically and sown into pasture in the first year. Because the area has been in gorse for many years the seed load in the soil is proportionately high and further germination is to be expected in the new pasture. The gorse seedlings are allowed to grow unhampered for two years during which time the gorse establishes to a height of two or three feet but the pasture also establishes with light stocking. At the end of this two year period the gorse is sprayed in the pasture with one spraying and complete control is gained with no damage in the end to the pasture. The clovers in the area are mainly annual clovers and by spraying gorse after the main seed setting period in the second year, even if the clovers are decimated, there is two years seed in the soil to bring about complete recovery or re-generation of the clover.

The methods of application of 2,4,5-T have been the subject of extensive experimentation in these areas. Gun spraying or hand spraying were too laborious and not particularly efficient. Powder forms of 2,4,5-T mixed with superphosphate were tried in the early stages as a pasture dressing where good control of the gorse seedlings was obtained with a very good residual effect up to 6-8 weeks. However, clover damage was very high with this application and work was discontinued on this account. The present system which is a very sound spraying technique, linked with very sound management, calls for a boom application of 2,4,5-T at the rates of 1-6 lbs. per acre, depending on the size and density of gorse, applied in 200 gallons of total spray liquid per acre. This calls for special pumps, booms, and other equipment which has also been designed specifically for these development areas. Where this boom spraying technique can be used on the undulating wheel tractor country it is both outstandingly successful and economical. Large areas are covered more accurately in approximately half the time it would take to gun spray and the saving in concentrate material lowers the cost by about one-third.

Reviewing the future development of New Zealand, the Australia and New Zealand Bank makes the predictions shown in Table I based on a sustained effort and a population increase of 2½% per annum:-

TABLE I

Year	Population Nos.	Sheep Nos.$\times 10^6$	Wool lbs.$\times 10^6$	Cattle Nos.$\times 10^3$	Dairy Cattle Nos.$\times 10^3$
1955	2,150,000	38	426	5,742	1,999
1965	-	45	540	6,082	2,180
1975	3,000,000	50.6	633	6,670	2,388
1985	3,500,000	56.4	705	7,215	2,566

The Bank also points out that there are 2.4 million acres of land, capable of easy development, situated mainly in the Auckland province (60%) and in the southern portion of the South Island. Naturally the use of weedkillers should bear some relationship to the overall annual production of the country.

I trust these figures will convey as much to you as they do to us. We are a small country with a big future and I am sure that agricultural chemicals, many of which will probably stem from original research in your country, will play a big part in ensuring that our planned development is achieved economically.

It has been a pleasure and a privilege to have been given an opportunity to try and give you some idea of the present position and future potential of my country and if in so doing I have failed to contribute to increasing your already wide knowledge of weed control, please accept my apologies.

SUBSTITUTED UREA HERBICIDES

Dr. A. E. Carlson
E. I. du Pont de Nemours and Company (Inc.)
Wilmington, Delaware

The practice of controlling weeds with chemicals is now looked upon as good farming but, more than that, the economies of chemical weed control are considered good housekeeping in industry, too.

There was a time, not too many years ago, when weed control certainly was not regarded as a science. I can remember the real birth of the science of weed control in the late 'thirties, when only a very few people were identified with weed control research. We owe a lot to those few courageous men who blazed the trail for weed control research as it is conducted today.

The volumes of data pertaining to weed control in the past 10 years certainly prove that much work is being done and that results are being accomplished. Organization of regional weed conferences, of which there are now four, began with your own Western Conference. Now we have gone national, so to speak, and have the Weed Control Society of America. This puts weed control on a par with other biological sciences.

The contribution herbicides have already made to better farming is well known to all of you. As new chemicals are introduced, they extend the farmer's basic weed control job, giving him practical and economically sound means to control unwanted vegetation so his crops and grazing land will be more productive. Weed control has now become an accepted practice with the farmer to such an extent that many states have seen fit to expand the extension staff to include weed control specialists.

Concurrently with this expansion of weed control know-how by governmental agencies, we have had a comparable increase in industrial weed control research. As a result of these many efforts, we are making progress toward understanding the behavior of chemicals in regulating the growth of plants.

Like a number of other chemical manufacturers, the Du Pont Company has had a share in bringing new herbicides into practical usage. Our principal contributions have been ammonium sulfamate and the substituted urea herbicides. I have been asked to talk specifically about the latter at this meeting.

The substituted urea compounds are an extremely interesting group of herbicides. Du Pont has prepared and studied over a thousand of them. At the present time, two of these compounds, monuron (3-(p-chlorophenyl-1,1-dimethylurea) and diuron (3-3,4-dichlorophenyl)-1,1-dimethylurea), are being offered by Du Pont for commercial use. A third, neburon (1-n-butyl-3-(3,4-dichlorophenyl)-1-methylurea), is being introduced in three eastern cities this year as a control for crabgrass and chickweed in lawns and turf. These three compounds plus fenuron (phenyldimethylurea) are all available from Du Pont to research workers who wish to do further study. All four are formulated as wettable powders. We also use other formulations such as pellets and liquid suspensions of monuron and diuron. It is the liquid suspension of diuron which is being used commercially for weed control in cotton in the South.

When comparing the relative efficiency of various weed killers, it is customary to consider a number of basic factors. One characteristic that gives the substituted ureas their versatility is a wide range of water solubility. Some of these compounds are soluble only at the exceedingly low rate of one part per million while others are much more soluble. Some of you from the high rainfall areas of Washington and Oregon have found that diuron is more satisfactory than monuron because it is only about one-sixth as soluble. But here in the Sacramento Valley, monuron, with a solubility of 230 parts per million, provides good results under your rainfall conditions. If you're looking for an even lower solubility than we find with diuron, you might want to try neburon, which dissolves in water at the rate of four parts per million. It has been effective for control of crabgrass in established turf, at four pounds (active) per acre. Evaluation of this compound in agricultural applications might point the way to chemical weed control in crops where no other chemical herbicide has made the grade.

So far as inherent effect on plants is concerned, we know that monuron and diuron are about equal, while neburon and fenuron are considerably less toxic to vegetation.

As we gain more and more experience with the use of the substituted urea herbicides, it becomes apparent that the interacting factors of water solubility, soil adsorption, and inherent toxicity to plants play an important part in determining the uses for which each of these products is most efficient. Monuron and diuron have shown greater versatility for both industrial and agricultural weed control than fenuron. They both have greater inherent plant toxicity and are less soluble in water than fenuron, which dissolves at the rate of 2300 parts per million.

Each of these two preferred compounds show advantages over the other -- depending on the conditions. For non-selective weed control, diuron, which is adsorbed by the soil somewhat more strongly than the monuron compound, and which has a lower water solubility, is generally preferred for use on light soils where rainfall is 20 inches per year or more, and on medium soils if rainfall is 30 inches per year or more.

Similarly, because of its greater water solubility and lower coefficient of adsorption, monuron is recommended in preference to diuron for use on heavy soils and on medium heavy soils where rainfall is less than 20 inches per year.

Where an area has been completely freed of vegetation, it can be maintained in this condition at relatively low cost by the use of 10 pounds per acre per year of one of the substituted urea herbicides, provided the soil is not disturbed. This applies principally to industrial areas. For such annual maintenance, diuron is the preferred product.

The substituted ureas, like all other agricultural chemicals, are subject to registration with the U. S. Department of Agriculture; and for some food crops residue tolerances have been established by the Food and Drug Administration. For some others, it has been found by repeated analysis that none of the chemical appears in the final product. A tolerance of one part per million has been established for monuron and diuron in sugar cane, pineapple, and cotton seed. The same tolerance has been established for monuron in asparagus, spinach, and dry bulb onions.

Du Pont toxicological studies with these compounds indicate that a tolerance of one part per million represents a very large safety factor.

Monuron has been registered with the U. S. Department of Agriculture for weed control on land where the following crops are being grown:

sugar cane	spinach (in heavy soils)
pineapple	dry bulb onions (in Minnesota and Wisconsin)
asparagus	cotton (in Arizona)
ornamental bulbs	citrus (in California)

Diuron, which is a much newer compound, is registered for weed control applications on land where the following crops are being grown:

sugar cane	cane berries (in western Washington and western Oregon)
pineapple	
cotton	grass seed crops (in Oregon)

In addition, both compounds are registered for use 1) in irrigation and drainage ditches 2) for spot treatment of perennial weeds in cropland and 3) for industrial weed control.

The only registered uses for neburon are for control of crabgrass and chickweed in established turf.

In addition to the registered uses, experiments to date indicate that the substituted urea herbicides show particular promise for control of weeds in alfalfa, peppermint, grapes, and potatoes.

The soil application of monuron for brush control on utility right-of-ways, railroads, and drainage ditches in a six-state area of the Midwest shows considerable promise. For effective control, the spray is applied to the ground encircling the base of the plant at a reasonable distance to include the major root system of the plant. It is not necessary to wet the stem of the plant. The sprayed ring should be about four inches wide. Treatment is effective at any time of the year when rainfall is likely to occur. Two to four ounces of the product have been used in each gallon of spray and one gallon should treat 18 to 20 plants.

Present recommendations for this method of using "Telvar" W weed killer apply only to Oklahoma, Texas, Kansas, Missouri, Arkansas, and Louisiana. Test work is continuing to see if the same recommendation can be adapted to climatic conditions, plant species, and soil types in other areas. Woody plant species which have been controlled by this method include: elm, red cedar, persimmon, hackberry, willow, sumac, buckbrush, and various species of oak.

Applications made during the growing season usually affect the plant within about a month, provided rainfall has occurred to leach material into soil. The above-ground part of severely affected plants in test plots died and became brittle within four to five months after the first appearance of symptoms. Applications made during the dormant season may not show any effects until after plants leaf out.

The substituted ureas look promising for control of certain species of brush on rangeland. Investigators in Texas have obtained good control of mesquite with applications of pelleted formulations in strips across the area or around the base of individual trees. It is also possible that this method of application can be adapted to industrial right-of-ways.

There is an interesting difference between the use of substituted urea herbicides in the old Cotton Belt and in your western irrigated areas. In the old Cotton Belt, the main weed problem occurs early in the season -- from the time seed is planted until the cotton plant is big enough to shade out weed seedlings and withstand mechanical cultivation. This situation used to require a large field force to keep weeds down with hand hoes. Now, one pre-emergence application will control weeds in Southern cotton fields for eight weeks or longer.

Here in the West, where your cotton fields are irrigated, you don't seem to have much of a weed problem until the cotton has grown too large for mechanical cultivation, and then annual wild morning glory often becomes serious. Here, the chemical is not applied until mid-season. Weeds are controlled by cultivation as long as possible and then the chemical is applied just before the last cultivation. Shallow cultivation is used so the chemical is mixed with the top inch (or less) of soil, where it will reach roots of young morning glory and many other annual weeds, without injury to the cotton.

Where the substituted ureas have been used for pre-emergence weed control in cotton, we have found that they do not remain in the soil to interfere with subsequent crops.

On irrigated cotton, however, where the chemical is applied in mid-season, we do not recommend planting any crop until spring of the year following herbicidal treatment.

When a grower tries any of the substituted ureas for the first time in one of his crops, we recommend that he make the first trial only on small areas. This is especially important where the operator is not completely familiar with the products themselves, or the methods of calibrating application equipment.

Some day, we may be able to write a prescription for chemical weed killers, must as we now balance a feed ration according to nutrient requirements, or plan a soil-building program on the basis of a soil test. Tailor-made weed killers, designed to fit specific conditions, now seem possible as research workers extend their knowledge of the family of substituted urea compounds.

The Du Pont Company has invested over $3 million in research to develop the substituted urea weed killers. This does not include any plant investment. But the prospective returns to American agriculture make this research seem worthwhile.

U. S. Department of Agriculture studies indicate that in various western row crops, hand-weeding, hoeing, and cultivating (essentially weed control practices) take up to 80 per cent of the pre-harvest man-hours that go into crop production. Some of the crops where costs are high include cotton, onions, potatoes, sugar beets, and dry beans. There is considerable challenge to cut this kind of labor investment -- and chemical weed killers look like one good way to do it.

WHAT WEEDS COST US IN CANADA#

E. G. Anderson, Secretary, National Weed Committee,
and Associate Botanist, Botany and Plant Pathology Laboratory,
Science Service, Canada Department of Agriculture,
Ottawa, Ontario.

From early biblical times, when thorns and thistles were sent to plague Adam and Eve (Genesis 3: 18), and when man accused his enemy of sowing tares in his crops (Mathew 13: 25), to the present day, weeds have played a significant role in man's struggle to develop agricultural production. In Canada, as the vast forests were slashed, the land cleared or prairie sod broken, native plants such as wild barley, pale smartweed, milkweed, ragweeds, field horsetail and gumweed, became active and were called weeds. The movement of seed from crops in new areas, and the need to carry fodder for livestock hastened the further spread and establishment of these weeds.

Weeds such as leafy spurge, toadflax, wild and tartary buckwheat, wild oats, field bindweed, Canada and perennial sow thistle and Russian thistle were introduced as impurities in seed supplies imported into Canada. By this means and through natural selection and hybridization and weed population developed and expanded until we can "boast" that we have more than 1000 weedy plants, and that most of the 205 species described in our new "Weeds of Canada" publication (1) are of economic importance. It is only in comparatively recent years that information has been secured on the incidence of the more important weeds. Surveys sponsored and financed by the Dominion Department of Agriculture, and Provincial Department of Agriculture and Universities, are indicating the very great hold some of these weeds have taken, particularly in Western Canada.

It has been estimated that wild oats, which is undoubtedly the number one weed problem in Western Canada, infests to some extent 75 per cent (30 million acres) of the seeded acreage. They are believed to cause, year in and year out in western Canada, far more losses than the losses caused by stem and leaf rust combined. A list of the other more important Canadian weeds would include couch grass, wild mustard, Canada and perennial sow thistle, lamb's quarters, wild buckwheat, common ragweed, red root pigweed, stinkweed, tartary buckwheat, pale smartweed, hemp nettle, foxtail and Russian thistle.

#Information in this paper does not include administrative and research costs, nor cost of labour for roadsides, railway and public utility weed and brush control.

Area infested with Perennial weeds in Western Canada

Weed	Manitoba Acres	Saskatchewan Acres	Alberta Acres	British Columbia Acres	Totals
Field bindweed (Convolvulus arvensis)	4,500	1,300	59 patches	1,000	6,800
Hoary cress (Cardaria species)	patches	1,300	5,574	600	7,474
Leafy spurge (Euphorbia esula)	8,000	7,948	962	100	9,010
Toadflax (Linaria vulgaris)	patches	40,000	1,275	patches	41,275

How effectively do weeds compete with our crops?

Cereals

One of the earliest experiments in Canada to indicate how weeds were effectively competing with crops, was conducted by Dr. T. K. Pavlychenko at the University of Saskatchewan in 1940 (2). He reported that a heavy infestation of wild mustard reduced the yield of Hannchen Barley by 22.8%, that of Marquis wheat by 44.9% and that of Banner oats by 45.3%, in comparison with clean check plots.

Work at the Regina Experimental Farm (3) also indicated the effect of wild mustard competition. Their observations based on an average of nine years showed that wheat was reduced 15% when wild mustard constituted up to 20% of the vegetation. When the mustard constituted up to 40% of the vegetation the yield reduction was 35%, and amounted to 53% when the mustard constituted up to 60% of the vegetation present.

Effect of wild mustard competition

Crop	Percentage of reduction in yield when wild mustard constitutes		
	1-20%	21-40%	41-60%
Wheat Average for 9 years	15	35	53
Oats " for 9 years	14	46	63
Barley " for 9 years	11	49	69

Mention should be made here that because the soil moisture is considerably less in most of western Canada than in Eastern Canada, the weeds there cause a greater loss in crop yield than they do in Eastern Canada. An experiment similar to the one reported for Regina (in Western Canada) was conducted at the Central Experimental Farm, Ottawa (4) (Eastern Canada). Mustard at Regina caused an average nine-year loss of 53% in wheat, but the five year average loss at Ottawa (from wild mustard plants at 227 per square yard) was but 12.7 per cent. Because similar low increases usually result when mustard is removed by spraying in Eastern Canada, and because a large proportion of the grain is seeded down with clovers, weed control practices have not been accepted as readily as in Western Canada. The number of crops susceptible to sprays of the hormone type has also added to the difficulties of "selling" chemical weed control in some areas.

In 1944 the University of Manitoba co-operating with the Manitoba Weeds Commission further indicated (5) the toll which weeds exact by a series of tests with Sinox. They reported that a mixed infestation composed chiefly of mustard, stinkweed and wild buckwheat when present at the rate of 912 per sq. yd., but effectively controlled by Sinox, in flax gave a yield increase of 90%.

Yields before and after spraying with Sinox

Crop	No. weeds per sq. yd.	Bushels per acre		
		Unsprayed	Sprayed	Increase
Durum wheat	185	17½	19½	11%
Bread wheat	137	21	24	14%
Barley	356	23½	41	75%
Flax	912	10	19	90%

That these weed populations are not unusual is indicated by a survey recently conducted by the Plant Science Department of the University of Manitoba (6). The random inspection of a number of fields when the grain was at the proper stage for spraying, was enlightening. The average number of broad-leaved weeds per square yard in wheat fields was 285 and that in barley was 382. If the estimated number of wheat or barley plants that would normally occupy a square yard of space in the field is 150, this would mean that there would be approximately twice as many weeds as wheat, and 2½ times as many weeds as barley plants in the fields examined.

Workers at the University of Manitoba (7) also reported the influence of wild mustard at different concentrations on the yield of wheat and flax. As anticipated, the yield decreased with the increasing density of wild mustard in the unsprayed wheat and flax plots. When the wild mustard was removed with 2,4-D there were significant increases in yields in both crops. Their work also emphasized the value of early spraying as the competition from the weeds had, in some of the tests, caused a reduction in the number of tillers or basal branching thus influencing the yields, up to the time the 2,4-D was applied.

Perennial weeds may cause even greater reductions

So far we have been discussing the effects of annual weeds on crop yields. Let us see what effect perennial weeds exert.

Reduction in Yield of Oats Due to Perennial Weeds (4)

3-year average, 1936-1938

Name of Weed	Bushels per acre	Losses per acre due to weeds	
		Bushels	Per cent
Weed-free plots	63.3	--	--
Couch grass	20.7	42.6	67.3

Perennial sow thistle	26.8	36.5	57.7
Canada thistle	36.6	26.7	40.2
Chicory	39.0	24.3	38.4
Field bindweed	44.5	18.8	29.7
Toadflax	45.9	17.4	27.5
Milkweed	47.0	16.3	25.7
Ox-eye Daisy	53.4	9.9	15.6
Bladder campion	56.7	6.7	10.6
King devil	57.7	5.6	8.8

This data also indicates the serious loss which perennial weeds can cause.

Husking Corn (corn for grain)

Agricultural authorities in Leeds County, Ontario, announced last fall (8) that average yield increases of 37.9 bushels per acre had been secured by the spray application of 4 to 6 ounces of 2,4-D acid per acre to husking corn. As very little corn of this or any type, has been sprayed for the control of weeds in Canada, the province of Ontario with its 320,000 acres would appear to be a very fertile field for 2,4-D salesmen.

Silage Corn

Weeds such as pigweed and lamb's quarters, predominantly, have been shown to reduce the green weight of silage corn by 5.4 tons per acre. (9) "It was found that 13.3 tons, green weight, was produced on plots which received no weed control or cultivation following planting. In plots where a straw mulch effectively controlled the weeds, the yield was 17.2 tons per acre. In plots where one cultivation 17 days after planting effectively controlled the weeds, the yield was 18.7 tons per acre." Any method of controlling the weeds was thus shown to pay high dividends.

Soybeans

Although soybeans are known to be poor weed fighters, it is interesting to note that yields were increased significantly by cultivation, as reported by Dr. G. P. McRostie (10), Ontario Agricultural College, Guelph, Ontario. Yields were increased from 1.96 bu. to 9.70 bu. by means of two additional inter-row cultivations with a cultivator, while four such cultivations increased the yield to 16.22 bu. The highest yield, 26.27 bu., was obtained when a finger weeder was used to give four additional inter-row cultivations. Our agricultural engineers have estimated (11) that it costs $1.00 per acre to pay for one cultivation with tractor and cultivator. If we assume that each of the 254,000 acres which produced soybeans in Canada (12) in 1954 was only cultivated twice and charge 60% of this cost to weed control we secure an amount of $304,800.

Estimated cost to control weeds in all row crops

If the same basis, namely 60% of $2.00 per acre of row crop, is applied to the estimated 1,529,553 acres of row crops in Canada in 1954, we get a total of $1,835,463 which is also chargeable to weeds. For our purposes let us use the round figure of $1,800,000.

Pastures

Only a small percentage of Canada's natural or uncultivated pasture land (7,146,903 acres in Eastern and 45,231,333 acres in Western Canada) is given any weed control attention. There is considerable evidence to show that the majority of the weeds and woody growth can be controlled, that fertilizer applications alone or in combination with breaking and reseeding, or even mowing, will control or reduce the weedy plants and thus increase the carrying capacity. Our main problem in this connection is to "sell" our "know-how" more effectively.

What do weeds cost us?

One of the earlier estimates regarding the loss in Canada from weeds due to their injurious effects on crop growth was made by Dr. E. S. Hopkins (13) who stated that it amounted to $69,380,000 in 1935. This was based on an estimated loss of ten per cent to the crop growth due to weeds in Eastern Canada and British Columbia, and in the Prairie Provinces a loss of fifteen per cent of the value of the crop. He pointed out that this did not include the cost of other items such as tillage, extra cost in harvesting and threshing, cleaning and hauling, etc.

A few years later (1949) Dr. G. P. McRostie (14) estimated that the cost of weeds through competition in Canadian cereal and row crops, hay and pastures, would be $131,500,000. This was 10 per cent of the total crop value. He also added a figure for the other items mentioned above, to make a grand total of $186,250,000 as the annual loss due to weeds in Canada.

In 1954, H. E. Wood (15) Chairman of the Manitoba Weeds Commission stated that weeds robbed western Canadian farmers of $255,000,000 using the following break-down.

The Cost of Prairie Weeds

Dockage losses	40,000,000
Competition to crops	166,000,000
Tillage control costs	35,000,000
Delayed seeding costs	4,000,000
Chemical control costs	10,000,000
Total weed toll	$255,000,000

Average cost on 248,000 farms = $1,028

Estimated loss due to weed competition in cereals, etc.

Estimates on the loss of crops due to competition from weeds have varied from 10 to 20 per cent of the total crop value. The author took 15 per cent of the 1953 value of Canada's cereals, mixed grains, buckwheat, peas (dry), flax-seed, sunflower seed, rapeseed, mustard seed, and tame hay, which totalled $1,661,925,000 (15). This weed loss would therefore be $249,288, 750 or $249 million in round figures.

Cost of Summer Fallow

With increasing emphasis being placed on the importance of adding supplementary water to increase the yield of almost all types of crops, in many parts of Canada, it is only natural that the water loss due to weeds should be seriously considered. Although the acreage being summer-fallowed has varied somewhat in recent years, there are still a large number of farm operators, particularly in Western Canada, who cultivate part of their land each season to prevent weeds from removing any or all of the soil moisture.

Data from the Soils Research Laboratory, Swift Current, Saskatchewan shows that of the 18.7 inches of rain (average precipitation for 23 years) an average of 4 inches (23 years) was conserved by summer-fallow. The moisture thus saved has often guaranteed a crop.

What does this summer-fallow cost? A minimum number of cultivations would be three during the summer season and in some areas as many as nine might be needed. Five cultivations might be an average figure. In our Departmental publication entitled "Cost of operating farm machinery" (11) we estimate that it costs one dollar to cultivate each acre each time. Thus, when the cost of five cultivations at one dollar each is multiplied by the 25,253,000 acres (15) in summer fallow in Western Canada in 1954 a value of $126,265,000 is secured. Let us round this figure to 126 million as the cost of controlling weeds in Western Canada's summer fallow. No estimate is made for the loss of revenue from these acres.

An amount for summer fallow work in Eastern Canada and in British Columbia should also be added. Unfortunately this is more difficult to assess. An indicating that it would also be a sizable amount is obtained when one considers the cost of controlling couch grass in Northern Ontario. There, as in most of Eastern Canada, it is the number one weed problem. To reduce a field infestation to about 5 per cent requires two years of black summer fallow. This usually requires 15 tillage operations at about one dollar per acre (11) for each operation, to which should be charged the loss due to no crop being planted. Average yields and values per acre for the crops usually grown would be $26 for hay (2 tons), $28 for oats (40 bu.), $30 for barley (30 bu.) and $237 for potatoes (150 bu.). For even the two lower valued crops, the hay and oats, this would be $54 per acre plus the $15 for summer fallow, giving a total of $69 wholly chargeable to the cost of controlling couch grass on one acre. At this rate a farmer in Northern Ontario is paying over one thousand dollars a year when he undertakes to control this weed on 30 acres of his land.

However, very few farmers actually keep their fields out of production for more than one year. The cost of control would be about $7. for seven cultivations plus the loss of revenue from any one of the crops mentioned. Thus the cost of cultivating one acre to control couch grass could fluctuate from $33 to $37.

After-harvest cultivation

After-harvest cultivation to control weeds is likely to be practiced on 50 per cent of the farms in Eastern Canada and in British Columbia. Assuming that each cultivates 30 acres twice at one dollar per acre, a conservative estimate of $11,231,100 is secured, all of which can be charged to weed control.

Cost of chemical weed killers

In spite of cultural methods and the use of increasing amounts of soil sterilant types of herbicides, weeds such as toadlfax are spreading at an alarming rate. Each of the provincial Departments of Agriculture subsidize the cost of chemicals and their application. The amounts spent annually in this manner are about $25,000 for Manitoba, $64,000 for Saskatchewan and $157,000 for Alberta.

We are indebted to H. E. Wood of the Manitoba Weed Commission (16) for information as to the amount of chlorate-borate herbicides used in Western Canada, principally for the control of perennial weeds.

Soil Sterilant Herbicides used in Agriculture

Province		Chlorate - Borate Compounds		
		1955 - Lb.	1954 - Lb.	1953 - Lb.
Manitoba		538,000	466,000	529,000
Saskatchewan		400,900	491,425	585,000
Alberta		400,000	440,000	438,000
	Totals	1,438,900	1,397,425	1,552,000

His data shows that an estimated total of 1,438,900 Lb. of chlorate-borate compounds were used last year in the 3 prairie provinces. Mr. Wood also reported that slightly more than 14 million acres of field crops (35 per cent of the seeded acreage) were sprayed in Western Canada last year - which is a new record. By contrast, only about 5 per cent of the seeded acreage in Eastern Canada was sprayed. The cost of the chemicals for these and other weed killing purposes is given in the Dominion Bureau of Statistics (17) report where it states that the total value of herbicides sold in Canada in 1953 was $5,197,566.

Cost of applying the herbicides

If a charge of 14 cents per acre is made for the labour needed to apply the selective hormone types of weed killers to the 14½ million acres which were sprayed in Canada last year, an amount of $2,030,000 results. This also can be applied to our growing weed bill.

The value of weed control equipment purchased in 1953

Another release from the Dominion Bureau of Statistics relates to the Agricultural Implements industry (18) and gives information as to the factory value of weed control equipment produced in Canada in 1953.

Weed dusters	89,020
Weed sprayers	
tractor mounted	569,092
tractor drawn	150,376
Tillage, cultivating	
and weed equipment (1954)	7,643,885
Total	$8,452,373

The Dominion Bureau of Statistics estimates that the retail value of these items would be 20 per cent higher. Therefore the value of this equipment would be $10,142,847.

Depreciation on weed control equipment

A depreciation rate of 6 per cent plus interest at 3 per cent should also be charged to weed control. This amounts to $5,400,000 using $60 million as the estimated value of the weed control equipment purchased in the last ten years. Where this equipment is stored in buildings a charge of ½ per cent of the price of each machine should be added.

Amount lost due to dockage

The average amount deducted (dockage) from the western crop of cereals and flax is three per cent. Applying this figure to the 1,147,000,000 bushels harvested in 1953, would give a figure of 34,410,000 bushels. At $1.25 per bushel this would be $43,012,500. An additional $6 million could be added for the handling and freight charges, on this dockage.

Cost of delayed seeding to control wild oats

Assuming that one half of the 8,599,400 acres of barley sown in Western Canada in 1953 was seeded later than if there had been no wild oats, in order to kill another crop of wild oats by cultivation, another charge of one dollar per acre should be made. This adds $4,200,000 to the weed bill.

Miscellaneous items

This general heading includes several intangible items which are extremely difficult to assess. One which should be given more recognition is the important role played by weedy plants in harbouring diseases and insects. The accompanying table lists 24 of these important pests. Among the diseases are stem rust of cereals, crown rust of oats and gymnosporangium rusts of apple and pear. Sixteen insects are also listed. If the weedy plants which harbour these pests were even reduced in numbers, the savings in pesticides and value of increased production could easily be $10 million.

Weedy Plants that are Hosts of Insects and/or Diseases Injurious to Cultivated Plants*

Weed Host	Insect or Disease	Cultivated Plants attacked
Barberry, common	stem rust	cereals
Black medick, vetches	pea-aphid	peas, alfalfa
Buckthorn, common	crown rust	oats
Cinquefoils	strawberry-weevil	strawberries
Couch grass	ergot	grasses and cereals
Docks, burdock Giant ragweed	stalk borer	dahlias, hollyhocks, asters, rhubarb, pepper, tomatoes, potatoes, tobacco, corn
Docks	rhubarb-curculio	rhubarb
Docks, peppergrass, Shepherd's purse, Pigweeds	melon-aphid	melons, cucumber
Hawthorn	apple maggot fire blight Gymnosporangium rusts	apple apple, pear apple, pear
Horsetail, field	rhizoctonia	potato, tomato

*Modified from "Common Weeds of Ontario." Bulletin 505, Department of Botany, Ontario Agricultural College, Guelph, Ont., Canada. 1955.

Cont'd.

Weed Host	Insect or Disease	Cultivated Plants attacked
Juniper	Gymnosporangium rusts	apple, pear
Lamb's quarters, Pigweeds, chickweeds	spinach flea-beetle	spinach
Lamb's quarters, Shepherd's purse, Common ragweed	Potato-aphid	potatoes
Lamb's quarters, Pigweeds, chickweeds	spinach leaf-miner	spinach, chard, beets, mangolds
Milkweed, ox-eye daisy, Wild carrot, dandelions, chicory, wild asters, etc.	aster yellows	china aster, lettuce, carrot, buckwheat, celery, potatoes
Mustards	cabbage-worm	cabbage, cauliflower, turnips, rape, broccoli, brussels sprouts, kale
Mustards	cabbage-aphids	cabbage, cauliflower, turnips, rape, broccoli, brussels sprouts, kale
Mustards	striped-flea-beetles	turnips, radishes, cabbage, cauliflower
Mustards	turnip-aphid	turnips
Pigweeds, wild carrot Mullein, goldenrods, Asters	tarnished plant-bug	dahlias, celery, chrysanthemums, beets, strawberries, asters
Ribgrass	rosy apple-aphid	certain apple varieties
Wild parsnip	carrot rust-fly	carrots, parsnips, celery, parsley

Another charge against weeds is the marked reduction they cause in the value of farm land. This can be as much as 50 per cent. A very conservative charge in this connection would be one million dollars for all of Canada.

Mention should also be made of the livestock lost or the unthrifty condition caused by eating poisonous or injurious plants.

The cost of cleaning seed grain and of reducing the dockage in market grain is also a considerable item. Seed drill surveys reveal that from 24 per cent (in Ontario) to 34 per cent (in Alberta) of the seed being sown by farmers, would be rejected under the Canada Seeds Act. Therefore we know that a considerable quantity of grain is cleaned each year and obviously more should also be cleaned. If we estimate that 50 per cent of the 67 million bushels of seed grain needed to sow the 45 million acres in wheat, oats, barley and mixed grain (in 1953 (12)) were cleaned at 5 cents per bushel the cost would be $1,675,000. An equal amount should be added as the money lost due to the reduction in value weeds cause in poorly cleaned or uncleaned seed.

The last item I wish to mention, is the relationship of ragweed to hay fever. It is estimated that 80 per cent of hay fever cases are caused by ragweed pollen. The number of those who suffer from this ailment has been estimated to be 2½ per cent of the population (19). As the greatest ragweed concentration in Canada is in the provinces of Ontario and Quebec let us see what 2½ per cent of the population of that area (8,653,223) would give us (212,500). Using the round figure of 200,000 hay fever sufferers as an estimate for all of Canada, and estimating that each spends a minimum of three dollars for medication, etc. a figure of $600,000 is secured.

Each year Canadian cities and Departments are devoting more money and time to this problem weed. The cities of Toronto and Montreal spend over $40,000 for ragweed control each year. Organized ragweed eradication campaigns are operating throughout all of Eastern Canada. As a gauge on the effectiveness of this work and to indicate where more is needed etc., a publication (20) entitled "Canadian Havens from Hay Fever" has been printed and widely circulated. In addition to information on the principal hay fever producing plants, this publication lists the 135 pollen stations which are operated throughout Canada, and also the ragweed pollen air index of each.

Conclusion

A summary of the items comprising this annual weed bill reads as follows:-

Canada's Annual Weed Bill
(Amounts rounded excluding Newfoundland)

Tillage costs in row crops	1,800,000	
Loss due to weed competition	249,000,000	
Cost of summerfallow in Western Canada	126,000,000	
After harvest cultivation in Eastern Canada	11,200,000	
Value of herbicides sold in Canada, 1953	5,100,000	
Labour to apply some of these herbicides	2,000,000	
Depreciation on weed control equipment purchased in previous 10 years	5,400,000	
Dockage losses	43,000,000	
Handling and freight charges on dockage	6,000,000	
Cost of delayed weeding of barley in Western Canada	4,200,000	453,700,000

Miscellaneous items		
Loss due to diseases and insects harboured on weedy plants	10,000,000	
Depreciated land values	1,000,000	
Cost of cleaning 67 million bushels	1,675,000	
Loss due to lowered grades in uncleaned or poorly cleaned seed	1,675,000	
Medication for the relief of hay fever	600,000	14,900,000
		468,600,000

Thus it is shown that weeds, our second crop, are costly tenants on our most valuable agricultural land for they cost an estimated $468,600,000 each year, or about $1,070 for each Canadian farm.

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ECONOMIC STUDIES OF WEED PROBLEMS

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There has been no difficulty in stimulating interest in activities that fall within the scope of this committee. On the other hand, it has been difficult to get research resources diverted to this field. However, progress reports of three studies in this research area were received for the research progress report.

Agricultural economists are cooperating with farm crops specialists in economic studies of tarweed control in Eastern Oregon. One phase has been devoted to study of the injurious effects on wheat of 2,4-D applied at times and rates used in tests to control tarweed. This part is basic to appraising the results of treatment in infested wheat. Treatments are to be applied to wheat with various levels of tarweed infestation. In the past two seasons difficulty has been encountered in securing various levels of infestation where other factors--soil, stand of wheat, topography, etc.,--are constant. In the fall of 1955 planting of plots of tarweed at various rates in a weed-free field of wheat were apparently successful and the control practices can be applied during this season.

Information on weed control practices in cotton was secured by a mail survey directed to cotton growers in the seven major cotton growing areas of California. Despite the amounts the respondents showed they spent for control, a "typical" or "mean value" of $14.28 per acre above normal cultivations, or about $21.00 including cultivation, four to six percent of the crop was still lost to weeds. This loss would be worth about 10 million dollars based on 1955 production and prices. The most serious weeds were water grass among the annual grasses, pigweed of the annual broadleaved weeds, and Johnson grass among the perennial weeds.

In a study of economic consequences of 2,4-D application in controlling Canada Thistle in the Gallatin Valley of Montana, a significant set of curves have been developed showing the relation between degree of infestation and yield of wheat. (Figure 1) As light an infestation as one or two shoots in 16 square feet will lower the yield sharply. Above 5-8 shoots, the relationship becomes almost linear. From an arbitrarily selected curve, representing wheat yielding at a given level if free of infestation, another chart was developed showing the break-even points from treatment each year over a three year period, with cost of treatment and price of wheat at various levels, and with thistle control (reduction of thistle shoot count) accomplished to the degree experienced in one series of treatments. (Figure 2) The treatment the first year was worth many times its cost, as was the second to a lesser degree. The third year treatment was still profitable, but nearer the margin. If the infestation was not eradicated, value of treatment the fourth year would depend upon the (unknown) rate of recovery of the thistle stand as well as the competition of any remaining thistles.

With regard to Canada thistle control, this preliminary analysis has these following pertinent points:

1. Infestation at low levels reduces yields very sharply.
2. Intensity of infestation beginning at rather sparse levels is directly related to yields.
3. Returns from high rates of kill continue to pay until the thistle population is extremely sparse.
4. Lower rates of success in control a) reduce the return the first year, and b) leave greater possibility for net gain in subsequent years (on the second chart, it will tip the first line to the right and probably bring the third up, and may even leave room for a fourth year treatment.)

We can make some interpretation from these in relation to general weed control problems, or raise some questions:

1. The selective weed killers (2,4-D, etc.) first came into popular use under conditions of heavy infestations of easy-to-kill weeds in relatively valuable crops (relative to cost of control). The situation with respect to control costs and value of crop was similar to the first-year treatment shown for Canada thistle.
2. Application has expanded toward the marginal area (the third-year treatment), weed infestations are reduced, and less valuable crops are being treated. Many of our most serious remaining problems are marginal because one or more of the following apply:
    a. high rates of application are required,
    b. relatively expensive chemicals are required,
    c. hard-to kill weeds remain,
    d. infestations, hence crop-yield reduction, are low, and
    e. low value crops are to be treated.
3. Because situations are marginal, more exact information on the factors of control is needed, such as:
    a. weed infestation--crop yield relationships,
    b. response of crop yields to control measures,
    c. effects of treatment on the crop itself, and
    d. rate of recovery of both perennial and annual weed infestations after treatment is discontinued.

We will continue to endeavor to secure more research resources in this field. The Farm Management Committee of the Western Agricultural Economics Research Council has appointed a subcommittee charged with the preparation of a proposed regional research project in this problem area, by June 1956. Such a project, if activated, could advance this work very rapidly beyond its present position. Much physical data susceptible to economic analysis is available. To make best use of existing data, and to provide even better data from the point of view of its suitability for economic analysis from new studies in the physical relationships of weed control, a great deal of cooperation of the physical scientists and economists will be required.

Figure 1.

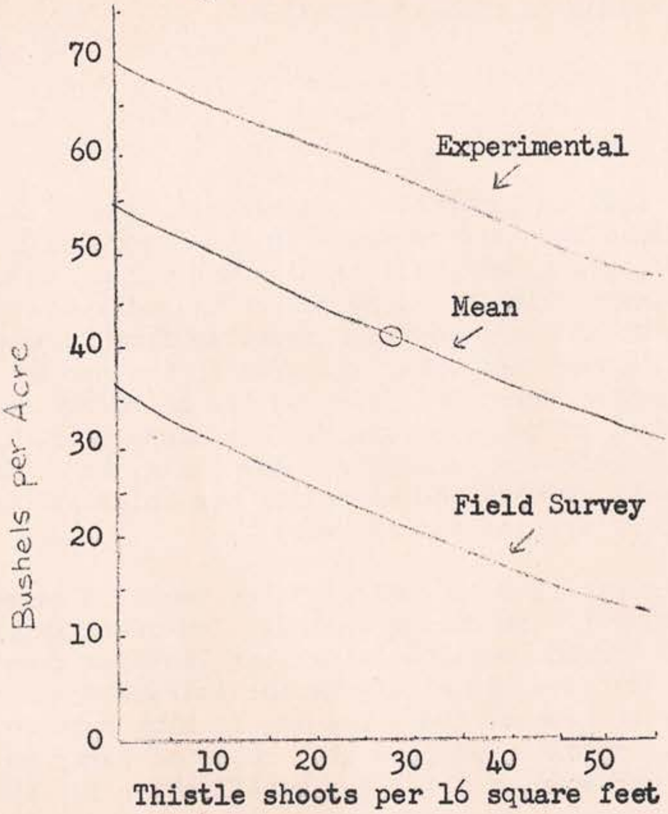
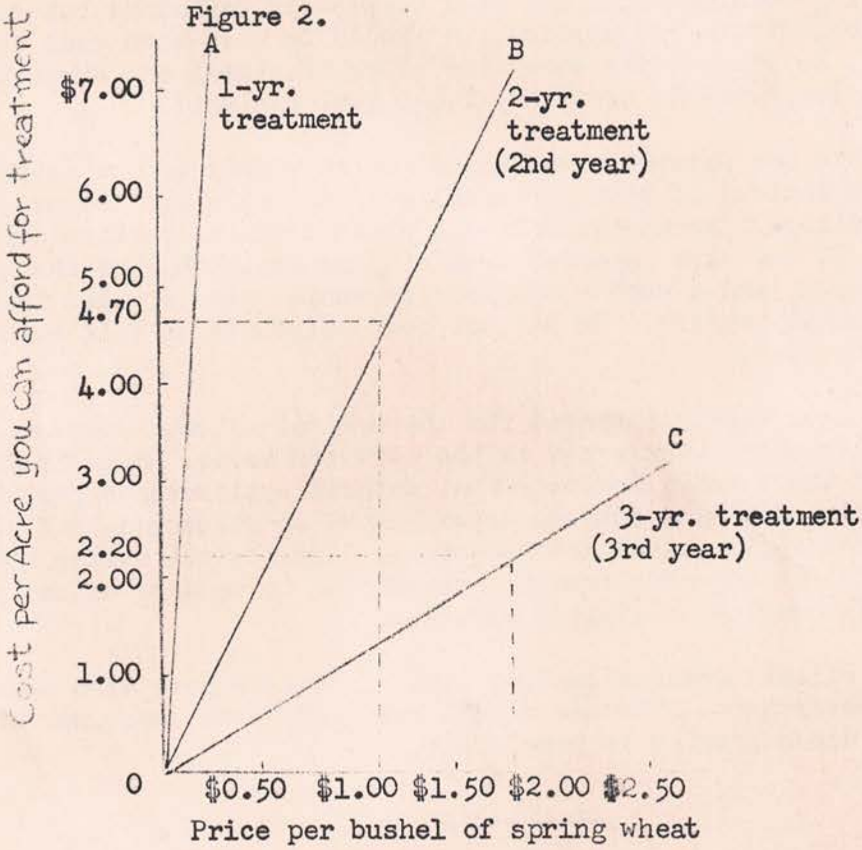


Figure 2.



PERENNIAL HERBACEOUS WEEDS

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The committee agreed that in spite of the widespread use of 2,4-D on Perennial broad-leaved plants the serious weeds in this group such as Canada thistle and Morning Glory are not being adequately controlled and are still spreading. One of the reasons which might be responsible for the rapid spread of the serious perennial weeds may have resulted from increasing negligence on the part of farmers and other agencies in the use of precautions and control measures that were used prior to the introduction of 2,4-D. These practices would consist of being careful to use clean seed, thoroughly cleaning field equipment before moving into a new field, and using spot treatments with sterilants to prevent the spread of new infestations that are found on areas previously free of these weeds.

Because of the failure of 2,4-D to control these weeds in selective spraying, weed control research work during the past few years in the western United States has centered around re-emphasizing sterilants as a means of eliminating infestations. In order to eliminate the infestation with the minimum of production loss of treated land, the use of high rates of 2,4-D have been explored widely. Results indicate that rates of forty to one-hundred and twenty pounds per acre of 2,4-D may be effective for the control of deep-rooted perennial broad-leaved weeds, if conditions are satisfactory. The erratic results obtained have not been completely explained but results to date appear to indicate the application should be made when cool soil temperatures will be present for some time after treatment and adequate moisture will be available to carry the 2,4-D into the soil.

Amino-triazole and Dalapon have been explored widely as new materials for non-selective control of both perennial grasses and broad-leaves when applied to the foliage. Amino-triazole has shown promise, particularly on Canada thistle. It has also appeared promising on Whitetop, Russian knapweed, Horsetail Rush, and a number of other perennial weed species including some of the perennial grasses. It has not been effective on Wild Morning Glory (convolvulus sp.).

Dalapon has been widely explored for the control of both Johnson grass in the Southern areas and Quackgrass in the northern areas. Results from southern areas of the country indicate that several applications per year are most effective in controlling Johnson grass. Work on Quackgrass has also indicated that repeat applications are necessary. Application during times when the Quackgrass is vigorous growing have proved to be more effective than during periods of moderate or limited growth.

New soil sterilant combinations for spot treatments have also been explored by many researchers. The use of chlorate and boron compounds with 2,4-D added have shown promise in some areas.

WOODY PLANT CONTROL IN THE WESTERN STATES

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(This report is based on 17 summaries received from 10 authors.)

Work on control of undesirable woody plants in the 11 Western States covers a wide variety of species and is conducted under a wide variety of environmental conditions. Xerophytes in the arid Southwest and hydrophytes in the wet and humid Northwest are represented as well as all intergradations between the two extremes. This report does not pretend to cover all of the work on woody plant control in the 11 Western States but does give a fairly good cross section of what is being done and some of the accomplishments that have been achieved.

Salt cedar (Tamarisk pentandra) is a problem, particularly in New Mexico, Arizona, and California. Mature trees are very difficult to control because of prolific sprouting following foliar treatment with systemic herbicides. The greatest success can be expected by making repeat applications on young regrowth. Tests in Arizona show that 5 applications with a total of 7.54 lbs./A give 100 percent control on 6 month old regrowth. With older regrowth higher rates and more applications were necessary to achieve control of 85 to 95 percent. Aerial spray tests in New Mexico have not been too successful, even when successive treatments were made in two years. Such an application to a mixed stand of phreatophytes only retarded the salt cedar and cottonwood, but willow was almost eliminated. One worker in New Mexico feels that the infestations of salt cedar that can only be treated by aerial applications will have to await a better herbicide than is now available.

Some work has been done on tarbush (Flourensia cernua) in Arizona. This plant is a weak sprouter and is relatively easy to kill. Date of spray tests have shown that there are two peaks of greatest susceptibility in a year. One of these occurs in March and April after the winter rains, while the other occurs from July to September during and immediately following the summer rains. The plant is most susceptible to the amine formulation of 2,4-D. Two percent concentrations in water have given kills greater than 95 percent.

Whitethorn (Acacia constricta var. vernicosa) is found in the same vegetative type as tarbush but it is a prolific sprouter and therefore is much more difficult to kill. The best kills, approximately 65 percent, have been obtained using a 3 percent concentration of a low volatile ester of 2,4,5-T in a 1:4 diesel oil:water emulsion. The periods of maximum susceptibility are the same as those for tarbush but different herbicidal formulations are necessary.

Herbicidal treatments on chaparral species in Arizona have been relatively ineffective. The dominant species in this type are scrub oak (Quercus turbinella), skunkbush (Rhus trilobata), adelia (Forestiera neomexicana), and point-leaf manzanita (Arctostaphylos pungens). The only species which was adequately controlled by aerial application of herbicides was manzanita. Eighty to ninety percent kills were obtained with 2 lbs./A of a low volatile ester of 2,4,5-T in water or a diesel oil:water emulsion. Total volume was 10 gals./A. Tests are now underway which are designed to determine the effectiveness of burning and chemical treatment.

An interesting observation has been made on the control of chamise (Adenostoma fasciculatum), a component of the chaparral type in California.

Three-year-old sprouts resulting from a wildfire were treated with various formulations of 2,4-D and 2,4,5-T by foliage application. Three months after spraying a wildfire swept through the area and burned out on an adjacent untreated area. Subsequent observation showed that the second burn was highly effective in killing the sprayed plants but did not kill the unsprayed plants. This situation is the reverse of what has been generally believed to be the best policy in combining burning with spraying. More work on spraying followed by burning may lead to some very interesting results.

Blue oak (Q. douglasii) can be controlled by the application of 2,4-D and 2,4,5-T amines applied by the cut surface method. Depth of application is quite important, however. Amines of the two herbicides gave approximately equal results when applied at a depth of 1 inch. At depths greater than 1 inch the amine of 2,4-D was distinctly superior to the amine of 2,4,5-T. The amine of 2,4,5-T has been superior at a depth of one-half inch.

Basal treatments on velvet mesquite (Prosopis juliflora var. velutina) have shown that season of application is not important. Comparable kills can be expected at all times of the year. The use of unfortified diesel oil is now a recommended practice. Kills of 95 percent can be expected using approximately 1 pt./tree. Many ranchers feel, however, that the addition of a fortifying agent is very desirable. Tests were conducted to determine if the total volume could be reduced by the addition of 1 and 5 percent concentrations of a low-volatile ester of 2,4,5-T. These tests showed that the 1 percent concentration in diesel oil using one-half pint per tree gave significantly better results than unfortified diesel oil. There was no difference, however, between the 1 and 5 percent concentrations.

Percent of kill still averages approximately 28 percent in aerial applications on mesquite. The present recommended treatment is 3/4 lbs./A of a low-volatile ester of 2,4,5-T in a 1:7 diesel oil:water emulsion and a total volume of 10 gallons per acre. Indications obtained from a few split applications appear quite promising, however. Lower rates and volumes are used in split applications so that the total cost per acre is approximately the same as for a single application. This technique is now receiving more attention.

Herbicides have also been used for thinning operations in ponderosa pine in Oregon. The undiluted amine of 2,4-D applied by the cut-surface method has given very effective and economical control. There is the danger, however, that epidemic populations of bark beetle will be built up in the standing trees that have been killed. Preliminary work indicates that trees treated in the fall are less susceptible to bark beetle infestations.

One of the principal problems in the conifer forests of the Northwest is the overtopping of conifer reproduction by shrubby species. Some of the worst of these species are manzanita (A. parryana var. pinetorum), snowbrush (Ceanothus velutinus), chinkapin (Castanopsis sempervirens), salmonberry (Rubus spectabilis), and red alder (Alnus rubra). Foliar treatments must be made with care since there is always the possibility of damaging the conifer reproduction. 2,4-D is apparently most damaging to pine. While a diesel oil:water emulsion is a better carrier insofar as the control of the brush is concerned, it also does the most damage to the pine. Generally pine is most resistant after height growth has stopped.

Basal treatments appear much more effective in the control of overtopping brush. The low-volatile ester of 2,4,5-T and the same esters of 2,4-D and 2,4,5-T in combination have given very good control when used at a concentration of 40,000 p.p.m. in oil. A horseshow-shaped adapter speeds up the operation by permitting the applicator to completely encircle a stem with the herbicide without having to move around the plants. Basal treatments are also more desirable because the possibility of sprouting is greatly reduced.

The various species of Ribes are still receiving a great deal of work. Generally the low-volatile esters of 2,4,5-T and 2,4,5-TP are most effective as foliage or soil drenching treatments. The soil drenching treatment differs from a foliage application in that the soil around the base of a plant is completely soaked. Concentrations of 2,000 p.p.m. in volumes of 250 gals./A give effective control in both types of treatment. An important element in the control of Ribes, as well as other woody species, is the season of treatment. During the period when the plant is actively growing a water carrier can be used. After growth has stopped, however, it is necessary to add an oil to the carrier. Generally the ratio of oil to water is raised as the plant matures, the highest ratio being used when the leaves have developed a relatively thick cuticle and are therefore more impervious to the absorption of herbicides. Local habitat variations are also taken into consideration so that plants are treated in a manner consistent with their relative susceptibility.

Preliminary work on Ribes has been done using CMU at rates of 128 and 256 lbs./A. Both of these treatments gave 100 percent kills in California.

Big sagebrush (Artemesia tridentata) covers a wide geographic range. Control measures vary somewhat by location but total cost and degree of control are approximately the same. In Oregon, for example, 1.1 lbs./A of butyl or PGBE esters of 2,4,5-T in water have given adequate control. The best season of treatment has been defined as the time Sandberg blue-grass (Poa secunda) starts flowering until its green color is about half gone. The cost of this operation in Oregon (chemical plus application) is \$3 to \$4 per acre. In Wyoming the ester of 2,4-D is recommended. A rate of 2 lbs./A results in 70-90 percent control. The type of carrier is not important if at least 3 gals./A are applied. The average cost in Wyoming is \$3.50 to \$4.00 per acre.

Rabbitbrush (Chrysothamnus nauseosus) is a serious pest in Nevada because of its ability to invade reseeded ranges. This plant is also a sprouter and is very difficult to kill. Applications of 2 lbs/A in successive years will, however, give adequate control. The geographic distribution of rabbitbrush ranges from British Columbia and Alberta south to Wyoming, Utah, Nevada, northern Arizona, and eastern California.

A good deal of work has been done on the mechanical control of juniper, principally Juniperus osteosperma, in Arizona and New Mexico. Cabling is effective in old, even-aged stands but decreases in effectiveness when many age classes are represented. This arises simply because the small trees will bend under the cable and snap back to an upright position without being uprooted. Chopping is practiced quite intensively on some of the Indian reservations. This method is very effective but also expensive in heavy infestations.

Some work has been done in burning followed by reseeding. A hot fire will kill most of the existing stand of non-sprouting species of juniper, but unfortunately the seed scarification caused by the fire often results in a second stand of juniper within a short time. Consequently, a secondary control operation is necessary. Burning needs a good deal of further study. Its application in the juniper type is not definitely known at this time. Work on the control of juniper with herbicides has been very limited. Apparently foliage applications of esters of 2,4-D and 2,4,5-T have little effect. Basal treatment has not been tried on this species. Experimental work on the chemical control of this plant will be undertaken very soon, however.

The foregoing is a very brief resume of woody plant control in the Western States. Not all of the noxious species are cited. The information given on control measures is incomplete in some cases and subject to change in all cases.

HERBACEOUS RANGE WEEDS

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Although approximately two dozen people have participated in one way or another in this project during the past two years, probably less than ten man-years are being expanded annually in strictly range weed research. Interest, however, has been high and some 16 persons have submitted 22 papers on range weed research during this two-year period. Unfortunately, the members of this committee have had no backlog of information from which to draw and much of the work has been only preliminary in nature. The members of the project in plenary sessions have made an attempt to survey and evaluate the range weed problems which we have facing us. It is concerning these activities that I would like to report.

In the first place, the complexities of range weed research are well brought out by consideration of the nature of the ranges involved. These ranges fall roughly into three general types where the work is now being carried out. There are the high-montane ranges of the Rocky Mountains and Sierra Nevadas, the coastal ranges of California, Oregon, and Washington, and the broad expanse of arid and semi-arid desert rangelands which occupy the entire intermountain area. Climatic and soil conditions vary considerably, not only between range types but also within an individual region.

Within each of the major range types the weedy species seem to fall roughly into three general classes, each of which requires separate methods for control. The first of these is the introduced species. Since nearly all of our range problems are the result of depletion of the native forage, the introduced species which have become problems seem to have definite ecological advantages over native species and are hence rapidly invading and replacing the native vegetation. Introduced range invaders are of particular importance in the semi-arid desert ranges of the intermountain region. In 1954, halogeton which has been the subject of approximately half of the range weed research to date, was reported by the Bureau of Land Management to occupy approximately 6 million acres in the intermountain area, about 4 million of which was on the public domain. Another important introduced invader is the Medusa-head rye which is presently occupying about 200 thousand acres in western Idaho and eastern Oregon and is continuing to invade much of our cheatgrass range. A considerable acreage in Oregon and California is infested with Mediterranean sage. Just as with cheatgrass, which is also an introduced invader, all of these other annuals or annual-like weeds, now seem definitely entrenched as part of the characteristic vegetation of the ranges now infested. Their ultimate control would seem to depend most upon encouragement of the slower-growing native forage species through better management practices or through reseeding with more competitive types of forage plants. It is in these areas of biological control measures where probably the greatest need for additional research lies.

A second type of range weed problem is illustrated by niggerhead, wild iris, and a number of the lupines, mules-ear and other species which are actually a part of the original native flora of the range. In localized areas these plants have found themselves in a position to expand and spread as the desirable forage has been removed or reduced through heavy grazing pressure. Here again the method of control is primarily one of management, but supplemental chemical measures and reseedings may also have a place in the elimination or control of these species and in their reduction to a desirable subcritical density.

A third type of range weed problem is constituted in poisonous native plants such as tall larkspur and arrow-grass which are not necessarily out of balance with the other vegetation. Since the plants are often widely scattered over rather extensive areas, their control frequently requires treatment at the individual plant level. Attempts to eradicate such plants have to date been largely unsuccessful as well as very expensive. Very little critical research has been carried out on the majority of these species.

In summing up, we have come to the conclusion that all types of control measures have a place in the solution of the range weed problems and should be investigated much more thoroughly than they have in the past. One of the primary areas in which additional information is needed, however, is in the economics of range weed control. Until the actual value of control on the very low-valued western rangelands is clarified, it will be difficult to procure sufficient funds to carry out the needed research. It is hoped that the future will be illuminating in this respect.

CONTROL OF ANNUAL WEEDS IN CEREAL AND FORAGE CROPS*

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*The information for this review was compiled from 8 summary reports submitted by 7 investigators for publication in the 1956 Research Progress Report of the Western Weed Control Conference.

During the past ten years, chemical control of weeds in cereal crops and in forage crops to a lesser extent has expanded very rapidly. In a report made in 1952 by the Agricultural Research Service and the Agricultural Marketing Service of the U. S. Department of Agriculture, it was estimated that 33.5 million acres of agricultural land were sprayed for weed control. Of the 33.5 million acres of land sprayed, there were approximately 18 million acres of small grains (wheat, oats, rye, barley, flax, and rice), 9.5 million acres of corn, 2.5 million acres of pasture and range land, and 3.5 million acres of other crops. Thus, it is seen from the acreage of cereal and forage crops sprayed that research men working on weed control in these crops have a big responsibility in providing adequate recommendations for control of weeds in these crops.

Weed Control in Cereal Crops

From the impressive figures on acreage of cereal grains sprayed in the United States it might appear that most of the problems of weed control in cereal crops have been solved. However, it is the opinion of this committee that much work remains to be done. Some of the unsolved problems requiring further research work are as follows:

Wheat

Every year weed workers in the Western States receive complaints of injury to wheat following spraying for weed control. This injury often occurs even though the applications were made in accordance with the recommendations of state and Federal research agencies in the area. The damage is usually expressed as sterility in the wheat heads and in some fields wheat yields are reduced as much as 50 percent or more as a result of this damage. Surveys made following such damage have revealed that one or more of the following factors usually accompany injury: (1) an ester of 2,4-D (2,4-dichlorophenoxyacetic acid) was used, (2) an oil carried was used, (3) the applications were made by plane, (4) low temperatures were noted either immediately preceding or following the treatment, (5) the soil nitrogen level was high.

In an attempt to find what is causing this damage, workers in Washington have been doing considerable work with different volumes of application, carriers, and stages of growth to find their effect on yields. In one test 3 volumes and 5 carriers were tested but had no effect on yield of wheat. In a second test 3 volumes, 2 carriers, and 3 stages of growth were studied. In this test stage of growth and carrier both showed significant yield differences.

Another problem in wheat is control of annual weeds which are resistant to 2,4-D or certain 2,4-D formulations. Since particular formulations are not usually mentioned in our recommendations, some weeds are not controlled by the recommended treatments. To gain further information on the effect of different herbicides on weeds, other tests were conducted in Washington in which 18 herbicidal materials were compared in two separate tests for control of gromwell, usually considered somewhat resistant to 2,4-D. In these tests it was found that certain 2,4-D esters were much more effective in controlling gromwell than other 2,4-D formulations or related compounds which were tested. Summary reports of these experiments in Washington are presented in abstracts included in the 1955 Research Progress Report.

Summer fallow

Where small grains are raised in an alternate crop-fallow program, severe soil erosion often occurs during the fallow year. This is particularly true where the soil is clean cultivated for weed control. To lessen the erosion problem, various chemicals are being tested to control weeds during the fallow year so that the grain stubble can be left undisturbed. In work conducted in Wyoming (reported in the 1955 Research Progress Report), it has been found that 2 pounds per acre of 2,4-D plus 5 pounds of Dalapon (sodium salt of 2,2-dichloropropionic acid) applied during the fallow year will control annual weeds without reducing wheat yields. In addition it was found that water penetration was greatly accelerated where a chemical fallow program was followed.

Oats, Barley, Rye

Another problem which the committee feels is unsolved is weed control in oats, barley, and rye. At the present time spraying with 2,4-D is the only treatment recommended for control of weeds in these crops. However, these crops are usually planted as nurse crops for legume plantings and as a result, 2,4-D cannot be used without severe damage to the legumes. Even when planted in pure stands, 2,4-D often injures oats and barley with resultant reductions in yield. Thus, it is felt that present recommendations are not adequate under many situations.

Research men in Montana ree working on this problem and reported work in which eight substituted phenoxy (acetic and butyric) acid derivatives and amino triazole (3-amino-1,2,4-triazole) were compared on oats. It was found that most of the chemicals tested gave good weed control. However, 2,4-D esters used in this test severely reduced oat yields when applied at rates normally recommended. Amino triazole also reduced yields while the phenoxy butyric acid formulations gave good weed control and no damage to oats. Thus, further work should be conducted with the phenoxy butyric acids to determine whether or not they will give satisfactory weed control in oats, barley, and rye. Since legumes have been found to tolerate the phenoxy butyric acids even when in the seedling stage, these materials are indeed promising.

Corn

In controlling weeds in corn, dinitro compounds and 2,4-D are the standard treatments recommended in most parts of the West. In recent work conducted in Oregon, it was found that 2,3,6-trichlorobenzoic acid and certain substituted urea compounds gave weed control superior to the standard treatments without injury to corn. Thus, these new materials deserve further testing.

Weed Control in Forage Crops

Pasture and Hay Crops

The committee agreed that weed control in pasture and hay crops has been neglected in the past and should be given more attention in the future. If the much discussed soil bank farm program becomes a law, weed workers will have an opportunity and an obligation to develop recommendations for control of weeds on land that is set aside under this program as well as on lands already in forage crops. In many instances, fields will be taken out of production because of weed infestations. This will create serious problems on these idle lands unless we can come forth with suitable programs for keeping the weeds under control in grass and legume crops.

This committee believes that several reasons are responsible for failure to work out adequate control practices on pasture and hay lands in the past. Until recently suitable chemicals were not available for use in these crops, particularly the legumes. This is no longer an excuse since the substituted ureas, substituted phenoxy butyric acids, and some phenoxy acetic acid derivatives have shown much promise for controlling weeds in both grass and legume crops. The second reason for neglect is that there has been little interest shown by farmers in controlling weeds in hay and pasture crops. If some economic studies could be conducted to point out just how much farmers were losing by allowing weeds to persist in their pastures and hay fields, perhaps more interest could be stimulated.

Grass and Legume Seed Crops

The recent swing to a grassland agriculture has greatly increased the demand for grass and legume seeds. If the soil bank program goes into effect, this demand will be increased even more. Annual weeds create many problems in forage crop seed production which warrant increased research work. They reduce yields, interfere with harvest, and reduce the quality of seed.

Work being conducted in Oregon indicates that substituted urea compounds at rates of 2 to 4 pounds per acre show much promise for controlling annual weeds in both grass and legume seed crops. In addition, MCP (amine salt of 2-methyl-4-chlorophenoxyacetic acid) and Dalapon show some promise for use in these crops. The substituted phenoxy butyric acid compounds should also be tested. Thus, we now have adequate tools to work with and should increase our efforts in these crops.

AQUATIC WEEDS: SUBMERSED AND EMERGENT

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(The following Summary Report is based primarily on eight abstracts which were received from five contributors working in four different states. These abstracts are included in the 1956 Research Progress Report of the Western Weed Control Conference.)

During the years in which research pertaining to the control of aquatic weeds has been conducted, most effort has been directed at cattails or submersed, rooted vegetation, which create problems in irrigation systems. In earlier years, cattail was found quite resistant to various formulations of 2,4-D. Some time later it was shown that the addition of light fuel oils plus an emulsifying agent greatly enhanced the effectiveness of 2,4-D and three or four well-timed applications would completely destroy the existing stand.

Although this method has been found effective and is being used commercially, it has definite shortcomings in areas where 2,4-D-sensitive crops are grown. Research is now concerned with discovering methods for controlling cattails in these areas.

Very promising results with 2,2-dichloropropionic acid (dalapon) and 3-amino-1,2,4-triazole (ATA) have been reported from California, Utah and Montana. In California, excellent kill was obtained by applying 12.0 lb/acre (50% material) of ATA just as the seed stalk was emerging. The addition of one quart kerosene per 100 gallons of water improved the results. In Utah combinations of 2,4-D with dalapon or ATA have been somewhat more effective than either of the latter materials by itself. Although results of the combinations produced the highest degree of kill, applications of dalapon or ATA by itself were also very effective and appear to justify extensive testing. In Montana similar results were obtained. Single applications of dalapon at 30 lb/acre were not satisfactory, but an original application of 10.0 lb/acre followed by re-treatment at the same rate caused a substantial reduction in cattail population. Single applications of ATA at 5.0 lb/acre caused no noticeable reduction while at 20.0 lb/acre only 20% regrowth was noted the following year.

Experimental applications of the methylated benzene materials (aromatic solvents) for the control of submersed aquatic weeds have been discontinued. These methods are presently finding considerable use in many of the western states and provide an efficient and economical means of controlling aquatic weed growth. The procedures are completely described in USDA Circular No. 971 issued October 1955 and entitled "The Use of Aromatic Solvents for Control of Submersed Aquatic Weeds in Irrigation Channels".

Experimental results with chlorinated benzenes (trichlorobenzene or O-dichlorobenzene) alone or in combination with aromatic solvents have effectively controlled submersed aquatic growth in drainage canals and other situations where water movement is very slow. Crop tolerance tests indicate that these materials cannot be used for treating water to be used for irrigation purposes.

The control of algae in canals, farm reservoirs and recreational lakes or ponds has received increased attention during the past several years. In these situations it is desirable to effect control of algae without endangering fish, animal or human life. Several materials have shown promising results under experimental conditions. Rosin Amine D Acetate (RADA) has controlled algae in canals and in reservoirs. Failures have occurred and these are usually associated with a high content of certain soluble salts. It has also been noted that some species of fish may be killed by RADA. Very limited work with 2,3 dichloro-1, 4-naphthoquinone (Dichlone) indicates that it may have potential use as an algicide.

The use of commercial fertilizer, a method frequently used in the Southern States has been investigated in California. Aquatic weed growth in a small farm pond was controlled by repeated applications of a pelleted 10-10-10 at a seasonal cost of $25.00/acre. Fishing conditions were greatly improved by this treatment.

Applications of Atlas A (sodium arsenite) at 10 ppm. have also resulted in effective control of aquatic weeds in small ponds. Results are influenced by the presence of certain soluble salts, and when these are present in sufficient quantity they may detract from the final result.

The control of aquatic weed growth in small lakes or ponds presents a problem of apparent increased importance. It is a phase of work somewhat overlooked by research workers and the opportunities to conduct experimental work should not be by-passed. The development of satisfactory control methods would certainly find a large number of appreciative users.

CHEMICAL AND PHYSIOLOGICAL STUDIES*

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* The information for this review was compiled from 13 summary reports submitted by 14 investigators for publication in the 1956 Research Progress

Report of the Western Weed Control Conference. Other material was secured by personal communication.

Work on the chemical and physiological aspects of weed control is currently being carried out in the majority of the 11 western states. Nevertheless, there is a serious deficiency of knowledge in this phase of research, and it is only with difficulty that biochemical and physiological studies maintain a pace with empirical research on many of the new herbicides.

During 1955 considerable emphasis has been placed on Halogeton glomeratus. Studies dealing with distribution, seed dormancy, effect of light intensity and photoperiod on growth and reproduction, and the effect of salinity and other factors on germination have been carried out. In addition, new herbicide formulations and carriers have been evaluated on greenhouse-grown seedlings.

In Colorado, studies on the protein fractions of potato have been continued by means of paper electrophoresis. Distinct alterations, both quantitative and qualitative, of specific protein fractions of the tuber have been shown to occur at various intervals after treatment with such herbicides as 2,4-D and maleic hydrazide.

It has been demonstrated in California that penetration of radioactive 2,4-D and amino triazole from the leaves of wandering Jew (Zebrina pendula) is not a linear function of concentration, and that a certain minimum concentration must be exceeded before significant penetration is achieved. At low concentrations 2,4-D penetrated more readily than amino triazole, and both compounds penetrated to a markedly greater degree at low concentrations from the lower leaf surface than from the upper. Penetration in Zebrina has also been investigated by means of fluorescent dyes. Cuticular penetration of the upper non-stomatal surface was determined in this manner, but again greater penetration was obtained through the lower surface. Stomatal entry was not indicated because dye patterns appearing in the cell walls held no relation to stomatal distribution.

The possible relationship between indole-3-acetic acid content of Arizona burroweed (Aplopappus tenuisectus) and its susceptibility to herbicides is under investigation. A technique for extracting the auxin has been developed, and future work will involve the establishment of seasonal variation in auxin content and correlation with herbicidal sensitivity at various periods. A similar study will be carried out on velvet mesquite (Prosopis juliflora var. velutina). Carbohydrate determinations will also be made on these plants to determine possible correlation with auxin content and period of maximum susceptibility. Studies on both greenhouse-grown and field mesquite have demonstrated a profound influence of emulsifier type and concentration under certain conditions. Further work on this subject as well as anatomical studies of phloem inactivation are planned for the coming year.

Oregon studies have included work on the soil adsorption of amino triazole. Variable adsorption of this compound was considered as one of the possible causes of erratic results achieved from pre-emergence treatments with this herbicide. Adsorption was not a linear function of concentration of solution applied, but was nevertheless considerable in the soil used.

Research in Washington on Canada thistle (Cirsium arvense) has shown the sucrose content of the roots to remain stable at various intervals after foliar treatment with 2,4-D. Reducing sugars were constantly depleted in the treated plants, but not to the degree they were in the non-treated controls. Conversely, dextrins and levulins increased with time, even to some extent in the treated plants, thus suggesting a translocation from deeper root levels. Related studies on bindweed root (Convolvulus arvensis) showed a decrease in weight between the 28th and 56th days after application of 2,4-D at 1 and 2 pound rates, which was later followed by a weight increase. Plants were also grown under two levels of nitrogen nutrition, each level being maintained at two degrees of soil moisture. Of the four possible combinations, plants growing under the high nitrogen-low moisture condition showed greatest reduction in root weight.

Experiments with kidney beans (Phaseolus vulgaris) have demonstrated that the addition of certain chlorinated acids or unsubstituted carboxylic acids to amino triazole result in decreased chlorosis development in primary leaves, but increased chlorosis in growth above the primary leaves. Further work of this nature was performed on barley (Hordeum vulgare).

Some interesting reports have come from Oregon. A new analytical method for the determination of isopropyl-N-phenyl carbamate utilized a color reaction, the optical density of which is measured at 580 mu.

A method of evaluating the herbicidal activity of chemicals by the Ferguson principle has been presented. It is based on the ratio of concentration required for production of a given response to solubility at a given temperature. Reaction rates of halogen-substituted acids with glutathione, a tripeptide containing the SH group, were shown to be quite variable -- a possible explanation for differences in physiological activity among chemicals.

A number of carefully determined physical properties of herbicidal chemicals was reported. These included density, solubility, ionization and surface tension. In addition, the partial molar volume of several chloro alkyl acids was determined and compared with the molar volume. It was considered that the relation of these values to one another may in turn be related to biological activity.

Volatility studies of various formulations of 2,4-D on cotton have been continued in the desert regions of Southern California. Temperatures of the soil surface and of the interior of cotton leaves, as determined by a delicate thermocouple, were exceedingly high. Such temperatures, approaching 160° F. in the case of soils, could well be an explanation for the slight volatility even of certain salt formulations of 2,4-D -- formulations which are normally considered to be almost non-volatile.

VEGETATION CONTROL ON RIGHTS-OF-WAY AND INDUSTRIAL SITES

J. R. McCambridge
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Portland, Oregon

"Vegetation Control on Rights-of-Way and Industrial Sites," deals principally with state and county roads, railroads, power companies, and industrial sites such as lumber, oil, automotive, and so forth.

The chemicals being used by these people today are Telvar W and Telvar DW, sodium chlorate, chlorate-borate combinations, borax, 2,4-D and

2,4,5-T, Dalapon, and Baron. All of these people are very conscious of their public relations program and are making a sincere effort to become familiar with all of the recommended herbicides and their proper uses.

The power companies are interested in soil sterilization in their substations to eliminate vegetative growth and trash to prevent fire hazards and to prevent accidents to personnel working in these installations. They must have a program using a material that is non-inflammable, non-poisonous, and non-corrosive to the underground mats. Power companies are working in close cooperation with the Bureau of Land Management and the Forest Service on their transmission line rights-of-way. They are working on programs of reseeding these rights-of-way with desirable grasses to prevent erosion. They are also doing selective brush control work using the low volatile 2,4-D and 2,4,5-T combinations and making the application selective to take out the tall-growing species and leave the low-growing brush to assist in preventing erosion.

I am not going into the details of the rates used of the various chemicals mentioned as the recommendations are covered pretty much in detail in the last twelve pages of the Research Progress Report of the Research Committee of the Western Weed Control Conference.

It is the general practice by public utilities, state and county road departments, and railroad personnel when using a foliage spray, to not spray brush over 6 feet high in order not to have unsightly dead brush along their rights-of-way. Usually when brush is higher than 6 to 10 feet, the growth is slashed and the stumps are treated with a solution using 1 gallon of brush killer in 20 gallons of diesel oil and spray to thoroughly wet the stumps. When using the dormant basal treatment, the same concentration of solution is used.

It is encouraging to me particularly, and I think to you here in attendance at this conference, that the state and county road maintenance people and the railroads and industry are taking such an active interest in weed control. In the past these people have been accused of not taking care of noxious weeds on their rights-of-way, allowing these weeds to encroach on agricultural land, but now they are active and doing everything they can and cooperating fully with state and county weed workers. Any help that can be given them I know would be appreciated and I feel personally that state and federal prople should be working more closely with these avenues of transportation, as new weeds certainly come in on trucks, box cars, and passenger cars. By working with highway, railroad and industry personnel, state and federal workers will have the opportunity to pick up any new weed pest rather quickly that may be encroaching into agricultural areas.

Industry and transportation engineers are faced with every type of weed problem that exists, from the plants in the grass family to the broad-leafed herbaceous weeds and all brush species. Therefore, they have the full problem of vegetation control in their operation.

The state and county road people are not only interested in soil sterilization; they are also interested in many phases of selective weed control, as it is necessary that some of their cuts and slopes be seeded with grasses and they must use the selective type of herbicides to remove the trash weeds and grasses from these plantings. They also are using ground cover plants, such as the ice plant here in California, to prevent erosion and for beautification. In the medium strips on the highways of California the oleander plant is being used for beautification purposes and it is necessary to use compounds selectively in these areas. Telvar W at 3 pounds per acre has been used in ice plant without damage to this ground cover. Dalapon has been used experimentally at the rate of 30 pounds per acre as a selective herbicide for removing grasses and other weeds from ice plant plantings and also from oleander basins.

In addition to using chemicals which are selective in their action on plants as mentioned above, there is a tremendous use of the soil sterilants for the control of all vegetation around sign posts, guardrails, bridges, and other maintenance points. The road engineering people are also using chemicals for establishing firebreaks throughout the various states to remove the trash type of vegetation which causes a tinder through which fire can travel from road rights-of-way into crop, range and forest lands. It is essential on public roads that the products used be non-poisonous, non-inflammable, and safe to personnel handling them and these chemicals must not create a hazard to crops adjacent to these rights-of-way.

All in all, industry, transportation, and public utility personnel are doing an excellent job. They are looking for help to do a better job, and again I repeat that if the state and federal people can give industry more assistance and know-how on the use of the various herbicides, I am sure they will be well received by industry and their assistance will be appreciated.

PROGRESS REPORT ON 3-AMINO 1,2,4-TRIAZOLE(AMIZOL)

R. H. Beatty
American Chemical Paint Company
Ambler, Pa.

3 amino 1,2,4-triazole referred to hereafter as Amizol will be sold in limited amounts under the trade name of WEEDAZOL by American Chemical Paint Company and amino-triazole Herbicide by American Cyanamid Company. Both of these commercial products will contain 50% Amizol and will be packaged in 4 pount and 25 pound packages. They will sell to the farmer for around 2.50 per pound.

Amizol will be sold as a non-selective herbicide for killing certain perennial weeds when land is not in crops grown for food. Since this chemical usually effects chlorophyll along with other effects not clearly understood at this time, plants treated will usually turn chloratic and die slowly.

Some woody plants react differently. Ash and Scrub Oak may not show any symption until the following growing season after a foliage spray, whereas Poison Ivy turns brown and dies quickly at rates as low as 1 pound per acre.

Amizol is inactivated or tied up in most soils and should not be considered as a soil sterilant. As far as selectivity in crops is concerned, Amizol seems to be quite selective when used at rates high enough to kill weeds in Cranberry, Grape, Citrus, Apples, and oats. The cranberry growers are ready to use Amizol as soon as residue studies are completed which are now underway.

Amizol is recommended on the following perennials. These recommendations have been approved by U. S. Department of Agriculture (Pest Control Branch).

Quack grass (couch or witch grass): Apply 4 lbs. Amizol per acre in 20 or more gallons of water. For best results, treat in the spring when quack grass is 4 to 6 inches tall. It is important to plow when treated quack grass shows a whitish color (usually 2 weeks after spraying). Make sure all the sprayed grass is turned under completely.

Bermuda grass: Use 5 lbs. Amizol in 20 or more gallons of water per acre in spring when grass is young. When grass appears whitish (usually 2 weeks after spraying) plow treated areas as deeply as practical so grass is turned under completely. Poor plowing or merely discing after spraying will give poor results.

Nut grass (sedge): Disc in the spring to cut up the nut chains as much as possible. When new growth occurs from these individual nuts, apply 4 to 8 lbs. Amizol in 40 gallons of water per acre to insure good wetting. Where soil has been severely infested, dormant nuts may germinate and require a repeat treatment. The combination of repeated applications and discing has given excellent control of nut grass.

Canada thistle and Sow thistle: Apply 4 lbs. Amizol in 20 or more gallons of water per acre. For best results, spray between the time most thistles have emerged and the bud-to-bloom stage. Do not mow treated plants. They may be plowed under 3 weeks after spraying.

Mix 2 lbs. Amizol in 50 gallons of water and spray plants to run-off. Spray between the time most thistles have emerged and the bud-bloom stage. Do not mow treated plants. They may be plowed under 3 weeks after spraying. 50 gallons of Amizol solution should not cover more than 1/2 acre of solid thistle.

Leafy spurge: Mix 2 lbs. Amizol in 50 gallons of water and spray plants to run-off. Apply when leafy spurge begins to bud and flower but before any seed pods form. Do not mow treated plants. For fall treatment where crops are to be planted in spring, spray Amizol solution when leafy spurge is in the rosette stage. Plow the treated area 1 to 2 weeks after fall application. 50 gallons of Amizol solution should not cover more than ½ acre solid stand of leafy spurge.

Russian knapweed: Mix 2 lbs. Amizol in 50 gallons water and spray plants to run-off. Apply spray solution when Russian knapweed is in the early bud stage. Later application may not be effective. 50 gallons of Amizol solution should not cover more than ½ acre of solid stand of Russian knapweed.

Horsetail rush (Northwestern area): Mix 2 lbs. Amizol in 50 gallons of water and spray plots to run-off during the growing season. Wet plants thoroughly. 50 gallons of Amizol solution should not cover more than ¼ acre of solid stand of horsetail rush.

Cattails and Tules: Mix 2 lbs. Amizol in 100 gallons of water and apply at least 500 gallons of solution to a solid acre of these plants. Wetting to run-off is essential. Apply Amizol solution from the time the catkins begin to appear until they are fully formed.

KNAPSACK SPRAYER FOR SMALL PATCHES

Knapsack sprayer: For treating any of the above weeks with knapsack sprayer, mix 2½ oz. (8 level tablespoons) of Amizol with 1 gallon of water and spray plants to run-off. One gallon of Amizol solution is enough to cover 1 square rod (272 sq. ft.) of uniformly infested weeds.

DIRECTIONS FOR KILLING WOODY PLANTS WITH HIGH VOLUME SPRAYER

It is important to cover the whole plant thoroughly, wetting leaves and stems to the ground line. Apply Amizol solution to run-off. Do not spray too early in the spring - wait until the first leaves have reached full size and the plants have finished their strong early growth. Until further data is obtained, do not mix Amizol with 2,4-D-2,4,5-T or amate.

Poison oak: Use 3 lbs. Amizol in 100 gallons of water.

Poison ivy: Use 2 lbs. Amizol in 100 gallons of water.

Prickly ash and buchbrush: Use 3 lbs. Amizol in 100 gallons of water.

White ash, scrub, red and white oak: Use 6 lbs. Amizol in 100 gallons of water. These plants usually die slowly and little effect is noticeable the year they are sprayed except poison ivy. The next spring, bleached leaves appear and there is gradual die-back until death results, usually that summer.

Other weeds which do not have label approval at this time but which Amizol is promising are: Toadflax, Milkweed, Horse Nettle, white top, several aquatic weeds and volunteer alfalfa.

We are continuing with our toxicity work and residue data especially with relation of quack grass and thistle being treated and followed with crops. Preliminary fish toxicity looks quite interesting. It seems as though Amizol concentration around 32,000 ppm may be biologically safe. It took 100,000 ppm. to kill blue gills. Several colleges have radioactive amizol and we believe some interesting work will develop with this material.

We will have a liquid formulation available for research this year 2 lbs. per gallon. We believe Amizol is a useful herbicide and will continue to find expanded use as we learn more about it.

I want to thank all of the research men here who have worked with Amizol. It is only by this cooperation between colleges, USDA and industry that new uses will develop.

CHLOREA FOR INDUSTRIAL AND RIGHTS-OF-WAY WEED CONTROL AND SODIUM ARSENITE FOR AQUATIC WEED CONTROL

J. R. McCambridge
Chipman Chemical Co., Inc.
Portland, Oregon

CHLOREA

Name: Chlorea (40% Sodium Chlorate, 57% Sodium Metaborate, and 1% 3(p-chlorophenyl)-1,1-dimethylurea).

Status: Development and Sales.

Uses: Registered. (Herbicide)

Results: (Dosage - Weeds Controlled - Cost)

For annual weeds and grasses apply 1 to 2 lbs. per 100 sq. ft. (435.6 lbs. to 871.2 lbs. per acre).

For perennials and deep-rooted plants apply 2 to 3 lbs. per 100 sq. ft. (871.2 lbs. to 1306.8 lbs. per acre).

Chlorea may be applied dry with sifter-shaker applicators or by mechanical spreaders similar to the lawn fertilizer spreader or it may be applied as a spray dissolved in water at the rate of 1 to 5 lbs. per gallon of total solution.

Weight per Gallon of Spray Solution of Chlorea

Chlorea	1.0 lbs.	2.0 lbs.	3.0 lbs.	4.0 lbs.	5.0 lbs.
Water	7.92 lbs.	7.51 lbs.	7.05 lbs.	6.59 lbs.	6.11 lbs.
Total lbs. per gal. solution	8.92 lbs.	9.51 lbs.	10.05 lbs.	10.59 lbs.	11.11 lbs.

Water Displacement of Chlorea

Rate of Chlorea used	1.0 lbs.	2.0 lbs.	3.0 lbs.	4.0 lbs.	5.0 lbs.
Water used to make one gallon	.95 gal.	.90 bal.	.85 gal.	.80 gal.	.75 gal.

This compound is so formulated that the chlorate-borate components are completely soluble with agitation at the rate of 4 lbs. in .8 gal. water (which brings the solution up to 1 gal. measure) at 40° F. with the CMU in suspension.

This high solubility brings about a concentrated spray solution which has an excellent contact action on emergent vegetation and permits the application of Chlorea for maintenance purposes at low gallonage per acre basis. With a concentration of 4 to 5 lbs. per gallon one can apply 400 to 500 lbs. per acre with 100 gals. total solution. These rates are very effective for complete control of annual weeds and grasses for an entire season and have a depressing effect to perennials.

Chlorea was designed specifically as an industrial soil sterilant for the control of both shallow- and deep-rooted vegetation. By utilizing the outstanding qualities of the herbicides, chlorate and CMU, we have formulated a product which has the following outstanding features:

1. Is toxic to all plant species.

2. Has long residual in the surface soil to control shallow-rooted plants and deep penetration for the control of deep-rooted plants such as biennials and perennials.

3. High solubility of Chlorea reduces cost of application as compared to the old chlorate-borate combinations and it is competitive in total gallonage application to the urea and propionic herbicide formulations.

4. Has good contact action on all plant species.

5. May be applied in the fall or spring months.

6. May be applied dry or as a spray.

7. Is non-poisonous and non-inflammable when applied as directed.

When to Apply: For annual weeds and grasses, apply in the spring or when weeds are small.

For perennial weeds and grasses, in areas of light winter rainfall (less than 20 inches), it is generally best to treat during fall or early winter. In areas of more than 20 inches of winter rainfall, spring application should be made.

If spring application is made, Chlorea should be applied when weeds and grasses are not over a few inches high, so as to avoid fire hazard from the dead and dry vegetation. If the vegetation is over 6 inches high, it should be cut and removed before treatment. Avoid application in hot, dry weather.

Uses - Industrial and Railroad

Chlorea is recommended for control of all vegetation: Around oil storage areas, lumber yards, lumber mills, industrial plants, warehouses, parking areas, outdoor theaters, machinery storage areas, power substations, telephone and power line poles; also for street and highway maintenance.

In soil prior to surfacing with black top or paving.

Around bridges, trestles, buildings, signals, storage yards, rail sidings.

Uses - Agricultural and Home

Chlorea is recommended for control of all vegetation: Along fence lines; around farm buildings, granaries, grain elevators; in driveways, tennis courts, playgrounds; on non-crop land and waste areas.

Chlorea should be used only where there is no danger of the material being leached into the root area of useful plants. Animals should be kept off the treated areas until rain has washed the chemical into the soil. Grazing freshly treated areas reduces effect of treatments and may induce salt-hungry animals to eat poisonous plants. The chemical will keep treated soil unproductive for one or more years and should be used only where unproductive soil is not objectionable. Avoid contamination of irrigation water.

Package Size and Price

50 lb. bags $18.35 - $21.10 cwt.

SODIUM ARSENITE

Name: Atlas "A" (Liquid Sodium Arsenite, 4 lbs. arsenic trioxide (As_2O_3) per gallon)

Status: Sales. Has been used for many years for the control of submersed water weeds in still waters; also some floating and emergent plants.

Uses: Registered. (Herbicide, Insecticide, Fungicide, Potato Vine Killer)

Results:

The Fish and Wildlife Service, U. S. Dept. of Interior, recommends sodium arsenite for controlling certain submersed vegetation in farm ponds, hatchery ponds and small lakes. This chemical has been used for a number of years and results show that sodium arsenite is an economical and effective chemical for submersed weed control in still waters.

Many species of submersed weeds, as well as some floating and emergent plants, are reduced or destroyed by sodium arsenite treatments. Control of over-abundant vegetation is essential for optimum fish production and to the maintenance of recreational assets. It does not appear desirable to eradicate all vegetation from a given body of water, as a certain amount of aquatic plant life is of value to the fishery.

Dosages Required: In small lakes and ponds (2 acres and less), during the warm growing season, 4 parts arsenic trioxide per million parts of water will kill even the heaviest growth of plants in both hard and soft waters. If weeds are not too dense, 2½ parts per million (ppm.) will generally give good results. Use 5 ppm. for lakes ranging from 2 to 10 acres in size, when treated in their entirety.

In large lakes it is often desirable to clear localized areas along the shoreline, cut channels through weed beds to give boats access to deeper water, and control vegetation around piers and swimming areas. A minimum area suitable for treatment is 200 feet by 200 feet, except where smaller areas are largely land-bound. Use 7½ ppm. for shoreline areas protected from wind and wave action and having an average depth not exceeding 5 feet and a maximum depth not exceeding 8 feet. Use 10 ppm. for shoreline areas exposed to wind and wave action and having an average depth not exceeding 8 feet and a maximum depth under 10 feet. Areas with greater depth are not suitable for treatment. Most large lake treatment-areas can be best treated with 10 ppm.

Ponds having continuous overflow, or those likely to overflow, must have their water levels lowered to prevent loss of treated water for at least 3 days. Ponds fed by large streams should not be treated because the sodium arsenite may be diluted and carried out of the pond before weeds are affected.

How to Calculate Volume of Water and Chemical Required: Before making any treatment, it is necessary to know the cubic foot volume of water to be treated. The average length multiplied by the average width of the body of water gives its surface area. This area multiplied by the average depth gives the volume of water. For simplicity, measurements should be expressed in feet; then the volume of water calculated will be in cubic feet.

Parts As_2O_3 Per Million	Gals. of Atlas "A" Required to Treat 1 Acre of Water (43,560 sq. ft.) At Indicated Depths and Parts Per Million							
Parts of	Depth of Water in Feet							
Water (ppm.)	1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.
2½ ppm.	1.7 g.	3.4 g.	5.1 g.	6.8 g.	8.5 g.	10.2 g.	11.9 g.	13.6 g.
4 ppm.	2.7 g.	5.4 g.	8.2 g.	10.9 g.	13.6 g.	16.3 g.	19.0 g.	21.7 g.
5 ppm.	3.4 g.	6.8 g.	10.2 g.	13.6 g.	17.0 g.	20.4 g.	23.8 g.	27.2 g.
7½ ppm.	5.1 g.	10.2 g.	15.3 g.	20.4 g.	25.5 g.	30.6 g.	35.7 g.	40.8 g.
10 ppm.	6.8 g.	13.6 g.	20.4 g.	27.2 g.	34.0 g.	40.8 g.	47.6 g.	54.4 g.

Parts As_2O_3 Per Million Parts of Water (ppm.)	Cu. Ft. Water 1 Gal. Atlas "A" Treats
2½ ppm.	25,640 cu. ft.
4 ppm.	16,025 cu. ft.
5 ppm.	12,820 cu. ft.
7½ ppm.	8,550 cu. ft.
10 ppm.	6,410 cu. ft.

How to Mix and Apply: Sodium arsenite sprays should be diluted with enough water to give uniform coverage of the area to be treated - the dilution rate depends largely on the type of equipment used for application. As a rule, the more the spray is diluted, the better the coverage.

Good results depend on sufficient chemical and its even distribution in the water. Once treatment is started on a given area, it should be finished as expeditiously as possible. Any delay will cause some decrease in the concentration of chemical already applied; this may influence results.

Sprayers of various types may be used. For large areas the use of a power sprayer is advisable. This equipment consists of a reservoir to hold the solution, a pump to draw water from the lake as well as chemical solution from the reservoir, and a nozzle through which the diluted mixture is directed uniformly over the water surface at 40 to 60 pounds pressure. Shoreline areas should be treated first. Fish and other aquatic organisms are repelled by sodium arsenite and are stimulated to leave the treatment area. Where plant growth is very heavy, it is desirable to treat only a section of the weed-choked waters at a time, allowing 5 to 7 days between each treatment. The delay between applications will allow plant decay in the treated section to progress beyond the point of heaviest oxygen consumption before another section is treated. Too rapid decay of vegetation will reduce the supply of oxygen in the water which is necessary for fish life. When this occurs in the entire pond at one time, fish may be killed by suffocation. The hazard to fish through suffocation is greater than the poison hazard. Congregation of fish along the shore or at the surface is an early sign of oxygen depletion; fresh water should be run or pumped in if this occurs.

Weeds Controlled: Sodium arsenite solution gives effective control of:

Pond or Surface Scum including mainly Hydrodictyon, Oedogonium, Cladophora and Zygnema (Algae growing below surface are not greatly affected by sodium arsenite).

Arrowhead (Sagittaria spp.)
Waterplantain (Alisma spp.)
Waterweed, or Elodea (Anacharis canadensis, Michx.)
Hornwort or Coontail (Ceratophyllum demersum)
Parrotfeather (Myriophyllum brasiliense, Camb.)
Water milfoil (Myriophyllum heterophyllum Michx.)
Curly-leaf pondweed (Potamogeton crispus L.)
Pondweed (Potamogeton nodosus, Poiret)
Leafy pondweed (P. foliosus, Raf.)
Fine-leaf pondweed (P. filiformis, Pers.)
Common poolmat or Horned pondweed (Zannichellia palustris)
Naiad (Naias flexilis and guadalupensis)
Wildcelery (Vallisneria americana)
Water stargrass or Mud plantain (Heteranthera dubia, Jacq.)
Water purslane (Ludwigia palustris L.)
Bladderwort (Utricularia gibba L.)
Watercrowfoot (Ranunculus aquatilis L.)
Certain other plants

Note: The use of sodium arsenite, as outlined, kills floating leaves of water lilies but rarely kills their roots. Cattails and lake bulrushes cannot be destroyed with reasonable amounts of sodium arsenite. Chara (Stoneworts and Muskgrass) are likewise very resistant to this chemical, but may be readily controlled by use of copper sulfate at 1 to 4 pounds per million gallons of water.

When To Treat: For best results treat early in the growing season when plants are young and growing vigorously, and before they have reached the fruiting stage. Young plants absorb the chemical more readily and are most easily killed. This will also reduce the possibility of oxygen depletion caused by decay of large masses of vegetation.

Effects of Treatment: A few days after spraying, treated plants turn brown, become limp and sink to the bottom where they begin to decay; with some species detached leaves come to the surface. In the usual course of events, the dead plants remain on the bottom ooze where they gradually disintegrate without objectionable odor. Time required for plants to decay will vary according to density of vegetation, water temperature and oxygen supply. Generally this period is from 10 days to 2 weeks. About 7 to 10 days following the decay, an algal bloom is likely to appear in the treated area. This lasts a short time and usually requires no treatment. However, if it appears serious, an application of copper sulfate should destroy it.

One application of sodium arsenite should control weeds for a summer. It does not kill the seeds or prevent encroachment from surrounding waters; therefore treatment is likely to be needed for at least 2 years and again when weeds have become re-established.

There are no harmful effects to fish from the use of sodium arsenite as described, since higher concentrations or longer exposure are required to kill fish. Fish and some aquatic organisms are repelled by sodium arsenite and tend to move out of treated areas; thus they are exposed to the chemical for only a short period of time. Furthermore, the chemical is progressively decreased by diffusion into untreated areas by wave and current action, also absorption by plants and bottom mud.

To the best of our knowledge, the use of sodium arsenite for aquatic weed control is not hazardous to waterfowl.

Precautions: It is considered good practice, as a safety measure, to advise against the use of treated water for bathing, watering lawns, or animals, or for any other purpose for a period of 3 days following treatment. At the end of that time the chemical should be sufficiently dissipated by dilution and absorption to make similar precautions no longer necessary. Cattle and other grazing animals should be excluded from the treated area until rains have washed the shore vegetation. Although domestic animals would probably not drink enough of the treated water to be injured, it is almost impossible to spray a pond thoroughly and not leave a certain amount of poison on the shore plants. Stock may be attracted by the salty taste and eat enough of the treated shoreline vegetation to be poisoned.

In treatment of the shoreline strip, care should be used so that trees, shrubs and other desirable plants growing on the bank will not be sprayed. Rice plants are extremely sensitive to arsenic; it is suggested that no arsenical treatment be made in waters intended for use in rice culture.

State laws vary regarding chemical treatment of waters; therefore, it is suggested that parties concerned acquaint themselves with the provisions of their state law and local regulations before undertaking chemical treatment for aquatic weed control.

Package Sizes and Prices

	Price
53 gallon drums	\$.82 - \$1.40 gal.
30 gallon drums	
5 gallon drums	
1 gallon cans, 4 in case	

DB GRANULAR AND UREABOR

D. W. Rake
Pacific Coast Borax Co.
Los Angeles, California

Recent herbicidal developments of Pacific Coast Borax Co. include "DB" Granular and "Ureabor."

"DB" Granular is a sodium borate-2,4-D acid complex, consisting of 90.5% sodium borates and 7.5% 2,4-dichlorophenoxyacetic acid (2,4-D). This is a free-flowing, dust-free, granular herbicide designed for dry application. "DB" Granular is registered for sale in the United States and Canada as a nonselective herbicide and designed primarily for the control of deep-rooted perennial herbaceous weeds. The range of application is 1 to 3 lbs. per 100 sq. ft. This range of application has given satisfactory control of such species as wild morning glory (Convolvulus sp.), hoary cress, Canada thistle, Russian knapweed, whitehorse nettle, leafy spurge, toadflax, etc.

"DB" Granular sells for 8 3/4 cents per pound, F.O.B., our plant, Wilmington, California, in carload quantities. Thus, the cost of material per 100 sq. ft. would range from 8 3/4 cents to 26 1/4 cents, or approximately \$38.00 to \$115.00 per acre. "DB" Spray Powder, a formulation similar to "DB"Granular, and designed for water spray application is also available in limited quantities. The price of this formulation is approximately 12 cents per pound, F.O.B., Wilmington, California.

"Ureabor" is a sodium borate-3 p-chlorophenyl 1,1-dimethyl urea (Telvar) complex consisting of 94.0% sodium borates and 4.0% substituted urea (active). This is also a free-flowing, dust-free, granular herbicide for dry application. "Ureabor" is registered for sale in the United States and Canada as a nonselective, general purpose herbicide. "Ureabor" is recommended for the control of both weeds and grasses, particularly on industrial sites and right-of-ways. The suggested rate of application is 1/2 to 2 lbs./100 sq. ft. with the higher rate applicable for control of perennial species or where the annual rainfall exceeds 35 to 40 inches. "Ureabor" sells for 22 1/2 cents per pound, F.O.B., Wilmington, California, in minimum carload quantities. The cost per 100 sq. ft. ranges from 11 1/4 cents to 45 cents.

Both "DB" Granular and "Ureabor" are so formulated that the herbicidal efficiency of borates and the organic component have been incorporated into one single herbicide. It has been proven the borate addition preserves the action of the organic component by inhibiting the breakdown and decomposition by soil microorganisms. These formulations further eliminate the necessity of expensive application equipment.

These dry granular concentrated formulations are unique in offering the user accurate and low-cost application. While hand spreading is safe and easy, we have developed the PCB Spreader which sells for less than $15.00 per unit, and which permits one man to effectively treat an area in the same time formerly required with heavy, expensive, and cumbersome spray equipment. A single man using the PCB Spreader and the newly developed granular herbicides is equivalent in operation to a spray crew.

ERBON (BARON) AND PRESENT STATUS OF DALAPON

R. N. Rayner
The Dow Chemical Co.
San Francisco, California

I have two compounds to cover so this will necessarily be a very brief discussion on each one. I would like to first say a few words about dalapon. Dalapon is the coined common name for 2,2-dichloropropionic acid. This is a systemic grass killer which when applied to the foliage of grasses as a spray is absorbed and translocated. In perennial grasses with deep rhizome systems, such as bermuda, Johnson and quack, the material is moved into the root system and results in the death of the underground portions of the plant as well as of the foliage. Dalapon is availabe in two formulations, one under the trade name Dowpon, for agricultural use and the other under the trade name of Radapon for industrial use. These are both formulations of the sodium salt of dalapon. Dowpon, the one available for agricultural use, is at the moment registered for only one crop, and that is sugar cane. We do have application in for registration, at least on an experimental label basis, for use of Dowpon on sugar beets. That has not yet been issued. Dalapon is primarily a grass killer. It does have some effect on broadleaf weeds and on broadleaf crops. The primary action is against grasses. It is effective against both annual and perennial species. The dosage required for the different annuals is considerably less than that required for the control of the majority, at least, of perennials. On annual species, such as barnyard grass, pigeon grass, annual brome, and annual hordeums, dosages in the range of 5-10 lbs. per acre are effective. Application on these species is preferably made in the fairly early seedling stage, or at least before the seed stock has started to emerge. Once the plants start to head, dalapon may not completely inhibit heading and seed formation. On most perennials, the dosage required is in the range of 20 to 40 pounds per acre. There are indications that the dosage is preferably applied in a split application, instead of applying the full dose, say 40 pounds, at a single spraying. A greater efficiency of the chemical is obtained by applying half of it in the initial application and the other half in a later application as regrowth indicates. As a matter of fact, there are indications that instead of applying the second half dose, that this may be reduced somewhat over the amount that was originally applied; that however, is only in the experimental stage at this time. On some perennial grasses, in particular quackgrass, tillage following spraying may increase the effectiveness of the chemical over the spraying alone. Toxicological studies with dalapon have been completed and show that dalapon is less toxic than common salt. In fact it is one of the least toxic to mammals of the many pesticides that are now being offered for current use. The acute LD 50 for rats, guinea pigs, rabbits, mice, chicks and steers is in the range of 3 to 8 grams per kilogram of body weight. The chronic two year feeding tests on rats show that they can tolerate without effect a dosage level of at least 50 mg. per kg. per day. Dogs tolerated the same daily dosage in tests carried out over one full year. Dalapon as in the formulations of Dowpon and Radapon will be available in good supply in 1956. The cost to the grower is approximately $1.00 per pound.

Erbon is the coined common name for the chemical 2(2,4,5-trichlorophenoxy ethanol) 2,2-dichloropropionate. In simpler terms, it is the dalapon ester of 2,4,5-trichlorophenoxyethanol. It is primarily a soil sterilant compound, non-selective in action. At the present time Dow is offering this compound as a formulation under the trade name of Baron. Baron contains four pounds of technical erbon per gallon. Although Baron is primarily a non-selective soil sterilant chemical, it does have some foliage-absorption, systemic effects, mostly on grasses. The systemic effect from foliage absorption on broadleaf plants is very minor. The formulation Baron is registered for use on non-agricultural land as a non-selective herbicide. At dosages in the order of 10 gallons of Baron per acre, it gives residual control of germinating weeds for periods of several months to a year or more depending largely on the rainfall. At 20 gallons per acre, it is effective on certain deep rooted perennial weeds when the amount of rainfall following application is sufficient to leach it to the depth of the root system. For example, on bindweed, 20 gallons of Baron per acre followed by 12-15 inches of rain will generally result in effective control. Some perennial grasses, Johnsongrass for example, may require somewhat higher dosages than the 20 gallons that I mentioned for bindweed. Thirty gallons would be suggested for use where Johnsongrass is the problem which is being attacked.

Concerning the drift hazard of this compound, it should be pointed out that it is 2,4,5-trichlorophenoxyethanol and not 2,4,5-trichlorophenoxyacetate which is in this compound and that the ethanol has very very low foliage activity. In tests conducted by spraying tomatoes in the greenhouse, several hundred parts per million of Erbon were required to produce any effect whatsoever and in field tests on cotton there were no observable symptons nor any reduction in the yield from spraying at rates of as much as one pound of erbon per acre in the Baron formulation. Baron is available at cost to the grower of approximately $6.60 per gallon.

HC-1281 OR 2,3,6-TRICHLOROBENZOIC ACID

Ely Bagley
Heyden Chemical Corp.
New York, N. Y.

Thank you for inviting me to serve on your panel to discuss "What's New in Weed Control." We welcome this opportunity to bring you up-to-date on HC-1281, trichlorobenzoic acid herbicide.

HC-1281 is Heyden's designation for a technical grade of 2,3,6-trichlorobenzoic acid. It is distinctly different from other varieties of chlorinated benzoic acids since the principal ingredient is the 2,3,6 isomer.

It has been established by experimental work over a period of years that this isomer is the most active. Other isomers have been shown to possess only slight or moderate herbicidal activity.

HC-1281 is presently in the research and development stage. Cooperators throughout the country who have worked with this herbicide have become intrigued with its possibilities and expressed a strong interest in this material. Therefore, the material will be made available to experiment stations and other organizations for continued development work. We are looking forward to further widespread and large scale development tests during the coming growing season, the third for HC-1281.

HC-1281 shows excellent promise for use in brush control and soil sterilization. We encourage further evaluation of HC-1281 for weed control along rights-of-way, roadsides, factory sites, and pipe lines. We have found effective weed control with long residual activity using HC-1281 alone or in combination with other herbicides, such as the ureas, amino-triazole, and grass killers. For this use we suggest rates of 10 to 30 pounds per acre depending upon the density of the stand and the varieties present.

Since your area is reported to produce 18% of the cattle in the nation, pasture renovation is no doubt important to you. Low rates of HC-1281, that is, 1 to 3 lbs. per acre, are effective in controlling pasture weeds, especially the broad leaves, without injuring the desirable grasses. The persistence of this herbicide in the soil and in the plant is of particular value in this use. HC-1281 has been reported to be effective against halogeton, mesquite, yaupon, and a number of other undesirable pasture species. Work in this direction is progressing and we look forward to receiving further information which we hope to share with you.

HC-1281 is very interesting for forestry applications. Ash, oak, cherry, elm, hickory and red maple among others have been found to be susceptible to HC-1281. The herbicide was applied as a basal or foliar spray, or in some cases, by soil injection. An impressive amount of work has been laid out by cooperative foresters, the results of which will become available as time goes on.

A crop use for HC-1281 which has been investigated in some detail in weeding of corn. One-half to two pounds per acre, applied as a pre-emergence spray has resulted in outstanding weed control and increased yield. As in the case with most other herbicides, higher dosages caused injury. Post-emergence sprays and lay-by sprays, while effective, do not appear to do as good a job as a pre-emergence application. Mixtures of HC-1281 with chloracetamides have done a successful job in New Jersey, Indiana and other places in controlling both grasses and broad leaves without crop injury. It would not surprise us if mixtures of HC-1281 with other herbicides result in better overall economy and weed control.

Other crop uses for HC-1281 include weeding onions and rice. These crops have been reported to be quite tolerant. We hope to investigate these uses more fully this season. Sorghum is also very resistant.

Your Committee has requested information on the approximate cost for HC-1281. Until a good deal more experimental work is completed, we shall not be in a position to draw up a price schedule. Everything possible will be done to assure a competitive price structure.

Please feel free to ask any questions you wish. We are currently preparing a new detailed brochure on HC-1281 which will contain much more information than I can give you in the short time allotted to me. When it is ready for distribution, we shall be glad to send you a copy.

DICHLORAL UREA

Robert J. Zedler
Carbide & Carbon Chemicals Co.
New York, New York

I. Name: The trade name of dichloral urea is CRAG Brand DCU, 73W. Our formulation is a wettable powder which contains 73% dichloral urea.

II. Uses and Status: CRAG DCU, 73W is an annual grass seed toxicant. Sugar beets, table beets, onions and cucurbits exhibit tolerance to the compound. The use of CRAG DCU, 73W on sugar beets is the only one registered. All others are experimental only.

III. Results - Sugar Beets: CRAG DCU, 73W has been tested since 1951. Successful results have been reported from Colorado, Wyoming, Oregon, Michigan and Ohio. The bulk of testing, however, has been done by the Great Western Sugar Company in Colorado and by the University of Wyoming. These tests show that CRAG DCU, 73W will control foxtail, barnyard or water grass, volunteer grains and wild oats for two to three months.

Rates of ten to twenty pounds per acre broadcast are suggested. The higher rates should be used under more arid conditions. We are recommending band applications, however, which reduces the chemical necessary to two and a half to five pounds per acre. Best grass control can be obtained with CRAG DCU, 73W if it is mixed with the soil just prior to planting. In order to do this in bands, the use of a Howry-Berg Spray-Tiller is suggested.

IV. Cost: The suggested grower price of one pound of CRAG DCU, 73W is $1.33. When using 2.5 pounds per acre, the per acre cost for material is just $3.33.

VAPAM - A GENERAL SOIL FUMIGANT

Joe Antognini
Agricultural Research Laboratory
Stauffer Chemical Company
Mountain View, California

VAPAM is the registered trade-mark for sodium methyl dithiocarbamate and has been offered as a common name to the American Standards Association. In pure form this compound is an unstable white crystalline solid. It is highly soluble in water, stable in concentrated aqueous solution and highly unstable in dilute aqueous solutions.

The fumigating action results from the production of a volatile end product when VAPAM comes in contact with moisture. The volatile end product diffuses through soils in a similar manner to other common soil fumigants. The rate and depth of penetration into soils and the rate of escape from soils is dependent upon such factors as soil type, method of application, rainfall after application, etc. Under most conditions crops can be safely planted 14 days after treatment. The conditions under which phytotoxicity will persist for a longer period of time are similar to those which result in long persistance of other fumigants.

VAPAM 4-S a 4 lb. per gallon aqueous solution of sodium methyl dithiocarbamate dihydrate is being marketed at the present time. After initial dilution and mixing of VAPAM 4-S for application continuous agitation in the rank is not necessary.

FEDERALLY REGISTERED for treatment of soils prior to their use for ornamental crops, vegetable transplant beds, turf and tobacco. Extensive residue analyses show that there are no residues in edible crops and extension of registration to include treatment of soil where food crops are to be grown is expected in the near future.

HERBICIDAL ACTION OF VAPAM is non-specific and non-systemic. It is relatively inactive as a contact herbicide but in soil it is highly active against roots, rhizomes, tubers, corms, and seeds except those which are dormant. As a result of its high activity in soil VAPAM is ideally suited for controlling an existing stand of vegetation while at the same time destroying seeds, rhizomes, etc. in the soil. In the control of hard to kill weeds such as Russian Knapweed and Bermuda grass special methods of application are required.

METHODS OF APPLICATION are numerous due to the water solubility and fumigation action of the compound. Although VAPAM is a fumigant a tarp or other similar material as a seal is not required. With surface applications where VAPAM 4-S is diluted, the water in which it is applied will act as a seal. With injection of undiluted VAPAM 4-S moist soil and rolling will act as a seal. Some of the more important methods of application and where each can be used economically are given below.

1. Sprinkling can - Home gardens (vegetable and ornamental), seed beds and any small area not suitable for the use of large equipment.

2. Hoz-on type applicator - Same area of use as above.

3. Sprays - Concentrate sprays and dilute sprays are suitable to small as well as very large areas. When concentrate sprays are used additional water must be applied immediately but with dilute sprays (300-600 gals./acre) no additional water is necessary.

4. Injection - Overall field application using relatively deep (6-12") injection and for bed top treatment using shallow (2-4") injection.

5. Irrigation - (a) Sprinkler irrigation for large and small areas where it is convenient to inject VAPAM into the sprinkler system. (b) Flood irrigation also for both large and small areas where deep penetration is desired.

With all methods except injection the depth of penetration depends directly on the amount of water applied. On most soils VAPAM will move 4-6" beyond the depth to which the water has penetrated. With injection the depth to which seeds, rhizomes, etc. are killed depends upon the depth of injection.

RATES OF APPLICATION in terms of VAPAM 4-S, the only formulation on the market, vary from 25 to 75 gallons per acre depending mainly upon the method of application, weeds, weed seeds, etc. to be controlled and depth to which control is desired. For control in the top 4-6" of soil 25 gallons per acre is sufficient. Where deep weed kill is desired 75 gallons per acre is required. At first the above rates appear high in comparison to rates of most other herbicides but are not prohibitive when one considers the following facts.

1. Seeds, roots, rhizomes, tubers, and corms are killed.
2. In addition to weed control soil insects, fungi, and nematodes are controlled.
3. It is not necessary to treat the entire area, i.e., bed tops or bands on the bed tops can be treated.
4. No special equipment is required which is important to all users and particularly to the user who is treating a small area.

COMMERCIAL USES are many and varied, some of which are listed below.

1. Home gardens - Home gardeners have found VAPAM to be an excellent shotgun treatment for a host of troublesome pests.

2. Nurseries - Nurserymen have found VAPAM to be a useful tool in sterilizing potting soil, greenhouse beds and in field planting.

3. Flower culture - Field flower growers have proven that the weed control obtained pays for the cost of treatment and in addition they receive the additional benefits mentioned above.

4. Vegetable transplant beds - Growers of transplants are incorporating VAPAM into their program to obtain weed, nematode, and disease free plants.

5. Turf - Landscape contractors are using VAPAM for soil preparation prior to seeding new turf and for the removal of old weedy and diseased turf.

In 1955 a high percentage of the VAPAM 4-S sold was purchased by small users who were inexperienced in the use of soil fumigants. Even with this type of trade practically all applications were very successful

PACKAGE SIZES OF VAPAM 4-S being marketed at the present are 1 gallon jugs for the home garden trade and 5 and 30 gallon drums for commercial users. Stauffer produces and packages VAPAM 4-S at Richmond, California, and at Chauncey, New York.

COST OF VAPAM 4-S to the consumer in the west is \$3.00/gallon in 30 gallon drums and \$5.60/gallon in 1 gallon jugs. On an overall acre basis the cost to the consumer is \$75.00 to \$225.00.

CDAA and CDEC

K. E. Maxwell
Monsanto Chemical Co.
Santa Clara, California

NEW PRE-EMERGENCE HERBICIDES

This discussion includes two chemicals of similar activity. Both of them are effective as pre-emergence herbicides. The first one, which is in the most advanced stage of development, is as follows:

CDAA

Chemical Name and Trademark

The new herbicide which has been referred to as CDAA is representative of a group of compounds, the chloroacetamides. CDAA is the abbreviated designation for α-chloro-N,N-diallylacetamide. CDAA formulations are being sold under the trademark RANDOX* by Monsanto Chemical Company.

Status

RANDOX is being sold during 1956 in a restricted area. Research and development studies are also in progress in certain geographical areas including the West Coast and on certain phases pertaining to expanded uses for the compound.

Uses

RANDOX (CDAA formulation) has received federal registration for use as a pre-emergence herbicide for control of grassy weeds in corn grown for seed and certified soybean seed products. It is being sold in the Mid-West only for those purposes during the 1956 season. Residue studies are in progress which are expected to lead to tolerances or exemptions for use of the compound on food crops.

Results

Dosage. Rates of 3 to 6 pounds per acre are effective. The compound remains herbicidally active 4 to 6 weeks, depending upon soil and seasonal conditions.

Weeds Controlled. RANDOX eliminates weedy grasses, some of them not controlled by other pre-emergence herbicides. It is also active against some broadleaves. Susceptible weeds are as follows. Among the grasses: annual bluegrass, watergrass, crabgrass, foxtail species, stink grass, wild oats. Among the broadleaves: carpet weed, pigweed, purslane, velvet weed, lambsquarters.

Crop Use. RANDOX causes relatively little crop damage to a wide range of crop plants even when the material is applied at twice the normal rate for effective weed control. Weeds are killed during the earliest stages of growth thereby preventing unnecessary losses of moisture and nutrients from the soil during a critical stage in the growth of the crop. Crops which are resistant to pre-emergence treatments of RANDOX are as follows: asparagus,

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* RANDOX, Reg. U. S. Pat. Off. by Monsanto Chemical Company

beans, beets, broccoli, carrots, corn, cotton, flax, onions, peanuts, radish, soybeans, spinach, sugar cane, turnips. Crop plants which have been damaged slightly by this compound at 12 pounds per acre are: alfalfa, birdsfoot trefoil, ladino, red clover and tobacco. Crops which have been severely damaged by the compound are: cucumber, watermelon and cantaloupe.

Effect of Soil Type

RANDOX is unique among pre-emergence herbicides in that it works well in heavy clay soils and soils high in organic matter. CDAA is moderately water-soluble and is quickly adsorbed on clays without loss of herbicidal activity. This prevents leaching and reduction of effectiveness because of dilution.

Residues

Preliminary tracer studies revealed no toxic residues in crop plants. There is no evidence to date that repeat treatments would result in accumulation of toxic residues in the soil. In fact, on the basis of known chemical decomposition such would not be expected.

Mammalian Toxicity

The toxicity of RANDOX is about the same as for 2,4-D. Irritation to eyes and cold sensitivity to skin, while disagreeable if care is not exercised, have not been objectionable in commercial applications and do not represent a hazard to health.

Cost

It contains CDAA formulated as a 4-pound-per-gallon liquid concentrate which sells for $13.50 per gallon. Applied at the flat rate of 4 pounds per acre in a 13-inch band, the cost is approximately $4.50 per acre.

CDEC

Name

The other compound also having pre-emergence activity has been referred to as CDEC, a member of the dithiocarbamates. CDEC is 2-chloroallyl diethyldithiocarbamate.

Status

The compound is in a research and development stage.

Uses

The compound has not yet been registered for sale.

Results

Dosage. The compound is effective at slightly higher dosage rates than CDAA, usually in the range of 4-12 pounds per acre. The compound differs, however, in certain important properties and in its activity against specific weeds and crops.

Weeds Controlled. CDEC is similar to CDAA in its herbicidal action in that it is primarily active against germinating grasses with an appreciable measure of activity, however, against some of the broadleaves.

Crop Use. Some crops are highly resistant to injury, for example, 80 pounds of CDEC in the laboratory gave no injury to corn root and 40 pounds gave no root damage to soybeans. It is promising for pre-emergence control of weedy grasses in horticultural crops in regions of high rainfall. High moisture and light soil types are favorable for maximum activity of this type of compound although CDEC will work on heavy soils provided ample moisture is present.

Cost. CDEC is not on sale at the present time. The price is expected to be within the economic range of utility.

Table No. 1

RANDOX - KNOWN WEED AND CROP TOLERANCES

A. WEEDS - Susceptible

1. Grasses

a. Annual bluegrass - *Poa annua*
b. Watergrass - *Echinochloa crusgalli*
c. Crabgrass - *Digitaria sanguinalis*
d. Foxtail species (all) - *Setaria* species
e. Stinkgrass - *Eragrostis cilianensis*
f. Wild oats - *Avena fatua*

2. Broadleaves

a. Carpetweed - *Mollugo verticillata*
b. Pigweed - *Amaranthus retroflexus*
c. Purslane - *Portulaca oleracea*
d. Velvet weed - *Abutilon theophrasti*

B. CROPS - All results based on pre-emergence treatments except those marked "B", which means both pre- and post-emergence applications were applied.

1. Resistant

a. Asparagus (B)
b. Beans (lima and snap)
c. Beets (table and sugar)
d. Broccoli
e. Carrots
f. Corn (field and sweet) (B)
g. Cotton
h. Flax
i. Onions (B)
j. Peanuts
k. Radish
l. Soybeans
m. Spinach
n. Sugar cane
o. Turnips

2. Damaged slightly by acetamides at 12 pounds per acre

a. Alfalfa (B)
b. Birdsfoot trefoil (B)
c. Ladino (B)
d. Red clover (B)
e. Tobacco (B)

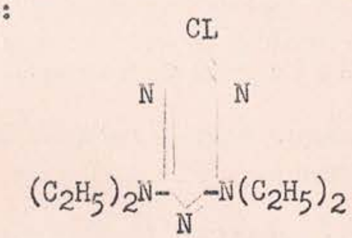
3. Severely damaged

   a. Cucumber
   b. Watermelon
   c. Cantaloupe

GEIGY 444

Vernon W. Olney
Geigy Co., Inc.
Fresno, California

CHEMICAL AND PHYSICAL PROPERTIES: Geigy 444 is 2-chloro-4,6-bis-(diethylamino)-s-triazine and has the following structure:



The pure material is a clear liquid with a slight odor.

MELTING POINT: 27°C.

SPECIFIC GRAVITY: 1.0956

SOLUBILITY: Geigy 444 is insoluble in water. It is readily soluble in the following solvents: Zylene, 95% Alcohol, Acetone and Chloroform.

FORMULATION: Geigy 444 is formulated as a 4 lb. per gallon emulsion concentrate. It is easily mixed with water, forming a milky white emulsion. It mixes well with fuel oil.

TOXICOLOGY: The acute oral LD_{50} of Geigy 444 to mice and rats is 1800 mg./kg. and 1950 mg./kg., respectively.

STATUS: Geigy 444 was tested by over 100 cooperators in 35 states, Alaska, Canada and Puerto Rico. It was tested on 40 different crops and numerous weeds both broadleaved and grassy. Listed below are the crops which have been included in tests throughout the country. In many cases only one test is represented.

A. Crops on which Geigy 444 has looked promising:

   Pre-emergence: gladiolus, snap beans, sugar cane, potatoes, black wheat.

   Post-emergence: tomatoes, fall fescue, Sudan grass, common rye grass.

   Pre- and Post-emergence: cotton (directed), vetch (low rates), carrots, barley (low rates), corn.

B. Crops on which results with Geigy 444 are doubtful either because of only one report or conflicting reports:

Pre-emergence: spinach (2# only), peanuts, broccoli, lima beans, peas, soybeans, creeping red fescue.

Post-emergence: brush control, red clover.

Pre- and Post-emergence: wheat, oats, orchard grass.

C. Crops which have been injured by Geigy 444 and which are not recommended for further work:

Pre-emergence: sorghum, cabbage, turnip, squash, lettuce, Lacino-clover, Lespedeza, brussel sprouts, cauliflower, mustard, cucumber, alfalfa.

Post-emergence: lawn grass.

Weed control in most of the tests represented above was very good - especially broadleaf weed control. Grassy weed control was poor in some areas and fair to good in others.

Dosages varied from 2 to 16 lbs. per acre with 4 to 6 lbs. being an average dosage.

This compound is strictly experimental and no costs have been determined as yet.

MILLER BILL WITH RESPECT TO THE CALIFORNIA PESTICIDE LAWS

Allen B. Lemmon
Chief, Bureau of Chemistry
State Department of Agriculture
Sacramento, California

The effect of the Miller Bill has been rather well illustrated by the panel members here tonight. You have heard them mention chronic toxicity tests, as well as acute toxicity tests on animals for the new herbicides. They have mentioned, with considerable pride, that analytical methods for these new materials are being developed and they mentioned residue data. This information is needed for enforcement of our spray residue law in California.

We will have the same tolerances under our spray residue act as the Federal Food and Drug Act will have as a result of the Miller amendment, and we will follow along in our registration of economic poisons on the same basis as that of the U. S. Department of Agriculture. It seems to me that the Miller amendment helps us get some of the information that we have been trying to get for a long time.

In years gone by, I think that you have heard the claim made by certain railroads that where sodium arsenite was used along right-of-ways, they were the largest buyers of high-priced prize stock in the whole State. The same thing has taken place when some of these new chemicals have come into use as herbicides and a cow dies over in a neighboring pasture, even though it seems certain that there has been no drift. Without adequate analytical methods and with insufficient evidence on the actual toxicity of the chemical, it has been rather hard to prove responsibility.

Now there are one or two problems for which we are going to need some answers. One of them is, what is going to be done about tolerances in meat, eggs, and milk? The Food and Drug Administration has announced the policy of allowing no pesticide residue whatever in milk. The tolerances to be permitted in meat and eggs are under consideration. Conferences are being carried on and the matter is being discussed.

There is another item that we think definitely will have to be determined. The present policy seems to be to set up a tolerance for each chemical on the basis of each individual crop. Proposals have been made to establish tolerances on groups of crops. With a State as large as ours, and the same thing applies to much of the West, we need tolerances to be based on groups of crops rather than for each individual one. As we secure more information, we are hopeful that it can be applied from one crop to the next, so it won't be necessary to make residue studies on every chemical on every crop.

The other item that may be of particular interest has to do with defoliants. Many of the same firms that are handling herbicides are also handling defoliants. Defoliants do not come under the Federal Pesticide Act but their residues do come under the Federal Food and Drug Act. They do come under our California pesticide laws. The Miller Act procedure for securing federal tolerance does not apply to the defoliants. How can we get such tolerances set up? The only way is under the old basic act which is by public hearings. One other answer would be an amendment to the Federal Pesticide Act to require registration of defoliants and desiccants the same as herbicides and other economic poisons. Then the Miller Act procedure could apply. This is something to think about and the inclusion would help bring the Federal Pesticide Act in accordance with what we have found out here in the West works fairly well.

GLENN COUNTY EXTENSION WEED PROBLEM

Milton D. Miller
Extension Agronomist
University of California
Davis, California

We have found it highly productive and mutually beneficial to cooperate closely with P. V. Harrigan, our Glenn County Agricultural Commissioner, and his staff, and with chemical companies, in Extension weed control activities in Glenn County. In practically every instance our tests and demonstrations have been done cooperatively with the Commissioner's staff.

During 1955, a total of 18 large scale weed control tests and demonstrations were carried on in Glenn County. During the past six years, approximately 187 such tests have been carried out.

Most of the materials used have been supplied gratis by the chemical companies. Our records show that in 1955 we were supplied with $628.05 worth of chemicals by firms in California for use in our field tests and demonstrations. You will realize how important a contribution this is when you consider that our total budget for test plot materials is only $500 annually. At least another $1500 was expended in time of Extension and research people and others in conducting these trials. In addition, the equivalent of 75 man-days were spent directly working with farmers on weed educational matters. Our general program is developed in cooperation with W. A. Harvey, Extension Weed Specialist on the Davis Campus.

In our opinion, our most effective way of implementing a new method of weed control is via field tests and demonstrations in the field on a few of the key farms of the county. For example, most of Glenn County's 8,000 acres of ladino for seed are annually sprayed each spring with 12 ounces amine 2,4-D directly as a result of local tests and demonstrations on three farms in 1949. In 1955, we had the following tests and demonstrations underway.

1. Pelleted IPC was used on the Elmo Ellis ranch, Artois, as a means of controlling winter grasses. Six pounds of technical IPC applied as 15% pellets increased seed yields 200 lbs. per acre. Pelleted IPC and IPC emulsion, when applied on January 17 to ladino clover planted in late October the previous year, did not damage the seedling clover (in the three to seven leaf stage) at time of application.

2. Dalapon, when applied at the rate of 5.1 lbs. per acre, seriously injured the ladino clover on two ranches in tests and did not significantly increase seed yields over the untreated grassy blocks, although the grass was eliminated from the treated blocks.

3. Chloro IPC pellets applied May 1 cut watergrass infestations in ladino clover seed fields by 75% on three ranches.

4. Pelleted Sesin, when tried on three ranches in the county, did not prove effective in controlling watergrass seedlings, when used at the rate of 10 lbs. 5% pellets per acre and 5 lbs. 5% pellets per acre.

5. Alfalfa weeds - Burning summer weeds in between cuttings gave effective control when an initial burn was used to wilt the alfalfa fields followed by a re-burn in about three days. The total cost of the two burns was $7.50 per acre. The burning operation delayed the ensuing cutting about two weeks, although plant vigor was stimulated. Dalapon, when used at rates of 6.5 lbs. per acre in 50 gallons water very effectively controlled watergrass and pigeongrass in alfalfa when applied in between second and third cuttings. The cost of this treatment was $9.20 per acre. The alfalfa showed no injury sumptoms.

6. Soil Sterilants - Four demonstrations were conducted in the county using various soil sterilants. These were done in cooperation with the County Road Department on road corners where weeds had proven to be a travel hazard and with Storm Drain Maintenance District No. 1, and on one individual farm. Although effective on annuals, CMU is not proving effective in controlling deep-rooted perennials such as Johnsongrass and Dallisgrass although it has proven effective in the control of tules and cattails in drainways. A combination material of CMU and deeper penetrating soil sterilants such as the borates has given best control of troublesome annual and perennial weeds on such sites.

7. Medusa head is a serious range weed and has been successfully controlled by plowing or discing under the weed just before it sets seed. The area is then fallowed during the summer and seeded to annual legumes in the fall. Phosphorus type fertilizer applied at legume planting time at the

rate of 40 to 60 lbs. actual phosphate per acre has insured more vigorous legume growth and better control of the weed.

8. Alkali Mallow was selectively controlled in Piper Sudangrass seed crop in the Willows area using Weedone 638 at the rate of 1 lb. actual emulsive acid in 100 gallons water per acre. The chemical was applied when the sudan was approximately 10 inches tall.

INDUSTRY: WEED CONTROL - WHAT IS BEING DONE AND WHAT IT COSTS

A. O. Jensen
American Cyanamid Co.
Oakland, California

The question of what industry is doing to better the problem of weed control in the State of California and the western states can probably be summed up in these words - competition, progress, and profit. The extent and degree of work that industry will do towards new obtaining chemicals, new uses of old chemicals, and improved uses of chemicals is hinged directly to profit.

Industry's research program is closely, but not entirely, correlated with the profits of chemicals now being sold and the profits forecast for chemicals that look promising. There is much more existence of research purely from the element of risk-taking by the private industry.

With our ever-rising economy research has shown management that it is a necessary investment. Regardless of the size of the industry as companies go, there is no avoiding the fact that research as such directly enhances sales and keeps you abreast and competitive with other companies.

I am sure that anyone here can, at random, pick out any number of chemicals that have been good herbicides and have looked outstanding in a given year or two or three years, and practically overnight have been completely replaced by a new chemical that has swept into the field relatively unknown but outstanding in all of its results. Thus, in short, that tells the story of why industry needs and maintains research. It could be misconstrued that industry maintains research entirely for the purpose of keeping ahead of the competitor, but that is not entirely the case by any means, because industry today has reached a level of thinking that is entirely different than it was twenty years ago (as best as I can obtain information on twenty years ago, because I certainly was not of the age to be thinking about industrial organizations at that time.) But, the economists in the various companies have clearly pointed out to the organization and management that it is to our own best good to be constantly developing new things just for the sake of mankind in general. Anytime that the level of mechanization, chemical use, living, or any other thing that pertains to raising our general stands can be attained, it is for the good of our organization. It really falls back on the fundamental basis that technical improvement increase jobs, money, sales, economy in general.

Prior to ten years ago, you could look at most of the industries that have operated here in the West that are in the agricultural field, and their primary purpose was for sales. They hired men with sales ability. The trend since 1946 has been more away from pure sales and more into servicing sales. This is due to the greater number of chemicals and the need for more precise use of them. If the chemical is good it begins to sell itself, and the farmers soon find it out and make use of it. But it rapidly becomes a problem of servicing and demonstrating, and the need for technically trained men immediately becomes apparent.

It is very hard to obtain any definite figures on the number of technically trained men that are being hired in western areas, but I think some generalizations can be made that point up clearly what the whole trend of industry's part in weed control is pointed towards. Up until 1945 our company, without naming other companies that I have checked into which have been the same, had in their employ generally in the range of 90 to 95 per cent sales people untrained in the fundamentals of agriculture. By that I mean non-agricultural-college graduate. Since 1945 and 1946 almost without exception this has been reversed - the trend has gone toward technically trained men.

Now in the west better than 75 per cent of the men are college graduates and most of the other 25 per cent almost without exception are men with seven to twenty or thirty years of practical experience in the field of agriculture. In other words, industry is simply not hiring men that do not have an agricultural background or many years of experience in dealing with agricultural products. It is not to their good interests as they do not have the training to work with these many new chemicals that are constantly being flooded upon us every day of the year. Nearly all of the major companies in the west that are basic to the west and have grown up here in the west have, in the last five to ten years, put on their staffs, men of highly technically trained nature to deal in the demonstrating and training of the sales personnel on the use of new chemicals. Many of the primarily sales companies here in the west of agricultural products have gone so far as to put on men simply for the purpose of testing new chemicals before they even try to sell them. This does two things for these companies: (1) it determines definitely what they can use the chemical for and proves to them that they can use it, and (2) it gives them the chance to train their own men in the usage of the chemicals, and probably I ought to add a third point which is, it puts them that much ahead of their competing company if they have much of the basic knowledge and test work of the new chemicals behind them.

When I was asked to give this talk, I gave it considerable thought and discussed it with a number of the men who have been in the agricultural industry here in the west for many, many years, and almost without exception they all said that prior to the last world war many of them did not feel the need - the necessity in a great degree - for men of Ph.D. caliber on their staffs. As a matter of fact, they said that they almost considered them a detriment due to the fact that they were strictly a sales organization and couldn't see any place for them. But today this is reversed almost 100 per cent. These companies are eagerly seeking these men and bringing them into industry. And, if you will talk to your college people, they will say that this is no mere dream; it's an actual fact because it is difficult to train men enough to fill the demand.

Right here in your western area I can name six or seven major companies that operate throughout the United States that maintain staffs of technically trained men that come under their own technical division, not in sales at all. Some of these divisions are as high as ten or twenty men just to operate here in the State of California and the western states. These men are doing fundamental research, some are doing transition research from basic laboratories back east, and testing the chemicals in the fields to determine their usage where they might fit, and some of these men are designed strictly for servicing of the sales division, the farmers, and custom operators. It costs real money to maintain this force. They travel widely, thus travel expenses are high, and competition for such help makes for higher wage levels. Taking into consideration travel expenses, company automobile costs, and miscellaneous expenses, it is hard to maintain such a research man for less than $8,000 - $15,000 per year.

One of the big reasons for the trend to this type of personnel is the fact that the farmers are becoming more and more mechanically and chemically inclined due to the high cost of labor. They are simply going over to other uses to eliminate and take care of some of the labor costs. Industry in non-farming and non-agricultural usage can pay the higher price, whereas the constantly dropping farm prices put the farmer in the squeeze of having to figure out alternative methods and the alternative's cheapest methods - the chemicals and mechanical needs, so the farmer is simply trending that way and is going to continue to go that way. Furthermore, this will increase his total efficiency. Thus, the ever-growing tide in this direction is going to continue probably unending. With this tide the farmer expects a lot of attention, a lot of teaching, and a lot of technical know-how, and even more, he expects a tremendous amount of service from his various agricultural companies.

Some local companies working in western states go as far as putting men down onto the level of handling only a certain number of farms in a given area. They may not have the accounts of all these farms, but they are there to service a certain given amount of them. For example, in Kern County they might only take a certain number of farms in the Wheeler Ridge area, this one man is agriculturally trained, has the best knowledge that his basic research men can give him on the chemicals that they have to sell, and he is going out and concentrate on every usage that he can get that chemical into use on these farms. As soon as you have this occurring throughout every area in the western states (where it is occurring more and more every year) the farmer begins very rapidly, in the light of the dropping farm prices, to take advantage of this man and use his knowledge to increase his production and efficiency. Very quickly this man begins to get business where there never was business before. A good example is in the field of control of aquatic weeds. In the past here in the west, it has been mostly a mechanical proposition. People have chained, dredged and drag-lined their canals and ditches for their water supplies year in and year out. It is a costly deal and takes big equipment, much man-power, and it ties up the canal for long periods of time. When this one man in Kern County can come along with two or three chemicals, each one designed for a given set of weeds in the canal, and with the use of a little $200 sprayer spray the whole canal system on the farm in a period of one or two days out of each year, you can immediately see the immediate reduction in the total cost when compared with a $20,000 dragline and many men. This is a good example of newer chemical control of ditchbanks today which can be accomplished with some of the newer chemicals for $15 to $20 per acre. If you go to mechanical control for the same thing it will cost you all the way from $200 to $400 an acre. Well, which becomes the cheapest proposition? It is very obvious immediately that the chemical cost is insignificant. It is the man-power and the time involved that becomes your most costly thing.

The use of this technique in servicing chemicals for weed control is extremely beneficial to the farmer, but just as beneficial to the chemical companies because this means that the chemical is going to be used more properly. The efficiency involved is going to be increased so much and the methods of distribution are going to become so much more clear-cut that there will be no question but what the chemicals are going to get their best tests and best usage under such methods.

THE REGULATORY PHASE OF WEED CONTROL IN CALIFORNIA

Robert M. Howie
Agricultural Commissioner Riverside County

The duties of the regulatory agencies in weed control in California may be divided into four important parts:

1. Plant quarantine inspection
2. Survey, detection, and identification
3. Noxious weed control
4. Regulation of weed control procedures

These duties are performed largely by the County Agricultural Commissioners and the following Bureaus of the California Department of Agriculture: The Bureau of Plant Quarantine; The Bureau of Rodent and Weed Control and Seed Inspection; and the Bureau of Chemistry. The County Agricultural Commissioners, of which there are 53 in the State of California, perform all of the above listed duties pertaining to weed control within their territorial jurisdiction. Certain of their functions are coordinated and supervised by the aforementioned Bureaus of the California Department of Agriculture and certain functions of the California Department of Agriculture are performed without assistance from the County Agricultural Commissioners.

Inspections of seed, feed grains, and nursery stock in transit for the purpose of intercepting noxious weed seed before it is introduced to an area which may be free of that particular weed pest, is an important phase of weed control which is performed by the Bureau of Plant Quarantine at State boundaries and by the Agricultural Commissioner at interior points. Both interstate and intrastate shipments are subjected to quarantine inspection. The State law provides that if the Director or Commissioner determines that the noxious weed seeds can be destroyed by a treatment the shipment may be so treated and released. Certain procedures have evolved from the handling of rejected carloads of feed grains, notably the development of an acceptable process of steam heating and rolling. Numerous such plants have been installed in California and officially approved for the processing of noxious weed seed infested feed grains. Although I do not have figures for the State, the volume of feed grain inspected, rejected and diverted to an approved processing mill is substantial. In Riverside County in November 1955, out of a total of 194 carload shipments received, 109 were rejected for noxious weed seed infestation. This is a typical month in a typical county.

Recognizing that quarantine inspection cannot protect every avenue of entrance of new or previously unknown species of weeds from entering and becoming established as a pest in an area, the second line of defense is survey. In many counties and in many areas adequate and timely surveys are made by both the Bureau of Rodent and Weed Control and Seed Inspection and the Agricultural Commissioners. Due to the geographical and climatic variation within California, there exists a variety of interests regarding certain weed species. Consequently, one county may survey for a certain weed or group of weeds which does not interest another county. Certain species, however, such as Halogeton or Camel thorn interest most of us and are the subject of coordinated and continuing surveys. The Bureau of Rodent and Weed Control and Seed Inspection maintains a plant identification laboratory for use in confirming field identifications or identification of previously unknown species.

The survey results usually dictate whether a control or eradication program is justified and the type of program that will be employed. The mechanics of operation of the many programs are not as varied as the methods of financing. One method quite widely used with minor variation is roughly as follows: A County Board of Supervisors, by Resolution or Ordinance, will authorize the Agricultural Commissioner to proceed at County expense to:

1. Treat infestations of designated weeds on County property.
2. Treat infestations of new species of weeds or weeds of limited distribution within the County with eradication as the objective.
3. Enter contracts with property owners to control or eradicate other weed species wherever they may exist within the County.

In the absence of such a County Weed Control policy the Agricultural Commissioner may fall back on provisions of the California Agricultural Code which empower him to utilize legal pest abatement procedures.

The California Legislature has specifically recognized certain weed species such as Camel thorn and Austrian Field Cress and has made special provision in the law for financing the control or eradication of those weeds.

Another legal weed control device which is available for use is the "Weed Free Area". The Director of Agriculture, after investigation and survey, may declare a defined area to be free of certain specified weed species. Upon this legal declaration it becomes unlawful to sell, distribute, or transport into the area any seed of the specified weeds, and it is unlawful for a landowner to knowingly permit any of the specified weeds to mature seed. A violator, if found guilty, is subject to the penalty for a misdemeanor.

Procedures and techniques used in weed control programs are very often developed and recommended by the Bureau of Rodent and Weed Control and Seed Inspection.

An important phase of regulatory activity affecting weed control has developed with the use of 2,4-D and related compounds which have been designated by the California Director of Agriculture as "Injurious herbicides". With the advent of these materials came large scale weed control operations in grain and other spots, by Commercial Pest Control Operators. These Commercial Operators are qualified and licensed by the Bureau of Chemistry and are registered in each County by the Agricultural Commissioner. Failure to abide by a reasonable set of regulations, promulgated to assure a good standard of workmanship, may and frequently does result in suspension or revocation of the Pest Control Operator's license.

Many instances of damage to crops other than the ones sprayed from careless application of injurious herbicides resulted in legislation requiring the user to obtain a permit to apply these materials. The permits are issued by the Agricultural Commissioner in conformance with the regulations of the Director of Agriculture. The Commissioner may and many times does add further conditions before issuing the permit. This system has been highly successful in preventing crop loss, particularly to cotton and grapes.

In conclusion let it be said that the Agricultural Regulatory Officials are interested and have a big place in the Weed Control picture.

FARMER'S VIEWPOINT

Charles M. Gordon, Farmer
Woodland, California

You probably wonder why I was selected to represent the farmer viewpoint on this panel. You know, that question puzzled me until I obtained a copy of this letter which was written to the Weed Council Program Committee by Walter Ball. He says:

"I suggest that you get a man whose thinking is not too profound, who won't upset the meeting too much with his views, and a man who has a lot of weeds of all varieties and descriptions so that he will know what we are talking about. Now I suggest that Bud Gordon is just your man." . . .

WELL! After that introduction I can hardly wait to hear what I am going to say.

I am going to start off by telling you an old Chinese legend. Accidently a bamboo house burned many centuries ago and the pigs therein were found to be delicious when so roasted. The news spread from village to village and houses were being burned right and left. It finally got so bad that the emperor put out an edict: 1. No fires were to be made under penalty of having an arm chopped off. 2. No homes were to be burned under penalty of having a head chopped off.

Now this legend may seem far fetched - but it isn't.

Today we use fires in our homes and in commerce and industry with only a small amount of regulation. And should a fire get out of control and do damage, we lean toward civil rather than criminal action -- and civil measures serve as a good deterent against carelessness.

From a legal standpoint in chemical weed control we are back in the days of the Chinese who were forbidden to make fires and burn their homes. We have so many regulations that a farmer is discouraged from personally using chemical weed control. Dealers who sell chemicals must obtain licenses and users must sign to buy 2,4-D. Also, a user must get insurance and a permit to apply 2,4-D. And that permit asks more questions than an application for a marriage license --- and who here will argue with me when I say that marriage is more dangerous than applying weed chemicals.

Once just for the heck of it, I answered the question "Size of Nozzle Used" by putting down 3.9 inches. No one noticed it. Now why ask the questions if no one reads the answers?

Who is asking the state legislature to pass all these control measures? Is it the pesticide applicators who want so much red tape that a farmer isn't going to want to bother spraying his own field? Is it some branch of our State Department of Agriculture that is seeking more power and authority? I can't answer that.

I can say that it would have been wiser the early days of Chinese History for the authorities to have done some research and have taught the peasants to roast pigs by other means than burning down their houses. Likewise, I maintain that it would be wiser to teach the proper uses of weed chemicals than to "red tape" them to death. For goodness sake let's not smother this new farming tool -- let's concentrate more on teaching and disseminating knowledge and not so much on regulation.

I am glad that there are some representatives of the chemical manufacturing industry here because I would like to throw them a curved ball. Your companies have gone hog wild on brand names. You can go into a grocery store and ask for baking powder - sure it might be "Aunt Martha's Baking Powder" or "Aunt Hettie's Baking Powder" but it does say Baking Powder.

Now, when you buy 2,4-D you have to ask for "Weed Blitzer #265." If the store doesn't have that they hand you some "Weed Went That-a-Way #489". Is it 2,4-D? If you have your bifocals handy you might find it on the scuffed small print -- but brother, don't expect to find the percent of actual 2,4-D. You might know how much 2,4-D you want in a mix to kill a certain weed, but if you have any reason to use a new brand of 2,4-D you are going to have to do some guessing.

Now I would like to make some general observations -- these might seem commonplace to you, but I paid to learn them.

1. A farmer needs a program for weed control. For example, if he makes a brush burn he must be ready with a range reseeding follow-up.

2. A rotation of crops is a must in weed control.

3. Cultivation is still our #1 weed control tool. Timing is important - get the weeds germinated but before they get too sturdy. Modern Soil Scientists might condemn the plow to oblivion - but it is still the farmer's #1 weed control tool.

4. Certified seed planting stock is the cheapest in the long run - not only because one is assured of better performance but because one is assured of fewer weed seeds.

5. Some farmers feel that their weed responsibility ends when they come to a county road or a state highway. I guess it does legally, but if they want a thorough job on the roadside weeds and if they want fast service, good timing, and a good job at low cost they would be wise to get after the roadside weeds themselves. They must remember that the government can only do that for which it is paid and if they ask the government to do something they can do themselves they're still going to have to pay for the job - through higher taxes. A farmer is foolish if he controls his own weeds but lets adjoining roadside weeds go to seed.

6. If your weed program slips for one year and the weeds go to seed you have lost the benefits derived from five years of control. In other

words, you might win a lot of battles with weeds but the war is never over. Lose one battle and the enemy infiltrates to such an extent that your last five battles were hollow victories.

7. Thanks to the suggestion of Murray R. Pryor, Weed Specialist with the State Department of Agriculture, I tried a morning glory spray practice that was so successful that I recommend this Pryor system be given more publicity. Oftentimes you want a good morning glory kill on a piece of land and at the same time you want a cash crop from the land. What crop will you plant? Murray Pryor recommended that barley be planted and three 2,4-D applications be made to the crop; the first at the usual time when the barley is 6" to 8" tall; the second application with a ground rig and at least 30 gallons of water per acre for penetration and applied just before the barley stems become brittle; and the third application after harvest and after the straw has been spread and the morning glory has had a chance to come through the straw. This Pryor system has given me a 96-98% one year kill.

8. Extension Service could put out a list of weeds showing what to use to kill each weed and how much to use. This list would have to be revised as more advances in knowledge become available.

We farmers are behind the economic "8 Ball". We can't put the brake on national production and thereby raise prices - the chemical manufacturers can. Consequently, we farmers cannot pass along an increased cost to the consumer where the chemical manufacturer can. Therefore we farmers bear the cost of weed chemicals and we have to see that the use of these chemicals is going to put money in our pocket -- or in the present cost-price squeeze -- we are not going to use weed chemicals.

Conclusion

In the past 15 years, Weed Control has taken giant strides, thanks to the scientist. With the advent of radio-isotopes and other new advances, the next 15 years will see even greater achievements. I sincerely hope that these advances can become tools for the average farmer -- but they won't if they are legislated out of practical usage.

IRRIGATION PROBLEMS AND COSTS

Oscar L. Fudge, Superintendent
Imperial Irrigation District
El Centro, California

I appreciate this opportunity to share with you a part of our experience on weed control work in the Imperial Irrigation District.

We have an irrigated area of roughly 30 x 50 miles down there in the southeast corner of the State, and served by some 3,100 miles of canal and drain channels. This system operates on demand the year around with the canal system being the only source of both domestic and irrigation water for the area.

The long period of relative high temperatures and the continuous flow of water promotes a vigorous growth of all types of weeds and brush native to the southwest, both annual and perennial.

Due to these factors weed control is one of our major operations, and thanks to the untiring efforts of research workers, and meetings such as this one, we are able to say that the weed problem on canal banks in our area is well on the way to complete control. In fact, with the chemicals now available most any desirable degree of control on both grasses and woody growth can be obtained.

In our weed control operations we utilize several different methods, each one to do a specific job, with the adjoining crops and type of growth being the determining factor.

(a) Burning is primarily used as a clean up operation following the use of chemicals,

(b) 2,4-D as a sodium salt, for woody growth,

(c) A combination of 2,4-D sodium salt and TCA for cattails and sedges,

(d) Dalapon for Phragmities and the early spring grasses, such as wild oats and canary grass.

(e) An emulsifiable aromatic oil is used through the summer on bermuda grass in small earth sections where quick relief is needed.

Until about a year ago we had a heavy infestation of Phragmities, an estimated 8,000 acres, which we were holding down with aromatic oil, but thanks to Dalapon we now have this pest under control and are looking forward to complete elimination.

The acre mile is used as the unit of measurement for all of our weed control work, both in the field and in the office. A mile of canal or drain can mean almost any thing as far as area is concerned. On our project a mile of canal or drain will have from six to twenty-five acre miles of area within the right of way. The 8 foot mile is an easy unit of measurement for the equipment operations to use on the daily reports.

In 1955 we burned 6,500 acre miles with 724,000 gallons of oil, on spraying operations with aromatic oil we covered 650 acre miles, using 62,000 gallons, sprayed 3,800 acre miles of woody growth and cattails, using 34,000 pounds of 2,4-D sodium salt and 103,500 pounds of TCA, sprayed 2,800 acre miles of Phragmities with 57,500 pounds of Dalapon, a total of 13,750 acre miles treated in 1955.

The years 1946, 1947, and 1948, were the last three years of burning as the only method of weed control, with an average expenditure of $271,000 per year. The following four years 1949 to 1952, inclusive, by gradually increasing the use of chemicals we were able to hold the average expenditure to $241,000 per year, even in the face of rising costs of labor, material, and equipment.

To better illustrate the tremendous efficiency of chemical weed control over the burning method, let us take two five year periods of experience and compare them.

In the years 1945 to 1949, inclusive, we spent $1,318,500 on burning, and that operation was confined to the inside of the channels. During this period we burned an average of 22,000 acre miles per year.

In the years 1950 to 1954, inclusive, we spent $1,388,500 on chemical - contact oil - and burning, with chemicals being the major operation. This combined operation was not confined to only the inside of the channels, but covered a major portion of the right of way. During this period we worked an average of 10,700 acre miles per year.

So we have an increase of $70,000 in the second five year period over the first, or a little over five per cent increase, in a period when costs of material, and services were on a continual rise, and still are.

This is by no means the only advantage of chemical control. We are now able to shut down our equipment for sixty days or more each year for a complete overhaul. We can drive down the roads and see the fields beyond the ditch banks, and we are helping the farmer reduce his insecticide expenditures. We are reducing seepage damage due to an expanding root system, and at last, we are able to expand the area of control.

In the past three years, 1953 to 1955, inclusive, we have been greatly expanding the area of control and have increased the expenditure to an average of $365,500 per year.

There are all kinds of weed control, but to my way of thinking there are only two, defensive and offensive, and chemicals have made it possible for us to choose the offensive.

Submerged waterweeds are a major problem in our system also, and are accounted for separately from the regular weed control program. We have several types to contend with, and most of them throughout the year.

Our primary method of control is by dewatering the canals for three days every four weeks. This method does not always work, due to sections of extra dense growth that will not permit the canal to drain. When this occurs we use a high aromatic solvent, also in cases where it is impossible to take a canal out of service the solvent is used. Of course, the drain channels cannot be dewatered, therefore, solvent is used exclusively to control the submerged growth. We are currently using Richfield Aquatic Solvent for this purpose.

The control of submerged waterweeds is a problem that grows larger each year. The necessary expenditure on this operation for the last year was about $110,000.

Our most pressing problem at this time is the control of cattails and sedges adjacent to crops that are susceptible to 2,4-D in its various forms.

During the past two years we have been doing some experiment work with various combinations of Amizol - Dalapon - and TCA, and to date these experiments have neither been a success or a failure, in fact, some have been very good at one stage of growth and no good at all at other stages.

The plant reaction to the various combinations of these chemicals is very interesting, and our observations of this plant reaction leads us to believe that there is a combination of these materials that will control cattails and sedges, and it is our intention to continue experimental work during the coming season.

I would like to say again that it is my honest opinion that with the chemicals now available those of us who are charged with the responsibility of control of weeds on canal banks and road sides can do a very efficient job. But, you cannot do the job without sufficient planning and timing to fit the area to be worked.

I also feel confident that research will come up with more and better chemicals to make our work more efficient.

CONTROL OF WOODY PLANTS WITH CHEMICALS IN COMBINATION WITH OTHER METHODS

O. A. Leonard
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Davis, California

The use of chemicals for controlling woody plants is expanding. With the increase in usage of chemicals it may be observed that one of the main avenues of use is in combination with practices that have been used in the past. Potentially, chemicals may fit into all fields of endeavor where some type of woody growth suppression or control is desired; for the most part, chemicals will be used as a supplement to other methods already being used. However, the introduction of chemicals into the control program represents a new approach to the problem and may considerably alter the finer details of the control program.

It is interesting to recall that most methods of woody plant control, aside from chemical control, have been used by mankind down through the ages. In spite of this, much research is still being conducted on the use and effect of these methods in the solving of many problems. In view of this why should we expect to have found all there is to know about chemical control already? Even without the discovery of a single new chemical, studies on learning how to use the ones we already have could go on for a long time. A tremendous amount of research remains ahead that will be conducted by investigators in a variety of fields of endeavor. The failure of one or more experiments to accomplish precisely what the investigator had in mind, does not necessarily signify a failure of the chemical, but more often that the failure is due to an inadequate understanding of the factors necessary for success by the investigator himself. Only through continuous and careful planning and experiment after experiment can solutions finally be obtained. I am afraid that many of us have been looking for some miracle chemical that will accomplish the almost impossible, without any or very little effort on the part of the investigator himself. Such investigators gave up after a little bit of testing and think that they have exhausted the possibilities for the beneficial use of the chemical. The main objective of this report is to show how chemicals used in combination with other methods may result in highly satisfactory control and represents an approach that bears much further study. In many of the examples listed, chemicals used alone would not result in satisfactory control.

The chemicals 2,4-D and 2,4,5-T have received considerable study for more than ten years. Many of the more obvious uses have already been discovered but certainly not all of them. We have just started to make progress with some of the less obvious uses but which, in the long run, may be of considerable importance. I should like to present some examples on how chemicals are fitting into a combination of practices involved in brush control, some of these uses not being clear when the testing was initially started.

Combinations with fire and other practices on chaparral and chamise lands

Old or mature chamise is relatively difficult to control by chemicals applied by aircraft and it is only moderately sensitive to the high volume application of sprays with ground equipment. Resident annual grasses have been slow in becoming established beneath the killed mature chamise and the hand seeding of introduced grasses has failed completely in plot tests. Evidently, the control of chamise with chemicals without the involvement of other practices holds slight promise at present.

After burning, it has been found that the chamise sprouts and seedlings are quite sensitive to sprays applied with ground equipment (Leonard, 1953, 1954), providing the applications were made under the proper conditions. Soil moisture appeared to be the most important factor influencing kill. Grasses seeded immediately after the burning were aided greatly by the reduced competition obtained by spraying the brush. Although good sprout and seedling control was obtained two years after burning, satisfactory kills were still obtained in some tests on sprouts that were four years old.

Many of the tests on the control of chamise, especially the aircraft tests, were cooperative with C. E. Carlson, California State Division of Forestry. A summary of the results from these tests is in the process of preparation and will be published jointly.

Early aircraft tests failed at translating the excellent kills obtained by broadcast applications with ground equipment. Relatively poor kills were obtained on two-year old sprouts with sprays applied by aircraft, whereas excellent kills were obtained by the same dosage of chemical applied with ground equipment. With further testing, it was found that chamise sprouts sprayed by aircraft during the spring season following a fall burn resulted in some excellent kills (Leonard, 1954). Results of more recent similar trials appear to substantiate these results. However, much more study is required to fully understand the reaction of chamise in different parts of California and on different soil types and under rainfall conditions.

One experiment (with C. E. Carlson) will be described in some detail, since this presents what is thought at present to be a promising procedure for converting a site covered with chamise into a grassland composed of perennial grasses. Initially, this site was covered with an impenetrable thicket of old chamise (Adenostoma fasciculatum) and whiteleaf manzanita (Arctostaphylos viscida), with a scattering of other woody species including leather oak (Quercus durata), interior live oak (Quercus wislizenii), coffeeberry (Rhamnus californica), redberry (Rhamnus crocea var. ilicifolia), toyon (Photinia arbutifolia) and redbud (Cercis occidentalis). The brush was crushed with a bulldozer and then burned in the fall of the year and seeded by airplane to Hardinggrass (Phalaris tuberosa), smilo (Oryzopsis miliacea), tall bluegrass (Poa ampla) and rose clover (Trifolium hirtum). The planted species were slow in developing because of the cold winter and spring. On May 10 the site was sprayed by aircraft using 2 pounds of 2,4-D (low volatile ester) applied in 1 gallon of Diesel oil and enough water to make a 10 gallon per acre application. The spray application accomplished the objective of killing most of the sprouting chamise plants and in severely injuring the other sprouting species. All of the brush seedlings were killed, including chamise, whiteleaf manzanita, lemmon ceanothus

(*Ceanothus lemmonii*), rush-rose (*Helianthemm scoparium*), deerweed (*Lotus scoparius*), yerba santa (*Eriodictyon californicum*), and goldenbush (*Haplopappus bloomeri*). The last four species listed are rapid growing and quickly furnish severe competition for the grass. The effect of the spray was to effectively eliminate nearly all competition during the year in which the sprays were applied and thus to aid in the survival of the small perennial grass plants.

By the fall of the year, those species of sprouting woody plants that were not killed by the sprays had developed new shoots up to three feet in length. The total number of such plants, other than chamise, averaged 43 per acre. Since regrowth was limited, the total volume of spray mixture needed to spray all of these sprouts on an acre was only two gallons. On the bases of past experience, some of these bushes will require one or two more spray applications before they are killed.

Although spraying didn't entirely eliminate all of the rose clover, the stand was greatly reduced. It would appear to be desirable to seed some rose clover the fall after spraying, in order to thicken the stand. It also would seem desirable periodically to apply some commercial fertilizer to encourage both the clovers and the maintenance of the stand of perennial grasses.

The above set of procedures appears to offer a new approach to the reclamation of chamise sites. The introduction of chemicals into the program of conversion makes certain procedures possible that have not been possible before. This new approach is accomplished by a series of control methods that have been used in the past, plus chemical control, to accomplish quicker, better and longer lasting brush control and to aid in obtaining better stands of desirable forage.

Combinations with fire and mechanical operations on live oak areas

Bulldozing and fire have been commonly used to remove stands of live oak. Close browsing by goats and removal of the sprouts by hand have helped to accomplish conversion of such areas to a grass cover. Generally these areas have not received the necessary follow-up sprout control measures, so that these areas have quickly reverted to even more dense stands of live oak than they were initially.

For several years ranchers have been using chemical sprays to control and eliminate live oak sprouts. Thus chemicals are being used in a sequence of operations necessary to achieve conversion to grass.

Sprays as used consist of a brush killer mixture containing 2,4-D and 2,4,5-T esters. In our tests, these mixtures have given better kills than the use of either ester alone. At present our recommendation is to use one gallon of brush killer (containing four pounds of active ingredients in most formulations) plus one-half to one gallon of Diesel oil and enough water to make one hundred gallons of spray mixture. Control is never complete with one application, two or three applications generally being required to accomplish satisfactory control. Timing and thoroughness of coverage are important factors influencing kill. It now appears that we have some chemicals that are more effective against live oak than either 2,4-D or 2,4,5-T. These are the propionics of the phenoxy compounds, or 2,4-DP and 2,4,5-TP. Control has been consistently the most effective with an ester of 2,4,5-TP or a mixture containing 2,4-DP and 2,4,5-TP (esters). It is interesting that 2,4-DP is slightly more effective than 2,4,5-TP during the period of active growth, but is rather poor at other times. A recommendation must take into consideration the wide variety of conditions under which the chemicals might be applied. It is anticipated that these chemicals will be available for use in the near future.

Cut-surface method followed by fire on woodland areas

The cut-surface method is a relatively inexpensive chemical procedure for killing trees (Leonard, 1955, 1956) and it has been used on several thousand acres in Madera county on digger pine (Emrick, 1955). The trees fall over within a few years and should then be eliminated by burning. On digger pine, ax cuts are chopped into the wood near the base of the trees, the cuts being spaced at 6 to 8 inch intervals around the trees. A pump-type oil can is used to apply about a teaspoon of 2,4-D amine (straight undiluted formulation) per cut. Winter and spring is the best season to treat.

Against oak trees, we now suggest that the cuts be sufficiently close together that all of the bark is severed. The cuts should be near the ground and should be deep enough to be well into the wood. The cuts should be filled with all of the 2,4-D amine that they will hold, which amounts to one-third to one-half teaspoon per inch of stem diameter. The best period for treating the trees is from late fall until mid-spring in the oak woodlands. After the trees have died and an appreciable number have fallen, a fire may be used to burn the fallen trees and the large accumulation of broken branches. This follow-up has resulted in some very hot fires and has aided in making a more effective burn. The method has an advantage over bulldozing, in that the killed trees will not sprout after burning, so that complete control of all of the woody growth by chemicals on these areas is simplified by the use of this method of control followed by burning.

Combinations with seeding and browsing on mixed coastal brush

Brush occupies some of the best hill soil along the California coast. A method that has been tried successfully (Jackson and Wheelwright, 1955) was to spray the brush by helicopter using a brushkiller. Noxious weed-free hay, having a mixture of seed of the desired species was fed in the brush after spraying. While eating the hay, the cattle broke down much of the brush and did considerable browsing. The seed that was incorporated into the hay was planted by the tromping action of the cattle. Follow-up spraying with ground equipment completed the conversion.

The inclusion of fire in the program of control, also, has been practiced. Burning is done during the fall following the spraying and the desired species of plants are seeded. Respraying with ground equipment is used to complete the control of the brush. In these humid coastal areas, a certain amount of spraying is necessary to keep brush from becoming re-established. The first type of brush to invade open pastures is coyote brush (Baccharis pilularis); fortunately, this plant is easily killed with the amine of 2,4-D.

Combinations with fire on some other brush problems

Three-year old chamise sprouts were sprayed in April and burned in August four months later. The combination of spraying followed by a burn within a few months was highly effective in achieving a high degree of control of the sprouts and was much more effective than with chemicals used alone. The fire alone resulted in the death of none of the chamise plants. An application of two pounds per acre of 2,4,5-TP per acre resulted in the death of only 10 percent of the chamise plants, which is rather typical of the effect of this chemical on chamise. Combined with burning, the kill was increased to 90 percent. Spraying not only resulted in a high degree of plant kill when followed by burning, but it also made the burn possible, since the fire went out soon beyond the borders of the sprayed area.

It has been reported from Israel (Naveh, 1955) that 2,4-D sprays are being used both before and after burning to aid in the control of brush. It is of interest to note that these dense stands of brush developed within a few years after centuries of grazing by sheep and goats was stopped.

With gorse (Ulex europaeus) fire is used and the regrowth is allowed to grow to a height of eighteen to twenty-four inches before it is sprayed.

Stump treatments following the cutting of brush and trees

Cutting trees down with a chain saw is impressive, but does not achieve permanent control of sprouting species; cutting brush with an ax, also, accomplishes control of a temporary nature.

Within recent years, stump treatments with brush killer mixtures containing 2,4-D and 2,4,5-T in oil have become widely used for treating stumps after cutting; this method appears to be effective against all woody plants when properly used.

For best results, the woody growth should be cut near the ground and the stumps sprayed immediately, using enough total fluid to wet the top of the stump and to have considerable run-down below the surface of the soil. The volume of fluid necessary to control sprouting varies with different species; however, the use of two fluid ounces per inch of stem diameter should be effective on practically all species. Our suggestion is to use four pounds of acid equivalent containing both 2,4-D and 2,4,5-T (one gallon of most brush killers) to twenty-four gallons of Diesel oil.

Conclusions

There are many aspects of brush and tree control where chemicals can be used advantageously in combination with other methods already in use, and several examples have been listed. It is to be anticipated that the use of chemicals in combination with other methods will continue to be broadened. Discovering the place of chemicals in improving present control practices represents an interesting and challenging field of research. Without the advent or discovery of a single new chemical, studies on the best use of chemicals for a multiplicity of purposes can continue into the indefinite future. That this is true is suggested by the fact that studies on the control of woody plants by fire, mechanical means, browsing and plant competition are still being pursued vigorously, even though human experience with these methods has been accumulated over a very long period of time.

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WEED CONTROL IN VEGETABLE CROPS

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The California Packing Corporation is primarily interested in tomatoes, asparagus, and spinach, as vegetable crops in California. Weed control is extremely important in these crops as a means of reducing cultural costs and increasing their yield and quality.

Weed control in tomatoes is our most difficult problem. At the present time, there is no herbicide effective against Watergrass, Pigweed, or Lambsquarters, that will not injure or kill tomato plants. We are using close cultivation and hand-hoeing to control weeds in direct seeded and transplanted tomatoes.

Asparagus culture involves two phases of weed control. These phases are weed control in the nursery where the seedlings are grown and weed control in established asparagus beds.

Hand-hoeing and cultivation in an asparagus nursery cost approximately one hundred dollars per acre. The use of herbicides with hand-hoeing and cultivation reduce this cost to about fifty dollars per acre. The asparagus nursery must be kept free from weeds as the slow-growing asparagus seedlings are easily stunted by Watergrass and Pigweed. The weeds emerge before the asparagus; so, we use a pre-emergence spray of sixty gallons per acre of Shell Paint Base Spirits applied with a ground spray rig. Control of seedling weeds is excellent with this oil. As temperatures increase, more weed seeds germinate with later irrigations. A mixture of fifty-six gallons of Shell Paint Base Spirits and twenty-four gallons of Shell Kerosene is applied as a post-emergence spray while the weeds are still seedlings. This mixture controls the weeds with no injury to the asparagus seedlings. CMU at dosages of from one to three pounds per acre depending upon soil type also gives effective weed control in an asparagus nursery; however, we do not use it as rainfall to leach the CMU into the soil is not dependable in the late spring.

From two to four pounds per acre of CMU has been used for the control of annual weeds in established asparagus. The CMU must be applied early in the Winter so that there is ample rainfall after application to leach the CMU into the soil.

Chickweed is sometimes a problem in early green asparagus, when the soil is wet and cannot be cultivated. The asparagus cutters are not able to see the asparagus spears because of the Chickweed and do not harvest them. These Chickweed areas are sprayed with an emulsion of dinitro ortho secondary butyl phenol, diesel oil, and water. The concentration of dinitro and diesel oil is varied depending upon the size of the Chickweed. IPC at four pounds per acre also gives excellent control of Chickweed but must be applied before or shortly after the Chickweed emerges. The emulsion applied as a spot treatment by ground rig just prior to harvest is usually the cheaper method; however, if air application is necessary, IPC in ten or twenty gallons of water per acre is used because of the low volume applied.

Weeds cannot be tolerated in spinach. The cost of their removal from the spinach at the cannery is prohibitive if very many are present. Heavy weed infestations reduce spinach yields by as much as fifty per cent. The quality of weedy spinach is lowered not only by weed contamination but by spindly spinach leaves with long petioles and small blades due to weed competition. Hoeing costs run from twenty to eighty dollars per acre in spinach. In some cases, fields or parts of fields are abandoned because the removal of the weeds is not economically feasible. By using herbicides with hoeing and cultivation, our costs average fifteen dollars per acre, and we deliver clean spinach to the cannery.

Chickweed, Shepherd's Purse, and Mayweed, are the primary weed species which cause the most serious problems in our spinach. We initially used four pounds of emulsifiable IPC applied by air or ground as a post-emergence treatment when the spinach had from two to four true leaves. IPC gave one-hundred-percent control of Chickweed, fifty-per-cent control of Shepherd's Purse, and no control of Mayweed. Our entire spinach acreage for the last two years has been sprayed with one pound of CMU per acre as a pre-emergence treatment to the soil immediately after the spinach was planted. CMU gives ninety per cent control of Chickweed, Shepherd's Purse, and Mayweed. CMU is effective on a wider range of weed species than IPC and is less expensive than IPC.

When rotating spinach after barley or wheat, these grasses become volunteer weeds in the spinach. CMU and IPC at the dosages used do not control barley or wheat. We have been able to control these grasses by applying ten pounds of sodium TCA as a pre-emergence treatment after planting followed by another ten pounds as a post-emergence treatment after the spinach has emerged.

The Agricultural Research Department is still screening herbicides on these vegetable crops in order to further decrease our cultural costs and increase the yield and quality of these crops.

WEED CONTROL IN CALIFORNIA COTTON

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A grower survey conducted over seven major cotton producing counties in California in 1954 listed Johnson grass and watergrass as the two most troublesome weed species associated with cotton production. One is said to be a perennial and the other an annual, but regardless of their classification as to growth habit, these and ten to twelve other species make weed control in cotton, unmistakably, a perennial problem. Some of the other species mentioned as troublesome were nutgrass, bermuda grass, morning glory, pigweed, lovegrass, crabgrass, puncture vine, lambs'-quarters, Russian knapweed, white horse nettle, sandbur, purslane, and Russian thistle.

Growers indicated via the survey mentioned, that as a mean value, they spent $14.28 per acre per season for weed control in cotton above normal cultivation in 1954 -- with some values reaching $50.00 per acre. By charging the cost of cultivation to weed control, the average figure becomes more than $20.00 per acre. This indicates that there is opportunity for much to be done toward reducing weed control costs, as well as increasing grades and possibly yields of cotton in some instances.

The wide variability of weed problems over the state, from planting to harvesting, requires a weed control "program" approach. It should be emphasized that the program should make the most efficient use of available recommended weed control practices. The timely use of properly adjusted cultivation equipment will accomplish much. Also Experiment Station research has shown that shallow sweep cultivation for weed control may be extended later into the season than the normal "lay-by" date. The use of the common hoe should perhaps be minimized, but not yet forgotten entirely. Proper land preparation to avoid "ponding" at the lower ends of the irrigation run will help control many annual weeds (particularly grasses).

Among the cultural implements, sweets are perhaps the most commonly used, however bed knives, disk hillers, rotary hoes and others have been used with much success for specific problems. For example, the use of disk hillers or other implements for "barring off", followed by hand hoeing and/or flame cultivation, appears to be the most satisfactory method of controlling nutgrass at present.

Since cultivation alone is normally inadequate to control Johnson grass and most other perennial weeds in cotton, it may be supplemented by hand hoeing or chemical spot treatment. Geese are also frequently used for controlling weedy grasses in cotton. No chemical has proven sufficiently selective to control a heavy infestation of Johnson grass in a growing crop. Two years data in California have shown that 2, 2-dichloropropionic acid (DPA) at concentrations of one-eighth and one-fourth pound per gallon of water and certain naptha-type oils applied as spot treatments were more effective (and required less time to treat) than hand hoeing for the elimination of scattered Johnson grass in cotton. DPA has not yet been released for this use, however. Isolated spots of perennial weeds in cotton fields may be treated with soil sterilants or fumigants, providing the grower is willing to sacrifice production in the treated areas. This method is often the most economical means of preventing widespread infestations of perennial weeds, especially broad-leaved species.

The long-recommended practice of flame cultivation should be more widely utilized for annual weed control. Cotton eight inches or more in height is tolerant to flame directed across the row. Weeds in smaller cotton may be controlled by such supplementary practices as rotary hoeing, cultivation with sweeps, disk hillers, or bed knives, hand hoeing, or possibly the use of oil sprays or residual herbicides. In tests during the past two years, flaming has given excellent control of annual weeds and sparse nutgrass. Costs were lower than for hand weeding, and improved weed control reduced trash content and raised grades of cotton. In some cases, flame cultivation has given increased yields and picker efficiencies; in no cases were yields reduced. Under heavy watergrass infestation, flame cultivation has shown an economic advantage in every case.

The effect of flame cultivation and various cultural and chemical practices upon watergrass and cotton in 1955 is shown in Tables 1, 2 and 3. Plots which were not flamed were thoroughly infested with mature watergrass at the end of the season. Hoeing showed a significant advantage in Treatment 6 only. This was due to the fact that, with the low bed planting, early dirting in cloddy soil did not satisfactorily cover small weeds and left the row profile in such a condition that the first flaming had to be omitted. Although yields were not reduced in the non-flamed plots, grass caused reductions in grade in 23 out of 24 classing samples. By contrast, only 8 out of 48 were classified as grassy in the six flamed plots. The losses due to grade reductions ranged from .44 to 1.94 cents per pound of lint cotton or from $3.74 to $16.50 per acre, based on a mean yield of 850.3 pounds of lint per acre.

Flame cultivation is discussed in more detail in the Proceedings of the Seventh Annual California Weed Conference and recommended procedures are available through the Agricultural Extension Service.

Considerable variation in results continues to characterize chemical weed control methods in cotton. Results ranging from poor to excellent were obtained with the following residual herbicides applied at several dates in 1955; two substituted ureas (CMU, DCMU), N-1 naphthyl phthalamic acid (Alanap 3), and isopropyl N-(3-chlorophenyl) carbamate (CIPC). These experiments showed the strong dependency of herbicidal response upon proper moisture relationships. Adequate moisture both to germinate weed seeds and, at the same time, to activate the herbicides in the region of weed germination is required for satisfactory results. When the beds were thoroughly wet (to the tops) either by unexpected rainfall or by special water management, weed control was satisfactory. The herbicides failed otherwise. When good weed control was obtained with these materials under very weedy conditions, grades were increased and net returns per acre were higher.

Residual herbicides show little activity upon emerged weeds at the rates used, therefore they must be applied in anticipation of the weed problem. In cases where the weed problem has already developed, the use of directed foliage sprays such as DPA or dinitro-o-secondary butyl phenol (DNOSBP) offers possibilities late in the season. The amount of early weed germination and the rate of growth late in the season will determine the practicability of these methods.

Narrow margins of selectivity, critical water management, toxic residues, restrictions imposed by the Miller Amendment - Public Law 518 - , and other factors have thus far prevented recommendation of the use of these herbicides in California cotton. Continued research should overcome some of these difficulties, but regardless of their performance, chemical herbicides should be considered (for the present, at least) as supplements to rather than replacements for sound cultural practices.

Table 1

VARIOUS WEED CONTROL TREATMENTS APPLIED TO WATERGRASS – INFESTED COTTON – FAMOSO, CALIFORNIA – 1955

Treatment	At Planting (12 April)	1st (11 – 12 May)	2nd (25 – 27 May)	3rd (1 June)	4th (8 June)	5th 1/ (13 – 14 June)	6th 3/ 1 – 5 July)	7th (8 – 12 July)	8th (29 July)	Total No. weeding Operation
1	Low Bed	Rotary hoe in row, beet knives at 6" plus sweeps	Rotary hoe in row, plus sweeps	Same	Same		Sweeps		22" Sweeps	6
2	High Bed			Same	Same					6
3	High Bed	Beet knives at 8", plus sweeps	Oiled 10" band plus sweeps	Same	Same					6
4	High Bed			Same	Same	Flame in row, plus sweeps	Same	Same	Flame in row 4/ plus 22" sweeps	9
5	High Bed		Row shielded 8" band, plus sweeps	Same	Same		Same	Same		9
6	Low Bed	Disc Hillers at 5" plus sweeps	Dirting by sweeps with shields raised	Same	Same	2/	Flame in row, plus sweeps	Same		8
7	Low Bed	Rotary hoe in row, beet knives at 6" plus sweeps	Rotary hoe in row, plus sweeps	Same	Same		Same	Same		9
8	High Bed			Same	Same		Same	Same		9
9	High Bed, Alanap 3 at 6#/A in 12" band	Beet knives at 10", plus sweeps	Same			Same		Flame in row, plus sweeps	Same	7

1/Two rows of all four-row plots were hoed, and hoeing time recorded 13 June.
2/First flaming omitted. Cotton was too short in cloddy ground due to early dirting after planting low in bed.
3/First irrigation – 18 June.
4/Plots were flamed *twice* at lay-by.

Table 2

THE EFFECT OF FLAME CULTIVATION AND VARIOUS CULTURAL AND CHEMICAL PRACTICES UPON WATERGRASS AND COTTON. FAMOSO, CALIFORNIA – 1955.

Treatment Number (see Table 1)		WATERGRASS			COTTON			
		Hoeing Time hrs./acre 1/ (June 13)	Plants per 10 of row (June 31)	Final Rating 2/ (Oct. 31)	Plants per 100 of row (Oct. 31)	Yield of Seed Cotton lbs./acre	Picker Efficiency Percentage	Trash Percentage
1	A	8.75		2.9	37	2590	93.6	9.2
	B	- -	1609	1.9		2200	94.0	9.4
2	A	6.67		1.4	37	2320	92.5	8.4
	B	- -	1612	1.3		2325	94.3	8.6
3	A	7.50		1.8	37	2240	93.4	7.8
	B		1614	1.4		2230	93.2	10.0
4	A	7.08		8.8	38	2375	92.0	6.1
	B	- -	1614	8.4		2300	92.0	7.8
5	A	9.17		8.8	38	2170	92.3	6.7
	B	- -	1624	8.0		1975	92.1	6.6
6	A	8.33		8.0	38	2190	91.5	5.8
	B	- -	1611	4.0		1970	91.9	7.8
7	A	7.50		7.9	35	2155	91.4	5.2
	B	- -	2610	7.4		2135	93.7	5.2
8	A	6.67		8.4	41	2335	93.0	5.6
	B	- -	1614	8.3		2285	93.4	6.7
9	A	2.92		7.3	29	2300	93.2	5.5
	B	- -	93	8.5		2180	90.8	5.5
L.S.D. at 5%		2.6		1.4	Not Sig.	Not Sig.	Not Sig.	1.9
at 1%		3.6		1.8				2.6

1/ Two rows (A) of all four-row plots were hoed June 13. This hoeing time represented only a smally percentage of the weeds which emerged following the first irrigation – June 18.

2/ Numerical ratings represent an average of 8 observations, ie. 4 replications each rated independently by two persons on an arbitrary scale of 0 (no control) to 10 (perfect control.)

Table 3

THE EFFECT OF VARIOUS WEED CONTROL PRACTICES UPON GRADES AND RETURNS PER ACRE FROM MACHINE PICKED COTTON GROWN UNDER CONDITIONS OF HEAVY WATERGRASS INFESTATION. FAMOSO, CALIFORNIA – 1955 1/

Treatment Number		Grades 4 samples 2/	Value $/cwt. Lint 3/	Value $/acre Fresno Spot Market (October 15)	Cost of Weed Control Practices $/acre 3/	Value Less Weed Control Costs $/acre Oct. 15th Market
1	A	1–M, 3–SLM*	33.71	286.64	15.21	271.43
	B	4–SLM*	33.08	281.28	6.90	274.38
2	A	4–SLM*	33.08	281.28	13.24	268.04
	B	4–SLM*	33.02	280.77	6.90	273.87
3	A	4–SLM*	33.02	280.77	18.52	262.25
	B	4–SLM*	33.02	280.77	11.40	269.37
4	A	1+M, 2–M, 1–SLM*	35.20	299.31	24.08	275.23
	B	1–M+, 1–M, 2–SLM*	34.51	293.44	17.35	276.09
5	A	4–M	35.77	304.15	21.56	282.59
	B	4–M	35.77	304.15	12.85	291.30
6	A	4–M	35.77	304.15	19.11	285.04
	B	1–M, 1–M*, 2–SLM*	34.15	290.38	11.20	279.18
7	A	2–M, 1–SLM+, –1–SLM*	34.77	295.65	19.98	275.67
	B	2–M, 1–SLM+, 1–SLM*	34.77	295.65	12.85	282.80
8	A	1–M+, 2–M, 1–SLM+	34.51	301.94	19.19	282.75
	B	3–M, 1–SLM	35.33	300.41	12.85	287.56
9	A	1–SL, 3–M	35.96	305.77	16.37	289.40
	B	4–M	35.77	304.15	13.60	290.55

1/Since yields were not significantly different, the mean yield of all plots (850.3 pounds of lint per acre) was used in computing grade losses due to grass. The value of the seed was considered adequate to cover ginning costs.

2/Final grades are shown. Asterisk means a reduction of one grade due to grass.

3/In addition to grade reductions, bales designated as grassy are further penalized depending upon the current market. The U.S. Classing office suggested a dockage of one cent per pound (100 points) for the market shown.

4/Weed control costs per acre were estimated as follows: Cultivating -- $1.15 each: hoeing -- $0.95 per hour; oiling -- $1.50 each; flame fuel -- $0.50 per flaming. (Equipment costs not included.)

CONTROL OF MORNING-GLORY IN LIMA BEANS AND OTHER CROPS

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The shielded-spray method of applying 2,4-D to control morning-glory in beans and other row crops continues to give satisfactory weed control with a minimum of damage to the crop being treated and practically none to nearby crops. This practice has been used by local lima bean growers for the past eight or nine years and is now spreading to other crops and into other areas of California. In addition to lima beans, crops which have been treated successfully are red kidney, pink, blackeye and string beans (all of which are more sensitive to 2,4-D than lima varieties), row-planted alfalfa (for seed), roses and various flower crops.

Most local growers have continued to use from one to one and one half pounds of an amine formulation of 2,4-D in 10 to 20 gallons of water per acre. In other areas, MCP has been used because of the greater safety provided for both the crop being treated and adjoining crops.

Cultural and seeding operations are scheduled to provide maximum growth of morning-glory when the bean plants are two to four inches tall, at which time the single application is made. (A few farmers use a preplanting treatment prior to this application.) The crop is protected by "shields" or inverted troughs about six inches wide and six or eight inches high. The area between the plant rows is sprayed with a boom arrangement which is enclosed with canvas crapes to prevent spray drift. The spray boom covers four rows at a time and is mounted on the tractor tool bar.

Results

Most morning-glory plants are not "killed" by one application, though the tops die back in a few weeks. By the time new shoots are sent up, the plants have covered the ground and the weeds remain spindly, causing little or no trouble with cultivating or harvesting. After several years of treatment, morning-glory patches have been thinned out considerably.

An evaluation of this treatment shows that:

1. The spread of morning-glory has been stopped.
2. Yields which were quite low have jumped back to normal.
3. Costly and bothersome cultural controls have been eliminated.
4. Harvesting has been made easire and cheaper.
5. Spraying has been very reasonable (materials \$1.00-\$1.75/A and application cost about \$1.00-\$1.50/A).
6. 2,4-D breaks down in a few weeks in warm, moist soils so no injurious residues will be left for future crops.

WEED CONTROL IN GRAPES

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The days of controlling weeds in grapes entirely by mechanical means has passed. In the middles, mechanical cultivation still is the most economical method, but grape growers have long been looking for some other method than the French plow for controlling the weeds in the row, particularly perennial grasses.

Annual weeds in grapes must be controlled so that they do not seriously compete for soil moisture or nutrients. It has been found that when entirely eliminated as in non-tillage, the fruit and vines are burned by the reflected heat from the bare soil. Perennial grasses, particularly Johnson grass, if not controlled in the row, interferes with the harvesting of the crop to the extent that in some cases tons of fruit have been left on the vines of a vineyard.

Weed control starts in the spring when the winter cover crop is worked under in the middles, with a disc or a turning plow. A French plow is necessary to take out the weeds in the row. This is the slow and most expensive part of the spring work, to say nothing of the possible damage to the vines through root pruning. Some time after the last spring rain this soil is then pushed back around the base of the vines to take care of the weed problem in the row. This is true for annual weeds but for perennials hand hoeing is necessary all season long. Throughout the summer and fall, usually for every two irrigations, there will be one cultivation in the middles. During winter the prunings are disced under just before the cover crop is planted and the cycle begins again.

To get away from the harmful effects of cultivation, such as impaired soil structures, poor water penetration and destruction of roots, some growers have combined weed oil sprays with cultivation, without damage to the vines, by using it in the row as a placement spray, and cultivations in the middles. For the grower whose vines are on a trellis or arbor this method has proved to be much more economical for control of Johnson or Bermuda grass than the numerous hoeings.

The sodium salt of dalapon, 2,2-dichloropropionic acid, has been used during the last three years in an experimental program for the control of perennial grasses in grapes in the San Joaquin Valley. For the last two seasons dalapon has been used in experiments at Fresno State College. In these experiments dalapon was sprayed on the ground in 4- and 12-foot wide bands centered on the vine rows which were planted 12 feet apart. A guard row was left between each treated row. Dalapon as the sodium salt was place-sprayed at 20 and 40 lbs. per acre and 100 gpa. These grapes, which were of the Carignane variety, had no weed problem and, therefore, the yield data, harvested October 13, obtained from four times replicated and randomized rows 600 feet long are a true representative of any phytotoxic effects of this chemical. Two months after application injury was noted in the 40-lb. per acre, 12-foot band treatments but none in the others. Table 1 gives the results of the 1955 experiment sprayed May 19. When sprayed the canes were upright, 1-3 feet long, and little or no spray touching the leaves. From the Table it can be seen that dalapon can be sprayed in the row at 40 lbs. per acre without any reduction in yield of Carignane grapes. Overall ground sprays at the 40-lb. dosage reduced the yield.

TABLE 1

YIELD OF CARIGNANE GRAPES -- DALAPON BASAL SPRAYS

Dalapon Lbs/acre	Band width	Lbs. grapes per row	Tons per acre
20	4 ft.	736	8.59
40	4 ft.	702	8.54
40	12 ft.	552	6.88
Check	--	718	8.59

Samples were taken from this experiment for residue analysis but the data are not yet complete. Therefore, at present no recommendation in grapes can be made.

The Fresno State College grape variety block was basal sprayed with 40 lbs. per acre of dalapon to control the Johnson grass. While all the grape varieties planted in California are not represented there were no deleterious effects observed on the many varieties treated. Even the wild root stock vines that are low growing were not seriously affected by the sprays.

This past year the Farm Advisors in the San Joaquin Valley have been working with dalapon in grapes quite extensively. They have been comparing dalapon and oils in single and multiple treatments on a number of varieties for control of Johnson and Bermuda grass. In all cases, as is true of open field work, with dalapon the best control was obtained with multiple treatments of 20 + 20 lbs. per acre or 20 + 10 + 10 lbs. per acre as 4-foot band treatment. The grass in the middles can be controlled by the regular cultivation during the season.

It should be pointed out that the optimum time for the first application in the spring is when the Johnson grass is 12-18" high and Bermuda is growing well. Repeat applications should be applied as soon as a fair amount of regrowth is evident. By this time the canes have probably fallen and while dalapon will not burn like the oil, reasonable care should be taken not to hit the leaves. These sprays can be applied by hand or by a boom as developed at Cornell University in New York.

ALFALFA WEED CONTROL PROBLEMS OF THE SACRAMENTO DELTA

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INTRODUCTION

The most important single problem confronting Sacramento Delta farmers as they attempt economic control of weeds in alfalfa is that of coordinating all the necessary steps to achieve practical, effective control. The problem has its beginnings before the alfalfa is planted and is with the grower throughout the life of the stand. Accurate appraisal, sound planning and effective management must be combined to make best use of methods and materials now available. General experience in the Delta has indicated there is room for improvement in all of these aspects of alfalfa weed control. In the limited time available for this discussion, we will present some of the growers problems as a challenge to our thinking on how these improvements may be achieved.

IMPORTANT WEEDY SPECIES

The weedy species most likely to be serious problems in alfalfa fields of the Delta include the following:

Broadleaf - chickweed, mustard, shepherd's purse, wiregrass (*Polygonum aviculare*) and lambsquarter.
Grass - perennial ryegrass, foxtail and annual bluegrass.

Each of these species has its particular characteristic as a trouble maker. For example, chickweed, because of its smothering type of winter growth, seriously retards spring development of alfalfa crown buds and shoots. This results in reduced yields and eventually in reduced stands. Mustard and lambsquarter are aggressive competitors in seedling stands and particularly troublesome in haying operations. They cure much more slowly than alfalfa, thus causing costly operational delays and serious reductions in hay quality. Foxtail is especially objectionable in hay because of its harsh, barbed awns. Thick stands of annual bluegrass will stop most mowers, thereby making the hay mowing job much more difficult and costly. Perennial ryegrass, an aggressive winter grower, can rapidly take over a stand of alfalfa. Ryegrass seed will often germinate over a two month period, thereby making herbicidal control difficult. Once established, the plants are extremely hard to kill. Of all the weeds listed, ryegrass is the most costly to control.

CONTROL PROBLEMS

Some of the weed control problems facing Delta hay growers can be solved through more effective management to make better use of currently available information and materials. Others of their problems arise from the limitations of present materials, both as to effectiveness and cost. The following discussion is intended to illustrate both of these types of problems as they are encountered in the control of weeds in seedling stands and in established stands of alfalfa. Such outline of the problems encountered may well provide a clearer basis of common understanding that will spell progress in the never ending search for improvement.

Seedling Stands

Management of seedling stands of alfalfa to assure weed control with present materials presents a real challenge to the ranch operator. He is first faced with the decision as to whether to kill the weeds before the seed is planted or after the alfalfa seedlings emerge. Both methods have their advantages and disadvantages, and both have been used by Delta growers. The most widely used to date in this area has been the spraying of seedling alfalfa stands with dinitro selective sprays. The requirements for successful use of the dinitro selectives are fairly exacting, and where these requirements have been met, results have been very acceptable. Unfortunately the requirements can not always be met. There may be weeds present that the selective won't kill (e.g. perennial rye grass seedlings), or weeds whose tolerance to the material is close to that of alfalfa (e.g. *Polygonum aviculare*). Or growers often encounter the condition of extended emergence of alfalfa seedlings with the net results that the smallest alfalfa will not stand the dosage required to kill the largest weeds. This condition is especially serious with air applications because plane spraying is most successful when weeds are very small. Frequently the only spraying possible is by plane because fields are too soft to support ground rigs when the spray job must be done.

In their search for a method more likely to result in effective weed control in all instances, growers are having a look at pre-plant cleanup of fields intended for alfalfa planting. Seedbeds are prepared well in advance of planting time, and after weeds have emerged, are sprayed clean with contact weed oils, usually applied by air. This method holds considerable promise, and will probably gain favor with the growers. The method does require, however, that ranch management recognize the importance of advance planning and the need for effective coordination of a sequence of inter-dependent operations, if satisfactory results are to be obtained.

Established Stands

In established alfalfa stands of the Delta, winter germinating weeds have usually emerged and are ready for spraying sometime during the month of December. At that time, alfalfa is dormant and usually remains so until mid-February. It is during this period that winter growing weeds can outcompete alfalfa, and, if uncontrolled, will reduce yields, reduce stands and result in a hay of lower quality that is more costly to cut and bale. Development of the contact spray program some eleven years ago has made possible substantial progress in cleaning up hay fields of the Delta.

Under ideal conditions for contact spraying, there should be little top growth of alfalfa and weeds should be very small. When spraying is done under such conditions, costs are not excessive and results are usually very satisfactory. It is when the grower encounters deviations from this ideal condition that costs go up and results are likely to be less satisfactory. Here are some of the problems:

1) Rye grass may emerge <u>after</u> a December spraying and become established the following summer. (Other weedy species common to the Delta usually do not.) If spraying is delayed to catch the later emerging ryegrass, the early emerging weeds are too large to kill economically.

2) Established ryegrass is not killed by the contact treatment.

3) Rains may start just prior to time for spraying and prevent ground rigs from getting on the fields. In this case, air application can be used as a fairly satisfactory substitute <u>only</u> if the alfalfa is very short and the weeds are small. If spraying has been delayed for an extended period, the materials requirements are substantially increased and costs may exceed the growers profit from his first cutting.

CONCLUSION

In looking to the future improvement of weed control in alfalfa, can we include in our thinking not only better use of what we have, but also the design of a more effective production management system in which <u>new</u> herbicidal materials take their place as effectuating tools? What would the grower look for in such new materials? Low cost and dependability are paramount. They should be versatile in range of species and size of weeds that can be economically controlled, or better yet, stop them before they start. In short, they should provide dependable control at low cost, and, if possible, relieve the ever increasing demand on ranch management for precise timing of operations.

WEED CONTROL PROBLEMS IN RICE

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Until 2,4-D came along, control of weeds in rice had always been handled by rotation with other crops and other cultural practices. Then 2,4-D applied by airplane offered a rather successful inexpensive means of combating serious weed problems. Its' use in rice resulted in many of the misfortunes that followed its use on other crops. There were many instances where it was used when actually it was not necessary. Some rates were too low to do a sufficient control job. Occasionally some drifted to nearby susceptible crops. Rice also began to show some reactions to the chemical that caused reduction in yield. These misfortunes resulted in the necessity of more research and know how on the use of 2,4-D on rice.

Beginning in 1950, a cooperative program involving the Agricultural Extension service, the Experiment Station, and the University got underway. To a degree this program is still going on.

An attempt was made to determine the causes of the injury that was being exhibited following the use of 2,4-D.

Greenhouse studies conducted by Pete Kaufman at Davis showed quite conclusively that:

1. Rice plants are more susceptible to 2,4-D when treated at relatively high temperatures than when treated at low temperatures.

2. That young plants were more susceptible than older plants (up to the boot stage).

3. That 2,4-D causes more damage when taken in by roots rather than by the leaves.

4. That there was apparently no differences among varieties in tolerance.

5. That rice was most susceptible to 2,4-D, intermediately susceptible to MCP and least susceptible to 2,4,5-T.

During that first year it was possible to describe a stage of growth that the rice plant was least susceptible to 2,4-D. During that season, it was when the plant was about 56-60 days old, about intermediate between the initial stooling stage and booting stage.

The 56-60 day stage is still being used quite successfully with qualifications as the timing gauge for 2,4-D application. Generally speaking this also coincides with the best time to hit the weeds.

Because of Kaufman's original suggestion that MCP and 2,4,5-T were more selective on rice, these materials were tried in a number of experiments throughout the rice area. 2,4,5-T seemed to be the most logical chemical because of safety; however, it was found to have little effect upon the various rice weeds. MCP gave good control for the weeds and has been proven to be more selective on rice when used under conditions that would generally result in injury if 2,4-D were used.

In my own work I have found that where I have not got any injury from 2,4-D I have about doubled the rice yields by spraying weedy rice. I have also found that where injury is evident the decrease yield due to injury pretty well offsets any increase one might expect from killing weeds.

From a practical point of view, MCP would be the material to use on rice. The material is more expensive; however, its safety factor far offsets this. I have sprayed approximately 3,000 acres of rice with MCP and witnessed at least another 3,000 acres being sprayed and did not see any injury. However injury has been reported in other areas from MCP so by necessity it also must be used with caution.

Some recent work with materials even more selective than MCP show promise. Silvex and 2,4-DP while not doing quite as good on weeds as MCP and 2,4-D nevertheless would be considered as possible materials because they are more selective than even MCP. Possibly 2,4,5-T should be further tested. It is possible that it may not be desirable to completely kill the weeds in rice especially since the chemicals required to do this may also injure the rice plant. Therefore, any material that will have no effect upon the rice plant, but in turn have enough effect upon the weeds to at least prohibit competition, will possibly have its place in a rice weed control program.

The most serious weed control problems in rice exist in those areas where 2,4-D like compounds are either prohibited by law or cannot be used because of susceptible adjacent crops. Most of the San Joaquin Valley rice is in this category. Therefore, other means must be used for controlling weeds. Good cultural practices and rotation are the only real means at hand. DN Selectives have been used with varying degrees of success in a spray program. Cultural practices are the only means of controlling the most serious pest of all--water grass. By cultural practices we mean soil preparation, irrigation and rotation. Continuous submergence is a necessity. The practice of draining fields to encourage a good stand only contributes to a good grass population. It is far better to have a poor stand free from weeds than to have a fair stand with weeds. The end results are far in favor of the clean fields.

Where stands have been lost because of weather and insect pests, reseeding has not been successful except when the field has been completely dried up, reworked and re-submerged. Time is the critical element in this case and because of lack of sufficient time, this practice will not always be possible.

In 1955 in the Dos Palos area, many of the early plantings failed because of critical cold temperatures in April. In one particular field ½ of the area was reseeded by merely flying on new seed. The other ½ was dried up, harrowed with a spring tooth harrow and replanted on June 3. The end results were far in favor of the reworked field. This field yielded 4,000# of rice per acre that graded 62-70 as compared to 1200# of rice per acre, grading 42-50 in the field that was not reworked. A grade of 48-70 is considered as No. 1 and is generally about average for California. At 1955 prices, the 62-70 rice brought $4.68 per 100# compared to $3.28 per 100 pounds for the 42-50 rice. This extremely low grade resulted from a very fowl weed condition with actually about 20% of the grain weight being weed seed. The gross income per acre of the two fields would be as follows:

No. 1 field (reseeded without reworking soil)--1200 pounds rice per acre at $3.28 = $39.56 per acre -- a loss of approximately $60.00 per acre.

No. 2 field (reseeded after reworking soil)--4000 pounds rice per acre at $4.68 = $187.20 per acre -- a net profit of approximately $80.00 per acre.

This is a good example of what it costs to grow weeds.

Dinitro selectives and Dinitro general have been used quite successfully in the Thornton area where it is impossible to get a permit to use 2,4-D. The procedure followed with Dinitro selective (Sinox W in this case) was to add 6 parts of material and one to two pounds of Ammonium Sulphate in 10 gallons of water per acre. The material should be applied on a hot day and generally after 11:00 A.M. to get best results. Best control is obtained when rice and weeds are burned back to the water level. The rice recovers in about 10 days.

This treatment would only be effective with lilies. Sedge and water grass would recover right along with the rice. The farmers using this treatment also report that it is ineffective for arrowhead.

LOCAL PROBLEMS OF WEED CONTROL IN SUGAR BEETS

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In many instances, costs of controlling weeds in sugar beets in California have exceeded $40.00 per acre. One grower in our Pleasanton area reported to me of spending $15,000.00 a year for weed control on his 300 acre farm. Besides taking a direct slice from Mr. Grower's profit pie through the payment of labor, weeds often remain to reduce yields by competition and provide constant grief during harvest. Since the advent of mechanical harvesting weed roots and loose trash present in beet loads cause serious receiving problems at the factory. Also trashy beets cannot be placed in a storage pile because of interference with normal ventilation.

Probably our most serious weed in sugar beets in California is watergrass (Echinochloa crusgalli). This grass germinates in late spring or early summer and presents a serious problem in thinning late planted beets. In early planted beets it may infest the field between the time of the last cultivation and harvest. In more specific areas pigweed (Amaranthus retroflexus) is the main weed responsible for keeping labor costs high.

During the past few years many advancements have been made in the development of mechanical tools which greatly aid in reducing weeding costs. The mechanical thinning machine used for reducing beet stands is also a very effective weeding tool when used on young beets and weeds. The mechanical thinner has not been accepted in California from the standpoint of complete thinning as in the intermountain states but California farmers would do well by searching its possibilities as an early weed control aid.

The Sinner Weeder is a tool used after the beets are thinned. By the action of two steel bands drawn beneath the ground surface on both sides of the row, soil is gently rolled under the beet leaves burying any small weeds that may have emerged after thinning. The Sinner Weeder is very well used in conjunction with the mechanical thinner and the use of the two or other similar mechanical tools has resulted in many successful crops of beets grown at a fraction of normal labor costs.

The cultural practices of growing a crop of sugar beets and the subsequent weed problems connected therewith vary extremely from one locale to another within the state. One of the more important factors is the time of planting. In the South San Joaquin Valley where winter months are very mild, beets are frequently planted in the fall for an early July or August harvest. Ofttimes, rain keeps cultivating equipment out of the fields so that by thinning time there is a serious winter weed problem. Should fall plantings in our northern area prove feasible, we will be faced with the problem of winter weeds over a much more extensive area. These include mustard (Brassica), white horsenettle (Solanium) and Malva as well as some annual grasses and volunteer grain. With cultivation often impossible during these winter months we will have to lean toward chemical weed killers for control.

Everyone is waiting for the day when a selective, economical chemical will remove the weeds from beets without reducing the stand or yield. It is very encouraging when you realize the amount of time and concentrated effort being put forth to attain this goal. Besides sugar company personnel there are people in the universities, extension, experiment stations and industry working with the same end in mind. With such a united effort it remains only a question of time.

Many chemicals are being screened each year by various investigating agencies for use in weed control in sugar beets. The more promising of these chemicals are included in commercial field trials on a large plot basis. Some are discarded, others are registered and placed into commercial use while still others are held for further investigation. The following list includes some of the chemicals that have been receiving most of the attention in the weed control in sugar beets.

Sodium T.C.A. (trichloroacetate) is one of the older materials used for watergrass control in California. Dosage is usually 10 pounds per acre and is applied pre-emergence. Where rainfall is sufficient to carry the material into the top few inches of soil without further leaching excellent control results. If no rain falls however, results are sometimes disappointing.

I.P.C. (isopropyl-N-phenylcarbamate) is another material that has been in use a number of years. It offers good control of wild oats and volunteer grain in areas where they are a problem. I.P.C. is generally applied at rates of 3-8 pounds per acre preplant and disced into the top few inches of soil.

Reports on endothal, amino triazole, C.M.U., M H 40, E. H. 6249 and Monsanto's new group of chemicals CDEA, CDAA and CDEC for use in sugar beets in California are sketchy and inconclusive. Perhaps with further experimentation as to dosages and methods of application these materials may find a place in the sugar beet picture.

DCU (Dichloral urea) is being reported as giving good results in the intermountain area for the control of foxtail (Setaria) and barnyard grass (Echinochloa) as well as some broadleafs. It is being sold commercially with a recommended dosage of 6 to 14.6 pounds active per acre sprayed and worked into the soil just ahead of the planter unit.

Dalapon (sodium salt of a, a-dichloropropionic acid) is still one of the most promising in the chemical weed control of sugar beets, being somewhat selective it holds certain advantages over other materials that must be applied pre-emergence. The grower can see his problem before going to the time and expense of applying a herbicide. Dosages of over 4 pounds sodium salt per acre when applied as an overall spray has generally resulted in reduced yields in California but possibly with the use of shields or directional sprays this could be overcome. It appears to give the best degree of control of watergrass when applied at the stool stage rather than the seedling stage. Dalapon is not yet registered for commercial use but residue investigation is now under way.

In a few short years the sugar beet industry will be converted to the use of monogerm seed. We sincerely hope that by that time the weed problem will be reduced through the use of chemicals thereby making complete mechanization possible.

WEED CONTROL IN IRRIGATED PASTURES

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California's 800,000 acres of irrigated pasture utilize about 1/9th of the total irrigated acreage in the state. Weeds have become an increasingly important problem. The high monetary loss, reduced yields of forage and quality is not realized by many irrigated pasture operators.

The pasture mixture comprising both legumes and grasses with usually 3 or 4, or in some instances, more species, somewhat complicates herbicidal use as compared with a single crop.

Chemical weed control has been very beneficial in improving irrigated pasture production. The use of 2,4-D on such species as Dock, Sedges, Plantain, etc., has been a marked advancement. As has also the use of Dinitrol for the control of Yellow Star Thistle. The full potential of chemical weed control in irrigated pastures has not been realized because other management factors have not been given proper attention.

Even at the risk of being somewhat old fashioned or out of date, it seems that a brief review of other irrigated pasture management factors is in order because they are, in effect, weed control tools--better yet, they permit control of weeds through prevention. This results in more feed of a higher quality being produced. Furthermore, when the irrigated pasture operator may want to employ chemical control, it too will be more effective.

There seems to be little logic to going in and attempting chemical control of such weeds as Dock or Sedge if the growth conditions in the pasture favor these weeds over the forage species. Here we refer to the excessive water conditions which prevail in many pastures where proper land preparation, adequate drainage, and good irrigation practices are not used. Careful land preparation is the first step in control of weeds in an irrigated pasture. While it is essential for proper distribution and economical use of irrigation water, grading to allow no low places in the field, draining the ends of checks, and levelling the land between the borders are all very important for controlling weeds. Most of the present weed problems in irrigated pastures are related directly to improper land preparation, and to the subsequent problem of improperly handled irrigation and drainage water.

Stand, too, is important. A sufficient plant population growing vigorously will serve as good competitors with the weedy species.

Many times pastures are low in fertility. The additional plant foods from commercial fertilizers often not only pay high dividends in increased yields, but again will serve to permit the desired pasture species to better compete with undesirable weedy plants.

One of the best ways to control weeds in an irrigated pasture is to carefully plan the grazing system. Longer growing periods between grazing will not only increase yields, but again encourages a better competitive growth on the part of the pasture plants.

The problem of poisonous species is often raised. Generally poisonous weeds are not a problem where management is such as to encourage a good growth of the desired plants.

Many pastures that have become excessively weedy can often be improved by taking out the irrigated pasture and working other crops into the rotation. In fact, this is becoming more and more of an established practice among irrigated pasture operators.

Mowing weeds before they mature is one of the cheapest and best methods of controlling them. Mowing also has other advantages: it discourages certain of the more aggressive species from becoming coarse and bunchy and the surplus feed can be used either as hay or ensilage during certain seasons of the year.

Fertilizer will encourage desired species to grow faster and compete with weeds. So a well-planned grazing system also will help to keep weeds under control. Vigorous, healthy, fast-growing grasses and legumes actively compete with weeds while plants that are grazed too frequently and closely will be very poor competitors.

Without a doubt the most underrated piece of weed control equipment on many California ranches is that of the mowing machine. Mowing machines are standing by, rusting, while actually they could be put to excellent use for better weed control on more of California's irrigated pasture acreage.

MORNING GLORY: A PROGRESS REPORT

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Locally Convolvulus arvensis is often spoken of as wild morning glory or morning glory; less often it is called bindweed, and infrequently creeping Jenny. In the language of the street this notorious member of the morning glory family is spoken of in harsh terms. I do not believe documentary evidence is needed to prove morning glory "noxious", for the reputation of this prodigal is well established. From the standpoint of distribution and total acreage infested, weed authorities rate morning glory as the most serious perennial weed in California.

The theme of our meeting, "Weeds: What Do They Cost You?", is surely a most appropriate one for morning glory. A development in Fresno County serves as a good example. Of $150,000 spent for all weed work during the past year, $100,000 was for morning glory control. The extensive use of carbon bisulphide in the State provides further evidence of the price which farmers pay for control. During 1955 at least 1,157,550 pounds of carbon bisulphide were used in 12 counties for "Morning Glory and Knapweed". Other reports show the seriousness of the problem. In 1940 a survey showed approximately 50,000 acres in Orange County were infested with morning glory, such infestations ranging from light to serious.

So that we may have a better perspective of morning glory as a pest, I think it would be helpful to quote a well-known authority, the late W. W. Robbins. In Doctor Robbins' report of 1940 on alien plants:

> "Jepson (1923-25 describes fourteen different species of Convolvulus as occurring in California. Most of these are natives, but three, Convolvulus arvensis L. (Wild Morning-glory), C. pentapetaloides L. (small-flowered wild morning-glory), and C. sepium L. (hedge bindweed), are European species.
>
> "Convolvulus arvensis, the only species of major significance within our borders, is generally distributed at lower altitudes throughout the state; a large portion of the cultivated lands are infested. Bolander (1870) lists it as occurring near San Francisco; Brewer and Watson (1876) as naturalized there. Parish (1920) reports morning-glory at San Bernardino in 1890, and at Descanso in 1897. Hilgard (1890) brands the species as "the most dreaded of the perennial weeds". Jepson (1893) lists C. arvensis from the lower Sacramento River. This pest was undoubtedly introduced into California several years before 1870, but up to 1890 it probably did not attract serious attention. It has spread rapidly, however, since the beginning of the century and is today one of the most widespread and troublesome weeds of orchards, vineyards, and cultivated fields."

One reason this plant has been so difficult to control is its delayed germination, due to a condition known as "hard seed". Results of experiments by F. L. Timmons show that "complete ridding of infested fields of bindweed may require 30 years or more of persistent attention to a special program of farm management until all the seeds have germinated and been destroyed". To control such a tenacious pest may seem futile, but we have ample evidence of control programs benefiting farmers.

During 1954 in Orange County, there were 10,000 acres of barley, 12,000 acres of bean land and 4,000 acres of miscellaneous crops successfully treated with 2,4-D for morning glory control. Best results were obtained in the spring and summer. In the Montpelier district of Merced County, during 1955, 1,720 acres of morning glory-infested fallow land were sprayed by aircraft and 800 acres by ground rig. In 1953 the morning glory on some 2,000 acres of lima beans in Stanislaus County was successfully controlled with 2,4-D applied by the shielded sprayer. In Los Angeles, Orange, Riverside, Santa Barbara and Ventura Counties and other districts the control of morning glory in citrus groves with 2,4-D is a standard practice; 2,4-D is also successfully used for morning glory control in asparagus. In San Joaquin County three thousand acres of asparagus were treated during 1954. The above are only a few examples of successful morning glory control.

2,4-D is used for morning glory control in small cereals, corn, orchards and on fallow lands. Clean cultivation is practical in vegetables and other crops. Carbon bisulphide is used extensively for soil sterilization in fallow and cultivated lands. Sodium chlorate, the borate mixtures, CMU, and other materials are used for spot treatments in cultivated lands and roadside sterilization; infrequently, the sodium arsenite bottle method is employed in such places as vineyards and orchards. Other methods include flooding and smother crops.

The rates of 2,4-D vary according to the situation, locality and general practice in the community. For selective weed control in such crops as barley, frequently the dosage is 12 to 16 ounces of 2,4-D per acre as the amine salt. After harvest or in summer fallow much higher rates are used, as much as two to three pounds of actual acid per acre when selectivity is not a factor. The emulsive acid of 2,4-D for non-selective spraying is a preferred formulation in some localities.

The general trend of spray programs is toward the multiple treatment procedure; that is, treating established infestations from two to three times during the growing season. The trend of selective treatment is away from the amine salt and toward the low volatile esters. Twelve ounces acid equivalent per acre is a common dosage rate. Volume rates for aircraft are usually five to ten gallons of water solution per acre, and ground rig rates range from 20 to one hundred or more.

In western Fresno County the following chemicals were useful for morning glory control during 1955: CMU, CMU-borate combinations, 2,4-D borate mixtures, sodium chlorate, and chlorate-borate compounds. Infestations treated by leaching these chemicals into dyked areas resulted in 50 to 95 percent control. Uneven topography in dyked areas results in poor control. Following control the chemicals are leached from the soil so that the treated areas may again be farmed.

For soil sterilization along roadsides in heavy adobe soils, sodium chlorate at the rate of eight pounds per square rod, applied early enough to insure five to six inches of rain, gives good control of morning glory and other perennials for about three years. Road maintenance often interferes with this method of control.

Carbon bisulphide as a soil sterilant is an outstanding example of a chemical which fulfills a specific need. Cropping may follow treatment with little delay. Raising rice, wherein the infested areas may be flooded several months, gives excellent control, approaching that of carbon bisulphide.

Smother crops, such as alfalfa for hay and clover pastures, have proven effective in the control of morning glory. Good results from smother crops are reported from Stanislaud and Merced Counties.

Cultivation in such vegetables as celery and asparagus has in some instances given a high degree of morning glory control. The results depend to a great extent on the frequency and thoroughness of cultivation; no doubt, in the case of celery shading is a contributing factor. E. A. Dudley, Deputy Agricultural Commissioner at Santa Ana, tells of an interesting incident involving cultural control in Orange County: "We have an acreage southeast of Santa Ana which was so badly infested with morning glory six years ago that a crop of beans could not be raised. A Japanese farmer purchased this land and put it into celery; there is no longer an infestation existing on this property, which consists of approximately 160 acres. We have also observed this in some of the asparagus fields."

In summary we can say that morning glory is a major weed problem in California; it has been here a long time; present control methods can and do greatly benefit farmers; but the eradication of this pest is extremely difficult, and the elimination of established infestations if a rarity.

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THE CONTROL OF JOHNSON GRASS (SORGHUM HALEPENSE) AND BERMUDA GRASS (CYNODON DACTYLON)

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Johnson grass and Bermuda grass are perennial grasses which spread by both rhizomes and seeds. These pests are widespread, being found in all states to the south and east of Iowa, and in all states west along the southern boundary of the United States. In California, a recent survey (Research Progress Report - 1956, Western Weed Conference) covering seven cotton producing counties showed that, of the land area reported, 4.5 and 3.0 percent were infested by Johnson grass and Bermuda grass, respectively. Irrigation ditchbanks and roadsides are lined with these weeds throughout most of the San Joaquin Valley of California, providing a continual source of seed for cropland invasion.

The type of control measure to be used for these weeds will depend upon many circumstances.

Cultural control

In areas where it can be used, tillage is a very useful tool for controlling these weeds, particularly when the infestation covers a large area. With heavy infestations, 6 to 8 dry fallow operations in one season will usually reduce the population of these weeds to a few scattered plants. Plowing to a depth of 8 or 10 inches followed by spring tooth harrowing to bring the rhizomes to the surface of the soil has proven to be a highly satisfactory control practice. For best results the soil must be dry. As is true for all weed control measures, there are objections to fallow. There is the loss of a crop during the period the land is being fallowed, and time and money are involved in the tillage operations without an immediate cash return. These appear to be important objections when dealing with high priced land; however, the reduced production costs and improved quality of crops in ensuing years would undoubtedly compensate for the losses encountered during the season the fallow operations were being done. The objections to fallow may be partially overcome through the use of short season crops followed by intensive tillage after the crop has been harvested. This procedure has resulted in satisfactory control of Bermuda grass and at times has reduced the stand of Johnson grass.

Alfalfa has been used with considerable success for the control of Johnson grass, however, a thick stand of alfalfa maintained for a period of four to five years is necessary to insure control.

Chemical control

Chemical control has generally not proven practical for large scale treatment of farm lands. The herbicides are costly; in most cases the land must remain out of production; and harmful residues are frequently left in the soil. The most logical use of herbicides for the control of these grasses appears to be on irrigation ditchbanks, along fencelines, along roadways, and as spot treatments in fields. The herbicides used in chemical control may be divided into two classes - those applied to the soil and those applied to the foliage.

Soil applied herbicides

The selection of the herbicide to be applied will depend upon (1) the solubility of the herbicide, (2) the amount of available moisture, either from rainfall or from irrigation, and (3) the depth of the root system of the species to be killed.

The sodium salt of trichloroacetic acid (TCA) is a water-soluble material which, when mixed with water at a ratio of one-half to one pound (acid) per gallon of water and applied at the rate of 100 to 160 pounds of acid per acre, has given good results for the control of both Johnson grass and bermuda grass. This herbicide has some contact action but kills are largely dependent upon its being absorbed by the roots. Since the material is quite soluble the proper amount of water is quite critical. With too little water, the herbicide fails to reach the absorptive areas of the roots, while an over abundance of water may move the material below the root zone of the grasses. TCA will volatilize readily at high temperatures and may be lost before the plants have absorbed sufficient quantities to kill the grasses. January and February applications have usually proven most successful in the San Joaquin Valley. In relation to many other soil applied materials, the residual effects of TCA in the soil are of short duration. TCA also has more selectivity than many other soil applied herbicides and as a result probably will not control broad-leaved perennial species of weeds such as field bindweed, white horse nettle or Russian knapweed, that may be growing with the grasses.

Several commercial products varying in the proportion of sodium chlorate to borate are available on the market, and are commonly known as chlorate-borate mixtures. These products when used at the rates of 4 to 8 pounds per 100 square feet of area have given satisfactory control of both Johnson grass and Bermuda grass. These products may be classified as intermediate in solubility, however, the proper amount of moisture is also critical in order to insure best weed control. Because of the nature of their solubilities, these herbicides may be expected to disappear from the soil in one to three years, depending upon moisture and soil type. The chlorate-borate mixtures show less selectivity than TCA and are more apt to control mixed species of perennial weeds.

There are three herbicides in the substituted urea group that are generally available. In order of descending solubility they are phenyl dimethylurea (PDU); 3-(p-chlorophenyl)-1, 1-dimethylurea (CMU); and 3-(3,4-dichlorophenyl)-1, 1-dimethylurea (DCMU). These products are less soluble than the chlorate-borate mixtures, and can be expected to give a more permanent type of sterilization. Late fall or early winter application of 50 to 75 pounds per acre may be expected to provide excellent control of Johnson grass and Bermuda grass provided sufficient moisture is available to move the herbicide into the root zone of the grasses. Because of their low solubilities, particularly DCMU, these products are preferred for treating the bottoms of ditches and other areas well supplied with moisture. These herbicides, in toxic amounts, may exist in the soil for several years.

Recently combinations of the substituted ureas with the chlorate-borate mixtures have appeared on the market. The main features of these combinations is that the herbicide has a wider range of solubility and thus may be used over a wider range of moisture conditions and weed growth. There are several other soil sterilant type herbicides, however, they will not be discussed because of their being either too expensive, too hazardous, or too little known as to their herbicidal properties.

Foliage sprays

The only two herbicides falling in this category that will be discussed are non-selective weed oils and 2,2-dichloropropionic acid, sodium salt (DPA). There are several non-selective weed oils available on the market, and these are generally characterized by a high boiling range, high aromatic content, and low gravity rating. For control of Johnson grass and Bermuda grass, these oils have given better control when they have been used straight rather than mixed with water. This is primarily due to the better wetting properties of the straight oils. The smount of oil to use will depend upon the amount of foliage to be wet. One hundred gallons per acre is usually sufficient to wet thoroughly Johnson grass foliage 12 inches tall. Bermuda grass is somewhat more difficult to wet than Johnson grass but usually will have less foliage. Repeated applications, perhaps 6 or 8 per season, are necessary to reduce grass populations. In succeeding years fewer applications per year (at lower gallonages) will usually suffice. Several seasons are required to eradicate Johnson grass and Bermuda grass with non-selective oils. Fewer applications will control the weeds sufficiently to prevent clogging of irrigation ditches but seldom accomplishes much toward eradication of the grasses. One advantage of weed oils is that they control the top growth of most vegetation at the gallonages mentioned.

DPA is a water-soluble compound that is absorbed by the foliage and translocated throughout the plant; thus the herbicide is moved to the underground stems and roots of the plant. At the present no recommendation for the use of DPA in crops can be made. Important considerations for insuring success with DPA are (1) thorough wetting of the foliage, (2) spraying only actively growing vegetation, and (3) avoiding treatment of grass with insufficient foliage or grass that has recently been mowed or burned. Two applications of 15 to 20 pounds (acid) per acre per application has given excellent control of Johnson grass and Bermuda grass. Applications should be made three to four weeks apart, depending upon the regrowth that has occurred. A third application of 10 to 15 pounds per acre may be necessary under some conditions. Repeated treatments are far superior to a single treatment with a high per acre rate. Spot treatments will be required in the second and perhaps third seasons for eradication of these grasses. Advantages of DPA as compared with oils are as follows: (1) Material costs are usually less; (2) fewer operations are required; and (3) DPA offers more permanency of control because of its systemic nature. The selectivity of DPA for grasses may in some cases be a disadvantage.

No control method for Johnson grass or Bermuda grass has been devised, thus far, which is completely effective. There will always be a few plants that survive. These and the seedling plants must be controlled either by cultural or chemical means in order to prevent a rapid re-infestation of the land.

WHITETOP

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Whitetop (Cardaria draba and two closely related forms, C. draba var. repens and C. pubescens) often called hoary cress is capable of establishing itself in many soil types and under many environmental conditions. The root system consists of well developed rootstalks which penetrate to a depth of several feet and spread horizontally in all directions. This plant requires persistent, properly managed control efforts for control or eradication on crop lands. Whitetop is scattered throughout almost all of California and is a pest of major importance particularly in alfalfa, sugar beets and truck crops. Yields of these and other crops may be decreased considerably by presence of this weed.

Whitetop has proven to be sensitive to 2,4-D treatments. However, stage of growth and activity of the plant definitely limit the influence of 2,4-D. 2,4-D applications are found to be most effective at the bud stage of growth in the spring and we have had reports of successful treatments of the late fall rosette stage. The low volatile esters and the amine salt formulations are apparently superior to the other forms of 2,4-D. These materials should be applied in a sufficient amount of water to thoroughly wet the plants.

In the coastal areas of California or in irrigated areas where the growing season of whitetop is extended, if at least three treatments of 2,4-D can be applied during the growing season usually about 95% control can be obtained after three years treatment. Initial rates of 4 pounds per acre of 2,4-D are more effective where a single application is made. However, under the multiple treatment method, after two or more treatments the kill caused by the 2 pound rate is much nearer that of the 4 pound rate so there is little advantage in using the higher rates. In the drier interior regions where only one application can be made during the growing season, the dormancy of whitetop extends the eradication period for several years more.

The most effective control of whitetop has been obtained in the Orange County area of southern California by combining cultivation or cultivation and cropping with chemical treatments of 2,4-D. The method used is treatment of the whitetop in the bud stage in the spring followed by cultivation 10 days to 2 weeks afterward. A single treatment of 2,4-D followed by cultivation has reduced the infestation by as much as 80 percent in one years time.

Carbon bisulfide has proven to be reasonably satisfactory for control, although sometimes it has failed, particularly in adobe clay soils.

Soil sterilization to eradicate whitetop on non-cropped lands has been quite unsuccessful in many cases for this plant is somewhat tolerant to sodium chlorate and is quite tolerant under some soil conditions, particularly alkaline soils.

In certain conditions, sodium chlorate has brought fair results, but it is required in relatively large amounts, under average conditions about six pounds per square rod. On adobe clay soils in the Davis area, this amount applied early in the winter has generally proven to be satisfactory. It must be remembered that the amount of rainfall following the application determines the penetration of sodium chlorate into the various soil types and the material has to be leached to the depth of the root system in order to prevent regrowth.

Additional progress is being made along the lines of soil sterilization and there is a product consisting of a formulation of sodium borates and 2,4-D that looks very promising at rates of one, 2 and 3 pounds per hundred square feet depending on rainfall received. In most of these plots practically 100% kill has been obtained, particularly at the 2 and 3 pound rates.

Amino triazole at rates from 4 to 8 pounds per acre applied in water as a drenching spray looks very good in our coastal areas although what occurs this spring in the way of regrowth will give us our final answer.

RUSSIAN KNAPWEED CONTROL

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Control of Russian knapweed has been satisfactory, generally speaking, in most areas of the State, when hormone spraysand soil fumigants were used in crop lands and soil sterilants on other areas. The amine and emulsive acid forms of 2,4-D, carbon bisulphide, chlorate or chlorate-borate mixtures, and the substituted urea compounds are the materials usually employed in control programs. Poor results, in any control program, are sometimes encountered in specific areas; in the case of knapweed poor results were realized in the west side of the San Joaquin Valley. Although good control was achieved there with the use of soil sterilants[1], the use of hormone sprays as recommended for other areas was not successful. In view of the extensive acreage of crop land infested in this area, it was desirable to attempt to develop an effective program using the hormone sprays. The balance of this paper will be a report of our efforts in that direction.

In cooperation with the Fresno County Agricultural Commissioner and the County Extension Service, test plots were established on the Murietta Farms southwest of Mendota in 1952. The plots were approximately ½ acre in size and located in a fallow grain field. The plots were sprayed in June with emulsive acid of 2,4-D at the rates of two, three and four pounds per acre in forty gallons of water and were duplicated in another part of the field. In September all plots were re-treated at the same rates. Examination in May, 1953, indicated no material reduction in stand; consequently the two and four pound rates were continued, and one of the original three pound rates was treated with six pounds at this time. The plots receiving four pounds were re-treated in July and October, 1953, which then made a total of five treatments. Results of all treatments were very poor; reductions of top growth up to 60 per cent were obtained, but re-growth from the roots would be 90 per cent or more of the original stand.

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At the suggestion of the rancher, it was decided to attempt control in grain during 1954. A heavily infested forty acre barley field was treated with amine at two and four pounds per acre. Amine was used rather than emulsive acid to minimize possible damage to the grain. Ground equipment, delivering seventy gallons per acre at forty pounds pressure, was used for the spray operation. The field was fertilized with fifty pounds of NH_3 in November, 1953 and irrigated in March, 1954. The first application was made May 5, 1954 when the grain was in the hard dough stage and the knapweed in the late bud and early bloom period. Examination of the knapweed, just prior to grain harvest six weeks after treatment, revealed very poor results. We had planned to re-treat the field in July and October, but insufficient re-growth after harvest, due to the extremely dry condition, made such applications inadvisable.

Russian knapweed in the Mendota area apparently becomes semi-dormant during the hot summer months. There is very little growth activity from July until cooler weather in October, especially in stubble fields and on fallow land. With this in mind, a series of fall treatments, applied when the knapweed was in the rosette stage, was decided upon. The area where the plots were established was burned and irrigated in early October, and treatments applied October 27, 1954. A comparison test of effectiveness, at two, four and eight pounds in eighty gallons of water, was made with the following materials: low volatile ester, amine and emulsive acid of 2,4-D; amine and ester forms of 2,4,5-TP; and 4-chlorophenoxyacetic acid. The effect of volume was tested, using four pounds of amine in twenty, forty, eighty and one hundred sixty gallons of water. The value of Vatsol and Multifilm 'L' as additives was also tested, using the 2,4-D amine at four and eight pounds in eighty gallons of water.

The plots were irrigated again in March and evaluated in May. Results of the comparison tests were as follows: 8 lbs/A of the amine and emulsive acid of 2,4-D and 8 lb/A of the 2,4,5-TP ester gave an 85 per cent reduction in stand. An 80 per cent reduction was received with four pounds of amine and emulsive acid and eight pounds of low volatile ester; and 75 per cent reduction with four pounds of low volatile ester of 2,4-D and four pounds of 2,4,5-TP ester. All other dosage rates and materials resulted in 50 per cent or less reduction in knapweed stand. The volume test results were as follows: 20 gal/A of material - 40 per cent reduction; 40 gal/A - 70 per cent; 80 gal/A - 80 per cent and 160 gal/A - 95 per cent reduction; in fact, there was only one plant remaining in this plot. The use of Vatsol at .1 per cent and Multifilm 'L' at 1 qt/100 did not increase the effectiveness of the amine at either the four or eight pound rate.

Another series of plots was established in December, 1954 using 2,4-D as a temporary soil sterilant. Amine and emulsive acid were applied at rates of twenty, forty, eighty, and one hundred twenty pounds per acre and low volatile ester at forty and eighty. These plots were irrigated in March and readings made in May. The amine and emulsive acid produced comparable results, giving 100 per cent control at 120 pounds, 99 per cent plus at eighty pounds, 95 per cent at forty pounds and 90 per cent with twenty. The low volatile ester was rated at 90 per cent with eighty pounds and 80 per cent with forty pounds. The effectiveness of these treatments was continuing through last fall.

Another attempt was made to treat knapweed in grain during 1955. A fall-seeded forty acre barley field, which had been irrigated and fertilized in October, was again used. Amine and emulsive acid of 2,4-D was to be used at two and four pound rates in one hundred sixty gallons of water. Two and four applications were to be made during the summer. The first of the four application series was sprayed in March, when the knapweed was in the rosette stage and the grain about six inches high. The second application was made June 1, when the knapweed was in the late bud and the grain in hard dough.

During the second spraying, a reduction was noted in the stand of knapweed in plots treated during March. This reduction was estimated at 50 per cent for the two pound rate of both materials and 75 per cent for the four pound rate. Just prior to the third treatment schedules for July, the rancher suggested we forego further treatments because of 2,4-D effects found in cotton one-half mile away. The effects were slight and did not occur until six weeks after the last application. Indications are that the injury was caused by dust carried from the treated field by a high wind during harvesting operations, since the symptoms appeared about three days after harvest was completed. Due to very little re-growth subsequent to harvest, further evaluation was not made.

The use of hormone type sprays, as a fall and spring treatment on Russian knapweed in the rosette stage or as a temporary soil sterilant, is indicated by the above trials. Further tests with these treatments are planned as are trials with the other and newer materials. The utilization of 2,4-D or related compounds for Russian knapweed control on the west side could achieve the following benefits: lower cost per acre; shorter periods of crop loss on sterilized areas; and application of materials during the non-hazardous period in the cotton growing area.

STATUS OF THE NUTGRASS PROBLEM IN CALIFORNIA

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Two tuber-producing sedges have become established in California -- purple nutgrass (Cyperus rotundus) and yellow nutgrass (Cyperus esculentus). These plants are of world-wide distribution in tropical and temperate zones, but are of comparatively recent naturalization into California. Both are serious weeds on cultivated lands. These plants are spread chiefly by means of their tubers being mowed on tillage implements and in soil on nursery stock and in fill earth. The seeds are low in viability, but reproduction by seeds does occur.

Purple nutgrass is distributed throughout California and is particularly abundant in the southern counties. The distribution of yellow nutgrass is also state-wide. However, it is present in greatest abundance in the San Joaquin Valley. There is evidence that purple nutgrass was introduced into southern California as recently as the 1880's. Although closely related and similar in appearance, the two species differ widely in their response to control measures. General failure to realize that there are two separate and distinct nutgrass plants has led to much confusion both in the development and application of control methods. At the present time both plants are in a stage of uncontrolled invasion of agricultural lands.

Nutgrasses can be distinguished from the true grasses by their triangular stems and arrangement of leaves into three ranks. Purple nutgrass is somewhat smaller than the other species and has darker green foliage. Its tubers are about one half-inch long, oval, and occur in chain fashion on rhizomes extending from 1 to 3 feet below the surface. Yellow nutgrass has a medium green or pale green foliage and produces round, pea-sized tubers terminally on rhizomes radiating from the mother plant. The two species may be reliably distinguished by the taste of the tubers. Yellow nutgrass tubers have an almond-like, pleasant taste. Purple nutgrass tubers have a bitter pungent flavor. The tubers of yellow nutgrass are often called "earth almond." Selected varieties of yellow nutgrass have been grown for human consumption in the Mediterranean region and as a food for livestock since prehistoric times.

Although both species have been present in California throughout a major portion of the period during which much of our land was brought into cultivation, a great deal of our acreage remains uninfested. This is not because nutgrasses are not well adapted to our conditions, but is due to the fact that they are slow spreaders. Dissemination of the tubers accounts for most new infestations of lands. Tubers are spread in fill soil, nursery stock, on tillage equipment, and by erosion. Rodents gather and store the tubers and thus disperse them. Once tubers are established in a new location, colonies form by lateral growth of the rhizomes. The plants arising from a single tuber may produce as many as 150 additional tubers in a growing season.

Once land is thoroughly infested with purple nutgrass, production of vegetable crops and most field crops is no longer economically feasible. This has led to the abandonment from further agricultural use of otherwise valuable land in the Coachella Valley. We recently made a population study of such a nutgrass infestation in the Coachella Valley. One acre of infested land was divided into ten equal plots, and eight cylindrical pits 1 foot deep were dug at random in each of the ten plots. The tubers were screened from the soil taken from the surface 6 inches, and counted separately from those taken from the horizon extending from 6 inches to 12 inches deep. The 80 pits thus sampled yielded population information having a high degree of statistical reliability. Tuber counts averaged 156.5 per pit for a total of 12,522 tubers counted. The tuber population in this field was therefore approximately 34.7 million tubers per acre in the surface foot, amounting to about 38.3 tons of tuber tissue in the surface acre foot. The ratio of tubers in the top 6-inch layer to those in the second 6-inch layer was approximately 1.75. With the realization that many tubers lay below the 12-inch level and were not counted, I think we can safely say that this field was infested with at least 40 tons of nutgrass tubers per acre.

It has been our frequent observation that heavily infested soils contain upwards of 500 tubers per cubic foot of surface soil. I think that this study, in addition to emphasizing the magnitude of the problem, also points out the difficulty of achieving control by one-shot methods. For example, a treatment can be 99 per cent effective and still leave 5 or more living tubers per square foot. A solid stand of nutgrass can come back in a matter of a few weeks following such a treatment. Under good growing conditions, the five tubers per square foot can regenerate the original tuber population in one season.

Since nutgrass does not infest all of our fields, we have two problems: one of preventing the introduction of these weeds into new fields; and another of controlling existing infestations. Growers who do not have nutgrass should learn to recognize it and be prepared to stamp out colonies as soon as they appear.

Fumigation is a successful and economically sound method for the elimination of small, invading colonies. Of the several fumigants available, methyl bromide will control both species. To fumigate, thoroughly till the infested soil when not excessively wet, spread a gas-proof tarpaulin over the soil supported above the ground by brush, lumber, or other dunnage, bury the edge of the cover in a trench and carefully seal with moistened soil. Introduce methyl bromide under the tarp at the rate of one pound per 100 square feet of soil area. Continue fumigation for twenty-four hours. Methyl bromide is poisonous to man and necessary precautions for the safety of personnel should be taken.

Liquid fumigants such as DD and EDB may also be used to kill the tubers in the soil. These materials are effective at rates of from 60 to 120 gallons per acre. DD and EDB may be injected with a hand gun, spacing injections about 1 foot apart. These materials are less effective than methyl bromide since it is seldom possible to kill all of the tubers near the surface.

Many practical tests of foliage applications of herbicides for control of nutgrass have been made. The following remarks apply only to purple nutgrass since my work and field observations have been concerned mostly with this species.

It is characteristic that purple nutgrass regrows rapidly following top kill by mechanical methods or contact herbicides. Field experience indicates that two seasons of frequent spraying with weed oil is necessary to obtain satisfactory control. Spraying as frequently as intervals of ten days or two weeks is required during the first season, however, regeneration of top growth becomes less rapid with successive sprayings and both the volume of herbicide and frequency of application become less burdensome late in the first growing season and throughout the second season. The extent and rapidity of regrowth following oil spraying is not fairly representative of tuber mortality early in such a spray program. Greater mortality of tubers is obtained than is apparent from top growth reduction. Our studies show that two successive mid-summer treatments with fortified diesel oil may reduce tuber populations as much as fifty per cent.

Repeated sprayings with 2,4-D and related materials dependent upon formulation are as effective and in some cases appreciably more effective than petroleum oils. Two successive summer applications of low volatile esters of 2,4-D, 2,4,5-T and MCP reduced tuber populations by approximately 60 per cent as compared to 40 to 50 per cent for two oil sprayings. 2,4-D is somewhat more effective than the other two materials when applied in comparable formulations. An emulsifiable acid formulation of 2,4-D was appreciably more effective than the ester formulations, two treatments reducing tuber population 80 per cent.

Regrowth following treatment with hormone type herbicides is slower than the growth following treatments with contact herbicides. When results are based on mortality of the tubers rather than rapidity and completeness of top-kill, applications of 2,4-D acid and esters at rates of 2 pounds per acre were consistently more effective than rates of 4 pounds per acre. The addition of even small amounts of oily solvents such as light summer oil or diesel oil to 2,4-D ester formulations, reduced mortality to the tubers. We might expect that the most effective formulation of esters would consist of the straight ester alone plus surfactant without the addition of oily solvent.

Other translocated herbicides such as dalapon and aminotriazol may be used in spray programs for the control of purple nutgrass. The extent to which these materials are translocated into the tuber systems is not well known. Preliminary information indicates that both dalapon and aminotriazole are more effective than contact herbicides.

There have been many tests with urea herbicides and other soil sterilants. In general, it can be stated that purple nutgrass is relatively resistant to the soil sterilants commercially available at the present time. Applications of 2,4-D to the soil at rates as high as 400 pounds per acre have failed to give satisfactory control.

Where widespread infestations occur, actual eradication is seldom feasible; however, appropriate control measures may be expected to supress it and return crop production costs to reasonable levels. Intensive cultivation is advantageous in reducing the stand of nutgrass, but has the disadvantage that it spreads the tubers into uninfested areas. As with contact herbicides, reduction in tuber population can be obtained only by a long-term program. Intensive cultivation combined with a crop which provides dense shade greatly reduces the vigor of nutgrass stands. In the production of cotton, for example, top growth of the nutgrass should be kept down by frequent cultivation and hand hoeing until the crop provides shade over the furrows. Solid stands of nutgrass may be reduced to low levels of density and vigor by this method by the end of the second or third growing season. Applications of 2,4-D emulsifiable acid at one and one-half pounds per acre alternated with plowing would be expected to provide more rapid control of purple nutgrass than programs using the chemical or cultivation method alone.

Recent data on the effect of drying on the viability of nutgrass tubers is of interest. When the tubers of both species are exposed to dry air or dry soil they lose moisture rapidly and become shriveled. Purple nutgrass tubers dry to about half their original weight and those of yellow nutgrass dry to about three quarters of their original weight. When placed in water or moist soil, yellow nutgrass tubers take up water and resume growth while purple nutgrass tubers were found to be dead. We feel that better mechanical control of yellow nutgrass can be obtained by tillage when adequate soil moisture is present, thus stimulating growth between tillage operations and depleting the food reserves of the tubers. With purple nutgrass, tests show that excellent control can be obtained by a thorough drying of the soil and following with deep tillage to cut the roots connecting the tubers with subsoil moisture. The effectiveness of this method is limited only to the extent of failure to thoroughly dry the soil and cut all roots extending to moist soil.

In summary we can say that the two species of nutgrass are pests of major importance and although much of our land remains uninfested, these weeds are continuously spreading. Growers should use every possible care to avoid introduction of nutgrasses into new fields. When infestations first appear in otherwise clean land, vigorous measures should be taken to stamp out the colonies before they spread. For such spot treatment, methyl bromide fumigation or repeated spraying with 2,4-D acid or other herbicides is effective. For fields that are extensively infested, intensive cultivation in conjunction with a shading crop, long-term spray programs, combinations of tillage and spraying, and summer fallow programs provide adequate control, although at considerable expense. Deep tillage of purple nutgrass stands when the soil is thoroughly dry will control this species, but is not effective against yellow nutgrass.

AGRICULTURAL SPRAY NOZZLE DESIGN, RESEARCH AND MANUFACTURING

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A dictionary defines the word nozzle as a spout for the discharge of liquid and the word orifice as a small pening or aperture. The present day spray nozzle is a far more complex and precise instrument than these definitions would imply. The high cost of labor, equipment, and material sprayed makes it necessary that the spray nozzle be correctly designed and accurately made.

In the agricultural spraying field there are four basic types of spray patterns generally used. These are the solid stream, hollow cone, full cone, and flat fan type spray patterns. The orifices are supplied as interchangeable orifice tips and are used in conjunction with the nozzle body, strainer assembly, and retaining cap, or they may be supplied as separate and complete nozzles.

The solid stream orifice is a round hole drilled into a thin plate or into an orifice tip. In the thin plate the edges at the inlet and outlet are kept sharp. This causes a contraction of the stream, but it assures a perfectly round pattern even at high pressures. In the orifice tip a tapered approach is normally used to insure full flow expecially at lower liquid pressures. Capacity is controlled by the diameter and length of the orifice and the velocity of the liquid through the orifice. Atomization is dependent on velocity differentials and air resistance. The tip is generally used for pest control work where a thin stream with minimum atomization is required, and as a metering device for controlling flow of liquids. An example would be the application of liquid fertilizers and soil fumigants.

The hollow cone spray pattern is produced by imparting a whirling action to the liquid prior to its leaving the orifice. This can be done by directing one or more liquid streams tangent to a whirlchamber. Capacity is controlled by the inlet hole size and the orifice diameter. By varying these dimensions it is possible to produce different spray characteristics. For example, if the inlet hole remains of one size and the orifice is enlarged, the nozzle will provide a wider included angle of spray. If the orifice diameter remains constant and the inlet hold is enlarged, the nozzle will provide a narrower spray angle. Liquid leaves the orifice as a thin sheet...atomization takes place directly after exit...the degree of atomization is dependent upon pressure, surface tension, specific gravity and other characteristics. Generally speaking the hollow cone nozzle will provide a finer break up than other orifices of equal capacity. Uses are airplane spraying, spraying of insecticides in row crops, blower type sprayers, etc.

The full cone spray pattern is produced by a whirling action of the liquid plus some means of filling in the center of the pattern. This calls for the use of an inner core or twirler. In one type of core a turbulence is set up within the nozzle and control of this provides a full cone pattern with good distribution of liquid. In another design the core has a hole drilled in its center for purposes of filling in the spray pattern. In both cases atomization or liquid break up begins to take place within a whirl-chamber or area before the orifice. The particles are larger than those provided by a hollow cone nozzle of equal capacity. The full cone is used wherever a larger droplet with more drive or impact is required. The relative sizes of the core slots and the orifice diameter are important to the spray characteristics. A large core slot with a small orifice will provide a narrow full cone spray, and conversely, a small core slot with a large orifice will produce a wide angle full cone spray.

The nozzle used most extensively in the agricultural field is the flat or fan type spray pattern. A flat spray can be formed by directing a solid stream of liquid against a deflector plane or by having two solid streams impinging upon one another. In the deflector plane nozzle the capacity is controlled by orifice size and the angle of spray is controlled by the deflector plane curvature. It is possible to make spray angles of 10° and 15° as well as 300°. The deflector plane nozzle is generally used at low pressures...defoliation is one application of several. The latest development in this type is known as the "Fieldjet". By its specially designed plane the nozzle will cover up to 36 feet. It provides excellent distribution throughout the pattern and should meet the need of many boomless spraying operations.

The converging stream principle has been refined through a great deal of development work to give us today's flat spray nozzle. In reality the same effect takes place. Converging streams of liquid meet within the nozzle to form a flat spray, and the V-slot governs the width of the resulting pattern. By controlling the inner shape of the orifice and the angle of the slot, we can predetermine the nozzle capacity and included angle of spray and the distribution of the liquid throughout the pattern. In the wide spray angle orifices the V-slot must be narrow and sharp. The flat spray nozzle is used to provide overall coverage and it is also used in row crop spraying. Applications involve the spraying of such chemicals as herbicides, insecticides and liquid fertilizers.

Although the use of nozzles to atomize or subdivide liquid into particles is very extensive, the actual processes taking place within and outside the nozzle are not completely known. For this reason the development of new designs is largely a matter of modification of standard principles and most of this work is done in the experimental laboratory. To cite an example, early in the agricultural spraying program it was found desirable to have a nozzle that would provide a pattern with reasonably good distribution and maximum projection. The application involved the spraying of secondary waterways where the use of a projecting boom was not practical. By modifying the V-slot of the flat spray tip it was found possible to provide progressively larger particle sizes from one edge of the pattern to the other. The larger particles provided greater trajectory and coverages up to 36 feet were made possible with a single tip. This "off-center" spray orifice brought about the boomless sprayer. There have since been other developments in this nozzle. One is the "Fieldjet" mentioned previously...other nozzle types will be discussed later.

In designing a nozzle to provide definite spray characteristics it is necessary to take into consideration not only the size and shape of the inlet and orifice, but also the properties of the liquid sprayed...specific gravity, viscosity, surface tension and temperature.

The main effect of the specific gravity is upon the flow rate. Basically, the velocity is affected. The higher the density or specific gravity the slower the velocity through the nozzle and thus the smaller flow rate. The following formula gives the relationship of the specific gravity to nozzle capacity.

$$\text{Capacity (liquid sprayer)} = \text{capacity (water)} \frac{1}{\sqrt{\text{Specific gravity}}}$$

In other words, the flow rate of a nozzle spraying a liquid other than water is the water flow rate divided by the square root of the specific gravity. The exact effect of specific gravity on the distribution is not completely known.

Viscosity of a liquid is usually the most important factor to consider because of its effect on all of the spray characteristics. In hollow cone nozzles the higher viscosities tend to slow down the whirling action and cause an increase in capacity. In the full cone spray nozzles this same tendency exists. Very viscous materials will eliminate the whirling action entirely and extrusion will take place in the shape of the orifice. In flat spray and solid stream nozzles (where there is no whirling present) the effect of viscosity is less apparent. The capacity will decrease with increases in viscosity. This is due mainly to frictional effects of the liquid. The effect of viscosity on spray angle is the same for all nozzles. With increase in viscosity there follows a decrease in the angle. Distribution is also effected. In flat sprays, increased viscosity usually brings about heavy edges in the pattern. These can often be overcome by the use of higher pressures. In hollow cone and full cone nozzles, the distribution will be good once the minimum operating pressure is reached.

The main effect of surface tension is upon the spray angle and the particle size. Surface tension acts upon the web of the spray produced by a nozzle. A high surface tension tends to pull this web together resulting in a smaller spray angle. A low surface tension allows this web to expand and a wide spray angle results. The effect is more noticeable in the hollow cone and flat spray types. The effect of surface tension on nozzle distribution is varied. Its effect on capacity is negligible.

Temperature is important because it varies the properties of a liquid ...specific gravity and viscosity...and these together with surface tension will alter the spray characteristics of a nozzle.

Besides studying the properties of liquids, the research laboratory must also contend with such factors as capacity, distribution, particle size, velocity and impact, wear tests, and evolution of new nozzle types.

Nozzle capacities can be determined by collecting sample volumes in a given time, or more readily, by the use of direct reading flow-meters. Agricultural spray nozzle capacities are usually small making it necessary to contend with the problem of clogging. It is important that the flat spray orifices be designed to operate satisfactorily without the use of a diffuser or other baffle. Correctly designed hollow cone nozzles should make use of a large inlet opening to keep clogging to a minimum. Small capacity nozzles should be protected by strainers, either built-in or external. The screen mesh should be sufficiently small to prevent orifice clogging, but as any orifice will pass a certain amount of foreign material, the opening in the screen need not be much smaller than the orifice diameter. Too fine a screen mesh will result in clogged strainer assemblies.

The distribution of liquid in a spray pattern can be determined by distribution tables or collecting pans. The distribution table can consist of a brass table top into which V-slots have been carefully milled at regular intervals. Each slot should connect to a calibrated tube. The table's use is of importance in the design of orifices providing modified spray patterns. The most generally used flat spray tip produces a spray that has a tapered edge. Its purpose is to provide as much uniformity as possible at the overlap of two patterns. For pre-emergence spraying it is more desirable to have uniformity throughout the pattern. This is possible in the "E" series or "even spray" nozzles. The liquid is sprayed in bands and there is no problem of overlap. For pre-emergence spraying in row crops, where a minimum amount of liquid is desired at the center, it is possible to provide the "LC" or light center series. Large collecting pans can be constructed of aluminum and held together by wooden racks. The large pans are used to determine distribution provided by boomless sprayers. The nozzle can be stationary or a special rig can be devised to simulate various rig speeds and permit study of spray in motion. Many developments and refinements in boomless spraying have been possible by this equipment. The original "off-center" tip covered approximately 20 feet. A slight modification in the form of the orifice improved the spray distribution; however, there the need for greater coverage. Exhaustive tests proved that this was not feasable with a single orifice, but it could be done very satisfactorily with a cluster of five orifices. A large off-center tip is directed to each side. The pattern supplied by the leading edge is supplemented by a very narrow angle flat spray nozzle. The area at the center is covered by a wide angle flat spray nozzle.

One of the most discussed characteristics of a spray nozzle is particle size...how it is produced...how it is measured...and what effect it has in agricultural spraying. The particle size is dependent on such variables as capacity, spray angle, pressure, type of nozzle, and properties of the liquid. There does not seem to be any complete theoretical treatment on the subdivision of liquid into droplets, and since the practical side of the problem is of most importance, we confine our work to the experimental laboratory. It is evident that large capacity nozzles will not provide the same particle size as small capacity nozzles...also that increase in pressure will result in decrease in particle diameter. This is true up to a certain limit. The particle size vs. pressure curve levels off, indicating that further increases in pressure will bring about relatively small decreases in particle size. A wide spray angle will tend to provide finer break-up and the type of nozzle has a definite bearing upon the particle size it will produce. The following list shows a comparison of three basic types of nozzles spraying water at 70° F. at a pressure of 100 p.s.i. The nozzles have the same flow rate and the same spray angle.

Mean Number Particle Size

1/4 T 12	68 Microns
1/4 T 6502	77 Microns
1/8 G 1	92 Microns

The hollow cone nozzle gives the finest break-up, the flat spray is second, and the full cone has the coarsest particle size. The term median number particle size denotes that 50% of the particles by count fall on either side of the given micron size. The main objective at the present time is to produce nozzles that will provide the greatest uniformity of particle sizes. In other words, the aim is to cut down the number of very fine and very coarse droplets and maintain a narrower range of particle sizes. The answers are not known as yet. Careful polishing of orifice surfaces helps reduce the particle size range but design factors are also involved and their relationship to the problem is now being studied.

Several methods have been devised for measuring the droplet sizes. One is the "tray method" wherein samples are collected and measured in small plastic trays containing a naptha base solvent, paraffin oil or other solution. The particles are measured by microscope or microprojection. The advantage of this method is that the small particles will maintain an almost perfect spherical shape and no correction of the measured size is necessary. One disadvantage is the possibility that a good portion of the smaller droplets, 20 microns and smaller, will not penetrate the surface of the collecting liquid and larger particles (150 to 200 microns) will tend to break-up on contact with collecting liquid. The second method is photographic. A spray is directed into a field between a double extension bellows camera and a light source. A wire having a diameter of .003" is placed in the field as a means of calibration. The particles are magnified ten times into a 4" x 5" film, and they are then viewed under a 27 X power microscope for manual counting. This method has a resolving power of approximately 10 microns. Below 10 microns the particles are not as sharply defined but they can be counted.

Controlled abrasion tests are of great importance in determining the relative wearing qualities of various materials and in suggesting design changes to prolong nozzle life. The results of these tests have made it possible to prolong the life of a core five times with only a minor variation in design. Tests now in process indicate that changes in another cone spray nozzle may afford 40 times more wear.

Spray velocity and impact are two other nozzle spray characteristics that are studied in the research laboratory. Again there are many variables present...type of nozzle, pressure, particle size, direction of spray and properties of the liquid. At present not enough data has been taken to correlate these factors.

The research and development laboratory must, of necessity, work closely with the engineering and machine design department. When specially formed orifices are developed, such as the off-center spray tip, a special machine must be built for its production. Two conditions must be fulfilled. The orifice must meet spray requirements and its design must lend itself to modern production methods. Generally speaking all orifices are made on special machines. These are machines that the nozzle manufacturer designs and builds himself. The equipment must provide means for the most accurate drilling and milling operations and wherever possible it should be automatic. Remaining parts of the nozzle, such as body, cap, strainer assembly, etc, can usually be made on standard hand operated or automatic screw machines. Drill presses, and other second operation machines come into play for the remaining operations.

The materials most generally used in the production of agricultural spray nozzles are brass, aluminum, and stainless steel. The material is usually in bar stock form although some parts can be fabricated in cast brass or cast aluminum. Brass can be machined accurately and at high speeds. It makes the least expensive nozzle and at the same time it can be used satisfactorily in a majority of the spray applications. Aluminum is used where weight is a factor and where the solutions used will affect brass. Aluminum makes good nozzle material but care should be taken to keep threaded connections lubricated to prevent alling. Stainless steel is specified for greater erosion and corrosion resistance. For example, the spraying of solutions containing suspended solids (wettable powders) will call for stainless steel orifices. Complete fertilizer solutions will require the corrosion resistance of stainless steel. Where maximum wear resistance is required, the orifice tips or inserts are supplied in hardened stainless steel.

There are two remaining steps in nozzle manufacture...production testing and marking. Normal machining tolerances are plus or minus .005"; press fits are held to plus or minus .001"; and concentricity tolerances are less than plus or minus .0005". Orifice sizes are controlled by actual capacity tests. Production testing is generally done in several steps. In the flat spray tip for example, the tip blank is given a visual check; the tip is tested for capacity and spray angle during the drilling and milling operation; and finally, there is a 100% visual spray test. The frequency of the capacity test will depend upon the tip size. In the small capacities it is customary to test every 10th tip. In larger capacities it may be every 20th or 25th tip. In the cone spray nozzles such as the "Conejet", the blank is given a visual check for dimensional tolerances; the initial milling set-up and the final formation of the orifice are subjected to capacity tests (generally every 25th piece), and after final assembly there is a 100% visual test.

All nozzles must be clearly marked for easy identification. The usual method is to stamp numbers on to the tip, and wherever possible it is desirable to have these numbers tie-in with the spray characteristics. For example, in the flat spray tip #8001, the first two digits identify the 80° spray angle and the last two indicate the nozzle's capacity of 0.1 gallons per minute at 40 p.s.i. water pressure. In the OC 20 tip, the first two letters indicate the "off-center" flat spray pattern; the number 20 shows a capacity of 2.0 GPM at 40 p.s.i. Cone spray nozzles are usually stamped with numbers corresponding to the capacities in gallons per hour at 40 p.s.i. Examples are the TX 1, TX 2, etc. Since capacity varies as the square root of the pressure, it is easy to approximate capacity at other pressures with the use of the slide rule. The numbers on the disc type orifices correspond closely to the number of 1/64" in the orifice diameter. For instance, the D 8 disc has a diameter of 8/64 or .125".

It will be noted from the foregoing discussion that a spray nozzle is more than a spout for discharge of liquid, and its orifice is more than a small opening or aperture. A spray nozzle is in reality a precision made tool. It must be so to meet the exact needs of the agricultural engineer and the all important needs of the farmer and grower.

RESEARCH STUDIES OF SPRAY DRIFT FROM AGRICULTURAL AIRCRAFT

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How far can lethal amounts of spray or dust particles drift? The answer to this question is of utmost importance to any agricultural aircraft operator applying toxicant materials in diversified farming areas. It is not a new problem. Early aircraft dusting of poisonous materials, such as lead arsenate, resulted in drifting of quantities to nearby pasture foliage sufficient to kill livestock. Recently, the drifting of 2,4-D to susceptible crops such as cotton, tomatoes, grapes, or alfalfa has caused a number of lawsuits resulting in state and county restrictions.

The Agricultural Engineering Department under the Agricultural Experiment Station of the University of California recently initiated a project on the engineering aspects of applying agricultural chemicals by aircraft. The initial work has been directed toward determining the magnitudes of factors influencing drift and methods enabling the aircraft operator to safely and efficiently apply the toxic materials. Basically, spray drift can be attributed to one or more of the following factors: the type of spray equipment such as nozzles, spray pressure, etc.; the influence of the aircraft in creating air currents and turbulent areas in its wake; the effect of microclimates such as wind velocity profile, humidity, temperature gradient and wind direction; and also the volatility and other physical characteristics of the chemicals. All the above factors are important and must be considered in analyzing the extent of spray drift.

INFLUENCE OF SPRAY EQUIPMENT - The nozzle type, size, pressure and location are important factors which determine the droplet size distribution and therefore the possible extent of spray drift. Very little information is available to indicate the droplet size as a function of the liquid characteristics, nozzle design and air velocity. To eliminate the tedious task and possible human errors involved in manual drop sizing techniques we are currently constructing an electronic droplet counter of the University of Wisconsin design. The unit will automatically determine the droplet size distribution from photographic negatives of the droplets and will enable us to work more efficiently and quickly. Figure 1, by Dr. F. A. Brooks (1)*, indicates the distance various size water particles will drift while settling 10 feet in air flow averaging 3 mph for the 10 foot depth. This figure emphasizes the fact that by increasing the droplet size from 10 microns to 50 microns the drift would be reduced from 1 mile to less than 200 feet. Thus, for minimum drift the typical hollow cone nozzle arrangement was replaced with the proposed solid jet nozzle. In addition the nozzle was directed backwards to obtain the least relative velocity between the air and jet for minimum atomization. A series of experimental tests were conducted to determine the feasibility of the solid jet system. A water soluble Saffranine "A" 147% concentrate red dye was added at the rate of 2 lbs. per 100 gallons of water. Slow motion pictures were taken of each installation, each operating at a pressure of 18 psi, and 9 gallons per acre. A noticeable uplift of fine droplets trailing the wingtip was present with the hollow-cone nozzles, but very

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*Numbers in parentheses refer to appended references.

little was present with the jet system. Additional checks were made on the droplet size by running 6-inch wide paper strips along the ground perpendicular to the line of flight. The droplet size produced by the jet was found to be considerably larger in the normal swath width of the plane.

The paper strip is also useful in determining the relative spanwise distribution of the spray. It offers a quick method for directly observing extremely high peaks or valleys in the distribution pattern. However, this may be confusing due to different drop sizes in the spray. To obtain accurate quantitative values of the distribution 3 by 6 inch stainless steel plates were placed at one foot intervals perpendicular to the flight path. The dye on the plates was washed off and analyzed quantitatively with a colorimeter. Preliminary checks on the 1/8 inch jet nozzles spaced uniformly at one-foot intervals indicated that the propeller wash caused a three-time variation in concentration near the centerline. Figure 2 illustrates the spray distribution from uniformly spaced nozzles and a relatively simple asymmetrical nozzle arrangement. With the exception of the propeller area, a uniform one-foot nozzle spacing was maintained. Nozzles were removed from the two-foot and three-foot positions left from the centerline. This leaves a three-foot blank on the left side. On the right, three additional nozzles were added by placing pipe tees on the center, the one-foot and two-foot from center positions. This gives a six-inch jet spacing in this area. Although not ideal, the arrangement represents a much improved pattern and provides a workable system. It should be noted the nozzle arrangement is only suitable for the 1/8 inch solid jet nozzles on the Stearman biplane.

A dual spray system was installed on a Stearman, 450 hp airplane. This provides a method for directly comparing the drift from different types of spray equipment operating under identical meteorological conditions. The system, similar to the one employed by Miller of the USDA, incorporates two separate tanks, pumps and booms which operate simultaneously. In operation a different tracer is placed in each tank. Then, from a given spray sample it is possible to identify the quantity contributed by each system. A hydraulic power transmission system was installed to drive the spray pump for each boom. Each system consists of the engine driving a piston-type hydraulic pump which in turn supplies energy to drive a hydraulic motor directly attached to the spray pump. The spray pressure can be conveniently regulated by means of appropriate speed controls on the hydraulic motor.

A number of techniques for sampling the aerosol spray particles drifting from the airplane have been investigated. This included research methods of scientists in the field of air pollution, atomic energy, chemistry, aeronautics, bacteriology, and meteorology. A high volume vacuum pump and a special (TFA #41) filter paper was selected as the collecting unit. The device has a capacity of 20 cubic ft./min. and will collect particles as small as 1/100 of a micron. To determine the concentration and plume of the drift "cloud" sampling units are located various distances downwind as well as at 10 ft. vertical intervals on a 50 ft. tower. Strontium and manganese salts were selected as the tracer elements because of easy analysis with a flame spectrophotometer. The instrument is capable of rapid quantitative analysis of these materials at concentrations as low as 1/100 of a part per million. Figure 3 represents the concentrations of the drift "cloud" during a 6.0 and a 5.5 mph crosswind. Note that only 200 ft. downwind the drift particles are carried over 50 ft. high.

INFLUENCE OF MICROCLIMATES - To enable correlation of the climatic factors influencing the spray drift, accurate data were compiled during each drift test. Temperatures were measured at five elevations, 6 ft.

to 60 ft., by means of aspirated thermocouples. The values were continuously recorded in tabular form by means of a Brown potentiometer connected to an electric typewriter. Wet bulb temperature was also recorded to enable determination of the relative humidity. In addition the wind velocity profile was measured by means of 5-cup anemometers. The wind velocity signals and the direction of the wind vane was continuously recorded by means of a 20-pen Esterline-Angus recorder.

The aircraft operator is also interested in the duration and frequency of periods of low velocity wind to plan his spray program. Figures 4 and 5 indicate an eight year average of the wind "lulls" present at Davis, California. For instance, at approximately sunrise, 15 days per month (June, July and August), there is a wind lull less than 2 mph. The data also indicates that as the season progresses the frequency of lulls increases. The operator is also interested in the duration of the lull and as shown a lull of less than 3 mph for four hours can be expected an average of 13 days in June, 17 days in July and 20 days in August.

INFLUENCE OF AIRCRAFT - A fundamental or basic study was initiated to determine the forces acting on the particles emitted from a given nozzle. This involved determining the magnitude and direction of the air currents produced by the airplane. This particular information would show possible causes of drift, suggest better nozzle locations and indicate the effect of various types of aircraft. The technique involved releasing small (4-inch diameter) gravitationally-balanced, hydrogen-filled balloons from the spray boom. The paths of the balloons were recorded by two movie cameras which uniquely illustrates the air forces acting on the fine aerosol droplets. Various types of aircraft were investigated to determine the characteristic air flow patterns they produced. The aircraft included were: the N3N, a common agricultural biplane; a Fairchild Model 24, a high wing monoplane; a Cessna 305-A, a high wing monoplane; and a Bell helicopter.

The results were graphically illustrated by a number of 2x2 slides showing the complete path of the balloons and their relative velocities. Principal results with the N3N indicates that the wing tip vortices may have a pronounced effect upon the spray drift. Tests also revealed that addition of "spill plates" on the wing tip did not have any decided effect on the wing tip vortices. The "plates" are used to make the controls more positive in action when the plane is flown at relatively low speeds. Theoretically, the strength of the trailing vortices from a simplified rectangular spanwise loading of the wing can be predicted by the basic Kutta-Joukowsky equation (2):

$$\Gamma = \frac{L'}{\rho V} = \frac{1}{2} C_L V c$$

Γ	Circulation, ft /sec
L'	Lift per unit length perpendicular to flow, lb/ft
ρ	Air density, slugs/cu. ft.
V	Flight velocity, ft/sec.
C_L	Wing lift coefficient
c	Wing chord, ft.

Thus, for a given airplane the strength of the vortices is a function of the plane's weight and its flight velocity. A series of tests were conducted with the Fairchild Model 24 airplane to experimentally determine the effect of various operating conditions, boom locations, and effect of ground on the wake of the airplane. The runs included the following conditions: 80 mph and 60 mph (with flaps) flight speed; boom 10 inches and 57 inches below wing; 10 and 15 ft. (pilot) flight elevation. The effect of decreasing the flight velocity with the use of full flaps is shown in figures 6 and 7. The reduction in flight velocity resulted in a stronger more turbulent vortex system plus a marked increase in downwash in the central section. Figures 7 and 8 illustrate that by lowering the boom the tip is put in an area of lower upward air velocity which may reduce the number of fine droplets entrained in the vortices. Tests at the higher flight elevations with reduced ground effect indicate that the trailing vortices are not carried out as far perpendicular to the flight path and the downwash is greater. However, since the initial release was higher the resultant paths remained higher which would subject the fine sprays to greater possible drift. Similar experimental tests with the Bell helicopter revealed some interesting information. It was operated at three different forward speeds: 15, 35 and 55 mph, and two different flight elevations, 6 and 12 ft (boom). At the lowest forward speed, figure 9, a violent turbulent wake was produced as indicated by the balloon paths and velocities. It should be noted that contrary to popular belief the actual air currents near the end of the boom are outward and up as the helicopter produces a trailing vortex similar to the fixed wing aircraft. Likewise, in the central portion of the boom there is a pronounced downwash which accompanies the strong free vortices. As indicated in figure 10, the strength of the vortices and downwash was materially reduced when the forward speed was increased to 55 mph.

Thus, for minimum drift with hazardous sprays it is desirable to (a) fly low, (b) keep the nozzles out of the wingtip area, at least 3 ft. from the wingtip, and (c) keep the boom as far from the wing as practical. Reed (3) formulated the expected distribution pattern for a low wing monoplane entirely on the basis of theoretical air flow about the wings and the resulting droplet trajectories. The theoretical trajectory data for 200-700 micron particles were correlated with the Fairchild 24, figure 11. Also the experimental trajectory of a hydrogen-filled balloon, representing an aerosol size particle, was superimposed and substantially agreed with the theoretical information.

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CULTIVATION AND SPECIAL MECHANICAL MEANS

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Today's farmer must, under the present cost-price structure, be efficient and productive to remain solvent. Today's cotton farmer and most row crop farmers spend from 10 to 25% of his production costs on weed control. But this is not the big loss. The big loss is the loss of production due to the lack of weed control measures. This one item is the present big stumbling block for complete mechanization of most California row crops.

Just what is the answer? I can't give the complete answer and I doubt if anyone can but, in my opinion, whatever the answer, cultivation will be a part of it. Why? Because any operation must move equipment through the field and if equipment is going through the field what less costly weed control method can be devised other than cultivation. True possibly fewer trips would be necessary by using other means, but our irrigated row crops still need the other two functions of cultivation; that of mulching and aerating the soil. Some soils, following irrigation, will crack so drastically that they break the feeder roots and place the plant in a state of stress and the water will practically run off others if not cultivated between irrigations. In my opinion other methods of weed control in row crops must work hand in hand with cultivation in order to be successful.

Actually cultivation tools have changed very little in the past few years, but many new variations on old ideas have come forth. The seemingly new idea of mounting harrow teeth on the cultivator dates back to the horse drawn cultivators of years ago. The horse drawn sweeps are basically the same idea and design except for a different angle and width of shank. It was through the efforts of the National Cotton Mechanization Project that a high speed sweep was developed and placed in production. This type of sweep allows the farmer on late cultivations to travel at speeds of five miles per hour and with very little lateral movement of soil.

Some new aids that we have seen in the past few years which help us with our cultivation are the shields and high clearance cultivation equipment. This allows the farmer to cultivate his cotton much later in the season. Some tools have become power driven such as the rotary harrows and rotary hoes. Power rotary hoes are used for cultivation, thinning, and some in seed bed preparation especially in sugar beet farming. The Sugar Beet Industry is to be complimented on the type of machinery they have for their cultural practises. Their practises of planting and cultivation are much more of the precision type than the average cotton farmer uses. The average cotton cultivator is not conducive to precision work.

A neighbor of ours has a power driven rotary knife type cultivator which he originally got for his beets, but now uses for all of his row crops. This precision type tool allows him to cultivate within one and one half inches ($1\frac{1}{2}$ in.) of his cotton rows, while we cultivate from three to four inches from the cotton. This tool also allows him to get on to ground that is wetter and again drier than we can with the conventional cultivator and still end up with a mulch instead of the baseball clods which we sometimes get.

Even though the cultivating tools have not kept pace with the precision farming of today, the efficient cultivation cannot be performed haphazardly.

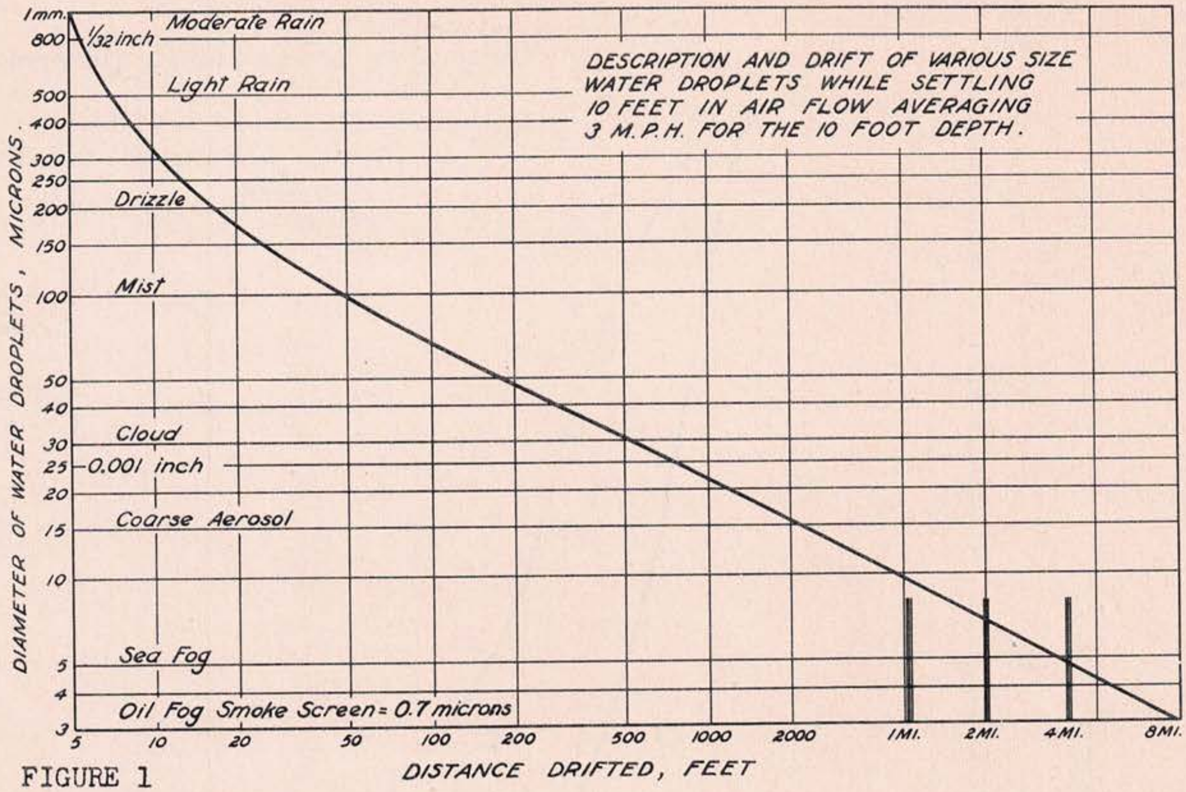


FIGURE 1

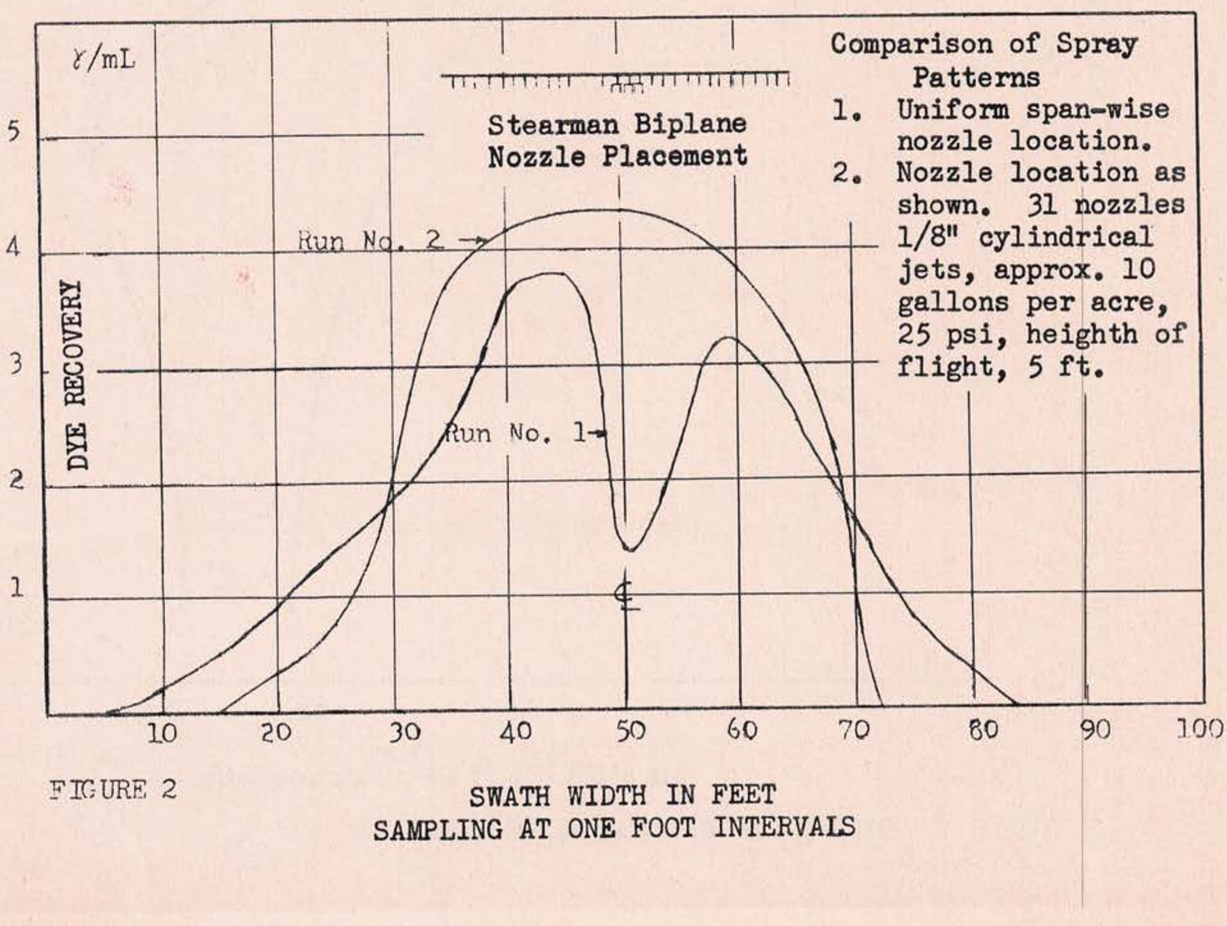


FIGURE 2

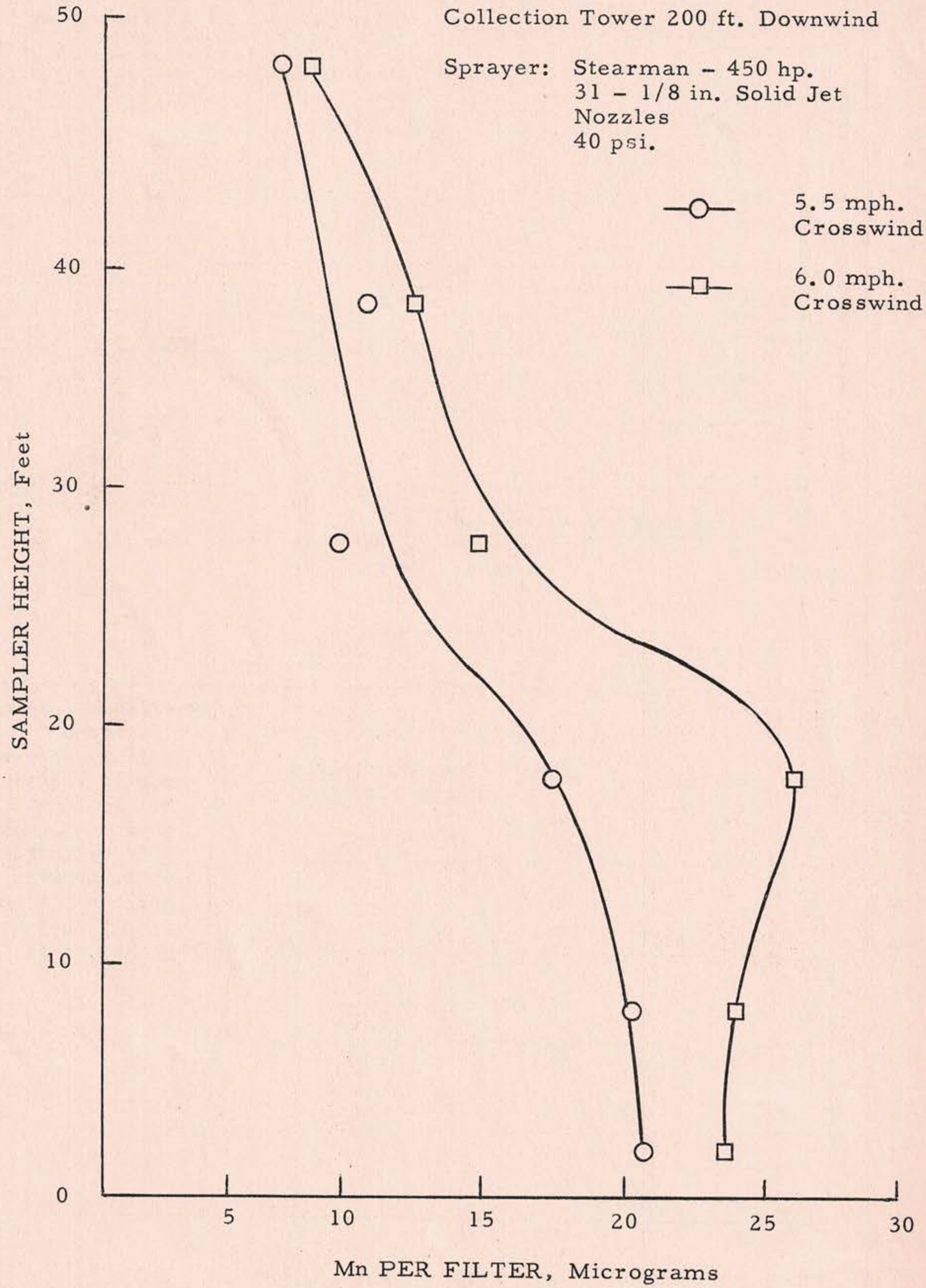


FIGURE 3. DRIFT OF MANGANESE TRACER

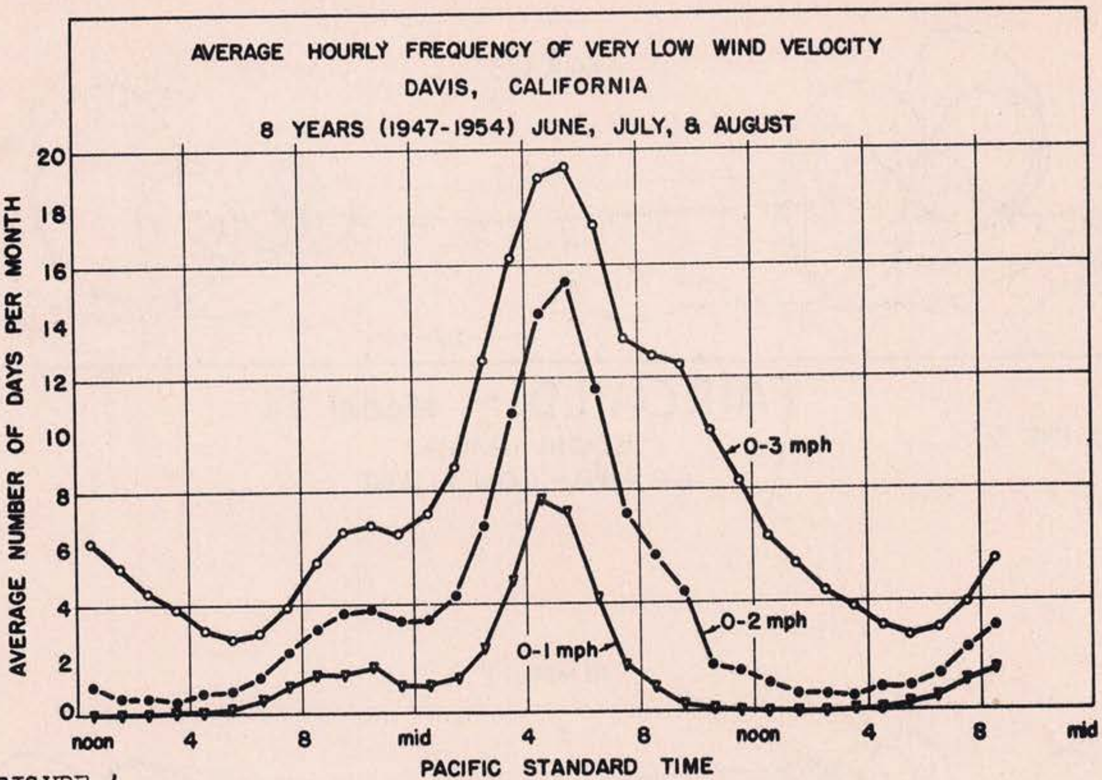


FIGURE 4

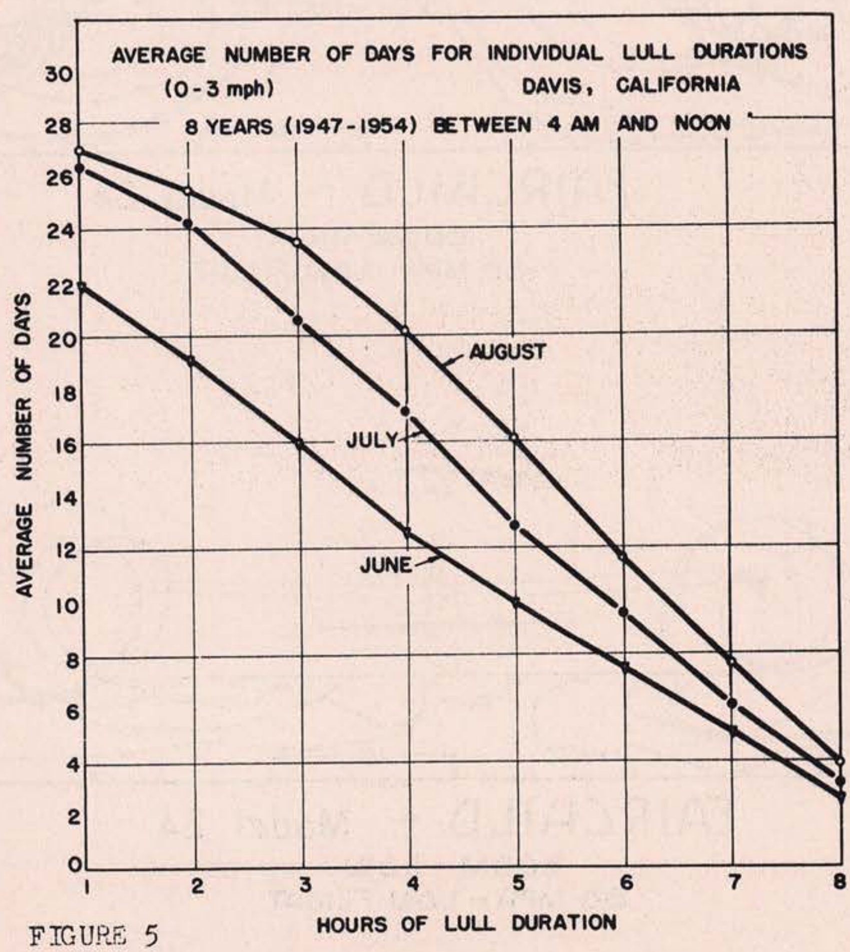
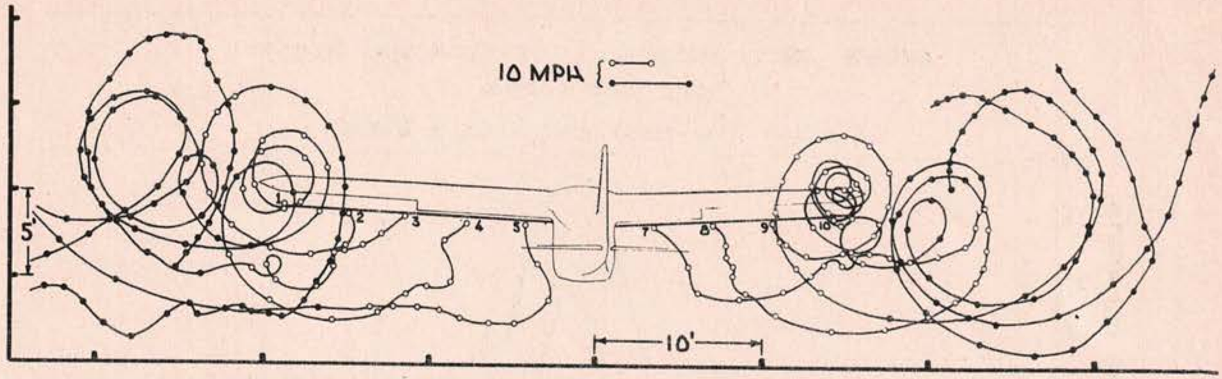


FIGURE 5

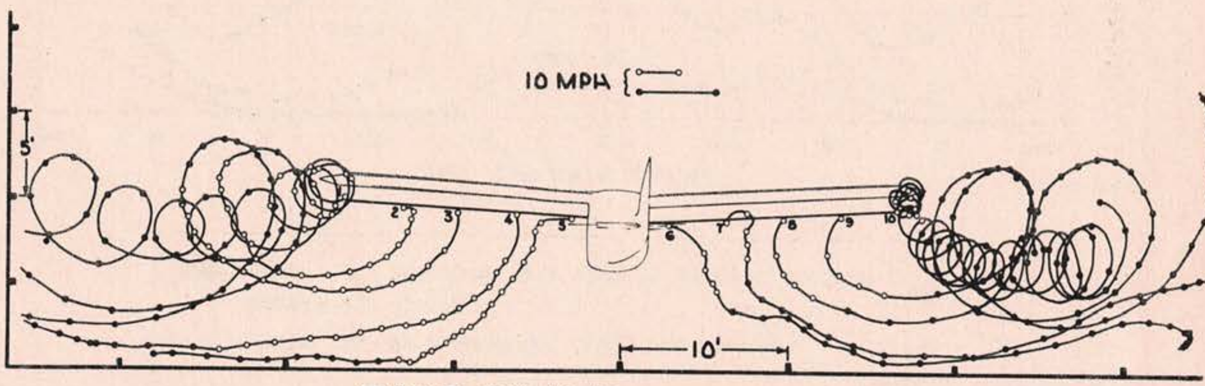


FAIRCHILD ~ Model 24

FIGURE 6

BOOM HIGH

60 MPH ~ LOW FLIGHT

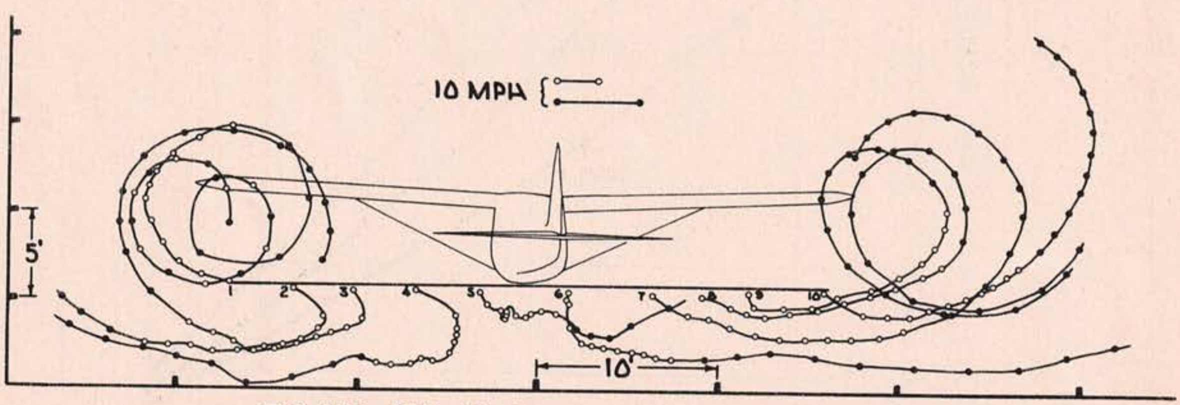


FAIRCHILD ~ Model 24

FIGURE 7

BOOM HIGH

80 MPH~ LOW FLIGHT



FAIRCHILD ~ Model 24

FIGURE 8

BOOM LOW

80 MPH ~ LOW FLIGHT

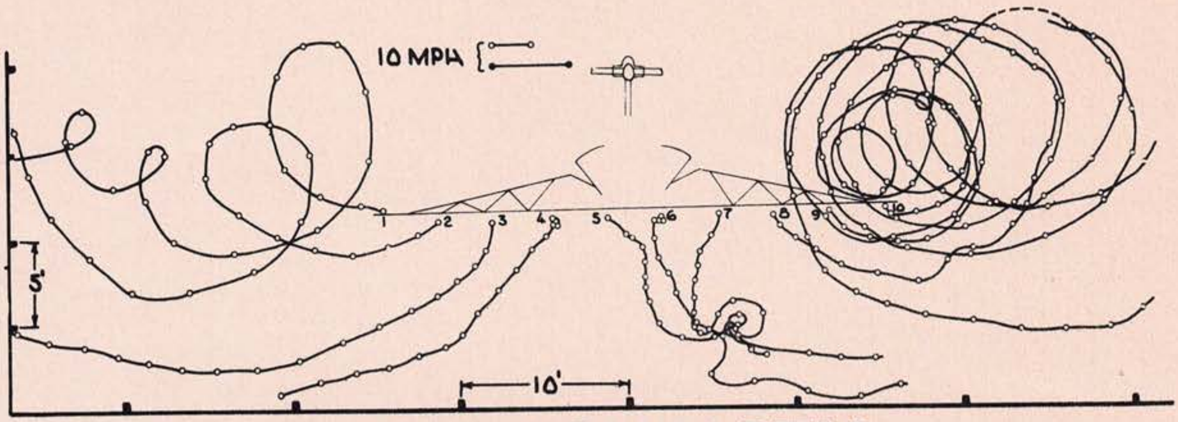


FIGURE 9

BELL HELICOPTER
15 MPH ~ HIGH FLIGHT

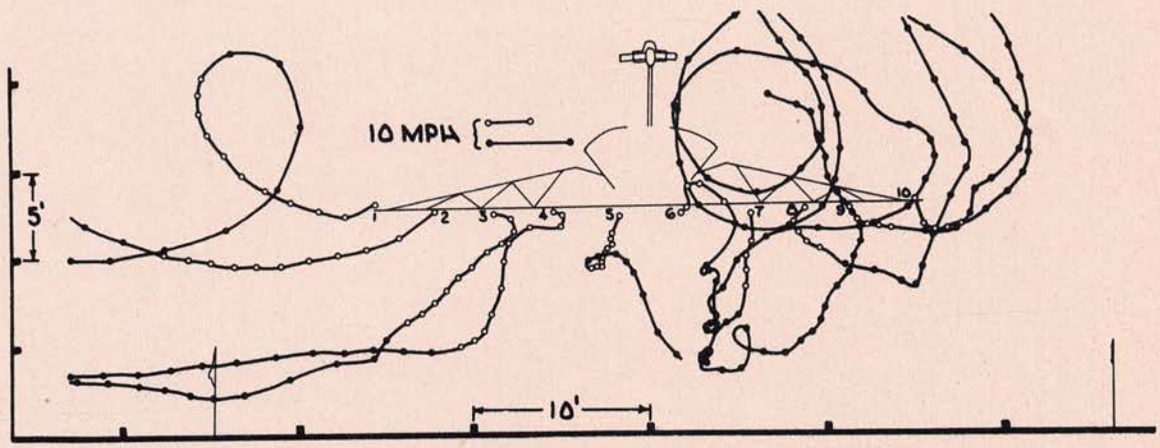


FIGURE 10

BELL HELICOPTER
55 MPH ~ HIGH FLIGHT

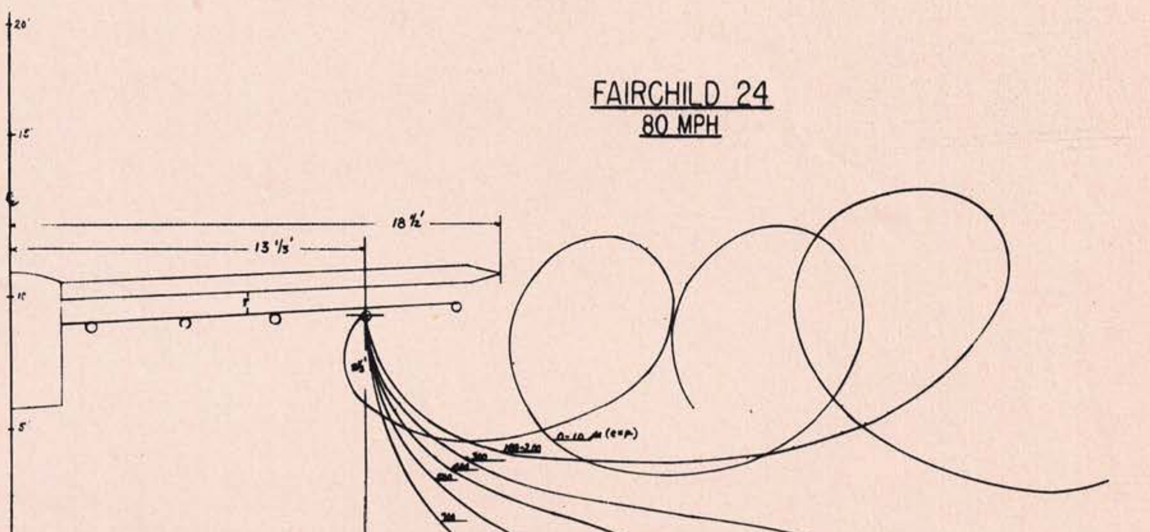


FIGURE 11

The good farmer not only has to time his cultivations, but each cultivation must perform its assigned task. The efficient farmer will take his time during the first two cultivations of cotton and it is at this time that the weed problem can be limited or turned loose. I still remember and respect George Harrison for his statement to me a few years ago that he would want an old F-12 tractor on his farm because it was the only tractor slow enough to do the job of cultivation that he wanted the first time through. The ability to "bar off" cotton with a two to three inch strip instead of an eight to nine inch strip is worth cutting the chopping bill two thirds.

After the first two cultivatings a wide variation of practises can obtain the same end. Whether the cotton is dirted or the row carefully skimmed to avoid building up unnecessary dirt around the plant actually isn't too important from the yield standpoint. I can still remember one year while at Shafter, an experiment was performed to point out to the farmer the folly of dirting cotton and the advantages of a good low profile. The main purpose was to show how much more efficiently the cotton could be picked on bed planted cotton with a low row profile. There was a definite improvement in the picking efficiency but the dirted cotton actually produced more cotton.

A very good example of a form of evolution in weed control happened at the Corcoran Irrigation District. Years ago laborers used to get in the water with hand scythes, then horses dragging a chain across canals would partially cut off the weeds and swampers would fork them out of the water. With the advent of the tractor the ditches were worked with discs by dropping the disc down the side of the bank as far as possible. This operation did a fair job of weed control on the top of the banks but was somewhat ineffective at the water line and, worse of all, it tended to destroy the banks. A large burner was manufactured that would reach across the banks. If the burning operation was repeated as often as needed it soon became prohibitive, costwise. When 2,4-D came into use the Corcoran Irrigation District sprayed all of their ditches for three years, or, I should say, until they were paying out more in damage claims than the spraying was costing. These applications of 2,4-D destroyed practically all of the tules and has since eased the weed control operation. Dormant sprays and aromatics were tested with costs ranging from $40.00 per mile to $2,000.00 per mile. Due to the many miles of canal banks the spraying program would begin to lag making larger amounts of spray necessary. Recently a Sloper mounted on a D-7 was used to clean the canals down to water line. This operation was very successful in regards to cleaning the weeds from the canal and in moving the loose dirt back upon the bank. However, this type of Sloper puts a heavy strain on the steering mechanism due to the side draft and causes excessive down time for the engine. So, following a pattern used by the Lower Tule River Irrigation District, a sloper attachment was used by mounting it on the front of a motor grader. This machine now covers five miles of ditches a day including all four sides or a total of twenty running miles. Again this is not the final answer. The Corcoran Irrigation District likes the effect of the burning and does so around locations which the Sloper misses and uses weed oil around the power poles and wooden structures. Again it is the combination of weed control practises that seem to be most efficient, and again cultivation or mechanical means is one of the main stays of the operation.

Just recently some factions of the farm machinery industry have started to meet the needs of the mechanized precision farmer of today.

In conclusion, our ultimate answer to weed control in row crops is going to be either flame or chemicals combined with good cultivation practises.

NEWEST ENGINEERING DEVELOPMENTS OF FLAME CULTIVATION IN COTTON

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University of California, Davis, California, respectively.

Introduction

Research in flame cultivation has been a part of the cotton mechanization project since 1948. This project is cooperative between the Department of Agricultural Engineering, University of California; California Planting Cotton Seed Distributors; and the U. S. Department of Agriculture.

What is flame cultivation?

Flame cultivation is the application of a carefully controlled fire (flame) to the drill row of growing plants at a rate that does not injure the growing crop. It is used primarily for the control of annual weeds and grasses in the drill row where mechanical cultivation cannot be used. A discussion of its use will be limited to weed control in cotton for this paper.

Why flame cultivate?

During a recent survey made by Miller and Foy, weed control specialists at the U. S. Cotton Field Station, Shafter, it was found that most growers in California spend from $10.00 to $50.00 or more per acre, per year for weed control measures in cotton. In addition to this cost, if weed control is not adequate to the end of the season, further losses may be realized due to grassy bale classifications as a result of rapid growing grasses and weeds that appear after normal "lay-by." Water grass was found to be a problem on more acres than any other single grass or weed. Not only are weeds costly in terms of dollars and cents, but the labor requirement for these operations may be very great. From 10 to 20 man hours/acre are usually required for each hoeing or chopping operation, and there are usually from 1 to 3 of these operations per year.

The cost of flame cultivation is approximately $5.00 per acre per season depending upon the number of operations. One "small" hoeing may be needed prior to the first flaming, but after flame cultivation has been practiced for more than one year, zero to five man hours/acre would be all the hoeing generally required.

How does flame cultivation fit in?

Weed and grass control have been one of the last remaining barriers to complete mechanization of cotton production. Flame cultivation is recommended for weed control in cotton. It has a greater range of possibilities for annual weed and grass control in irrigated cotton when properly used than other known methods. It may also assist in the control of perennial weeds and grasses by destroying seedlings, or injuring some established weeds so that other control measures will be more effective. Flame cultivation is not a once-over 'cure-all' weed control measure, but it is a dependable maintenance control method that must be combined with the best mechanical cultivation practices possible. A good uniform seedbed and planting depth are of primary importance to insure uniform plant height so that flaming may begin early in the season. If uniform plant height is not present, weeds and grasses may get 'ahead' of the crop before the shortest cotton is tall enough to flame safely; and other control measures must be resorted to (hand hoeing) before flaming may be continued successfully during the remainder of the season. A good profile should be established early in the season for flame cultivation because, after flaming begins, it is not desirable to throw fresh soil to the plants. Fresh soil contains new weed seeds that will germinate after the next irrigation and greatly hinder control that is established.

Heavy parallel action dirt shields have proven to be an advantage in shielding dirt from the row and leaving a desirable profile for flame cultivation. These shields (California Agricultural Experiment Station Bulletin 747) also can be used as the carrier for nozzles for the application of selective post emergence herbicidal oils to cotton in the 2 to 6" stage.

Flame cultivation has been practiced for more than a decade with varying results. There have been three major types of burners that have been used. These are the round burner set at a 15° angle to the ground, the flat burner set at a 45° angle to the ground, and the most recent development, the Arkansas burner, with a deflector set at a 30° angle to the ground. The combustion chamber on the Arkansas burner is actually set horizontally, so adjustment is very simple.

<u>Recommended settings:</u>

The Arkansas burner is set with the tip of the deflector 4" above the drill row and 6" horizontally away from the drill. The two burners are staggered in the row with 6-10 inches between them, so the flame from each burner will not 'bounce' together. A Spraying Systems fan nozzle tip is used as the orifice. The 2-2502 tip size is recommended for general use. Speeds of from 2 to 4 MPH may be used safely; however, extreme caution should be used at the lower speeds because of the possibility of damage to the cotton. Normally, 30 pounds pressure at 3 mph would be recommended for the first flaming and on subsequent flamings, the pressure may be increased gradually to 50 or 60 pounds.

It should be expected that the lower leaves will be burned on the cotton plants but this has never been proven harmful.

One handicap that has been experienced with flame cultivation equipment in the past is the code established by the Safety Engineers Board. The requirement was that there must be 10 feet between the tank and burners. As of this year, the code has been changed to compare with that of other states, and it is now possible to have a rear tank mounting and rear burner mountings. This will greatly facilitate construction mounting and driver comfort, as the front mounted burners were uncomfortable to the operator.

<u>Results of research</u>

The results from three years' flame intensity trials are shown in Table No. 1. These trials were conducted on Hesperia fine sandy loam soil where nutgrass was a problem. The cotton was 10 - 12 inches tall before the first flaming began, and 4 to 5 flamings were applied each season. The speed was 3.1 mph for each test.

Table No. 1. Flame Intensity Trials

	psi	Yield, Bales/Acre 1952	1953	1954	Ave.
Check	0	2.13	3.08	2.68	2.63
Flamed	20	2.21	3.07	2.61	2.63
Flamed	30	2.19	3.10	2.61	2.63
Flamed	40	2.03	3.12	2.67	2.61
Flamed	50	2.11	3.13	2.65	2.63

No significant differences were noted in yield data on any treatment during any year. The rate of LP-Gas used varied from 2.15 to 4.21 gallons per acre per application. The results shown in this table indicate that flame pressures may be regulated according to the severity of the weed problem without adverse effects upon yield or plant population.

In 1955 a new flame intensity trial was designed with a greater range of LP-Gas applied per acre. This range was from 2.8 to 11.1 gallons/acre. This test was applied at two locations: Hesperia fine sandy loam, Shafter, and Delano clay loam at Famoso. There is a moderate nutgrass problem at the first location, and a very serious watergrass problem at the second location. Table No. 2 shows the gallons of fuel used per acre application on each sub-plot and also the lint price average from four replications at the Delano clay loam soil location.

Table No. 2. Flame Intensity Trials - 1955

	Approx. gal. fuel/A Both locations 2 mph	3 mph	3½ mph	4mph	Lint value cents/lb. at Delano Clay loam soil location			
Check	0	0	0	0	34.83	34.83	34.96	35.40
2-2502 tip[1]	5.6	3.7	3.2	2.8	35.65	36.08	36.58	35.57
2-2503 tip[1]	8.3*	5.6	4.8	4.2	35.65	36.40	36.21	36.27
4008 tip[1]	11.1*	7.4*	6.3*	5.6	36.27	36.46	35.52	35.58

[1] Spraying Systems fan nozzles used as the burner orifice
* Caused significant yield reduction

On plots receiving 6.3 gallons of propane per acre or more per application there was a significant reduction in yield at both locations; however, there was no significant difference in yield on all other plots at either location. Flaming began when cotton was 6-9 inches tall and 40 psi fuel pressure was used throughout the season during each flaming on all plots. The plot received four flamings during the season with the exception of the plot where the 4008 tip was used and that received only two flamings.

The average price per ound was $0.3604 for lint from all flamed plots as compared to $0.3501 for unflamed. The first flaming was after the first irrigation. This test was spot-hoed early in the season on all plots. The reduction of price on the check plots was due to grassy bale classification.

A new <u>early</u> flame cultivation test was started this year and flaming was very successful on 4" tall cotton. Several years of preliminary work has been conducted to establish proper procedures for the test. The test was located on two soil types: Hesperia fine sandy loam and Delano clay loam. There was no difference in yield or final stand count between any of the plots on either soil type. The 4" flamed plot had the best weed and grass control of any of the plots. Yield and lint value data are shown in Table 3.

Table No. 3. Early Flame Cultivation Test. 1955

Treatment	1st & 2nd pick. Hesperia fine sandy loam soil Bales/A.	1st Picking Delano Clay loam soil Bales/A.	Lint value cents/lb.[1]
Check	2.24	1.51	33.15
Flamed 4"	2.18	1.49	36.15
Flamed 6"	2.21	1.41	35.83
Flamed 8"	2.26	1.60	36.15

[1] Fresno Spot Market Price October 13, 1955
No difference in yield at either location

The average price for lint from flamed plots was 0.3604 cents, and the average price for unflamed, unhoed plots was 0.3315 cents. One lot graded grassy out of 12 lots on flamed plots; whereas all lots were graded grassy on check plots. The first flaming was conducted with a 2-2502 tip in an Arkansas burner at 3 mph and 30 psi. The burners were front cultivator mounted on gauge shoes during the first flaming. The first flaming was conducted before the first irrigation on Delano clay loam soil, and immediately following first irrigation on Hesperia fine sandy loam soil. The diameter of the cotton stalks on the Delano clay loam soil was as follows at the time of the 4" flaming:

16% - 1/16" diameter
45% - 3/32" "
36% - 1/8" "
3% - 5/32" "

Thirty-nine percent of the plants were less than 4" tall at the time of the first flaming. The results of this work and previous research on flaming of 4" cotton indicates that the size of the cotton may be much smaller than previously recommended for safe flaming. The present recommendations are for the plants to be 8-10" tall with a stalk diameter of 3/16". The only apparent reasons for requiring this size, were that previous equipment could not maintain any closer adjustment to the row than that, and also, with previous burners, flame deflection is a more serious problem. With the Arkansas burner, surface irregularities in the row do not seem to affect its performance as long as the 6" adjustment laterally from the row is precisely maintained.

All of the research indicates that early flaming has great possibilities for "bridging" the gap in mechanized weed control measures in irrigated cotton. Flaming of 4" cotton should not be considered until the grower has experience in flame cultivation. Proper equipment and cultural practices must be very satisfactory for that precise operation.

The results shown in Table No. 4 are taken from late planted cotton especially planted for this test, and the cotton was not grown to maturity. Also, the barley was planted on June 21 and flamed when three weeks old. The first evaluation of this test was three days after flaming and the final evaluation was in one month. The barley was planted on a smooth flat bed in three rows 4" apart. It was used for a relative indicator of the effectiveness of flame cultivation, and should not be confused with actual control to be expected from any weed or grass species after one application. Also, barley is not vigorous during this time of the year, as indicated in the final readings, whereas slightly injured grass such as watergrass would tend to recover if not flamed again. Any of the treatments where the cotton survival is 93% or more should be satisfactory. On a separate test on flame cultivation of 4" cotton, driving 3 mph and using 30 pounds fuel pressure; there was no difference in final stand count between flamed and unflamed treatments.

The results of this test with respect to cotton survival do not apply to cotton that is more than 10 - 12 inches tall. (Refer to Table No. 1).

Table No. 4. The Relationship of Speed and Pressure to % Cotton Survival (4" height) and % Barley Kill using the Arkansas Burner. 1955.

Speed	Sub-Plot		Pressure 20	30	40	60
1.75 mph		(gal/A)	4.45	5.4	6.35	7.93
	% 4" cotton survival		51	52	40	0.0
	% Barley killed (initial reading)		92	96	98	98
	% Barley killed (final reading)		100	100	100	100
3.0 mph		(gal/A)	2.59	3.15	3.70	4.62
	% 4" cotton survival		95	95	88	37
	% Barley killed (initial reading)		65	85	90	95
	% Barley killed (final reading)		80	95	100	100
4.0 mph		(gal/A)	1.95	2.39	2.78	3.47
	% 4" cotton survival		100	100	94	93
	% Barley killed (initial reading)		50	70	75	85
	% Barley killed (final reading)		60	70	80	95

Conclusion

Flame cultivation can be used safely and effectively in cotton for the control of annual weeds and grasses. It could save from $5.00 to $50.00 per acre per year for weed control costs alone and possibly additional savings due to improved grades of cotton where grassy bale classifications would otherwise cause a reduced price for lint. The labor requirement for cotton production can be greatly reduced by the use of flame cultivation. Cotton should be 8 - 10" tall before the first flaming unless the operator is experienced, and has precise equipment; then the flaming of 4" cotton is possible for additional weed control.

Flame cultivation should be used to control small weeds and grasses instead of waiting until they are the size to require hand hoeing.

Research has proven that continued use of flame cultivation year after year will usually rid the field of annual weeds and grasses, and its use should continue as an insurance measure against future infestations from other sources.

GROUND SPRAYERS

Bryant Washburn
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Volumes can be written about ground sprayers, so I am going to confine my remarks to experiences I have had over a period of years in building, rebuilding, and operating rigs.

In order to properly design a rig, it is essential to know where and how it is to be used. For instance, the capacity of the tank cannot be as great when used on the peat soils of the Delta area as those used on firmer ground. Boom lengths in hilly country have to be shorter than those used on larger flat expanses.

Pumps have to be larger if the spray rate is high and the tank is to be refilled by its own pump; whereas a rig to be used only on fence lines and where an overhead fill is always available, can have a much smaller capacity pump and tank.

The tank sizes most commonly used for field work in this area vary from 750 to 1000 gallons. I have rigs ranging from 280 to 1900 gallons. The large ones are used for specialized jobs.

Military trucks have been ideally suited for conversion into rigs, and I have in use some six different makes. The ½ ton Dodges are good for small rigs, the Fords for field use; Chevrolets for brush and sterilizing purposes and the Whites, Autocars, and Federals work out well for specialized monstrosities and truck tractors, to pull semi rigs and nurse equipment.

Although seldom mentioned, nurse trucks and trailers are a vital part of any spray operation.

I used to think that an 850 gallon trailer was pretty big stuff. Now a 4000 gal. semi-trailer doesn't begin to fill the bill.

On one Contract which required five spray rigs in operation, the following equipment was necessary to keep them going: Two pickups, one shop & supply truck, one 750 gal. gasoline tank trailer, one large flat bed semi-trailer and tractor, two smaller flat bed trailers, one 1800 gal. mixing semi-trailer and tractor, one 2000 gal. semi-trailer & tractor, one 3000 gal. semi-trailer and tractor and one 4000 gal. semi-trailer and tractor.

A portable shop trailer or truck is very important when operating at a considerable distance from the home base. By having welders, compressors, electric power plant etc., as well as spare parts, nozzles, tires and tools available; on the spot repairs or alterations can be made with little down time for the spray rigs.

The pump is the heart of any rig, and I have been having "heart trouble" for a long time. My first "attack" came with centrifugals, which were directly connected to Briggs & Stratton engines. Everything went fine during the summers when pressures were only about 60#, but when we needed 100# in the winter to spray alfalfa, breakdowns were common because the engines had to be run too fast.

I next went to power take-off drives and tried Granco pumps, which are a knuckle type construction somewhat similar to the front axle of military trucks. They were of the positive displacement type, and therefore required an external by-pass valve. The rotors were made of brass, and in time were cut out by abrasion.

Next came gear pumps to replace the Granco; they worked well, but eventually they too would wear so that pressures could not be maintained. By resurfacing the end plates, gear pumps can be satisfactorily overhauled, and we are still using them on both power take-off drives and engine driven installations.

I have just mounted one of the large new Hypro pumps on the rig that is here today. It is driven by a one cylinder gasoline engine. I have hopes that this set-up of pump and motor will be the answer for field spraying at pressure to 150 pounds.

The disadvantage of the power take-off drive is that the pump is only running while the truck is in forward motion or while standing still out of gear. The speed of the pump is governed by the speed of engine, which means that when the truck is slowed, the pressure falls; when the engine is reved up the pressure goes up.

With an independently powered pump, pressure can be maintained at all times.

Of course we make use of belt driven centrifugal, vane centrifugal, and high pressure orchard type pumps.

My first rig had 16' booms made of 1¼ standard pipe. These took a remarkable beating, but in time crystalized and broke, due to vibration. As longer booms were needed trussing was tried and extra heavy pipe used. These heavy booms however presented more problems. They were so heavy that they pounded themselves to pieces on rough ground, and necessitated heavier cables and super-structure.

For several years we have been trying thin wall conduit (EMT) and find that it is light and extremely rigid. We are trying a new set of 70' booms made of this tubing on the rig here today. A feature of this boom is a shear pin where the push rod attaches to the boom. It is hoped that if a tree or fence post is snagged, the shear pin will let go before the boom is bent and damaged.

The boom also has a check valve incorporated in each nozzle. These extra long bodies and screens have been a great aid in holding plugged tips to a minimum. We have certainly been able to cover many more acres per day since they were developed.

Throughout the rig, threaded joints should be held to a minimum in order to avoid leaks. The pump, regulator, etc. should be constructed as units to they can be removed easily for overhaul and repairs.

We have found it necessary to cut the rivets out of the rear wheels, move the rims, and weld in place; so the rear tires will follow the front, and leave as narrow tracks as possible in grain fields. We usually increase the tire size to allow for better floatation.

Fewer and lighter tracks make the Farmer happy, and he is the boy we have to please.

PLOT AND LABORATORY SPRAYERS

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The success of 2,4-D as a weed killer has caused great interest in the use of chemicals for the control of undesirable plants. Thousands of experimental plots are sprayed every year with this and other chemicals. New chemicals are constantly being developed and screened in the greenhouse under controlled conditions, with the chemicals showing most promise being further tested in the field. Special equipment for applying sprays in the greenhouse and on small plots has been developed by several research teams (1, 2, 3, 4, 5, 6). The equipment discussed here was developed for Dr. Virgil Freed, W. R. Furtick and E. R. Laning for screening of chemical for herbicidal use. Special equipment for applying sprays in the greenhouse and on small plots is required to help insure reproducible results. It is essential that the equipment apply a given amount of chemical to each plot of a group of replicated plots. To insure constant dosage the equipment should spray at constant pressure and at a constant speed.

GREENHOUSE SPRAY BOOTH

The requirements imposed on the greenhouse sprayer for Oregon State College were:

1. Spraying should similate field spraying as close as possible.

2. Chemical drift should be held to a minimum.

3. One man should be able to take care of all operations without help.

4. The equipment should be easily cleaned requiring a minimum time to change from one chemical to another.

5. Due to crowded greenhouse conditions the equipment should occupy a four and one-half foot wall space.

6. The equipment must be self contained and reasonably portable and should be able to pass through a standard three-foot door.

To approximate the type of coverage obtained with field sprayers, two methods of obtaining uniform relative motion of the nozzle to the plant are available. (1) A standard weed spraying nozzle passing at a constant velocity and at a fixed height over stationary plants, or (2) plants either potted or in flats are placed on a constant velocity conveyor to pass under fixed spraying nozzles as described by Shaw (6). The first method was chosen for our conditions because space was at a premium and the spraying crew limited.

The greenhouse sprayer is actually a spray booth about 2 feet deep, 4 feet wide and 3 feet high. The base of the spray chamber is a grill at table height on which the plants are set for spraying. The booth is completely enclosed with the exception of the front which has an opening about 2 feet high and 4 feet wide. An exhaust fan and duct removes spray mist from the booth. Along the top of the booth run two tracks for the spray car. The car resembles a miniature section car for the railroad. Mounted on the car is a 1/50 horsepower reversible 14.4 rpm gear reduction motor. An airplane cable 3/32" diameter is fastened to each end of the spray booth and has one wrap around the car motor pulley. Speed of travel of the car is determined by the size of the pulley the cable is wrapped on. By using a step cone pulley the speed of travel can be quickly changed. The car has an adjustable support for the spray nozzle and the spray tank. The spray tank is an oil can from a pressure oiler. The oil cans come in several sizes and are readily interchangeable. A diaphragm air compressor furnishes air at 40 psi. A diaphragm pressure reducing valve on the air line controls spraying pressure.

A cushion of air on top of the liquid in the tank forces the herbicide out through a 1/4 inch copper tube to stop cock and nozzle. The stop cock at the nozzle is used to start and stop the spray.

The air compressor switch and the motor reversing switch are mounted to the left of the booth opening in easy reach of the left hand. The rates of application can be controlled by nozzle tip size. Nozzle height, air pressure and the size of pulley in contact with the traction cable.

FIELD PLOT SPRAYING

Many of the early field plots were put on by the research worker packing either a 4-gallon knapsack sprayer or compression sprayer and carrying a hand boom with two or more nozzles. Some demonstration plots in the counties are still put on in this manner. Using the above equipment it is difficult to get the uniformity of application desired.

To help insure uniformity, push cart plot sprayers have been developed (1, 2, 3, 4, 6). The compression sprayer has been mounted on a light weight cart with bicycle wheels. Constant pressure is maintained by mounting a GI 2100 cubic inch stainless steel oxygen tank on the cart for compressed air storage. The pressure for filling the tank in the field is supplied by a portable gasoline engine driven air compressor. An air pressure reducing valve in the air line connecting the air storage and the compression spray is set for desired spraying pressure.

The operator can easily maintain the desired rate of travel by observing the speedometer dial. The Stewart Warner Tractor Speedometer drives off the bicycle tire. Speeds to 1/10 mile per hour can be easily read and distances are recorded to 1/100 of a mile.

The over-all width of the sprayer (4), not including the boom, is held to under 30 inches. This is to enable the sprayer to be used between rows of nursery stock and caneberries for the application of basal sprays. The over-all dimensions of the sprayer are also held to a minimum, as space is limited in the pickup truck used for carrying the herbicide equipment. One man can load the sprayer in a pickup bed for transporting.

For plot spraying where long booms are desired, a sprayer with wider tread might be preferred.

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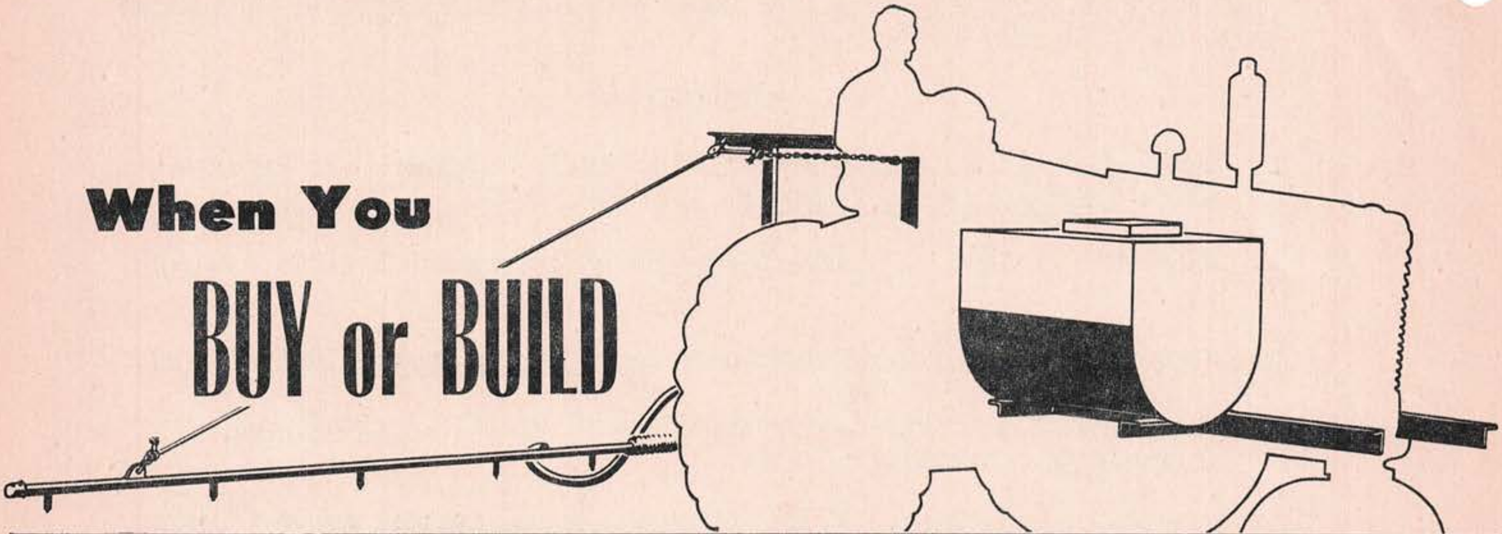
When You BUY or BUILD A Field Sprayer



WHEN YOU BUY OR BUILD A FIELD SPRAYER

N. B. Akesson, R. G. Curley, and W. E. Yates*

Small field sprayers, tractor mounted or of the trailer type, have become important pieces of farm equipment.

These sprayers develop pressure from 25 to 100 pounds per square inch and apply volumes from 10 to 25 gallons per acre. They have been used widely for applying 2, 4-D in weed control. With simple modification they can also be used to apply insect and fungus control chemicals.

The purpose of this leaflet is to suggest adjustments you can make to "get the most" out of a small field sprayer. Each basic unit of a field sprayer is discussed in turn. Information is provided on selecting the parts for building a sprayer along with a brief word about checking your sprayer for accurate pressures and volumes.

TANKS

Tractor-mounted spray tanks frequently are 55-gallon petroleum drums placed horizontally, one on each side of the tractor. These tanks may also be mounted in a vertical position on the hydraulic lift at the back of the tractor. With this arrangement the boom can be adjusted for proper height by raising or lowering the entire sprayer with the hydraulic system. This latter arrangement is perhaps the easiest one to mount.

On trailer-type rigs, a cylindrical tank of 100 to 250 gallons capacity is frequently used. The tank can be mounted either crosswise or fore and aft on the frame.

Cylindrical iron tanks or those with well-rounded bottoms are desirable to prevent dead spots during mixing and agitation. Black iron of 12 to 18 gage remains the most popular tank material. No generally available tank interior paint will stand all of the chemicals in use.

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Between spraying jobs, you can minimize corrosion of the tanks and working parts by placing a few gallons of diesel or lubricating oil in the empty tank and circulating this through the sprayer. Most agricultural chemical formulations — whether for control of weeds, insects, or fungi — can be cleaned from the spray tank by using cleaning soda or lye followed by a thorough rinsing.

However, if the sprayer has been used with 2, 4-D, it cannot be used safely to apply insecticides or fungicides to highly sensitive broad-leafed crops, such as cotton, grapes, alfalfa for seed, sugar beets, tomatoes and beans. With less sensitive crops, a thorough cleaning of the tank and system with lye (2 pounds per 100 gallons water for water soluble materials, or lye plus kerosene for oil soluble materials will be satisfactory.

MIXING AND AGITATION

Chemical spray materials must be mixed thoroughly with the proper proportions of diluting water before they are applied. These materials are formulated as solutions, emulsions, or wettable powders. A mild agitation is all that is required to mix and maintain solutions and emultions containing adequate emulsions. However, the powders of wettable suspension readily ''settle out'' if not continuously agitated, and the emulsion without emulsifiers will separate if agitation is stopped.

Tanks can be agitated by either mechanical paddles or by hydraulic jet means. Agitation systems usually are not standard equipment on the light, inexpensive sprayers. Unsatisfactory agitation is the usual result of putting a nozzle or other restriction in the tank end of the hose line from the by-pass regulator valve. Most of the pressure energy in the liquid is lost in passing through the regulator. The job of the by-pass regulator is to provide relief for the positive displacement pump when the boom is shut off and to regulate pressure on the boom. Pumps can be severely damaged and regulator troubles can develop if the regulator line is restricted in any way.

Jet agitation is inexpensive and easy to install and does a satisfactory job when properly used. The illustration in Figure 1 shows how to place the agitation jets in a horizontal cylindrical tank for best results. Note that for the agitation a separate line takes off from the immediate discharge side of the pump with a valve to reduce the intensity after initial mixing. Table 1 indicates the jet size required for satisfactory mixing and agitation of given horizontal tank sizes. The jets may be made by drilling the proper size hole in a pipe plug or cap, or may be purchased as the tip used in certain nozzles. (Fig. 1 Table I - Table II.)

TABLE I

Required Jet Size for Jet Agitation
Tank dimensions and pressures as shown

Tank diameter feet	System pressure psi*	One jet of size shown is required for each foot of tank length
2	25	3/32"
	75	2/32"
2.5	25	4/32"
	75	2/32"
3	25	5/32"
	75	3/32"

*pound per square inch
Table based on horizontal, round, or rounded bottom tanks; for solutions, emulsions with emulsifiers and wettable suspensions not over 1/10 pound per gallon. With no emulsifiers, or wettables, from 1/10 to 1 pound per gallon double the volume of flow as found from Table II below. See Figure 1 for further details.

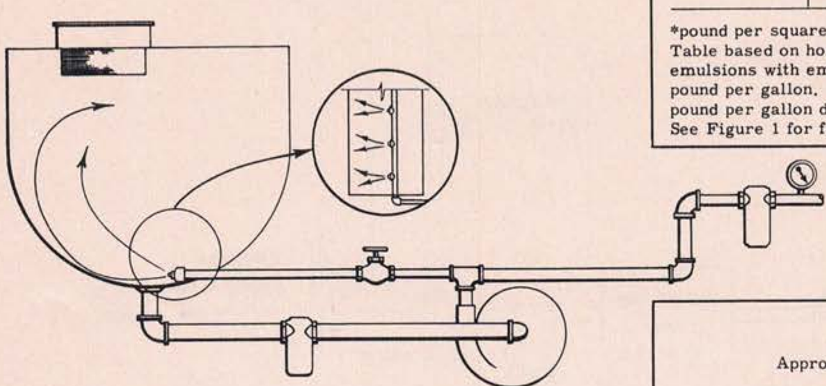

Figure 1.

Diagram of the spraying equipment with jet agitation and a centrifugal pump which does not require a by-pass regulator.

Insert shows: View of tank from above. Jets are spaced 12 inches or less from one another and 1/2 that amount from tank ends.

TABLE II

Approximate Discharge (gallons per minute) for Single Jet

Pressure	Jet Diameter inches						
psi	2/32	3/32	4/32	5/32	6/32	7/32	8/32
25	.75	1.25	2.25	3.5	5	7.0	9
50	1.25	1.75	3.00	4.5	7	9.5	12
75	1.50	2.25	3.75	6.0	8	12.0	15

Use this table, multiplying by the number of nozzles used, to obtain total volume flow for jet agitation.

When the vertical 55-gallon oil drum (22 x 36 inches) is used as a sprayer tank, the installation of jet agitation is made as in Figure 2. The jets are about 2 inches above the tank bottom and aimed directly across the tank. More liquid must be recirculated in the vertical tank than the horizontal, for sufficient agitation. About 2 gpm (gallons per minute) at 50 psi (pounds per square inch) are required from each of the 2 nozzles when using spraying solutions, emulsions with emulsifiers, and wettables not exceeding 1/10 pound per gallon. This requirement can be met by two, 3/32 inch drill holes or jets. Such a hole will pass about 1-3/4 gpm at 50 psi. (Table II)

When the emulsions used are without emulsifiers, or wettable concentrations of from 1/10 to 1 pound per gallon, then each jet must discharge about 3 gpm at 50 psi. Two 1/8-inch jets or drill holes will fill this requirement.

PUMPS

Because of the abrasive or corrosive action of certain spray formulations there isn't a single inexpensive pump which will handle them all. Pump types include rotary (gear, cam, vane, or roller) centrifugal, piston and diaphragm. All of these are, with the exception of the centrifugal, available for direct power-take-off operation. The centrifugal pump requires a speed step-up drive in order to obtain the necessary spray pressure.

Be sure your pump has sufficient capacity for any spraying job you may have. The total capacity is the sum of (1) spray discharge (2) jet agitation (3) safety or wear factor.

Power-take-off driven pumps on commercially available light-weight rigs are frequently limited to the inexpensive brass, or iron gear-types. These pumps normally operate at maximum pressures of 75 to 100 per square inch and flow rates ranging from 5 to 11 gallons per minute. Gear pumps should not be used to pump wettable suspensions and care should be used to keep dirty water out of them.

(Refer to Table VI, page 6 for discussion of various pump types.)

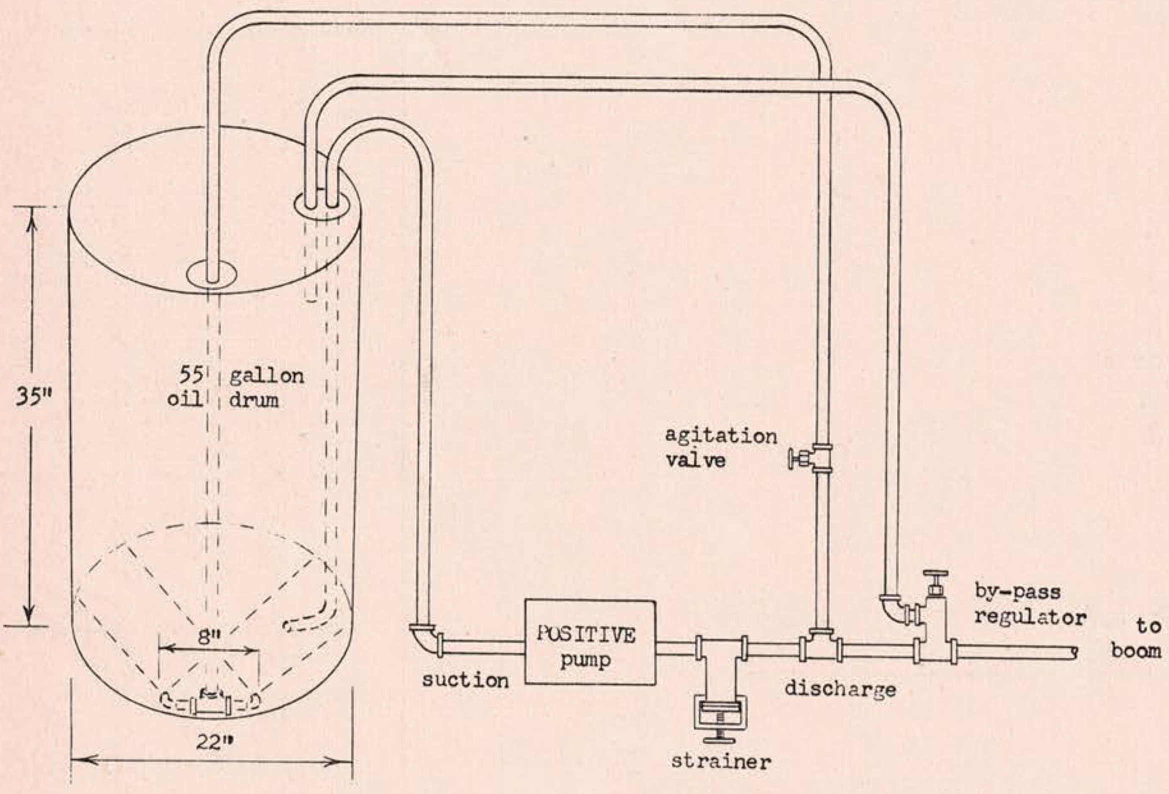

Figure 2. SCHEMATIC DIAGRAM OF A LOW VOLUME SPRAYER

NOZZLES

The flat fan-type nozzle is best for uniform field application. The spray distribution from any one nozzle is shown in Figure 3. The solid lines show the spray fans as arranged on the boom. The dotted lines illustrate the volume of spray material from each nozzle. This shows why the nozzles cannot be arranged to have the edges of the spray fans just meet. A certain amount of overlap is necessary for uniform coverage. Single coverage requires a total lap of 1/2, or 1/4 lap between each pair of spray fans.

Double coverage may be obtained by raising the boom to twice the height without changing the nozzles or nozzle spacing as shown in Figure 3. The amount of material applied per acre remains the same. Double coverage may also be accomplished by decreasing the nozzle spacing by one half on the boom with the same boom height. If this is done, the size of the nozzles must be reduced to maintain the same rate of application. Reducing the nozzle size increases the possibility of clogging.

Table III shows the relationship between nozzle spacing, nozzle fan angle, and nozzle height. The table is made for uniform coverage at a height of 6 inches above ground. The adjustments indicated should take care of alfalfa or plants of a similar height. For coverage at other heights, add or subtract from the figures given.

TABLE III
Height of nozzle above ground in inches.
Flat Fan type nozzles, Uniform coverage·1/2 lap

Nozzle Spacing, Inches	60° Fan	80° Fan	90° Fan	110° Fan
12	19	15	14	11
16	23	18	16	13
18	26	19	17	14
20	28	21	19	15
24	32	24	21	16

Figures are for uniform coverage at a point 6 inches above the ground. For uniform coverage at ground level, subtract 6 inches.

The droplet size generally should be kept small. This is accomplished by using small orifice-sized nozzles with wide fan angles. A wide fan angle tends to produce small droplet size rather than force, the latter of which is not important when material is released close to the plant (as with ground rigs). Another method for decreasing droplet size is by increasing pressure. About four times as much pressure is required to cut droplet size in half. Hence, it is more practical to obtain small drops by nozzle design rather than pressure.

Volume of flow is directly related to the area of the nozzle orifice (the square of the diameter). The best way to make any significant change in the rate of flow is to change the nozzle tips. (Pressure will also increase the rate of flow but as with droplet size the effect is less direct. The pressure will have to be increased by about four times to double the flow.)

BOOMS

Pipe size for the boom is determined largely by structural strength rather than capacity.

No material is entirely non-corrosive. Stainless steel is hightly resistant to corrosion but is expensive. Copper pipe or polyethylene tubing supported by angle iron makes a very corrosion-resistant boom. Galvanized iron pipe (not less than 3/4 inch diameter) with nozzles tapped off the side or top, is most widely used for booms.

The end of any boom should be fitted with a plug for draining.

Boom length is determined largely by the size of operation and the width of irrigation borders. For light-weight rigs, 20 or 30 feet is about maximum.

BOOMLESS OR BROADCAST SPRAYERS

Considerable interest has been shown in the boomless or broadcast rigs, principally because they offer the least expensive rig. They have no boom or small nozzles which require a certain amount of care in keeping clean. The rest of the machine is much the same as the one for the boom-nozzle type rig.

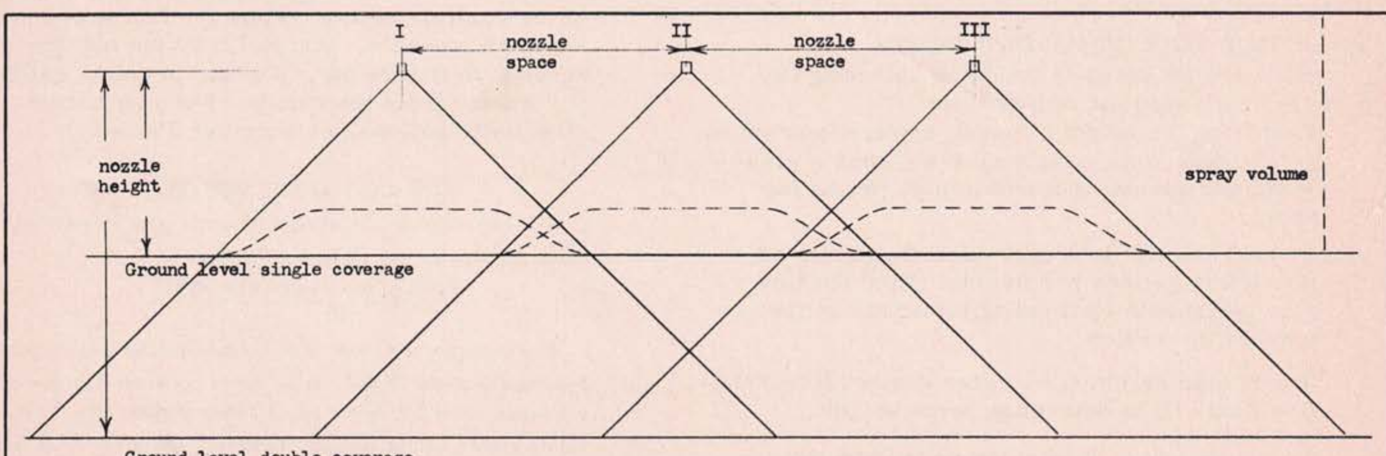

Figure 3.

COVERAGE AND VOLUME DISTRIBUTION
Typical flat fan type nozzles

Solid lines indicate spray cover
Dotted lines spray volume
Note: ½ fan lap each nozzle

Accurate placement and uniform coverage are difficult to maintain with the boomless rigs in a day-by-day operation of the sprayer. The slightest air motion disrupts the calibration and the spray pattern making it difficult to match the swaths. The relatively coarse drop size necessary to obtain wide swaths does not give good coverage.

SCREENS

Screening is essential to keep dirt and rust particles out of the fine spray nozzles. All material entering the tanks should be screened through a 12- to 18-mesh fly screen at the tank opening. If this cannot be done the same size screen should be placed between the pump and tank. A finer screen of 25- to 40-mesh, 20 to 30 square inches in size, should be placed between pump and boom. Nozzle screens are desirable to reduce stoppage by nozzle plugging.

TABLE IV

Total Sprayer Output-Gallons Per Minute
(Divide by Number of Nozzles to Obtain Flow per Nozzle)

Speed MPH	Gallons Per Acre	Swath Width 10 ft.	15 ft.	20 ft.	25 ft.	30 ft.
	10	.4	.6	.8	1.0	1.2
2	15	.6	.9	1.2	1.5	1.8
	20	.8	1.2	1.6	2.0	2.4
	10	.5	.7	1.0	1.2	1.5
2.5	15	.7	1.1	1.4	1.7	2.1
	20	1.0	1.5	2.0	2.5	3.0
	10	.6	.9	1.2	1.5	1.8
3.0	15	.9	1.3	1.8*	2.2	2.7
	20	1.2	1.8	2.4	3.0	3.6
	10	.7	1.1	1.4	1.7	2.1
3.5	15	1.1	1.6	2.2	2.7	3.3
	20	1.4	2.1	2.8	3.5	4.2
	10	.8	1.2	1.6	2.0	2.4
4.0	15	1.2	1.8	2.4	3.0	3.6
	20	1.6	2.4	3.2	4.0	4.8

*Example: With a swath width of 20 feet, a sprayer must apply material from all nozzles at the rate of 1.8 gallons per minute to apply 15 gallons per acre at 3 miles per hour.
For twice the speed, swath width or gallons per acre the total output figure would be doubled.

SELECTION OF COMPONENT PARTS

Here are the steps to follow in selecting the parts for building your own sprayer:

1. Decide on the length of boom, application rate in gallons per acre, nozzle spacing, nozzle pressure, and operating speed in mph (miles per hour).
2. From Table IV determine total flow from all nozzles in gallons per minute. Find the flow rate per nozzle by dividing total flow by the number of nozzles.
3. Select nozzles which will give desired flow rate. Use Table III to determine boom height.
4. Select the pump. The pump must have the capacity to deliver the material at the rate required and at the desired operating pressure. The minimum pumping rate in gallons per minute for the pump is the sum of nozzles output plus agitation requirements. Thirty percent should be added to the pump capacity to compensate for wear.

Let us use an example in selecting the component parts for a particular job.

1/ We have decided on a 30-foot swath, 18-inch nozzle spacing, application rate of 15 gallons per acre, nozzle pressure of 50 psi and an operating speed of 4 miles per hour.

2/ From Table IV the total nozzle flow is 3.6 gallons per minute. An 18-inch nozzle spacing on a 30 foot swath gives a total of 20 nozzles. Dividing 3.6 by 20 gives us a flow rate for each nozzle of 0.18 gallons per minute.

3/ Consult a nozzle dealer or dealer handbook to select nozzles with a flow of 0.18 gallons per minute. From Table III using a 90 degree fan angle and a spacing of 18 inches we get a nozzle height of 17 inches.

4/ Assume we use 4 gallons per minute for agitation. Then the total required pump capacity will be 30 percent more than the sum of nozzle flow and the gpm required for agitation in the tank. (The capacity is 4 + 3.6 increased by 30 percent to compensate for wear.) We can write it: 7.6 x 1.3 = 10. Our pump must handle 10 gpm at our operating pressure of 50 psi.

CALIBRATION — Check your Rig for Accuracy

Whether you buy or build your rig it should be checked to be sure it is applying material at the proper rate.

1. Check your ground speed. If you don't have a speedometer on your tractor, time the tractor over a distance of 500 feet. Divide 500 by the number of seconds and multiply by 1.46 to get miles per hour. Another method is to pace the tractor for 20 seconds. The number of steps in 20 seconds divided by 10 gives miles per hour.
2. Check the flow rate of some of the nozzles, one at a time. Make sure the operating pressure is at the desired setting. Time the filling of a pint jar from a nozzle. Divide 7.5 by the number of seconds to fill the jar, in order to obtain gallons per minute from the nozzle. For converting directly to gallons per acre use Table V.

HOW MANY ACRES PER DAY?

You can estimate the number of acres your sprayer will cover per hour by the following formula:

$$\frac{\text{Width of the swath (ft) x MPH}}{10}$$

For example, a 30 foot wide boom traveling 4 miles per hour would cover $\frac{30 \times 4}{10}$ or 12 acres per hour. The above rig would cover 120 acres in a 10 hour working day. This figure allows for the operator to spend 20% of the total field time in non-spraying operations such as turning, refilling the tank, etc.

TABLE V

CALIBRATION
Based on Number of Seconds to Fill Pint Jar

Speed MPH	Gallons Per Acre	Nozzle Spacing				
		12 in.	16 in.	18 in.	20 in.	24 in.
	10	186*	139	124	111	93
2	15	139	104	93	83	70
	20	93	70	62	56	46
	10	149	112	100	89	74
2.5	15	111	83	74	67	55
	20	74	55	49	44	37
	10	124	83	83	74	62
3.0	15	92	69	61	55	46
	20	62	46	41	37	31
	10	106	80	71	65	53
3.5	15	79	59	53	47	39
	20	53	40	35	32	26
	10	93	70	62**	56	46
4.0	15	69	52	46	41	34
	20	46	35	31	28	23

*An example of how to use the table. If it took you 186 seconds to fill a pint jar at one nozzle, and you know that your ground speed will be 2 miles per hour and your nozzle spacing is 12 inches you can ascertain that you will be delivering 10 gallons per acre.

**Another example might be to run your machine at 4 miles per hour with a nozzle spacing of 18 inches. If it takes you 62 seconds to fill a pint jar with one nozzle you can estimate you will be delivering 10 gallons per acre also.

For higher speeds or gallons per acre the time to fill the jar is proportionally less.

TABLE VI

The following chart lists the pump types with a brief comment on each.

Pump Type	Some Principal Features	
	Advantages	Disadvantages
Centrifugal	Universally adaptable for use with all sprayer formulations. Low wear with abrasive materials. High volume.	Expensive. Relatively low pressure. Not self-priming.
Piston	Universally adaptable for use with all sprayer formulations. High pressure. Easily replaceable parts.	Expensive. Heavy. Low volume.
Diaphragm	Low wear with abrasive materials. Easily replaceable parts. Medium price. Medium pressure.	Low volume. Synthetic rubber diaphragm non-resistant to weed oil.
Roller	Medium price. Durable when made of non-corrosive steels and plastics except when used with wettable suspensions. Medium volume.	Pump life shortened when used with wettable suspensions.
Gears (non-corrosive steel)	Inexpensive. Medium pressure.	Low volume, medium pressure. Wears rapidly when used with wettable suspensions.
Gears (iron, brass, bronze)	Least expensive. Medium pressure.	Short lived. Unsatisfactory for wettable suspensions.

OUR NEW FRONTIERS

W. A. Harvey
Extension Weed Control Specialist
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If the idea of "New Frontiers" in weed control seems strange to you, put on your coonskin caps and ride with me for a little while. I believe I can show you horizons far beyond those we customarily view.

All of us are concerned with particular weed problems - fiddle-neck in barley, nettle in carrots, live-oak trees on range land, a host of such problems all of which must be solved as particular problems - but for a little while this morning let's take a broad-view of weed control. And to help us think big let's think in terms of VEGETATION CONTROL rather than WEED CONTROL.

Control of vegetation is basic to agriculture and presents a challenge on all of our lands. We in weed control have the background to be of service in this much broader aspect of agriculture. There are horizons here that we haven't dared view. Of course we don't have all the answers to vegetation control - we don't even understand all the problems. But the distance we can go is limited only by our vision and our thinking and our daring.

Let's look at the potential here in California. We have approximately 100 million acres of land in this state. It can be divided, roughly, as follows:

25 million acres of barren and desert land
25 million acres of coniferous forest
27 million acres of brushland, made up of
- 10 million acres of woodland-grass
- 7 million acres of chamise
- 5 million acres of big sagebrush
- 2 million acres of coastal sage
- 3 million acres of other chaparral

10 million acres of open grass range and pasture
10 million acres of cultivated farm lands, with
- 7 million acres irrigated

3 million acres of urban and industrial areas

What are the problems and what is the future for vegetation control on these acres? We will have time for only a brief glance at the major areas and major potentials that now seem important. And these will change as our knowledge increases and our vision clears. The barren and desert lands lie almost unused agriculturally. Many of these acres cannot be improved with our present knowledge and our present water supplies. Others will go under irrigation as water becomes available or more equitably distributed. On all of these acres patrol action is desirable to prevent invasion of harmful or unwanted species. The spread of halogeton into such areas is an example, as is the invasion of Camel thorn along the Mojave river in San Bernardino County. Opportunities for improvement of these lands is limited but cannot be ignored.

Vegetation control opportunities on the 25 million acres of coniferous forest land are many and varied, including (1) weed control in forest tree nurseries, (2) control of ribes species which are alternate hosts for white pine blister rust, (3) control of brush in tree plantings to reduce competition and fire hazard, (4) control of weed trees to release production species, and (5) maintenance of fire breaks. In addition to these, there are other problems such as the 16,000 miles of trails and 22,000 miles of roads in the forests which must be kept clear of vegetation by mechanical and chemical methods. Weedy and poisonous species often infest the grazing lands within the forests. All of these, and many others, present opportunities for vegetation control - the encouragement of desirable plants and the elimination or reduction of less desirable species.

The 27 million acres of brush lands present a tremendous challenge fo our thinking and our action. In terms of California agriculture they present a major frontier that we are only beginning to recognize. We think of these as cheap lands that can bear only a small cost for vegetation control. But perhaps we should view them from the standpoint of potential value in terms of what they can be worth if the present vegetation is controlled and more desirable vegetation substituted. What can they produce - perhaps in pounds of beef or wool - rather than what are they now producing. It is onto these acres that our livestock industry and perhaps some of our dry farming must expand.

Today we import about 50% of our beef and lamb because of a shortage of range land for cow and calf operations to raise our own feeders and because sheepmen find it more profitable to ship in replacement ewes from out of state.

We do have answers to the challenge presented by a number of the brush species but much remains to be done. The answers come from many sources and represent not only information on how to get rid of brush but also on how to produce desirable plants on these same lands. It will avail us little to eliminate species unless we can encourage more desirable species. Remember we are thinking in terms of controlling vegetation, not just eliminating vegetation. Here is more than one fourth of our state, much of which can be tremendously more productive than it now is. A frontier - sure, and one requiring all the ideas and ingenuity we can muster if we are to tame these lands.

Of course we must start on the species and on the sites most susceptible to improvement with our present knowledge. Much of the 10 million acres of woodland grass can be improved with known methods of vegetation control. Big sagebrush, coastal sage and coyote brush can be controlled with our present chemicals. Chamise is more difficult but not impossible to control. The tools available for a logical attack on the brush infested acres include burning, chemicals, reseeding, fertilization and livestock management. Selections from and combinations of these methods must be made to meet individual situations.

The 10 million acres of open grass range and pasture presents problems of undesirable grasses such as Medusa head and Goat grass as well as other grasses that may be palatable though not highly productive. In addition there are problems with poisonous plants and weedy broadleaved species of doubtful forage value. Improvement and extension of this range land is a major challenge in vegetation control.

In much of our thinking on weed control we consider only the 10 million acres of cultivated land on which we grow crops. Here are indeed a multitude of problems with weed losses ranging from a few dollars per acre up to several hundred dollars. Cut flower growers may spend

$400 per acre hand-weeding and one grower reported that he spent $800 to weed a commercial crop of stock. Much of our program today will be devoted to specific problems on these lands.

There are frontiers even in this area - nut grass for an example, and selective sprays for many of our row crops. Even our old friend wild morning glory has not been defeated. Major attention to the problems on these lands is reducing our frontiers here, but there is room for improvement in many of our existing methods and many problems with no satisfactory solutions and situations with no feasible answers. Thus on this 10% of our acreage that has received most attention we have answers to no more than 10% of the problems. Frontiers still available? Sure there are.

The 3 million acres of industrial and urban areas present a tremendous array of problems ranging from vegetation control on industrial sites, trackage, storage yards and parking lots to turf maintenance. And turf is big business in California. A survey in Los Angeles County revealed 63,000 acres of actual turfgrass with a present cost of establishment of 262 million dollars and 90 million dollars spent annually for maintenance. And this is for just one county that we think of as mostly free-ways!

It is on these acres that per acre costs are relatively less important as long as the plant manager or the home owner gets the desired vegetation control.

Since we cannot increase the 100 million acres of land we have in California we are faced with using what we have more effectively. And we are also faced with a continuous process of up-grading. The industrial and urban acreage is increasing at the expense of our good farm land which is in turn edging into the grass lands. Additional grass land must be reclaimed from the brush and perhaps additional farm land from the desert.

In this brief view of the horizon in vegetation control I hope I've been able to show you the frontiers that now exist. Like all frontiers, they aren't easy to conquer and they are new frontiers because they are as yet largely unconquered. There's plenty that's new and exciting in vegetation control if we are pioneers enough to face these frontiers with vision. Vegetation control is basic to agriculture and we in weed control are concerned with VEGETATION CONTROL.

BUSINESS MEETING OF THE CALIFORNIA WEED CONFERENCE

The Business Meeting of the California Weed Conference was called together by President, Paul F. Dresher.

"Our thanks to the many people responsible for the success of the details of this Conference were expressed in resolutions by the Western Weed Control Conference last night. It was a pleasure to work with President Ball and his Executive Committee."

"You will recall that two years ago President Marcus Cravens appointed a Study Committee with Dr. Vernon Cheadle as Chairman. This Committee has, after careful analysis, outlined duties of Officers and Committees which make the Conference run smoothly. The Committee will continue its splendid work. Dr. Cheadle will give a brief report in the proceedings."

Treasurer's report--J. T. Vedder, Treasurer

Cash on hand January 1, 1955	$782.20
Receipts from Proceedings and Registration	918.83
Disbursements for printing, postage, stenographic help	730.35
Cash on hand, January 31, 1956	974.68

Report by Nominations Committee--L. J. Berry, Chairman

The following set of officers were nominated and elected to serve for the next year: President: James W. Koehler; Vice-President: Vernon I. Cheadle; Secretary: O. A. Leonard; Treasurer: J. T. Vedder.

Next Meeting

The ninth California Weed Conference will be held in Fresno, California, next January 22-24, 1957. Headquarters will be in Hotel Californian.

REPORT OF THE STUDY COMMITTEE, CALIFORNIA WEED CONFERENCE

The Study Committee in the past year had a two-fold program. In one of its efforts, revisions were made of three forms to be supplied to the Secretary of the Conference. These include Suggestions for Participants on the Program of the California Weed Conference, a Check List for California Weed Conference, and a Time List for California Weed Conference. These forms are designed to save both time and energy in discharging many of the routine responsibilities of the officers and thus to free them for constructive thinking about the other, often more intangible, aspects of successful Conferences.

In the second part of its program, the Committee deliberated on the feasibility of establishing a weed advisory committee to be composed of members from various agencies directly or indirectly faced with weed problems. The outcome of these discussions was a four-page memorandum which was distributed to some of the concerned agencies, and which will be distributed to still others by Mr. Paul F. Dresher, President of the California Weed Conference during this period. As a result of this memorandum, a brief meeting, at a call from President Dresher, was held by certain members of a skeleton weed committee during the Conference. Other meetings are planned for the future.

Respectfully submitted,

W. S. Ball
P. F. Dresher
E. A. Dudley
W. A. Harvey
R. M. Howie
Ed. Littooy
J. K. Sexton
J. P. Simons
V. I. Cheadle. Chairman

BUSINESS MEETING OF THE WESTERN WEED CONTROL CONFERENCE

The Business Meeting of the Western Weed Control Conference was called together by President, Walter S. Ball.

Reports of the various committees were given and are presented below.

The Conference voted against holding annual meetings (item 5, report of Executive Committee). Item 2 of the Executive Committee Report was adopted, so the next meeting of the Conference will be in Spokane, Washington in February 1958.

The following officers were elected: President: Henry Wolfe; Vice-President: R. A. Fosse; Secretary-Treasurer: W. R. Furtick.

REPORT OF THE EXECUTIVE COMMITTEE

Walter S. Ball, Chairman

The meeting of the executive committee of the Western Weed Control Conference was called to order by President Walter Ball on February 14.

1. Present were: Walter Ball, W. A. Harvey, W. C. Robocker, Boysie Day and C. E. Seely.

2. An invitation to hold the 1958 meeting in Spokane, Wash., February 1958 was unanimously accepted. A motion was made that the Western Canadian Conference be invited to the 1958 WWCC. The motion carried.

3. Industry Committee Chairman Stahler moved that the treasurer be authorized to reimburse Boysie Day for the cost of getting out the Research Progress Report. The motion was carried. After payment for the 15th Research Progress Report, the balance stands at $227.58. We have one bill outstanding for Walter Ball's transportation to the National Meeting at New York City. The secretary-treasurer's report was accepted by the committee.

4. A motion was made by W. C. Robocker and seconded by C. I. Seely that Denver be recommended by the executive committee for the 1960 meeting. Motion carried. C. I. Seely moved that the 1960 meeting be held the first week of February. The motion was seconded by Boysie Day and carried.

5. A motion was made by L. M. Stahler that the WWCC hereafter hold an annual meeting and if convenient, this meeting to be held in conjunction with a State weed control conference in the state where the meeting is being held. The motion was seconded by Boysie Day. The motion was carried by a 3 to 2 vote.

REPORT OF REGULATORY COMMITTEE

Lee M. Burge, Chairman
Ariel M. Jorgenson
Lambert Erickson
Auburn L. Norris

The Regulatory Committee has discussed by correspondence and in open discussion during the present conference many problems facing the regulatory people. Particular problems arising between State and Federal agencies as well as State and County control people are of concern to the whole conference.

As provided in the Constitution adopted at the Tucson meeting, your regulatory committee urges that committee chairmen be appointed early in the year to allow time for development of a good program of the education and regulatory section. This section should be active to properly disseminate research information and to forcefully bring to the attention of the proper governmental agencies problems of mutual concern.

During this season regulatory people representing counties, states, and other agencies have expressed a strong desire to have their own section meeting prior to the general session.

The following problems have been considered of utmost importance by the committee:

In spite of all our complaining the Federal Seed Act still permits 2% total weed seeds on foreign imports. History of many of our present day noxious weeds indicates that they were imported in foreign seed as relative unknowns. The Western Seed Officials have time and again requested a tightening of this allowance of 2%, to no avail. A request to the Secretary of Agriculture asking a reduction of this tolerance, therefore, seems justified. We suggest 1/2% on cereals and 1% on legumes and grasses.

Foreign imports of screenings, seed, grains, and fertilizers appears to be a serious problem, particularly to states adjacent to foreign boundaries. The rest of us indirectly are affected by such imports. In this respect we could request the Secretary of Agriculture to provide that such entries comply with the regulations set up in the respective states of entry, or stringent over-all Federal regulations be provided.

Payments for weed control under the A.S.C. program have been stricken from the docket for the year 1956. The statistical reports for past years indicate that this program in an over-all analysis was quite popular. Insofar as we can learn, Secretary Benson has not given any substantial reasons for eliminating this practice. It, therefore, seems advisable that we ask him to reconsider his action in this respect.

Many agencies in both Agriculture and Interior are engaged in range seeding programs. Individual state relations have been quite satisfactory with these agencies in that they have at state request, submitted samples for analysis either before purchase or before planting. However, this is strictly a voluntary move based on personal relations. It would appear advisable in view of the expanding range seeding programs that we request both the Secretary of Interior and of Agriculture to provide that seed intended for planting in any given state meet the requirements of that state insofar as noxious weeds are concerned.

5. It may also be advisable to request that seed planted and partially paid for with Federal funds under the A.S.C. programs must meet the requirements of the state where planted. We find that in many cases seed for these programs is purchased by farmers from out of state sources, which does not give the state a chance to check on such seed. Our recommendation is that the state regulatory divisions take a firm lead in working out a cooperative agreement with A.S.C. committees and an understanding of agreement providing that such seed meet all requirements of the state laws.

We further recommend that the Constitution be amended to provide that both the education and Regulatory chairmen be members of the executive committee. At present one committee chairman (research) is designated as a member of the Board.

Resolutions covering the regulatory matters above have been presented to your resolutions committee for consideration.

REPORT OF THE RESOLUTIONS COMMITTEE

F. L. Timmons, Chairman
Bruce Thornton
D. C. Tingey

The Resolutions Committee moves the adoption of the following resolutions and further moves that the Conference Secretary be instructed to send copies of each resolution to the appropriate agencies and/or individuals concerned.

Resolution No. 1

WHEREAS, the Silver State Press of Reno, Nevada, performed the printing and binding of 300 copies of the Proceedings of the 14th Western Weed Control Conference at Tucson, Arizona, March 22-24, 1954, at a price of only one-half the customary rate,

NOW, therefore be it resolved that the 15th Western Weed Control Conference assembled at Sacramento, California, on February 15, 16, and 17, 1956, express our appreciation to the Silver State Press for this cooperation and service.

Resolution No. 2

WHEREAS, the WWCC and CWCC have greatly enjoyed and benefitted from the excellent arrangements and facilities provided for holding this joint Conference,

NOW, therefore be it resolved that we express our appreciation and thanks to the following:

The Sacramento Convention Bureau

Hotel Senator and other hotels in Sacramento

The California Farmer for printing the programs

The Agricultural Engineering Department of the University of California at Davis for outstanding exhibits, demonstrations and discussions on weed control equipment

The Special Committees on Arrangements consisting of Murray Pryor, Ed Littooy, Bob Moore, Mr. & Mrs. E. A. Morrison, and Margaret K. Bellue for much time and effort in ably taking care of local arrangements.

Resolution No. 3

WHEREAS, the WWCC and the CWCC have greatly enjoyed and appreciated the diverse and interesting program arranged for this joint Conference,

NOW, therefore be it resolved that we express our thanks to the Executive Committee of the two Conferences who served as a Joint Program Committee.

Resolution No. 4

WHEREAS, our officers for the past biennium, Walter S. Ball, President, Wm. A. Harvey, Vice President, and W. C. Robocker, Secretary-treasurer, have spent much time and effort in assembling and distributing the Proceedings of our 14th Conference and in making this 15th Conference meeting a success,

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

Resolution No. 5

WHEREAS, research is the basis of advancements in weed control and reports of research are important to the members of this Conference,

NOW, therefore be it resolved that the 15th Western Weed Control Conference assembled at Sacramento, California, February 15, 16, and 17, 1956, commend the Research Committee for the preparation of the Research Progress Report, and

BE it further resolved that this Conference commend Boysie E. Day for his capable leadership as Chairman of the Research Committee.

Resolution No. 6

WHEREAS, the first meeting of the National Weed Control Conference was held in conjunction with the North Central Weed Control Conference at Kansas City, Missouri, in December 1953, and

WHEREAS, the charter meeting of the Weed Society of America was held in conjunction with the Northeastern Weed Control Conference at New York City in January 1956, and

WHEREAS, the second meeting of the Weed Society of America is scheduled to meet with the Southern Weed Control Conference at Memphis, Tennessee, in January 1958,

THEREFORE, be it resolved that the 15th Western Weed Control Conference, at this meeting held in Sacramento, California, on February 15, 1956, hereby invite and request that the third meeting of the Weed Society of America be held in conjunction with the 17th Western Weed Control Conference in 1960 at a place and on dates to be determined at this 15th Conference, and instruct the Secretary to extend such invitation and request to the officers of the Weed Society of America as soon as practicable.

Resolution No. 7

WHEREAS, The Federal Seed Act permits an overall tolerance of 2% weed seed in foreign imports of crop seeds, and,

WHEREAS, many of our present day noxious weeds were imported as relative unknowns in foreign crop seeds,

NOW, therefore be it resolved, that the Secretary of the United States Department of Agriculture be asked to consider reducing the overall total weed seed allowance from 2% to 0.5% in cereal crop seeds and to 1.0% in seeds of grasses and legumes, and,

FURTHER, that he direct that the noxious weed seed content in such foreign imported crop seeds must meet the requirements of the seed and weed laws of the state of entry.

Resolution No. 8

WHEREAS, foreign imports of fertilizers, screenings, and feed grains have permitted entry of objectionable weed seeds into this country,

NOW, therefore be it resolved the Secretary of the USDA be requested to require that all imports of the above named materials must meet the requirements of the state of entry.

Resolution No. 9

WHEREAS, certain Federal agencies are expanding range seeding programs, and,

WHEREAS, seed used in these plants have at times proven to contain noxious weed seeds,

NOW, therefore be it resolved that the Secretary of the U. S. Department of Interior and the Secretary of the Department of Agriculture be requested to require that all seed used for such range seeding meet the weed and seed law requirements of the state where said seed is used.

Resolution No. 10

WHEREAS, crop seed used under the Agricultural Stabilization Committee programs have not in the past always met the requirements of local seed laws, and,

WHEREAS, such seed could tend to nullify weed control efforts by state and local agencies,

NOW, therefore, be it resolved that the regulatory agencies in the eleven Western States take a firm lead in proposing to their respective state Agricultural Stabilization Committees agreements to provide that state ASC seed dockets require that all seed used under ASC programs meet the requirements of the state seed and weed laws.

Resolution No. 11

WHEREAS, under public law the Federal agencies controlling public lands have the authority to control noxious weeds on such lands, and

WHEREAS, adequate surveys and incentives to carry out the needs for such control have not been apparent,

NOW, therefore be it resolved that the Secretary of the U. S. Department of Interior and the Secretary of the U. S. Department of Agriculture be requested to direct their field personnel to develop adequate programs for control of primary noxious weeds such as medusa head rye, Canada thistle, tansy ragwort, perennial larkspur, Mediterranean sage and/or other noxious weeds of equal importance in the different states.

REPORT OF THE NOMENCLATURE AND TERMINOLOGY COMMITTEE

C. I. Seely, Chairman
Bruce J. Thornton
W. A. Harvey
D. W. Bohmont

The Nomenclature and Terminology Committee recommends that the Western Weed Control Conference approve the following report on chemical nomenclature and that the following be required in all publications of the Conference including the Research Report.

1. All herbicides not approved by the Nomenclature and Terminology Committee for acceptable designations be reported by their full chemical names.

2. In referring to derivatives of any chemical the specific derivative shall be identified. For example, sodium salt of 2,4-D or butyl ester of 2,4-D.

3. In publications the first time an herbicide is referred to in the manuscript the full chemical name should be given followed in parenthesis by the accepted designation.

4. In chemical names the Chemical Abstracts system of nomenclature should always be used but where this may cause confusion due to other commonly accepted names the others may also be given to identify the compound.

5. Each copy of the Research Report shall carry a list of the correct

chemical names and approved designations of all herbicides approved by the Terminology Committee.

6. When changes in terminology approved by the Weed Society of America are published in "Weeds" these changes shall automatically be accepted by the Western Weed Control Conference.

7. The Western Weed Control Conference endorses the procedure for accepting common names for herbicides as an American Standard as set forth by ASA-K62 and encourages commercial companies to sponsor common names for their herbicides as soon as they are commercially available for public use.

8. Approved nomenclature for chemicals used as herbicides:

Chemical Name	Designations accepted for use in all publications of WWCC	Previous designations for identification only
2,4-Dichlorophenoxyacetic acid	2,4-D	
4-Chloro-o-tolyloxyacetic acid 2-Methyl-4-chlorophenoxyacetic acid[2]	MCPA	
2,4,5-Trichlorophenoxyacetic acid	2,4,5-T	
3,4-Dichlorophenoxyacetic acid	3,4-DA	
p-Chlorophenoxyacetic acid 4-Chlorophenoxyacetic acid[2]	4-CPA	
2-(2,4-Dichlorophenoxy)propionic acid	2-(2,4-DP)	
2-(4-Chloro-o-tolyloxy)propionic acid 2-(2-methyl-4-chlorophenoxy)propionic acid[2]	2-(MCPP)	
2-(2,4,5-Trichlorophenoxy)propionic acid	2-(2,4,5-TP)	silvex[1] 2,4,5-TP
2-(3,4-Dichlorophenoxy)propionic acid	2-(3,4-DP)	
2-(p-Chlorophenoxy)propionic acid 2-(4-Chlorophenoxy)propionic acid[2]	2-(4-CPP)	
4-(2,4-Dichlorophenoxy)butyric acid	4-(2,4-DB)	2,4-DB
4-(4-Chloro-o-tolyloxy)butyric acid 4-(2-Methyl-4-chlorophenoxy)butyric acid[2]	4-(MCPB)	MCPB
4-(2,4,5-Trichlorophenoxy)butyric acid	4-(2,4,5-TB)	2,4,5-TB
4-(3,4-Dichlorophenoxy)butyric acid	4-(3,4-DB)	
4-(p-Chlorophenoxy)butyric acid 4-(4-Chlorophenoxy)butyric acid[2]	4-(4-CPB)	
2-(2,4-Dichlorophenoxy) ethanol hydrogen sulfate 2,4-Dichlorophenoxyethyl sulfate[2]	2,4-DES	2,4-DS, SES

Chemical Name	Designations accepted for use in all publications of WWCC	Previous designations for identification only
2-(2,4,5-Trichlorophenoxy)ethanol hydrogen sulfate 2,4,5-Trichlorophenoxyethyl sulfate[2]	2,4,5-TES	natrin
2-(4-Chloro-o-tolyloxy)ethanol hydrogen sulfate 2-Methyl-4-chlorophenoxyethyl sulfate[2] 4-Chloro-o-tolyloxyethyl sulfate[2]	MCPES	methin
2-(2,4-Dichlorophenoxy)ethanol benzoate 2,4-Dichlorophenoxyethyl benzoate[2]	2,4-DEB	sesin
Trichloroacetic acid	TCA	
2,2-Dichloropropionic acid	dalapon[1]	
2,2,3-Trichloropropionic acid	2,2,3-TPA	
1,3-bis(2,2,2-Trichloro-1-hydroxyethyl)urea Dichloral urea[2]	DCU	
a-Chloro-N,N-diallylacetamide	CDAA	
a-Chloro-N,N-diethylacetamide	CDEA	
Isopropyl ester of carbanilic acid Isopropyl N-phenylcarbamate[2]	IPC	
Isopropyl ester of m-chlorocarbanilic acid Isopropyl N-(3-chlorophenyl)carbamate[2]	CIPC	
2-Chloroallyl ester of diethyldithiocarbamic acid 2-Chloroallyl diethyldithiocarbamate[2]	CDEC	
3-Phenyl-1,1-dimethylurea	fenuron[1]	PDU, Karmex FW
3-(p-Chlorophenyl)-1,1-dimethylurea	monuron[1]	CMU, Karmex W
3-(3,4-Dichlorophenyl)-1,1-dimethylurea	diuron[1]	DCMU, Karmex DW
3-(3,4-Dichlorophenyl)-1-butyl-1-methylurea	neburon[1]	DMBU
Pentachlorophenol	PCP	
4,6-Dinitro-2-secondary butylphenol	DNBP	
4,6-Dinitro-2-secondary amylphenol	DNAP	
4,6-Dinitro ortho cresol	DNC	
2,3,6-Trichlorobenzoic acid	2,3,6-TBA*	4CBA
2,3,5,6-Tetrachlorobenzoic acid	2,3,5,6-TBA*	

Chemical Name	Designations accepted for use in all publications of WWCC	Previous designations for identification only
N-1-Naphthyl phthalamic acid	NPA	alanap
7-Oxabicyclo (2.2.1) heptane-2,3-dicarboxylic acid 3,6-Endoxohexahydrophthalic acid[2]	endothal	
Phenyl mercuric acetate	PMA	PMAS
Potassium cyanate	KOCN	
Hexachloro-2-propanone Hexachloroacetone[2]	HCA	
Isopropylxanthic acid	IPX	NIX
1,2-Dihydro-3,6-pyridazinedione Maleic hydrazide[2]	MH	
Trichlorobenzenes	X-TB*	TCB
2-Chloro-4,6-bis(diethylamino)-S-triazine	CDT	
3-Amino-1,2,4-triazole	ATA	AT, amizol
Octachlorocyclohexenone (See Note 1)	OCH	oktone
bis(Ethylxanthic)disulfide) Ethyl xanthogen disulfide[2]	EXD	
Methane arsonic acid Monomethyl arsonic acid[2]	MAA	sodar
Arsenic trioxide	white arsenic	
Sodium tetraborate	borax	
2-(2,4,5-trichlorophenoxy)ethyl-2,2-dichloropropionate	erbon[1]	

Note 1. This name would be used by Chemical Abstracts because the position of the double bond in relation to the double bond oxygen is not known. This compound could be either octachloro-2-cyclohexen-1-one or octachloro-3-cyclohexen-1-one. It could also be a mixture.

* These compounds are usually available for use as herbicides as mixed isomers. When possible the isomers should be identified and the source of the experimental chemicals given.

1 Common names under consideration for acceptance as US standard and have been approved for use by the Terminology Committee.

2 Previously used chemical name given for identification only. The preceding name is the same compound using Chemical Abstracts system of nomenclature and is the one which should be used.

REPORT OF EDUCATION COMMITTEE

Rex Warren, Chairman
Henry Wolfe
Robert Higgins

The Education Committee met with extension service representatives from Washington, Oregon, California, Nevada, New Mexico, Utah, Idaho, Wyoming, and Montana. The following program was adopted:

Extension Weed Specialist's Meetings

The Education Committee recommends that Extension Agronomists or Extension Weed Specialists meet at each regular Western States Weed Conference. On alternate years this group to meet at the time the Conference Research Committee meets. We request that the President of the Western States Weed Conference appoint a Chairman of the Extension Committee whom would serve as a member of the Program Committee for the Western States Weed Conference. When arranging the program for the regular meeting of the Western States Weed Conference and the Research Committee time should be allocated for a meeting of the Extension weed workers.

State Weed Organizations

State weed organizations are active in most of the Western states. We recommend that all states have some type of a statewide weed group. Such groups help weed programs by:

(a) Disseminating research and other weed control information.

(b) Coordinating activities in weed control between state and federal agencies and industry.

(c) Sponsoring needed weed legislation.

Weed Surveys

Weed seeds are spread many ways. Henry Wolfe, Weed Specialist, Pullman, Washington reported on a weed survey conducted in the state of Washington. Similar surveys would be of great value in all states. Things learned from the survey are:

(1) The number and kind of weed seeds in seed samples. (Information from seed laboratories).

(2) How many weed seeds are spread by hauling clean seed in dirty trucks. (Sweep or vacuum the truck bed before loading bulk seed).

(3) Farmers plant weeds with their grain. (Collect seed from farmers' drills and analyze sample for purity).

(4) How many weed seeds are spread through irrigation. (Collect some samples of water; screen to remove weed seeds).

(5) Birds scatter many weed seeds. (Check with Game Commission or analyze craw of pheasants during hunting season).

These are but a few of the interesting things that can be learned through a survey. This information is excellent for discussions at granges, farm bureaus, community clubs, chambers of commerce, and similar places.

This report to be mailed by the past Education Committee Chairman to Extension Agronomists and Weed Specialists and Directors of Extension in the 11 Western States.

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PREFACE

The Research Progress Report has been prepared in advance of the 1956 meeting of the Western Weed Control Conference as a supplement to the conference proceedings. It consists of abstracts and summaries of current findings of research workers throughout the conference area. This report is particularly to be recommended for its timeliness. Results are fresh from the laboratory and field plots and were assembled in time to be available at the conference meeting only by a last-minute effort of the personnel of the research committee. Hasty preparation must necessarily forego some of the safeguards obtainable by more leisurely coordination between authors and editors. Time has permitted only the correction of obvious typographical errors, and I fear not all of these. Questions of clarity and content requiring correspondence with the authors remain unresolved.

The content of the report must, therefore, be considered as tentative and not for publication, being primarily a "notebook" for correlating the latest findings of research workers.

The research committee is organized into ten projects each having a project leader. The real burden of assembling and summarizing the information contained in this report has been on the shoulders of these project leaders.

To them and to the many research workers of the West who have contributed reports of their findings, I want to express my warm appreciation for their cooperative efforts.

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PROJECT 1. PERENNIAL HERBACEOUS WEEDS

W. R. Furtick -- Project Leader

SUMMARY

A total of thirteen reports were received from eleven different investigators in six different states. Results were reported on eight different weed species.

Broad-Leaved Perennials

Canada thistle (Cirsium arvense). In Colorado various soil sterilants and 2,4-D were effective in reducing stands of Canada thistle present in a bluegrass pasture. Sodium chlorate, at six pounds per square rod, Polybor Chlorate at twelve pounds per square rod gave eighty to ninety-five percent reduction of Canada thistle stands. Borax Db (a mixture of Borax and 2,4-D) was also quite effective in controlling Canada thistle at rates of three and six pounds per square rod. Similar rates of Polybor, Borascu (concentrated), Sta-klor (mixture of Sodium chlorate, Borax, and TCA), CMU, DCMU, and Silvex (2,4-5 Trichloro phenoxy propionic acid) were rather ineffective under the conditions of this trial. The amine and low volatile (Propylene Glycol Butyl ether) ester formulations of 2,4-D were not damaging to the bluegrass, however, the micronized formulation of 2,4-D gave some slight reduction in the bluegrass stand.

Morning Glory (Convolvulus arvensis). Results from trials conducted in Colorado during 1953 indicated that various soil sterilants and 2,4-D amine were effective in reducing stands of Morning Glory, (Convolvulus arvensis). Experiments were conducted on light sandy loam non-irrigated soil and on irrigated heavy clay loam soil. Indications were that with the exception of CMU, much more effective results were obtained on the light sandy loam non-irrigated soil. Sodium chlorate at four and six pounds per square rod, Chlorax (mixture of Sodium chlorate and Borax) at six and nine pounds per square rod, Polybor Chlorate at eight and twelve pounds per square rod, Polybor at ten and fifteen pounds per square rod, Borascu (concentrated) at twelve and eighteen pounds per square rod, and 2,4-D amine salt at one-half and one pound acid equivalent per square rod gave ninety-five to one-hundred percent reduction of Morning Glory on the light sandy loam irrigated soil.

Russian knapweed (Sentaurea picris). In Colorado stands of Russian knapweed were reduced ninety to one-hundred percent by various formulations of 2,4-D at rates of one-half and one pound per square rod. Silvex which is 2,4-5 Trichloro phenoxy propionic acid gave one-hundred percent stand reductions at each rate. Sodium chlorate at four and six pounds per square rod, Polybor chlorate at eight and twelve pounds per square rod, Sta-klor (mixture of Sodium chlorate, Borax, and TCA) at two and four pounds per square rod and Borax Db (mixture of Borax and 2,4-D) at five and eight pounds per square rod gave almost complete control of Russian knapweed. CMU and DCMU at rates of one-fourth and one-half pound per square rod were generally ineffective. Results from Washington where 2,4-D and Amino-triazole were applied at two and four pounds

per acre to Russian knapweed during the very early bud stage, indicated that two or more years of treatment would be necessary to accomplish a satisfactory kill of this weed species. Although these two compounds gave complete top kill following the first application, regrowth was abundant the following year.

Tall Whitetop (Lepidium latifolium). 2,4-D amine and Borax Db (combination of Borax and 2,4-D) gave excellent control of Tall Whitetop in Colorado. Borax Db at rates of two, four, and six pounds per square rod gave ninety and one-hundred percent reduction of Tall Whitetop stands. 2,4-D amine salt at one-fourth, one-half, and one pound per square rod completely eliminated this weed species. Sodium Chlorate, Stay-klor (a mixture of Sodium chlorate and Borax, and TCA), CMU, and DCMU also gave effective control of Tall Whitetop.

Woolly-leaved Poverty Weed (Granseria tomentosa). In Colorado 2,4-D amine and CMU were effective for the control of Woolly-leaved Poverty Weed. One-hundred percent control was obtained using 2,4-D amine at one-fourth, one-half, and one pound per square rod and CMU at one-eighth, one-fourth, and one-half pound per square rod applied to Woolly-Leaved Poverty Weed during October, 1953. The Woolly-leaved Poverty Weed was growing on a sandy loam non-irrigated soil, which, however, received fair precipitation over the period of the test. The results with 2,4-D amine were surprising in that previous results from foliage applications of 2,4-D formulations gave unsatisfactory results.

Perennial Grasses and Sedges

Nutgrass (Cyperus rotundus). Methyl bromide and Ethylene dibromide were used as temporary soil sterilants on Nutgrass in New Mexico. Methyl bromide at one and two pounds per one-hundred square feet applied to compacted and non-compacted plots resulted in over ninety-five percent reduction of the Nutgrass stand. There was a slight advantage in favor of the non-compacted plots at the one pound rate. At two pounds there was little difference in results. The non-compacted plots were tilled to a depth of ten inches whereas the compacted plots were only roto-tilled lightly to a depth of less than three inches to facilitate treatment.

Ethylene dibromide was applied in Shell Number 10 oil at dilution rates of one to five and two to five representing forty-eight and ninety-six gallons per acre. Stand densities on the compacted and non-compacted plots treated with Ethylene dibromide were reduced over ninety-five percent at both rates.

Foliage applications of 2,4-D amine at twenty, forty, and eighty pounds per acre, Amino-triazole at four, eight, and sixteen pounds per acre, Amino-triazole at four, eight, and sixteen pounds per acre plus 2,4-D at four pounds and Dalapon at ten, forty, and eighty pounds per acre were effective in reducing the density of Nutgrass from observations thirty days after treatment. Later observations indicated 2,4-D to be the most effective, however, after sixty days surviving growth was noted in all plots and was increasing.

Johnson grass (Holcus helepensis). Reports from California indicate that Dalapon at ten, twenty, and forty pounds per acre is quite effective for the control of Johnson grass. Combinations of Dalapon and Amino-triazole provided considerable control but no synergistic effect was apparent. Amino-triazole at rates of four, eight, and sixteen pounds per acre and Maleic hydrazide at twenty pounds per acre did not give satisfactory control. It appeared that early treatments and split applications of Dalapon, three to four weeks apart were more effective for seasonal control of established Johnson grass. Mowing or mowing and oiling did not significantly increase kills of Johnson grass over a single application of twenty pounds of Dalapon. Poor moisture conditions, insufficient vegetative growth, discing, or burning subsequent to treatment reduced the effectiveness of Dalapon.

The results obtained with Dalapon for the control of Johnson grass will vary with the time and season of application, according to reports from Arizona. Tests which varied as to the time and season of application indicated better results with late season treatments. The previous season, good results were obtained by late summer or early fall treatments of Johnson grass with Dalapon in excess of ten pounds per acre. In Arizona, burning Johnson grass at different intervals, repeated throughout the season was not effective in completely eliminating this perennial weed. Results indicate that extreme inhibition of Johnson grass can be obtained by close interval burning, however, healthy rhizomes could still be found in the treated areas.

Foxtail (Hordeum jubatum). Results of studies conducted in Nevada on Foxtail, which is a mechanically injurious plant, indicated that the mature plant has considerable drought resistance as well as a high tolerance to wet conditions. Greenhouse tests show that this weed is capable of establishing itself with the water table at the surface although the root and top growth are somewhat restricted under these conditions. Results from the greenhouse indicate that young Foxtail plants are unable to tap water tables below about twelve inches before death will result. This points to the possibility of withholding irrigation water during fall and spring establishment periods to eliminate new seedling infestations of this pest. In Nevada, Dalapon at rates of sixteen, thirty-two, and forty pounds per acre and combinations of Dalapon with Amino-triazole at rates of thirty pounds of Dalapon and four pounds of Amino-triazole were effective for controlling Foxtail. IPC, Chloro IPC, and TCA were much less effective on this weed species.

Distribution of Weeds

A report from Colorado indicated that the most predominant perennial type weeds were the Common Bindweed (Convolvulus arvensis) and Whitetop (Cardaria draba). Halogeton (Halogeton glomeratus) was a special weed which was also quite prevalent. This survey in Colorado located initial infestations of potentially dangerous weeds such as Blue Wheat (Helianthus ciliaris), Siberian pea (Zygophyllum fabago), Black henbain (Hyocyamus niger), Horse nettle (Solemun carolinesis), and other serious weeds. The relative density of poisonous plants such as St. Johnswort (Hypericum perforatum), and Alta fescue (Festuca arundinacea) have been determined from this survey.

REPORTS OF INDIVIDUAL CONTRIBUTORS

The control of Canada thistle (Cirsium arvense) in a bluegrass pasture with soil sterilants. Thornton, Bruce J. This test was conducted in a bluegrass mountain pasture. Sodium chlorate and Borascu were put on dry, the other materials being applied in spray form with water as the carrier. The applications were made on October 20, 1954.

The materials used, the rates of application per square rod, and the effects of the treatments on both the thistle and the grass, as observed 12 months later, are presented in the following table:

Herbicide	Pounds per Square Rod	Method	Percent Reduction Canada thistle	Percent Reduction Bluegrass
Sodium chlorate	3	Dry	25	50
	6		90	80
Polybor Chlorate	6	Spray	10	90
	12		70	95
Polybor	7.5	Spray	10	85
	15		40	100
Borascu, conc.	9	Dry	0	85
	18		40	100
Sta-Klor 1/	2	Spray	0	85
	4		10	90
CMU	1/4	Spray	10	100
	1/2		40	100
DCMU	1/4	Spray	0	100
	1/2		10	100
Borax DB 2/	3	Spray	70	70
	6		85	80
2,4-D Micronized	1/2	Spray	80	10
	1		95	10
2,4-D Amine salt	1/2	Spray	75	0
	1		95	0
2,4-D Heavy ester 3/	1/2	Spray	80	0
	1		95	0
Silvex 4/	1/2	Spray	10	0
	1		10	0

1/ Mixture Sodium chlorate, Borax, TCA.
2/ Mixture Borax and 2,4-D.
3/ Propylene glycol butyl ether ester.
4/ 2 (2,4,5-Trichlorophenoxy Propionic Acid).

(Colorado Agricultural Experiment Station)

Two tests for the control of Field Bindweed (Convolvulus arvensis), in cultivated fields, Tests I being on light sandy-loam non-irrigated soil and Test II being on heavy clay-loam irrigated soil. Thornton, Bruce J. Sodium chlorate and Borascu were put on dry, the other materials being applied in spray form, using water as a carrier. The applications were made on October 8, 1953, and November 6, 1953, respectively.

The materials used, the rates of application per square rod, and the results of the treatments, as measured in percent reduction one year later, were as follows:

Test I. Sodium chlorate at four and six pounds gave 95 and 99 percent reduction; Chlorax at six and nine pounds gave 95 and 98 percent reduction; Polybor chlorate at eight and twelve pounds gave 95 and 100 percent reduction; Polybor at ten and fifteen pounds gave 85 and 95 percent reduction; Borascu (conc.) at twelve and eighteen pounds gave 70 and 90 percent reduction; CMU at one-fourth and one-half pound gave 20 and 60 percent reduction; PMU at one-fourth and one-half pound gave 20 and 30 percent reduction; 2,4-D amine salt at one-half and one pound (acid equivalent) gave 95 and 100 percent reduction.

Test II. Sodium chlorate at four and six pounds gave 75 and 85 percent reduction; Chlorax at six and nine pounds gave 65 and 85 percent reduction; Polybor-chlorate at eight and twelve pounds gave 70 and 80 percent reduction; Polybor at ten and fifteen pounds gave 60 and 80 percent reduction; CMU at one-fourth and one-half pound gave 45 and 65 percent reduction; PMU at one-fourth and one-half pound gave 65 and 80 percent reduction; 2,4-D amine salt at one-half and one pound (acid equivalent) gave 0 and 30 percent reduction.

Note: Chlorax is a mixture of sodium chlorate and borax.

(Colorado Agricultural Experiment Station)

The control of Russian knapweed (Centaurea picris), in an abandoned field, with twelve soil sterilants at two rates each. Thornton, Bruce J. Sodium chlorate and Borascu were put on dry, the other materials being applied in spray form, using water as a carrier. The applications were made on October 7, 1954.

The materials used, the rates of application per square rod, and the results of the treatments, as measured in percent reduction one year later, were as follows: Sodium chlorate at four and six pounds gave 90 and 100 percent reduction; Polybor chlorate at eight and twelve pounds gave 85 and 100 percent reduction; Polybor at ten and fifteen pounds gave 40 and 50 percent reduction; Sta-klor (mixture of Sodium chlorate, Borax, and TCA) at two and four pounds gave 70 and 99 percent reduction; CMU at one-fourth and one-half pound gave 5 percent reduction at each rate; DCMU at one-fourth and one-half pound gave 0 percent reduction at each rate; Borax Db at five and eight pounds gave 95 and 100 percent reduction; 2,4-D micronized at one-half and one pound gave 90 percent reduction at each rate; 2,4-D amine salt at one-half and one pound gave 99 percent reduction at each rate; 2,4-D heavy ester (propylene glycol butyl ether ester) at one-half and one pound gave 80 and 95 percent reduction; Silvex ((2(2,4,5-Trichlorophenoxy propionic acid)) gave 100 percent reduction at each rate.

(Colorado Agricultural Experiment Station)

The effect of some growth regulating herbicides on the stand of Russian knapweed. Rasmussen, L. W. An area of abandoned cropland heavily infested with Russian knapweed (Centaurea picris) was selected in the spring of 1954. An experiment was designed to determine whether or not certain growth regulating type herbicides would kill Russian knapweed growing without competition in an area which gets approximately sixteen inches of precipitation a year. The herbicidal materials included in the test were two emulsifiable acid formulations of 2,4-D, one low volatile ester of 2,4-D, and amizol (3-amino 1,2,4-triazole). These materials were applied at rates equivalent to two and four pounds per acre. They were applied in water sprays at a volume of sixteen gallons per acre when the knapweed was in the very early bud stage. The eight treatments were arranged in a split plot design with materials constituting the main plots and rates of application the sub-plots. The plots were randomized and the main plots were replicated six times. The sub-plots were 15 x 20 feet in size. The spraying was done by one pass over a plot with a fifteen foot boom, plot sprayer operated at 30 psi pressure and at a speed of three feet per second. One-foot border strips around each plot were treated with Polybor chlorate to kill weed roots which crossed between plots.

Stand estimates were made before the first spray treatments as a measure of initial stand. These estimates were made using a specially designed frame 1 x 5 feet in size divided into five one-foot sections. Weed coverage estimates were made for each section. (See article by author in section on techniques in this report). Preliminary statistical analysis of the coverage estimates showed no peculiarities of distribution and the stands on the plots for each treatment were uniform. The ratio of mean square for treatment to error mean square was 1.01. The coefficient of variation was 14.1.

Coverage estimates were made in June, 1955, approximately one year after treatment. The regrowth in 1955 was generally abundant despite the fact that all herbicides killed the top growth following the first application in 1954. This response was not unusual for deep rooted perennial weeds and does not indicate that good kills eventually cannot be achieved. Analysis of the 1955 coverage data showed the variation among treatments to be considerably greater than it was in 1954 for the initial stands. The differences among the treatments were not significant at the 5 percent level of probability, however. A comparison of the rates of each material showed no significance except with one material, the low volatile ester of 2,4-D. With this material the difference in favor of the four pound rate was highly significant (P=0.01). It was apparent that two or more years of treatment would be necessary to accomplish a satisfactory kill of this weed species.

The treatments were all repeated on the same plots in 1955. The applications were made at the early bud stage of growth. Data to reflect the effect of two years' treatment will be obtained in 1956.

Each year the 2,4-D treatments caused the typical formative effects on the top growth. No flowers developed on treated plants and the tops appeared dry and dead approximately sixty days after treatment. The Amino triazole caused slight bending in the stem apex region followed by killing of the buds. The lower portions of the top growth showed chlorophyll breakdown in the leaves but little or no drying occurred until approximately seventy days after treatment. Some regrowth in the spring of 1955 also showed a carry-over effect of the Amino triazole, as indicated by the creamy white leaf coloration.

(Washington Agricultural Experiment Sta.)

The control of Tall Whitetop (*Lepidium latifolium*), on an abandoned acreage, with nine soil sterilants at three rates each. Thornton, Bruce J. Tall Whitetop resembles the Common Whitetop (*Cardaria* spp.) except that it grows to a height of three to three and one-half feet in the San Luis Valley in Colorado, where this test was made, as compared to a height of from twelve to twenty inches for the Common whitetop in the same area. Sodium chlorate and Borascu were put on dry, the other materials being applied in spray form, using water as a carrier. The applications were made on October 24, 1954.

The materials used, the rates of application per square rod, and the results of the treatments as measured in percent reduction one year later, were as follows: Sodium chlorate at 2, 4, and 6 pounds gave 20, 80, and 90 percent reduction; Polybor chlorate at 4, 8, and 12 pounds gave 30, 60, and 70 percent reduction; Polybor at 5, 10, and 15 pounds gave no reduction; Borascu (conc.) at 6, 12, and 18 pounds gave 0, 30, and 30 percent reduction; Sta-Klor (mixture of sodium chlorate, borax, and TCA) at 1-1/2, 2-3/4, and 4 pounds gave 20, 75, and 85 percent reduction; CMU at 1/4, 3/8, and 1/2 pounds gave 70, 90, and 90 percent reduction; DCMU at 1/4, 3/8, and 1/2 pounds gave 30, 60, and 50 percent reduction; Borax Db at 2, 4, and 6 pounds gave 90, 100, and 100 percent reduction; 2,4-D amine salt at 1/4, 1/2, and 1 pound gave 100 percent reduction at each rate.

(Colorado Agricultural Experiment Station)

The control of Woolly-leaved Poverty Weed (*Franseria tomentosa*), in a cultivated field, with eight soil sterilants at three rates each. Thornton, Bruce J. Sodium chlorate and Borascu were put on dry, the other materials being applied in spray form, using water as a carrier. The applications were made on October 7, 1953.

The materials used, the rates of application per square rod, and the results of the treatments, as measured in percent reduction one year later, were as follows: Sodium chlorate at 2, 4, and 6 pounds gave 90, 95, and 100 percent reduction; Chlorax (Sodium chlorate and Borax mixture) at 3, 6, and 9 pounds gave 90, 95, and 100 percent reduction; Polybor chlorate at 4, 8, and 12 pounds gave 90, 100, and 100 percent reduction; Polybor at 5, 10, and 15 pounds gave 90, 100, and 100 percent reduction; Borascu (conc.) at 6, 12, and 18 pounds gave 90, 100, and 100 percent reduction; CMU at 1/8, 1/4, and 1/2 pound gave 100 percent reduction at each rate; PMU at 1/8, 1/4, and 1/2 pound gave 80, 100, and 100 percent reduction; 2,4-D amine salt at 1/4, 1/2, and 1 pound gave 100 percent reduction at each rate.

This test was located on a sandy loam, non-irrigated soil, receiving fair precipitation over the season. The general effectiveness of all treatments was rather surprising, but especially so in the case of the 2,4-D treatments in view of the generally unsatisfactory results previously obtained from foliage applications of 2,4-D formulations on this plant. (Colorado Agricultural Experiment Station).

The performance of different chemicals for the control of Nutgrass (*Cyperus rotundus*). Long, John A. A report submitted to the 1955 research report described results of chemical treatments on nutgrass for the 1954 growing season. During the 1955 growing season studies were continued to compare methods of application in addition to chemical formulations.

I. Temporary Soil Sterilant Application. Methyl bromide (Dow MC-2) and ethylene dibromide (Dow W-85) were applied at two rates on compacted and non-compacted plots containing high densities of nutgrass. Methyl bromide at rates of one and two pounds per 100 square feet was uniformly distributed beneath a plastic covering. Ethylene dibromide at dilutions of 1:5 and 2:5 in Shell # 10 oil was applied with a Mack Weed Gun. The 1:5 and 2:5 dilutions represented rates of approximately 48 and 96 gallons per acre. A quantity of 20 cc per injection point was used at 10 inch staggered spacings. Non-compacted plots were tilled to a depth of 10 inches. Compacted plots were roto-tilled lightly to a depth of less than three inches to facilitate treatment. Nutgrass densities on compacted plots treated with 1 pound of methyl bromide showed a reduction of approximately 50 percent. Density of nutgrass on non-compacted plots was reduced over 80 percent by the 1 pound treatment of methyl bromide. Plots treated with 2 pounds of methyl bromide resulted in over 95 percent reduction in nutgrass densities. At the 2 pound rate the difference in results between compacted and non-compacted plots was negligible. Stand densities on compacted and non-compacted plots treated with both rates of ethylene dibromide were reduced over 95 percent. Eradication was obtained on one plot of this series. A later test showed kerosene to be equally effective as a carrier for ethylene dibromide.

II. Foliage Application. Several chemicals were applied to the foliage of nutgrass on June 1, 1955. The treatments were randomized and replicated within three density groups. Spray volume was equivalent to 80 GPA. Height of nutgrass at the time of treatment was four inches. Grass density counts were made before treatment and thirty days following treatment. The chemical treatments, rates employed, and comparative grass counts are listed in the following table.

Chemical	Rate per Acre	Grass Density (6 sq. ft.) Before Treatment	30 days after Treatment
2,4-D alkanolamine	20	54	9
	40	102	12
	80	78	9
Amino triazole	4	84	18
	8	42	42
	16	12	24
Amino triazole plus 2,4-D*	4	36	12
	8	48	24
	16	66	12
Dalapon Sodium 2,2-dichloro-propionate	20	48	48
	40	54	36
	80	72	24

* 2,4-D alkanolamine constant at four pounds for each rate of Amino triazole.

Relatively effective reduction in density of nutgrass was obtained by some formulations in this test at the end of a thirty day period. Surviving growth on all treated plots was increasing sixty days after the initial treatment. The need for follow-up competitive cropping or cultivation was emphasized in this test. (New Mexico Agricultural Experiment Station)

The chemical control of Johnson grass on irrigation ditch banks. Miller, J. H. and Foy, C. L. Several field experiments were conducted in two counties of California in 1955, to evaluate various translocated herbicides for Johnson grass control. Variables studied were chemicals, rates, dates (growth stage), split versus single treatments, moisture conditions, and various supplementary practices such as mowing, oiling, disking, or burning either before or after spraying. Replicated square rod and half-square rod plots in randomized block and split plot designs were used for Experiments 1 and 2, respectively.

The conditions of previously unsprayed grass at each of the three dates of treatment for Experiment 1 was as follows: May 5 - 10 to 16 inches tall, completely vegetative; June 1 - 3 to 4 feet tall, in bloom; June 28 - 3 to 6 feet tall, soft dough stage. In Experiment 2 the condition of the Johnson grass at the time of first spraying was as follows: Plots 1, 3, and 4 - 1-1/2 to 3-1/2 feet tall, boot to early bloom; Plots 2 and 5 - 1 to 1-1/2 feet tall, entirely vegetative; Plot 6 - 2 to 5 feet tall, late flower to soft dough stage. Moisture was adequate in both experiments to support vigorous growth of Johnson grass throughout the season.

The various treatments used and the results obtained are shown in Tables 1 and 2. The data were examined by analysis of variance method. Desired comparisons may be made by use of the appropriate L.S.D.

A third test (non-replicated) similar to Experiment 2 was conducted under conditions of limited moisture. One other difference was the substitution of disking to a depth of six inches following spraying for re-treating with the same herbicide. All treatments were applied at a somewhat later date to less vigorous plants. The results of the three tests may be briefly summarized as follows:

1. 2,2-dichloropropionic acid (DPA) used alone was more effective for Johnson grass control than any other herbicide tested. The combinations of DPA and 3-amino-1,2,4-triazole (AT) provided considerable control, although no synergistic effect was evident. AT alone failed to control Johnson grass satisfactorily, in spite of severe temporary chlorosis. Maleic hydrazide (MH) gave satisfactory control only when applied to vigorous young regrowth after mowing.

2. Split applications, 3 to 4 weeks apart, were generally more effective than a single application of the same total amount of herbicide. The four most effective treatments in order, were (a) two applications of 20 pounds of DPA per acre on May 5 and June 1, (b) the same applied June 1 and June 28, (c) two applications of DPA-AT combination at 12 + 4 pounds per acre on May 5 and June 1, and (d) the same applied June 1 and June 28. In addition to appearing somewhat more effective for seasonal control of established Johnson grass, the

earlier treatments, for all practical purposes, prevented seed formation and kept the ditch free of seedling Johnson grass and annual grasses during the period of maximum seed germination.

3. Neither mowing before nor mowing or oiling after treatment resulted in significantly increased kills of Johnson grass over a single application of DPA (20 pounds per acre) alone. However, these supplementary practices controlled some non-grass species not adequately controlled by DPA.

4. Johnson grass adequately supplied with moisture in full vegetative to floral stages of development (usually 1 to 5-1/2 feet tall) was most responsive to DPA. Poor moisture conditions, insufficient vegetative growth, senescence, and disking or burning at given periods subsequent to treatment tended to reduce its effectiveness. (Field Crops Research Branch, ARS, USDA, and University of California, Davis).

Table 1. The effect of various chemicals, rates, and dates of application upon dense stands of undisturbed Johnson grass - Tulare County, 1955.

Chemical Treatment	Rate - lb. per acre (Active) May 5	June 1	June 28	Total	Number of Applications	Weed Control Rating 1/ 27 September
DPA	10	----	----	10	1	3.5
DPA	10	10	----	20	2	5.3**
DPA	----	10	----	10	1	3.3
DPA	----	10	10	20	2	5.6**
DPA	----	----	10	10	1	3.9*
DPA	20	----	----	20	1	4.1**
DPA	20	20	----	40	2	8.4**
DPA	----	20	----	20	1	5.6**
DPA	----	20	20	40	2	7.8**
DPA	----	----	20	20	1	4.3**
DPA	40	----	----	40	1	4.7**
DPA	----	40	----	40	1	5.9**
DPA	----	----	40	40	1	3.9*
AT	4	----	----	4	1	1.8
AT	4	4	----	8	2	2.5
AT	----	4	----	4	1	2.0
AT	----	4	4	8	2	1.8
AT	----	----	4	4	1	1.5
AT	8	----	----	8	1	1.7
AT	8	8	----	16	2	2.3
AT	----	8	----	8	1	2.0
AT	----	8	8	16	2	2.0
AT	----	----	8	8	1	2.7
AT	16	----	----	16	1	3.0
AT	----	16	----	16	1	2.5
AT	----	----	16	16	1	3.4
DPA + AT	6+2	----	----	6+2	1	2.8
DPA + AT	6+2	6+2	----	12+4	2	4.4**
DPA + AT	----	6+2	----	6+2	1	1.9
DPA + AT	----	6+2	6+2	12+4	2	4.2**
DPA + AT	----	----	6+2	6+2	1	4.3**
DPA + AT	12+4	----	----	12+4	1	3.9*
DPA + AT	12+4	12+4	----	24+8	2	6.3**
DPA + AT	----	12+4	----	12+4	1	4.5**
DPA + AT	----	12+4	12+4	24+8	2	6.0**
DPA + AT	----	----	12+4	12+4	1	4.4**
DPA + AT	24+8	----	----	24+8	1	4.1**
DPA + AT	----	24+8	----	24+8	1	2.9
DPA + AT	----	----	24+8	24+8	1	4.3**
Check	----	----	----	----	---	2.5
				L.S.D.	at 5% level	1.2
					at 1% level	1.6

1/ Numerical ratings represent an average of 9 observations, ie., 3 replications each rated independently by three persons on an arbitrary scale of 0 (no control) to 10 (perfect control). For ease of reading, asterisks are used to denote treatments which were statistically better than the check at the two levels of significance.

Table 2. The effect of various supplementary cultural and chemical practices upon the herbicidal efficacy of certain herbicides used for Johnson grass control - Kings County, 1955.

History of Supplementary Practices	Weed Control Rating - September 27 1/ Chemical - Rate of Application DPA 20 lb/A	AT 8 lb/A	DPA - AT 12-4 lb/A	MH 20 lb/A	Check	Means (Supp. Prac.)
Undisturbed Sprayed June 2	7.4	2.1	6.8	4.4	1.9	4.52
Sprayed June 2 Mowed May 13	8.1	2.5	7.5	6.8	1.5	5.28
Undisturbed Sprayed June Mowed June 29	7.9	1.3	6.0	1.4	1.7	3.66
Undisturbed Sprayed June 2 Oiled June 29	8.5 2/	1.5	6.0 2/	1.5	1.7	3.84
Mowed May 13 Sprayed June 2 Re-sprayed June 29	9.2	4.6	8.1	6.4	1.4	5.94
Mowed May 13 Sprayed June 29	6.4	2.6	7.2	2.9	1.7	4.16
Means (Chemical)	9.92	2.43	6.93	3.90	1.65	

L.S.D. (chemical means) at 5% level .94
at 1% level 1.55

L.S.D. (Supp. Prac. Means) at 5% level .88
at 1% level 1.19

L.S.D. (chemicals within each supp. practice) at 5% level 2.01
at 1% level 2.83

L.S.D. (Supp. Prac. within each chemical) at 5% level 1.96
at 1% level 2.66

1/ Numerical ratings represent an average of 6 observations, ie., 2 replications each rated independently by 3 persons on an arbitrary scale of 0 (no control) to 10 (perfect control).

2/ Missing plot data calculated for one replication. Data lost because of fire.

Burning for control of Johnson grass with L. P. gas burning equipment. Arle, H. Fred and Hamilton, K. C. During recent years the use of liquified petroleum gas burning equipment has found limited use as a means of controlling Johnson grass. Usually two or three burner jets are mounted on the end of a balanced movable boom, thus facilitating directional control of the flame. The fuel used for this experiment was 100 percent propane. A flame temperature of 3000 - 3500 degrees was obtained at the point of burning.

To obtain information regarding the proper time interval between successive burnings for maximum control an experiment was started during April 1955. Plots 100 feet in length and replicated three times were established along a concrete lined canal. Johnson grass was already in excess of three feet tall and, therefore, the entire plot area was burned twice within eight days and all top growth was completely destroyed. A schedule of repeated burning at intervals of 2, 3, or 4 weeks was then established for the entire season.

At a burning interval of two weeks, grass usually attained a height of 10-12 inches before being destroyed. By mid-July (after seven burnings) only 50 percent of the original top growth remained. Four additional burnings completely eliminated all top growth. These plots were given no further treatment after September 6.

Grass on plots burned at 3 week intervals attained an average height of 20 inches before being burned back. As in the case of the closer burning interval, only fifty percent of the original stand remained after seven burnings and the season's total of 10 burnings effected an apparent 75 percent reduction in stand.

The four-week interval appeared somewhat too long for best results. Grass usually grew to a height of 30-36 inches before burned back. In some areas the growth became so dense that top growth was not completely destroyed and this resulted in very rapid re-establishment. Eight burnings effected a reduction of 35 percent.

Although regrowth of Johnson grass was completely inhibited during the last part of the season with the closest interval of burning, a few healthy looking rhizomes could be found. It is expected that some of these may sprout during the spring of 1956. Healthy rhizomes were much more numerous on plots burned at intervals of three or four weeks. (Contributed by the Field Crops Research Branch, ARS, USDA, and the Arizona Agricultural Experiment Station, cooperating).

The effect of rate and time of application in the control of Johnson grass with 2,2-dichloropropionic acid (DPA). Arle, H. Fred. During 1953 and 1954 preliminary experimentation with the sodium salt of DPA produced somewhat erratic results in the control of Johnson grass growth on canal banks. It was indicated that results varied with time of seasonal application. During 1955 the effect of applications of the sodium salt of DPA made at various times throughout the season were studied in greater detail.

Applications were made at 10, 20, 30, and 40 lbs/ A with each treatment being replicated three times. Each of these rates was applied in 160 gallons of water per acre. The wetting characteristics of the lowest rate were not completely satisfactory while at the three higher rates good wetting of Johnson grass foliage was obtained. The first series of plots was given the initial treatment on April 11. On this date the grass had reached a height of 12 inches and a few seed heads were already evident. On plots which were given their first treatment at later dates, Johnson grass top growth was destroyed either by oiling or mowing and then sprayed when regrowth had attained a height of 12-15 inches. Grass on plots given initial treatment during late October was somewhat larger.

Although the terminal height growth of grass appeared to be inhibited after the early applications there were no further symptoms of injury during the two weeks following treatment. Top growth was then destroyed by application of an aromatic oil by the owner. Regrowth was considerably delayed by all rates of treatment but by mid-June it was necessary to retreat all plots at the original rates. The second treatment had little or no apparent effect on growth and two additional treatments were made during the season.

On an adjacent area the first application was made on June 24. Very little control resulted from the 10 pound per acre rate and retreatment was necessary within three weeks. The other plots of this series were given their second application on August 1. A third application was made on September 21. Greatest reduction in grass population was obtained by the 30 and 40 pound per acre applications.

The third series was initially treated on September 2. The 10 pound per acre rate was not effective and retreatment was necessary three weeks later. At higher rates, top growth began yellowing at the tips within two days. Injury symptoms continued to develop slowly and there was no regrowth prior to first frost on November 12.

A final series of plots was given the first application October 27. Grass was approximately three feet tall, heading, but still in a stage of vigorous growth. Death of top growth is progressing slowly and is somewhat more rapid at higher rates.

Although final survival readings must be delayed until growth is resumed in 1956, the results indicate better control with late season applications. In previous seasons good results were obtained by late summer or early fall treatments. (Contributed by the Field Crops Research Branch, ARS, USDA, and the Arizona Agricultural Experiment Station, cooperating).

<u>The effect of depth of water table on Foxtail (Hordeum jubatum)</u>, Cords, H. P. Foxtail is considered to be the most serious weed of native meadows and pastures in Nevada. This mechanically injurious plant is particularly abundant in areas with high water table conditions. For this reason, a number of studies relative to the effect of various water table levels on this weed were initiated.

Initial tests were conducted in the greenhouse to find the effect of various water table depths on root and top growth of Foxtail germinated in initially saturated soils without subsequent irrigation. These tests showed that this weed is capable of establishing itself with the water table at the surface, but that root and top growth were somewhat restricted under these conditions. Also, with the soils used in these tests, Foxtail was unable to tap water tables below about twelve inches before exhaustion of the surface moisture resulted in death of the plant. These latter results indicate that withholding irrigation water during the fall and spring establishment periods of Foxtail may possibly be one way of eliminating new seedling infestations of this pest.

In the spring of 1955, native sods heavily infested with established Foxtail were transferred to field phytometers with water tables established at 1, 4, 18, and 24 inches and with complete drainage. After an initial period of two months in which surface irrigation was employed to insure rooting, no further watering was done. The vegetation in these phytometers was harvested September 29, 1955, separated as to species, oven dried and weighed. The principal species in these sods were Foxtail and Spikesedge (Eleocharis sp.), the latter species being a major constituent of wet pastures in many areas of Nevada. The Spikesedge produced the most dry weight at the one-inch water table depth. Only under those conditions did it furnish sufficient competition to reduce the amount of Foxtail growth. At the 18 inch and 24 inch depths, Foxtail produced two and four times as much dry weight, respectively, as did the Spikesedge. With complete drainage, all the Spikesedge died, but a few foxtail plants survived. These results indicate that established Foxtail has considerable drought resistance as well as a high tolerance of wet conditions, and that field drainage alone will not eliminate it. (Nevada Agricultural Experiment Station)

Chemical control of Foxtail (Hordeum Jubatum L.), Cords, H. P. A series of spray plots involving IPC (Isopropyl N-phenylcarbamate), CIPC (Isopropyl N-(3-chlorophenyl) carbamate), TCA (Trichloroacetic acid, sodium salt), and Dalapon (2,2-dichloropropionic acid, sodium salt) was established in July, 1954, and evaluated in June , 1955. These plots were on an infrequently irrigated Saltgrass pasture which was not grazed during the period of the test. Because of the rather erratic occurrence of Foxtail in these plots, only the most general conclusions may be drawn. However, Dalapon appeared to be the only effective chemical, with the highest rate of this compound (48 pounds per acre) resulting in complete elimination of Foxtail in all replications. Lower rates (16 and 32 pounds per acre) allowed some Foxtail to survive. The 48 pound rate also resulted in effective kills of the Saltgrass.

In May, 1955, a second series of spray plots was established on a heavily irrigated native pasture in which the principal species were Foxtail and Spikesedge (Eleocharis sp.). Dalapon, TCA, and Amino-triazole (3-Amino, 1, 2, 4-triazole) were each applied at three rates along with one combination of Dalapon and Amino triazole (30 pounds Dalapon plus four pounds Amino triazole per acre). These plots were heavily irrigated the day following treatment and heavily grazed the remainder of the season. Evaluation was made by counting the number of Foxtail plants in four 5 x 24 inch areas within each plot immediately before treatment and on October 15, 1955. The survival of old plants was about 3.5 percent on all plots including the check, with no significant difference between treatments. This almost complete elimination of old Foxtail regardless of treatment was attributed to the heavy grazing schedule which was started early and continued throughout the season. Visual observation during June indicated that Dalapon and the combination of of Dalapon with Amino triazole were the most effective chemical treatments. A similar small area that was not grazed or chemically treated had a large number of surviving old plants. All plots had some Foxtail seedlings at the time of evaluation. None of the treatments resulted in serious damage to the Spikesedge. (Nevada Agricultural Experiment Station)

Survey to determine the exact distribution of weeds and poisonous plants in Colorado. Harrington, H. D., Klinger, Bruno, and Klein, William. Reconnaissance surveys of weeds and poisonous plants were made in the northeastern, northwestern, southwestern, south central, and the southeastern parts of Colorado during the growing seasons of 1954 and 1955. Lands important for cultivation or grazing came in for special attention. The sampling areas were usually along the main highways or along the smaller roads leading into the more traveled ones. The infestations of certain weeds and poisonous plants were noted and charted on County maps. Various field workers such as County Agents were of great assistance.

Weeds: The weeds charted were mostly of the creeping perennial type such as the common Bindweed (Convolvulus arvensis) and Whitetop (Cardaria draba), although certain non-creeping perennial or annual weeds were included if they happened to be of special interest or concern. Examples of this latter group are: Halogeton (Halogeton glomeratus) and Houndstongue (Cynoglossum officinale). The area covered by patches of the creeping perennial types was estimated in each case and from these data an evaluation as to the relative importance of each one in the various parts of the State will be attempted.

This study has secured information on the remarkable local spread of rather uncommon weeds like Leafy Spurge (Euphorbia esula) in Larimer County, St. Johnswort (Hypericum perforatum) in the area west of Denver, Tansy (Tanacetum vulgare) in eastern Garfield County, Tall Whitetop (Lepidium latifolium) in the San Luis Valley, Halogeton (Halogeton glomeratus) in Mesa County, and many others.

One of the purposes of this survey was to locate initial infestations of potentially dangerous weeds. Examples of such infestations located were Blueweed (Helianthus ciliaris) in Baca County, Siberian Pea (Zygophyllum fabago) in Mesa County, Black Henbane (Hyocyamus niger) in northwestern Colorado, Horsenettle (Solanum carolinensis) in Mesa County, White Horsenettle (Solanum elaeagnifolium) in southeastern Colorado and Camels Thorn (Alhagi camelorum) in the San Luis Valley.

Poisonous Plants: (Hypericum perforatum) St. Johnswort, Klamath weed. By means of a detailed survey, the distribution and relative density of H. perforatum in the Boulder-Denver region have been established. Over an area of about 20 square miles southeastward of Boulder, heavy stands of the plant occur in patches, some of which are over a half mile in length. The range of H. perforatum in this area as known at present extends about 30 miles southward from Boulder and 10 to 11 miles eastward. Densest stands occur in the extreme north and extreme south portions of the area.

Alta fescue (Festuca arundinacea). Fescue foot continues to be a problem in the west central part of Colorado, where Alta fescue has been planted for hay and grazing. Distribution of the species is being noted in the reconnaissance survey of weeds. Demand for information on possibilities of killing the plant has occasioned an exploratory application of herbicide on several small plots at Rifle, Colorado. (Colorado Agricultural Experiment Station)

The use of CMU in ditch sterilization under low rainfall conditions. Campbell, C. Harvey, Jr., and Kortsen, Robert A. The lack of dependable and adequate rainfall in the lowland desert area made the use of CMU for ditch weed control difficult. Early applications to ditches failed to give control and in some cases caused damage to crops when the ditches were used.

The problem of movement of CMU ((3-(p-chlorophenyl)-1, 1-dimethylurea)) out of the ditch was solved with the use of a soaking method which moves the CMU into the soil. The CMU was applied to a newly cleaned ditch at the rate of 40 pounds per acre in 400 gallons of water. After all outlets were tightly closed, the ditch was filled to capacity and the water left in the ditch till the soil surface dried. The drying process lasts three to seven days, after which the ditch is ready to use.

Treatments were made on soil textures ranging from sandy loams to heavy clays. Applications were made in the spring, summer and fall. Spring applications have given up to eight months control with the 40 pound per acre application. The principal annual weeds controlled were Lambsquarter (Chenopodium album), Pigweed (Amaranthus spp.), Watergrass (Echinochloa crusgalli), and Redweed (Polygonum aviculare). The perennial weeds were Bermuda grass (Cynodon dactylon), Morning Glory (Convolvulus arvensis), and Alkali mallow (Sida hederacca).

A re-treatment of twenty pounds per acre of CMU the following year in the spring has extended the control for another year. In seven tests an initial treatment rate of 40 pounds per acre has given the best control. Lower rates of 20 pounds have not given control of Bermuda grass, the principal perennial weedy species. Rates up to 120 pounds per acre have not proven to be superior enough to warrant the added cost. The optimum timing for initial treatment and re-treatment is under study at the present time on several ditches.

CMU treatments have given the best and most economical control on the heavier soils. In the light sandy soils complete removal of weed growth is not desired as the ditches erode. This treatment is also not satisfactory when Nutgrass (Cyperus rotundus) is a problem as the Nutgrass is not controlled and the removal of all the weed competition increases its spread. (Imperial County Agricultural Extension Service)

Project 2. HERBACEOUS RANGE WEEDS

L. L. Jansen, Project Leader

SUMMARY

A total of ten reports of recent progress in herbaceous range weed research were contributed this year. In contrast to the preceeding three years it is interesting to note that only two of these papers deal with halogeton (last year two-thirds of the twelve papers submitted dealt with this one plant). It is believed that this change is not due to any decrease in interest in halogeton, but can probably be attributed to the inability of halogeton workers to meet the earlier deadline date set for submission of papers. The twofold increase in work dealing with other weeds is therefore very gratifying.

The bulk of the progress reported is of a preliminary nature, and the subject matter shows much greater diversity than in previous years. Because of these facts, no attempt will be made to summarize the various results obtained. The types of research presented also emphasize the complexity of our range weed problems. The ten papers submitted have therefore been considered under the following headings: (1) the introduced range invaders (both poisonous and non-poisonous), (2) non-poisonous native species, and (3) poisonous native species.

Introduced range invaders. -- A number of annual species have been introduced into our western ranges during the past several decades, and have spread very rapidly throughout many of the most seriously depleted range lands. These species include Medusa-head rye (*Elymus caput-medusae*), halogeton (*Halogeton glomeratus*), cheat grass (*Bromus tectorum*), and the biennial, Mediterranean sage (*Salvia aethopis*). These species have in general found the lack of competition on the depleted ranges to present no barrier to rapid invasion, and now appear to be firmly entranched as a part of the permanent annual flora in many areas. Encouragement of native perennials and revegetation of the areas appear to be the most feasible means of coping with these species. Only two of the species, Medusa-head rye and halogeton were the subject of work submitted this year. On the control of Medusa-head rye, one paper deals with basic ecological studies with emphasis on management and replacement control, and another is concerned with a comprehensive investigation on combinations of cultural, chemical and replacement control measures in contrast to non-disturbance. Under the heterogenous conditions which exist in the arid and semi-arid intermountain range lands, the majority of which must be classed as non-arable, the techniques now being investigated on Medusa-head rye should have considerable general application to other weed problems.

Two papers representing ecological studies on *Halogeton glomeratus* were submitted. In one the effect of light on the growth and seed production was studied and in the other the effect of elevation. The data presented provide valuable information on the ecological requirements of halogeton.

Non-poisonous native species. -- In contrast to the introduced range invaders, species which are native to existing vegetational complexes constitute a slightly different type of weed problem in that they seldom occur over extensive areas and seem to be more localized problems. Natural

revegetation of infested areas with native forage species through management practices is probably the best solution for this type of problem also, although other control measures may be highly desirable from a supplemental standpoint. In some instances the situation with regard to size of infestation, highly productive soils, and accessibility, may warrant the use of cultural methods and reseeding along with supplemental chemical control. Such is the case with the extensive infestations of niggerhead (Rudbeckia occidentalis) in eastern Oregon, which are the subject of one report. In three other reports the use of chemical control measures alone on niggerhead, wild iris (Iris missouriensis), hoary velvet lupine (Lupinus leucophyllus canescens) are given. It is encouraging to see that considerations are being given to the evaluation of chemical control measures not only upon the weedy species but also upon the depleted native vegetation.

Poisonous native species. -- A third type of range weed problem is illustrated in the reports on arrowgrass (Triglochin palustris), and tall larkspur (Delphinium occidentale). These plants are poisonous natives which constitute an intergral part of the natural vegetational complexes. They are classified as weeds, however, since their poisonous nature makes them "unwanted". Control measures often amount to treatment of each individual plant with the plants themselves being widely scattered over large areas. In addition, many of these poisonous species are actually perennial, producing a seasonal herbaceous top-growth. This factor further complicates their control.

The reports of the individual contributors which follow immediately, have been arranged according to the above categories of problem classification.

REPORTS OF INDIVIDUAL CONTRIBUTORS

Introduced range invaders. --

A study of the Medusa-head problem in Idaho. Hironaka, M., and Tisdale, E. W. The control of Medusa-head rye (Elymus caput-medusae) by replacement with more desirable species is the primary objective of the research conducted by this station. Emphasis is placed on restoration of perennial forage either by management practices, artificial reseeding, or a combination of both. In addition, the life-history and ecological relationships of Medusa-head are being studied.

Most of the Medusa-head rye infestation in Idaho is on non-arable lands. Artificial seeding seems feasible on those areas that are not too steep, but because of excessive rockiness the use of grain drills to cover seed is out of the question over most of the area. First year's evaluation of a reseeding trial conducted in an area that receives about fourteen inches of precipitation indicates that fall burning of Medusa-head followed by broadcast seed covered with the use of a pipe harrow may prove practical. Intermediate, pubescent, and crested wheat grasses all show promise of establishing successful stands. It is too early to ascertain which of the species tried in the experiment is the best competitor of Medusa-head.

Observation and sampling of an exclosure which has been protected from grazing for four years show large increases in number and vigor of Poa secunda and Sitanion hystrix. This marked increase of native perennials on a range which appeared to be occupied entirely by annuals indicates the importance of grazing management practices in the control of Medusa-head. Significant increase of other native forage species have not occurred during this period. This appears due to the scarcity of parent plants, and possibly the inability for the seeds of some species to penetrate through the Medusa-head litter to mineral soil.

The deep accumulation of medusa-head litter also creates a fire hazard. Litter depths of four to five inches are not unusual. The average litter accumulation in a dense infestation in the Little Willow Flat area in 1955 was from 1¼ to 1½ tons per acre air-dried. These figures do not include the current year's production.

Apparently associated with excessive litter accumulation small patches (less than one to about fifteen acres) almost completely free of Medusa-head have developed. These patches, at present, support annual weedy forbs such as: Helianthus annuus, Epilobium paniculatum, Lactuca scariola, and Eremocarpus setigerus. The cause of these patches is not known but it is possible that an excessive amount of organic matter has accumulated and the carbon-nitrogen ratio increased beyond the critical point for Medusa-head growth. This hypothesis will be tested by studies planned for next year. (Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow, Idaho.)

Chemical and cultural treatments for the control of Medusa-head rye (Elymus caput-medusae). Erickson, Lambert C., and Parish, Robert S. A four-phase study to determine the potentials of cultural, chemical, re-vegetation, and non-disturbance practices for the control of Medusa-head rye on Idaho range land was initiated in April of 1955.

Four large blocks were first outlined in a dense stand of Medusa-head rye. This was a winter annual stand two to three inches tall averaging 318 plants per square foot. Plots within each block were then designated for burning, plowing, discing, and non-disturbance. The vegetation was fired on the "burn" plots and thereafter the herbicides - Dalapon, amino triazole, IPC, and CIPC - were applied as subplots within the cultural plots. The herbicides were therefore applied as post-burn, but as pre-cultural treatments. The herbicides were applied at 0, 2, 4, 6, or 8 pounds per acre. Thereafter, the plots to be plowed or disced were treated accordingly and the grasses were seeded throughout all of the four blocks. Five species of grasses were used. These were so seeded that all the species were present in every treatment combination. This design gave four cultural and check replications, four replications per chemical, but only one replication of a chemical rate in combination with a cultural treatment. There were a total of 480 individual plots. The five grass species were: crested wheatgrass (Agropyron cristatum), beardless wheatgrass (A. inerme), intermediate wheatgrass (A. intermedium), bulbous bluegrass (Poa bulbosa), and hard fescue (Festuca ovina var. duriuscula).

The results indicated that cultural treatments were definitely helpful in controlling Medusa-head. Plowing alone gave approximately 95 per cent control, and plowing in combination with any one of the herbicides gave 100 per cent control. Discing alone gave approximately 50 per cent control; while discing plus Dalapon or amino triazole at a 2-pound rate gave 100 per cent control. Six pounds per acre of IPC or CIPC were necessary for 100 per cent control on the disced areas. Burning alone in the early spring gave little control, although it gave an additive effect in combination with the herbicides, as compared to check treated areas.

Some of the chemical treatments likewise gave good responses on the undisturbed areas. Dalapon at all rates - 2 pounds and up - gave 100 per cent control. Amino triazole gave 100 per cent control at the 6-pound rate and approximately 90 per cent control at the 2-pound rate. It took 8 pounds per acre of IPC to give 100 per cent control, and the 6-pound rate gave approximately 50 per cent control. For CIPC, the 8-pound rate gave approximately 90 per cent control.

Due to the absence of spring rains, the spring establishment of the perennial forage grasses was not successful. According to readings taken October 20, 1955, grasses were becoming established only in the plowed areas. (University of Idaho Agricultural Experiment Station.)

The effects of varying light and radiation on size, weight, and seed production of halogeton. Robocker, W. C. An experiment to determine the effects of shading on some characteristics of halogeton, simulating an ideal situation of light competition with other plants, was set up in two replicates in the spring of 1955. Light and radiation were reduced by means of frames covered with one, two, and four thicknesses of plastic window screen, supported 6 inches above the ground.

Approximate reductions of light intensity, determined by a photographic exposure meter, and radiation, determined by a General Electric radiation meter, were from 100 per cent for full sunlight to 50 per cent, 24 per cent and 8 per cent. There was little difference in the average diameter, distance between first and second nodes of the main branches, and percentage dry matter among the four levels. With decrease in light and radiant energy from 100 per cent to 8 per cent, average dry weight decreased in an almost linear manner from 31.6 grams to 5.0 grams per plant, and reduction in the number of seeds per plant appeared to follow a similar pattern. This was due to lack of development of branches, with leaves and fruits, from the secondary branches. The ratio of black to brown seeds on the first secondary branch showed little change with reduction to 24 per cent of full light and radiant energy. Reduction from 24 per cent to 8 per cent, however, besides causing the marked reduction in the number of seeds produced, caused a change in ratio of black to brown seeds from 3.4 to 21.0. (Field Crops Research Branch, ARS, USDA, and Nevada Agricultural Experiment Station, cooperating.)

Effects of increasing elevation on establishment and persistence of halogeton. Robocker, W. C. Elevation stations established in 1954 and 1955 were maintained at 4,500, 6,100, 6,700, 7,000, 7,600, 8,000, and 8,600 feet. Where halogeton was not already present, boxes with screened bottoms were placed in the ground in pairs, one with soil native to the site and one with soil introduced from a location where halogeton was known to grow. The black form of seed was planted at a depth of 1/16 to 1/8 inch and then covered with 1/8 to 1/4 inch of crushed granite. Rain gauges and maximum-minimum thermometers with bulbs 12 inches above the ground were installed at each station in 1954. In 1955, in addition to air temperatures taken at a 12-inch height, maximum-minimum thermometers were also installed to take temperatures at the soil surface and at a 6-inch soil depth at all stations up to and including 7,600 feet. Moisture was adequate throughout the summer at all stations, and temperatures did not go below freezing from approximately the middle of June until the middle of September below the 8,000-foot station.

Seed was fall planted, naturally or artificially, at all except the 8,000-foot station, where transplants were set out in late June. Where seeding was not natural, spring planting was also made. Germination and seedling emergence occurred from all fall-planted seeds. Emergence of spring-planted seed occurred at elevations of 7,000 and 7,600 feet, but not a 6,700 feet. No seedlings of either planting survived at 8,600 feet and no seedlings from spring planting were noted.

Transplants in rosette and cotyledon stages at 8,600 feet elevation survived and produced one to two brown seeds per plant, but no black seeds. At 8,000 feet, near Angel Lake (Wells), no seed was produced from the transplants. Temperatures fell below freezing during each two-week period throughout the summer at that station. Two spring-seeded plants survived at 7,600 feet and together produced eight black and four brown seeds. At 7,000 feet, seedlings from both fall and spring planting survived and produced a small amount of seed. There was no seedling survival at 7,000 feet and above in 1954. (Field Crops Research Branch, ARS, USDA, and Nevada Agricultural Experiment Station, cooperating.)

Non-poisonous native species. --

Wild iris or flag (Iris missouriensis) control with foliage applications of a light and heavy ester of 2,4-D, a light ester of 2,4,5-T, a 50-50 combination of light esters of 2,4-D and 2,4,5-T, and Dalapon. Thornton, Bruce J. This exploratory test was conducted in a mountain meadow at an altitude of over 7000 feet. The carrying capacity of the meadow was greatly reduced as a result of a heavy infestation of wild iris over the area.

The butyl ester and propylene glycol butyl ether ester of 2,4-D were applied at 2 and 4 pounds (acid equivalent) per acre. The isopropyl ester of 2,4,5-T and a 50-50 combination of 2,4-D and 2,4,5,-T were applied at 2 pounds per acre. Applications were made in water at 20 and 100 gallons per acre, in oil at 10 and 50 gallons per acre, and in oil-water emulsions of 5 plus 20 gallons per acre and 10 plus 40 gallons per acre. Dalapon was applied at 20, 40, and 80 pounds (acid equivalent) in 100 gallons water per acre.

Observations made 14 months after treatment indicated all applications of 2,4-D, both light and heavy esters, to give practically 100 per cent control regardless of type or rate of carrier used. No injury to the grass was evident except in the case of the 4 pound rates of the butyl ester, which reduced the grass stand an average of 25 per cent, and both rates of the heavy ester which reduced the grass 40 and 50 per cent respectively. The ester of 2,4,5-T and combination 2,4,5-T and 2,4-D were somewhat less effective than the 2,4-D formulations and gave some indication of grass injury. Dalapon at 20, 40, and 80 pounds per acre gave 95 per cent, 100 per cent, and 100 per cent iris reduction respectively, and also 100 per cent reduction of the grass at each rate. (Colorado Agricultural Experiment Station, Fort Collins, Colorado.)

A comparison of different rates of 2,4-D for the control of hoary velvet lupine. Klomp, Gerard J. Three rates of 2,4-D isopropyl ester were sprayed on hoary velvet lupine (_Lupinus leucophyllus canescens_). Replicated plots, each 1/10 acre in size, were located on a sheep range at about 6,800 feet elevation in a subalpine grassland type. The hoary velvet lupine is an undesirable species which invades the green fescue (_Festuca viridula_) climax. Scattered remnants of green fescue on the plots will be studied to determine their reaction to spraying and to release when the lupine is controlled. The lupine was sprayed while the plants were still growing actively and flower buds were beginning to appear (July 24).

The rates of 2,4-D isopropyl ester applied with 50 gallons of water per acre were: 1/2, 1, and 2 pounds per acre acid equivalent per acre, compared with untreated check.

Lupine responded rather quickly to spraying, the plants beginning to wither and dry within a few days. Flower development stopped immediately and no seed matured. Preliminary checks indicated a high degree of control. Subsequent examinations will be made to determine actual kill and the relative efficiency of the different levels of 2,4-D application. The 1956 season should yield indicative data in this direction. (Field Crops Research Branch, ARS, USDA, La Grande, Oregon.)

A study of niggerhead control by spraying, cultivation, and reseeding. Klomp, Gerard J. A series of 12 plots, each 50 feet by 60 feet, was established on ranges heavily infested with niggerhead (_Rudbeckia occidentalis_). Heavy grazing use in the past has killed out desirable grasses and forbs and has fostered the increase of the unpalatable niggerhead. Control of niggerhead is important on the sites involved because the deep soil is potentially highly productive where grass reseeding can be accomplished. Practical methods of niggerhead control which must precede or accompany reseeding efforts were compared for efficiency of weed control and effect on subsequent reseeding. These methods included:

1. Spraying with 2,4-D ester at 2 pounds per acre in 25 gallons of water.

2. Cultivation to a depth of 6 inches, using duck foot plows.

3. Reseeding 10 species of grass by (a) drilling in rows 12 inches apart; (b) broadcasting; and (c) broadcasting and covering.

Combinations of treatment and planting time are being studied. The replicated blocks of plots include the following treatments:

1. Reseeding in fall; spray in spring.

2. Spray in spring; reseed in spring.

3. Spray in spring; reseed in fall.

4. Cultivate in spring; reseed in spring.

5. Cultivate in spring; reseed in fall.

6. No treatment; reseed in fall.

Parts of this study were established in the fall of 1954. Observations made during the growing season of 1955 indicated 95 per cent control of niggerhead by spraying and by cultivation. Numerous niggerhead seedlings indicate rapid reinvasion unless reseeded grasses are able to suppress. Grass establishment appears equal on either sprayed or cultivated areas. The study is being continued to determine eventual establishment of grass as affected by spray or cultivation treatments. (Field Crops Research Branch, ARS, USDA, La Grande, Oregon)

A comparison of different rates of 2,4-D for the control of niggerhead. Klomp, Gerard J. Three rates of 2,4-D isopropyl ester were sprayed on niggerhead (Rudbeckia occidentalis). Replicated plots, each 33 feet by 66 feet (1/20 acre) were established in a dense, uniform stand of niggerhead growing on a deep fertile soil in a cattle range in the open fir type. The plants were sprayed when they had made nearly maximum growth and flowers were beginning to bud which, at this elevation of 6,000 feet, was July 21.

The rates of 2,4-D isopropyl ester applied with 50 gallons of water per acre were: 1/2, 1, and 2 pounds acid equivalent per acre, compared with untreated check.

After spraying, growth stopped almost immediately on all niggerhead plants, and the characteristic malformation occurred. Flower development was arrested and subsequently, no mature seeds were found. The plants dried early, the heavier applications resulting in a more pronounced reaction. Observations of results will be continued in 1956, and as long as necessary to determine actual control. (Field Crops Research Branch, ARS, USDA, La Grande, Oregon)

Poisonous native species. —

The control of arrowgrass (Triglochin palustris) with soil sterilents. Thornton, Bruce J. Arrowgrass is chiefly detrimental because of its poisonous nature, having been responsible for serious livestock losses. It apparently thrives on alkaline soils under conditions of high soil moisture. This exploratory test was conducted in a badly infested meadow at an altitude of over 7000 feet. Treatments were made on October 29, 1954.

The materials used, rates of application per square rod, methods of application, and the results, as observed 12 months after treatment, were as follows: Sodium-chlorate at 3 and 6 pounds (dry)--little effect; Polyborchlorate at 6 and 12 pounds (spray)--little effect; Polybor at 7 1/2 and 15 pounds (spray)--little effect; Borascu at 9 and 18 pounds (dry)-little effect; Sta-Klor (a mixture of sodium chlorate, borax, and TCA) at 2 and 4 pounds (spray)--little effect; TCA at 1/2 and 1 pound (spray)--little effect; Borax DB granular at 3 and 6 pounds (dry)--60 and 80 per cent reduction; CMU at 1/4 and 1/2 pound (spray)--90 and 100 per cent reduction; DCMU at 1/4 and 1/2 pound (spray)--90 and 100 per cent reduction.

Of the materials used only the substituted ureas and Borax DB had any marked effect on the arrowgrass. The action of the latter suggests the possible effectiveness of heavy applications of 2,4-D, which treatments are now under test. Foliage treatments are also under test. (Colorado Agricultural Experiment Station, Fort Collins, Colorado.)

The effect of several substituted phenoxy compounds on Tall Larkspur. Baker, Laurence O. Tall larkspur (Delphinium occidentale (Wats.) Wats.) in the Bridger Mountains northeast of Bozeman has been treated with various rates of several substituted phenoxy compounds. At one location plots were treated at a bud stage of growth on June 28, 1953 and again July 8, 1954. Esters of 2,4-D, 2,4,5-T and 50-50 mixes of the two and 2,4-D amine with 50 pounds ammonium sulfamate were used at rates of 1.5 and 3.0 pounds per acre. The effects of these treatments were determined by counting the number of larkspur stems per plot. There was no apparent control. The number of stems per plot present in 1955 was greater than before treatments were made. At another location rates of three and six pounds per acre of 2,4-D ester, 2,4,5-T ester, 50-50 mixes of 2,4-D and 2,4,5-T and Kuron were applied at the early bloom stage of growth (July 8, 1954). Increased stem counts occurred on all plots except on those treated with 2,4,5-T and six pounds of 2,4-D. Decreases of only 2, 3, and 16 per cent resulted from treatments of three pounds 2,4,5-T, six pounds 2,4-D and six pounds 2,4,5-T, while increases ranging from 4 (check plot) to 43 per cent (six pounds Kuron) occurred on all other plots.

A third experiment was conducted at another location with the same chemicals. Rates of application were 1.5 and 3.0 pounds per acre applied at the bud stage of growth. This area had been burned to remove brush prior to the growing season in 1954. There was little grass competition. All plots showed a reduction in stand of larkspur which varied from 24 per cent (check) to 72 per cent (3.0 pounds 2,4,5-T). The average difference between reduction on treated and untreated plots ranged from 11 ($1\frac{1}{2}$ pounds of a mixture of 2,4-D and 2,4,5-T) to 48 per cent (3.0 pounds 2,4,5-T).

In these three tests no treatments have been satisfactory. There is some indication that 2,4,5-T is slightly more specific than the other chemicals, but the difference is not large enough to warrant recommending it. (Montana Agricultural Experiment Station, Bozeman, Montana.)

PROJECT 3. UNDESIRABLE WOODY PLANTS

F. H. Tschirley, Project Leader

SUMMARY

A total of 17 papers were received from 10 authors in five different states. Reports are given on the effects of herbicides on 20 different undesirable woody plants.

Salt cedar (*Tamarix pentandra* and *Tamarisk gallica*). The two scientific names probably refer to the same plant. The Arizona plants were referred previously to *T. gallica* but were changed by Kearney and Peebles in "Arizona Flora". In Arizona tests were made on regrowth that was 6, 18, and 25 months old. Best kills were obtained on six-month-old regrowth with a brushkiller mixture having esters of 2,4-D and 2,4,5-T. Tests on seedlings showed that an ester of 2,4,5-T and the brushkiller mixture gave kills of almost 100 percent with one application on three and eleven month seedlings. An amine of 2,4-D was decidedly inferior. Percentage of kill was greatly reduced when the same treatments were made to older seedlings.

Low-volatile esters of 2,4,5-TP look most promising of the selective herbicides in New Mexico, but it is felt that salt cedar has suffered very little retardation in spite of repeated treatments. Achieving an adequate percentage of kill is especially difficult by aerial application. Karmex D.W. has also been used but results are not yet available.

Cactus (*Opuntia fulgida*). This cactus is receiving increasing attention in Arizona. During the past year, detached joints were sprayed with CIPC and MH. CIPC caused death of the detached joints at concentrations of 1 - 4 percent. It was also noted that untreated joints sprouted during the summer but not during the winter. There is a possibility, therefore, that this cactus could be chained during the winter without the danger of having joints sprout and form new plants.

Whitethorn (*Acacia vernicosa*), tarbush (*Flourensia cernua*), and creosotebush (*Larrea tridentata*). These three species grow as a vegetative type in southeastern Arizona and part of New Mexico. A date-of-spray test was conducted which indicated two peaks of maximum susceptibility. The first occurred in March and April after the winter rainy season and the second from July to September after the summer rainy season. An herbicide evaluation study was also conducted on whitethorn and tarbush. Whitethorn is a sprouter, making it difficult to control, and the highest kill was 65 percent. Low-volatile esters of 2,4-D or 2,4,5-T appeared to be about equally effective. Tarbush is more susceptible to selective herbicides than whitethorn. Formulations of 2,4-D are most effective. Kills of 95 percent or more were obtained with both esters and amines of 2,4-D.

Chaparral. The principal species in this vegetative type is shrub oak (*Quercus turbinella*). It is also the most difficult to control.

Other species in the chaparral type are manzanita (Arctostaphylos pungens), skunkbush (Rhus trilobata), and adelia (Forestiera neomexicana). Successive aerial applications of selective herbicides produced little effective control. In the summer of 1955 about 300 acres of chaparral was burned. Sprouts of shrub oak are being sprayed at monthly intervals with a number of herbicides.

Chamise (Adenostoma fasciculatum). Some good results were obtained on three-year chamise sprouts by a combination of spraying and burning. Three months after spraying a wildfire swept through an area that had been treated with esters of 2,4-D, 2,4,5-T, and 2,4,5-TP and burned out beyond the plot boundaries. Burning was highly effective in killing sprayed plants, but none of the unsprayed plants were killed. Other experiments have shown that burning a year or more after spraying is not any better than burning alone.

Blue oak (Quercus douglasii). Holes were drilled to different depths at six-inch intervals around the base of the stem. Two ml. of undiluted amines of 2,4-D and 2,4,5-T were put in each hole with a hypodermic syringe. Depth of application influenced the percentage of kill markedly. At depths greater than one inch, 2,4-D amine was superior. The amine of 2,4,5-T is expected to be superior at a depth of one-half inch.

Mesquite (Prosopis juliflora var. velutina). The use of fortifying agents in diesel oil for basal spraying of mesquite was tested. The use of a good fortifying agent can reduce the cost of treatment since a lesser volume is required than when diesel oil is used alone. There is probably a tendency to use too much spray material when a fortifying agent is used, however. If that is the case differences in cost would soon be equalized. There is no seasonal difference in kill when trees are basally sprayed with either diesel oil or fortified diesel oil.

Ponderosa pine (Pinus ponderosa). The amine of 2,4-D has been very effective in killing young ponderosa pine by the cut-surface method in thinning operations. There is a danger, however, since the killed trees are a good place for bark beetles to develop. Trees killed late in the season showed least susceptibility to the Ips beetles.

Manzanita (Arctostaphylos parryana var. pinetorum), snowbrush (Ceanothus volutinus), and chinkapin (Castanopsis sempervirens). These three species form a brushy overstory that suppresses young ponderosa pine. Both brush and trees were foliage-sprayed in an attempt to control the brush but not harm the pine. The problem is complicated since three different species must be controlled. At present the least damage is done to pine after height growth has stopped. Manzanita can still be killed at this time of the year. 2,4-DP and 2,4,5-TP look promising for the control of chinkapin.

Red alder (Alnus rubra). This species can be well controlled by basal treatment. Diesel oil fortified with 2,4,5-T ester and with a brushkiller mixture was sprayed on the lower part of the stem. Percentage of kill averaged 95 percent.

Salmonberry (Rubus spectabilis). Salmonberry also overtops and suppresses conifer growth. Foliage sprays are unsatisfactory because of damage to conifers and the vigorous sprouting habit of salmonberry. Basal treatments in the dormant season are very encouraging but results are still preliminary.

Ribes. Ribes species can be controlled with low-volatile esters of 2,4,5-T and 2,4,5-TP. The foliage must be completely covered, however, and sprayed to the point of drip. Oil must be added to the carrier after the plants have stopped active growth. Combining dalapon with 2,4,5-T has been effective in reducing the density of grasses, sedges, and rushes as well as controlling Ribes on areas that have received a prescribed broadcast burn. Reducing the density of sod forming plants facilitated planting of western white pine seedlings and permitted better survival and growth.

Effect of several herbicides on regrowth and seedlings of salt cedar (Tamarisk gallica). Arle, H. Fred and Bowser, C. W. Applications of an amine 2,4-D and a 50-50 mixture of an ester formulation of 2,4-D and 2,4,5-T to regrowth salt cedar have been continued. These materials were applied at approximate rates of 1.3 and 2.6 lb/A (2400 and 4800 ppm) for the first two applications and for later treatments the amount of herbicide used became progressively less on plots where a kill of salt cedar was obtained.

The initial applications were made during September 1951 on plant regrowth which was six months old. Other plots received their first treatment during May 1952 (regrowth 13 months old), September 1952 (regrowth 18 months old) and May 1953 (regrowth 25 months old). Repeat applications were made each May and September following the first treatment.

Best results were obtained with the higher rate of brushkiller when the initial application was made to six-month-old regrowth. Five applications and a total use of 7.54 lb/A resulted in 100 percent kill. Five applications of the same material and a total use of 9.28 lb/A have killed only 58 percent of salt cedars when the first application was delayed until regrowth was 25 months old. Eight applications of amine 2,4-D at the higher rate used a total of 12.6 lb/A but killed only 81 percent when the first application was made on six-month-old regrowth. When treatment was delayed until regrowth was 25 months old, 11.0 lb/A were applied in 5 applications and only 40 percent of the original stand has been killed. Results of applications with both materials at the lower concentration were consistently inferior.

A somewhat similar experiment was conducted on salt cedar seedlings to determine when they develop resistance to herbicides. Applications of amine 2,4-D, an ester of 2,4,5-T and the similar ester of 2,4-D-2,4,5-T in a 1 to 1 combination at 2.0 lb/A were made to seedlings which were 3, 11, 15 and 23 months old.

Applications of 2,4,5-T and the combination resulted in almost complete kills from the initial treatment when plants were 3 or 11 months old. Follow-up applications killed the few survivors. Applications of amine 2,4-D at this stage of growth have killed only 25 percent of the seedlings. When seedlings were allowed to reach an age of 15 months (5-6 feet tall) effectiveness of treatment was much reduced. Two applications of 2,4,5-T of the combination effected only a 50 percent stand reduction while results from amine 2,4-D were almost negligible. Applications made when seedlings had reached 25 months were still less effective. (Contributed by the Field Crops Research Branch, Agricultural Research Service, USDA, and the U. S. Bureau of Reclamation, USDI.)

Woody plant control. Lowry, Orlan J. During 1954 approximately 12,500 acres of mixed phreatophytes were aerial sprayed along the Rio Grande above the headwaters of Elephant Butte Reservoir, New Mexico. Top kill of varying degrees was obtained depending on the chemicals used and the kind of plant treated. The highest percent kill was obtained when low-volatile esters of 2,4,5-T were applied at the rate of 2 pounds per acre in 5 gallons of mixture as compared to the low-volatile esters of 2,4,-D and amine of 2,4-D. Plant kill on adult plants averaged about 10 percent on salt cedar and 75 percent on willows.

During the early part of 1955, some 2,500 acres of mixed adult phreatophytes, which were earlier sprayed, were broken over and burned. This was done not only to conserve water but to rid the area of the jungle in order that a ground spray program could be initiated. From work thus far conducted, it appears that woody plant regrowth can be controlled by repeated annual sprayings with the hormome herbicides. After two years, willow regrowth along drain ditches has been almost eliminated when sprayed annually with amine of 2,4-D at 2 pounds per acre in 25 gallons of emulsion. The regrowth of salt cedar has been materially retarded and become more scattered, and cottonwood regrowth has been materially stunted.

Applications of relatively new chemicals to plots of salt cedar have been made. The PGBE ester of 2,4,5-TP (Kuron) and the amine salt of 2,4,5-TP (Kuramine) applied in August at the rate of 3 pounds per acre in 25 gallons of water resulted in all the plant leaves being shed. No estimate of plant kill can be made until next growing season. Karmex D.W. when applied at the rate of 8 pounds and 12 pounds per acre in 50 gallons of water on salt cedar plants 6 to 8 feet tall, resulted in kill on all tip leaves and branches and appeared to progress downward in the stems. Additional observations will be made next year to ascertain the results more completely.

Repeated efforts should be made to develop and obtain a chemical which could safely be used for woody plant control without injury to adjacent susceptible growing crops. (Bureau of Reclamation - Region 5.)

Chemical control of salt cedar (Tamarix pentandra). Whitworth, J. Wayne. Salt cedar infestations are becoming more and more widespread on the river channels, dams and floodways of New Mexico. This pest is a potential threat as well as a robber. A threat because it reduces the carrying capacity of floodways, and a robber because of heavy pumping of much needed water through its voracious transpiration system.

The spread of salt cedar has suffered very little retardation in spite of repeated sprays of the 2,4-D and 2,4,5-trichlorophenoxyacetic acid formulations. The data in table 1 indicate that the propionic formulations of 2,4,5-T (2(2,4,5-trichlorophenoxy) propionic acid) may be statistically more effective than the acetic formulation, but, from a practical standpoint, 46 percent kill is scarcely better than 21 percent.

New and more effective herbicides are required if salt cedar is to be controlled on areas that are inaccessible to ground equipment. On the few thousand acres of salt cedar infested land in New Mexico that is accessible to ground equipment, salt cedar could be controlled with currently available herbicides by the same combination that has proved effective for controlling persistant perennials on farm land--tillage, chemicals, and competing crops such as grasses. However, many thousands of acres can be reached only by airplane, and for these a better herbicide needs to be formulated.

Table 1. Percentage root kill of salt cedar plants May 24, 1955, from herbicides applied at the rate of 4 lb/acre (acid equiv.) on September 3, 1954[1].

HERBICIDES	AVERAGE PERCENT ROOT KILL[2].
2,4-dichlorophenoxy acetic acid.................	19
2,4,5-trichlorophenoxy acetic acid..............	21
2,4,5-trichlorophenoxy propionic acid............	46
2,4,5-trichlorophenoxy propionic acid.......... and 4 lb/acre Amizol (3-amino-1,2,4-triazole)	44
NO TREATMENT..	14

CV = 18 percent L.S.D. (.05) = 10 percent

1. All herbicides were of the low-volatile ester type, and were applied using a volume of water equal to 40 gallons/acre.
2. Average percent root kill was based on total number of plants in a 4' x 20' area divided into number of plants showing no regrowth. Salt cedar plants were approximately 4 feet tall at the time of treating. (New Mexico State Agricultural Experiment Station.)

Cactus Control study. Turner, R. M. A combination mechanical-chemical method for killing jumping cholla (*Opuntia fulgida*) has been under study for the past year. During the course of this work, a tendency was noted among the untreated joints comprising the control to sprout during the summer season, but not during the winter. This has suggested the possibility of controlling this plant by some mechanical method alone, such as chaining, provided the control measures are taken during the proper season.

The work of the previous year with isopropyl N-(3-chlorophenyl) carbamate (CIPC) and maleic hydrazide (MH) has shown that the MH had little effect upon the joints, but CIPC at concentrations of 1 to 4 percent caused death of the detached joints. The loss of viability in the joints when sprayed with this chemical was greatest in those groups which received no water other than natural precipitation.

Next year detached joints will be placed under different temperature and moisture regimes in an effort to determine whether there is some season during which these joints die without sprouting. (Arizona Agricultural Experiment Station.)

Control of whitethorn, tarbush, creosotebush. Turner, R. M. During the past year, the work on whitethorn (*Acacia vernicosa*), tarbush (*Flourensia cernua*) and creosotebush (*Larrea tridentata*) has involved two separate studies: (1) Work designed to determine that season when these plants are most susceptible to a low-volatile ester of 2,4,5-T (Esteron 245), and (2) a study begun in July, 1954, and completed in July, 1955, which had as its objective the evaluation of certain chemicals for use in control of the first two of the species mentioned above.

The date-of-spray study was conducted on two separate areas and at present the evaluation of results is complete for only one of these. There appear to be two rather distinct periods of greatest susceptibility of these plants to 2,4,5-T (applied at rates of 2 and 4 percent). One of these periods occurs during the summer rainy season (July - September) and the other occurs in March and April following the winter rainy season, but at a time when increasing temperatures probably favor physiologic activity of the plants.

The chemical evaluation study, conducted by Mr. James B. Garner, and described in an M. S. thesis, involved the use of esters and amines of 2,4-D, 2,4,5-T, and 2,4,5-TP ester (Kuron). These chemicals were applied at rates of 10,000, 20,000, 30,000, and 40,000 ppm. Most of these treatments were made with 4:1 and 1:0 water:diesel oil carriers. Some applications were also made with a 1:1 water:diesel oil carrier.

Tarbush was more susceptible to 2,4-D than to 2,4,5-T. Treatments which resulted in plant kills higher than 95 percent were:

Herbicide	Concentration, ppm	Carrier
2,4-D, triethanol amine	20,000	Water
" , "	30,000	"
" , "	40,000	"
" , PGBE ester	40,000	"
" , triethanol amine	20,000	4:1 HOH:DO
" , "	40,000	" "
2,4,5-T, triethanol amine	20,000	" "

Whitethorn was equally susceptible to formulations of 2,4-D and 2,4,5-T. The best plant kills (65%) were obtained with a PGBE ester of 2,4,5-T in a water carrier at a concentration of 30,000 and 40,000 ppm and the same formulation in a 4:1 water:diesel oil emulsion at a concentration of 30,000 ppm.

No significant difference in percent of kill could be detected among the different carriers when the data were analyzed by analysis of variance.

The date-of-spray test will be continued until August, 1956, which will mark the completion of two years of this study. Future plans will not be made until the evaluation of this study is complete. (Arizona Agricultural Experiment Station)

Chaparral control studies. Turner, R. M. Aerial application of 2,4-D and 2,4,5-T during two successive summers has produced little effective control of chaparral species in central Arizona. Total kill of oak (*Quercus turbinella*) was negligible, skunkbush (*Rhus trilobata*) was easily killed back to the ground, but sprouted vigorously from the root crown; adelia (*Forestiera neomexicana*) was relatively immune to the chemicals, some treatments causing up to 50% total kill; manzanita (*Arctostaphylos pungens*) showed a plant kill of 80-90 percent when treated with a PGBE ester of 2,4,5-T at 2 lbs/A a.e. in 10 gallons of carrier per acre. Carriers of 4:1, 1:1, and 0:1 water:diesel oil were equally effective.

During June, 1955, roughly 300 acres of chaparral were broadcast burned. The sprouting oaks in the burned area are being sprayed at monthly intervals to determine whether a combination chemical-prescribed burning program can be used to control chaparral.

Eight different chemicals or formulations are being applied in a 1:9 S/V Sovaspray 100:water carrier with Dow Dynawet added as emulsifier. The following chemicals are being used:

1.	2,4-D	dimethylamine salt (du Pont)	1% ac. eq.
2.	2,4-D	PGBE ester (Dow)	1% ac. eq.
3.	2,4,5-T	triethylamine salt (Dow)	1% ac. eq.
4.	2,4,5-T	PGBE ester (Dow)	1% ac. eq.
5.	2,4,5-TP	(Dow's Kuron)	1% ac. eq.
6.	2,4-DP	(Dow's S-1280)	1% ac. eq.
7.	Dalapon (Dow)		1 lb/10 gal.
	2,4-D	dimethylamine salt (du Pont)	0.5% ac. eq.
	2,4,5-T	triethylamine salt (Dow)	0.5% ac. eq.
8.	Amino triazole (A.C.P.)		1% active ingred.

This present study will be continued for at least one year. Future plans will be determined by the outcome of this study. (Arizona Agricultural Experiment Station.)

<u>Effect of burning, spraying and reburning chamise on sprout kill.</u> Leonard, O. A. Three year-old chamise (<u>Adenostoma fasciculatum</u>) sprouts (resulting from burning in August 1951) were sprayed with the esters of 2,4-D, 2,4,5-T, 2,4-DP and 2,4,5-TP in April of 1954. A wild-fire swept through the plots three months after treatment and burned most of the plot area but died out in the unsprayed brush beyond the boundaries of the plot area. Most of the plots were burned completely, especially those plots that had had sprays which were sufficiently effective to kill most of the chamise sprouts (such as the four and eight pound rates of all of the chemicals). The plots that had received the two pound rates, except for 2,4,5-T, had many chamise plants that had already developed succulent shoots at the time of the fire (especially with the 2,4-DP and 2,4,5-TP). These plots did not burn as completely as did those that had received a greater quantity of chemical per acre.

The results in the table indicate that burning was highly effective in bringing about a kill of the sprayed plants. The reburn did not result in the death of any of the chamise plants which had not been sprayed; however, certain physical differences did exist between the sprayed and unsprayed plots. The fire was probably hotter on the sprayed plots than on the unsprayed plots because shoots had been desiccated by the sprays; in addition, dormancy of the buds had been broken after the spraying and these buds had developed into shoots which were killed by the fire. The fuel supplied by grass did not contribute much to the burn, since there were only about 100 pounds of dry grass per acre on the area.

Kill of three-year-old chamise sprouts as a result of spraying (in April) and burning (in August).

Chemical	Pounds of acid equivalent per acre	Percent of chamise plants killed: Burned after spraying	Sprayed only
2,4-D*	2	93	33
2,4,5-T	2	93	--
2,4-DP	2	55	10
2,4,5-TP	2	82	10
Untreated	-	0	0

*Propylene glycol butyl ether esters were used and these were applied in one gallon of odorless kerosene and enough water to make twenty gallons per acre.

All treatments in which four pounds of chemical were used (regardless of the chemical) resulted in a high degree of chamise sprout kill, when combined with the burning.

In other experiments, it has been found that reburning chamise the next year or later after treatment has not been effective in improving the kill of the chamise sprouts over the effect of burning alone (the effect of burning alone was zero in the experiments referred to; however, it is often quite effective, when combined with heavy browsing by deer, goats, or sheep). Evidently, in order to be successful, the reburn of chamise should follow the spraying within a few months. (University of California, Davis)

Effect of depth of application on the kill of blue oak using the cut-surface method. Leonard, O. A. This study was undertaken to repeat a previous study that the author had made using the same materials applied in the same manner to blue oak (*Quercus douglasii*). The number of trees used per treatment was ten.

Holes were drilled to different depths every six inches around the bases of the trunks and 2 ml. of the undiluted formulations (4 lbs. acid equivalent per gallon) were applied in each hole using a hypodermic syringe.

Data presented in the table below demonstrate that depth of application of the amine had a marked influence on kill. The bark itself was about one-half inch or less deep. This depth of applications was not effective in killing many of the blue oaks and there was no difference in the results between 2,4-D and 2,4,5-T. It is anticipated, however, that more trees will die and that the greatest death will occur at the shallow depth with the 2,4,5-T amine - the same as happened in the first experiment. When the amines were placed one inch deep, there was little difference between the two amines; however, the amine of 2,4-D was considerably superior to the amine of 2,4,5-T when applied at depths greater than one inch. These results were obtained in the previous test and were, therefore, expected.

Depth of application, inches	Percent kill of blue oak trees	
	2,4-D amine	2,4,5-T amine
0.5	20	20
1.0	90	80
2.0	70	20
3.0	20	0

The results suggest some interesting biochemical differences in the movement and rate of breakdown of the 2,4-D and 2,4,5-T in the different tissues. (University of California, Davis.)

The effect of concentration and season on basal spraying of velvet mesquite with fortified diesel oil. Tschirley, Fred H. Some ranchers in southern Arizona have long felt that adding a fortifying agent to diesel oil for basal spraying of velvet mesquite (*Prosopis juliflora* var. *velutina*) is advantageous. Since plant kills of 95 percent using unfortified diesel oil are common, the only justification for using a fortifying agent would be to redice the total volume used and thereby reduce cost.

A study was started in 1953 to answer that question. Two replications having 20 trees each were treated with unfortified diesel oil and diesel oil fortified with 5 percent and 1 percent of butoxyethanol ester of 2,4,5-T (Weedone). Volume was approximately one-half pint per tree. One pint of unfortified diesel oil must be used to obtain plant kills of 95 percent.

An analysis of variance showed the difference between unfortified oil and 1 percent fortified to be significant at the 5 percent level. There was no significant difference between the 1 percent and 5 percent concentrations.

Table 1. Effect of concentration and time of application on basal spraying with fortified diesel oil.

Time of application	Percent plant kill			
	5 percent	1 percent	Unfortified diesel oil	Average
Aug., 1953	90.0	82.5	50.0	74.2
Feb., 1954	97.5	100.0	37.5	78.3
May , 1954	95.0	87.5	32.5	71.7
Average	94.2	90.0	40.0	

LSD for concentration means 6.94

There was no significant difference between dates of treatment. This is supported by other studies in which treatments were made at monthly intervals for an entire calender year.

Cost figures have been calculated using base figures of $0.13 per gallon and $13.86 per gallon for diesel oil and 2,4,5-T ester, respectively. The recommended volume of one pint per tree for unfortified diesel oil costs $1.60 per 100 trees. The cost of fortified oils used in this test was $0.90 and $1.25 per 100 trees for the one and five percent concentrations respectively.

There is an advantage in using fortified oil if the applicator is very careful. There is probably a tendency to use too much, however, when the per-tree volume is as low as one-half pint. If so, the difference in cost would soon be equalized without increasing the percentage of plant kill. (Field Crops Research Branch, ARS, USDA.)

Fortifying agents in diesel oil for basal spraying of velvet mesquite. Tschirley, Fred H. The recommended control measure for scattered stands of velvet mesquite (*Prosopis juliflora* var. *velutina*) is basal spraying with diesel oil using approximately one pint per tree. Herbicidal formulations are constantly being tested, however, for their use as fortifying agents. A cheap, efficient herbicide could lower the cost of basal treatment by reducing the volume required with diesel oil alone.

The herbicides listed below were applied in August, 1953. The results given are final. A five percent concentration of the herbicide in diesel oil was used in all treatments. Volume was approximately one-half pint per tree.

	Percent plant kill
2,4-Dichlorophenoxyacetic acid	
ACP-638, emulsifiable acid	0
LV-400, isooctyl ester	10
ACP-L-290, butoxyethanol ester	0
2,4,5-Trichlorophenoxyacetic acid	
ACP-329, butoxyethanol ester	70
ACP-302, butoxyethanol ester	70
ACP-533, butoxyethanol ester	90
Bramblecide, pentyl ester	100
2,4-D : 2,4,5-T mixtures	
Brushkiller #22, 1:1, tetrahydrofurfural esters	60
ACP-926, 2:1, emulsifiable acid	10
ACP-903, 2:1, amine salt	0
Brambleweedicide, 1:1, pentyl esters	70
3,4-Dichlorophenoxyacetic acid	
ACP-L-601, butoxyethanol ester	10

(Field Crops Research Branch, ARS, USDA.)

Thinning dense young ponderosa pine stands with Amine 2,4-D by the cut surface method. Dahms, Walter G. Killing young ponderosa pine by chemical means in thinning operations has shown some promise. Trials in 1954 and 1955 have demonstrated that the trees are extremely susceptible to the amine of 2,4-D applied by the cut surface method. In one experiment with trees from 5.0 to 6.0 inches in diameter as little as 0.8 of a c.c. of 2,4-D in one cut consistently caused death. The 2,4-D used contained 4 lbs. acid equivalent per gallon. Cost of chemical killing is but a fraction of that for cutting trees by conventional methods. However, trees killed with 2,4-D are attractive to bark beetles and a good place for them to develop which may induce insect attacks on reserved crop trees also. Beetle-caused crop tree losses on 2,4-D thinning plots scattered over central and eastern Oregon ranged from none to almost a complete loss in one case. Trees killed late in the growing season showed the least susceptibility to Ips beetles (the most serious tree killers) that season. Such trees probably will not be susceptible to beetle attack by the time next year's flights begin, but that point has not yet been demonstrated. Some means of beetle control, such as might be obtained by use of a good systemic insecticide, is needed to make thinning with the amine of 2,4-D a really useful tool for foresters. (Pacific Northwest Forest and Range Experiment Station, Forest Service, U.S.D.A.)

Releasing ponderosa pine from brush in central Oregon. Dahms, Walter G. Releasing suppressed ponderosa pine trees from overtopping brush requires that the brush be controlled without serious damage to the trees. The main problem arises from the limited number of trees that are already above the brush and therefore fully exposed to any foliage spray. This year's work was aimed at release of trees from manzanita (*Arctostaphylos parryana* var. *pinetorum* (Rollins) Wiesl. & Schrieb.), snowbrush (*Ceanothus volutinus* Doug.) and chinkapin (*Castanopsis sempervirens* Dudley) with a minimum of damage to the trees.

In order to determine whether these brush species could be controlled without damage to intermingled pine trees both trees and brush were sprayed with 2,4-D and with 2,4,5-T at dosages ranging from 1/4 to 1-1/2 pounds per acre. The first spraying was done on May 5th, shortly after the snow had left, and the last on October 13th, after 2.1 inches of fall rain. 2,4-DP and 2,4,5-TP were tried in a more limited way on both trees and chinkapin. Straight water and emulsion carriers containing summer oil were used.

Observations on 1953 and 1954 plots have shown numerous pine trees on the edge of aerial spray areas that are standing unharmed above 2,4-D killed brush. Also numerous trees that were almost completely defoliated have put out vigorous new foliage where terminal buds were uninjured.

Tentative observations from the 1955 studies are as follows:

1. 2,4-D is most damaging to pine trees, 2,4-DP and 2,4,5-TP the least damaging with 2,4,5-T about intermediate.

2. Summer oil emulsified in the carrier greatly increased harm to pine trees but also increased effectiveness on brush.

3. Trees were most susceptible to spray damage after the buds began to elongate. They appeared to be considerably more resistant after height growth stopped.

4. By August 2nd the trees appeared to be able to tolerate 1/2 pound of 2,4-D in an emulsion carrier containing 1 percent summer oil, enough to do a good job of controlling manzanita.

5. 2,4-DP and 2,4,5-TP look promising for control of chinkapin intermingled with pine trees.

(Pacific Northwest Forest and Range Experiment Station, Forest Service, U.S.D.A.)

Chemical basal treatment to control red alder. Ruth, Robert H., and Berntsen, Carl M. Encroachment of red alder (Alnus rubra) on conifer sites is a problem on many areas. Although red alder is readily controlled by foliage spray of 2,4-D, basal treatments are more practical for individual trees or small groups too tall for efficient foliage spraying from the ground. Basal treatments were tested on 6-year-old alder where stand diameters ranged from 1 to 6 inches and heights averaged 20 feet. Chemicals were sprayed on the lower 12 inches of the stems for trees up to 3 inches in diameter. Larger trees were treated to a height equal to 4 times the diameter of the tree. Each stem was thoroughly wetted on all sides until some chemical ran down around the root crown. Equipment was a backpack pressure spray can equipped with a horseshoe shaped adapter that would spray all sides of the stem at once. Chemicals were propylene glycol butyl ether esters of 2,4,5-T and the combination of 2,4,5-T plus 2,4-D. Carrier was diesel oil. All treatments were made in clear weather when the stems were dry.

Results 15 months after treatment averaged 96 percent kill. Foliage generally started to curl within 2 weeks after treatment. Defoliation was almost complete before the end of the first growing season. The cambium under the bark that was sprayed was brown and apparently dead; above the sprayed area it was green on most trees. Some trees leafed out the following spring and then died. The 4 percent still alive are largely defoliated and some are expected to die. There was no resprouting. All stems were still standing 15 months after treatment, but there were signs of rapid deterioration. Costs per tree using the 43,000 ppm concentration of 2,4,5-T were $0.044. The 2,4,5-T plus 2,4-D mixture at 21,500 ppm cost $0.031 per tree. (Pacific Northwest Forest and Range Experiment Station, Forest Service, U.S.D.A.)

Chemical treatments to control salmonberry. Ruth, Robert H., and Berntsen, Carl M. What can be done to reduce the competition from salmonberry (Rubus spetabilis) and other brush plants that overtop conifer plantations along the Oregon Coast? This question has been the subject of several exploratory studies since 1952. Foliage sprays of 2,4,5-T or a combination of 2,4-D plus 2,4,5-T at a concentration of 4,375 parts per million will cause about 90 percent defoliation of salmonberry. However, scattered sprouts appear the first season, followed by vigorous sprouting the next, which again overtops many conifers. Stronger concentrations of chemical are more effective on salmonberry, but also injure conifers and retard their growth.

In 1954 planted Sitka spruce trees that had been overtopped during their second growing season were released by covering each tree with a metal cone, then spraying the surrounding brush with strong concentrations of selected chemicals. This technique was generally effective; although some spruce trees were injured though covered during the spraying operation. The main problem, however, was to locate the trees under the dense brush. Dormant season treatments offer one possible solution since the conifer seedlings can be easily located during the winter when leaves are off the brush.

In April 1955, at the end of the dormant season, a study was started to explore control of salmonberry by basal treatments. First season results were very encouraging since most treated plants did not leaf out or send up basal sprouts. Examination of roots showed considerable root kill.

Foliage applications were also tried for treating scattered patches of salmonberry on clear-cut areas. Equipment was a light portable pump and 300 feet of high pressure hose. When convenient, the pump was set up on a road; otherwise, it was set up on the bank of the creek nearest the brush patch. Costs were $20.00 per acre, but it is believed this figure can be materially reduced. Chemical used was 2,4,5-T at the rate of 4 pounds acid equivalent per acre during dry weather and 5 pounds per acre during wet weather. (Pacific Northwest Forest and Range Experiment Station, Forest Service, U.S.D.A.)

Chemical control of ribes in the western white pine forests of Idaho, Washington, and Montana. Mass, V. D. Tests of hormone-type herbicides and improvements of spraying practices continue to be a major activity in the development of ribes control methods.

In 1954, four formulations of 2,4,5-T were tested on ribes. Methods of application were compared by applying aqueous spray both as foliage and as soil drenching-type treatments. Plots were 1/10-acre in size and consisted of 5-year and younger Ribes viscosissimum and R. lacustre. Treatments were replicated twice during the active growth period when Ribes species are most susceptible to 2,4,5-T. Average percent of ribes killed by formulations of 2,4,5-T applied as foliage and as soil drenching-type treatments are compared in the table below.

Average percent of ribes killed at a concentration of 2,000 ppm a.e. and a volume of 250 gal/A.

Formulation of 2,4,5-T	Type of spray treatment: Foliage	Type of spray treatment: Soil drenching
2,4,5-T, butoxy ethanol ester	86	100
2,4,5-TP, isooctyl ester	88	100
2,4,5-TP, propylene glycol butyl ether ester	85	100
2,4,5-TP, amine salt	51	83

Results indicate that both the acetic and propionic ester forms of 2,4,5-T are equally effective on immature ribes for similar methods of spray application. The soil drenching-type treatment is required for killing most ribes. Soil drenching differs from foliage-type treatment by spray being generously applied to soak soil around root-crowns of ribes plants 8-inches and taller, otherwise, leaves, tips of all growing branches, and stems are wet to the point of dripping. Ribes are more susceptible to the ester than the amine forms of 2,4,5-T.

The effectiveness of 2,4,5-T esters for ribes control by the forests depends upon the care taken in applying spray to individual plants. When spray crews are adequately trained and supervised by experienced foremen, highly satisfactory results are accomplished by chemical methods. For example, the St. Joe National Forest reports a 99 percent kill of ribes on 326 acres of cutover land sprayed in 1952, and a 96 percent kill on 1,000 acres of cutover land sprayed in 1953. Studies show ribes survive spraying by reason of (1) failure to apply spray as a drench to soil around root-crowns of plants 8-inches and taller, (2) failure to spray large plants from 2 or more opposing sides thereby wetting all foliage to the point of dripping, or (3) failure to systematically cover the entire work strip between string lines with spray.

An aqueous spray of 2,4,5-T is effective on ribes only so long as the plant is actively growing. Thereafter, to maintain satisfactory results, oil:water emulsion sprays are employed. From about mid-August until a killing frost occurs, the oil:water emulsion spray consists of 3 to 5 percent oil volume (stove oil or Diesel oil). After a killing frost, oil volume is varied from 5 to 10 percent of the total volume depending upon the degree of fall defoliation and amount of frost in ground surface. Spray is applied to wet stems and winter buds, but effectiveness of fall spraying depends upon the thorough drenching of plant bases and soaking of soil from 4 to 12-inches around root-crowns. To facilitate soil drenching, blunt pointed prongs are attached to spray nozzle heads. These are used to make 2 to 3-inch deep reservoirs for depositing spray in the soil around root-crowns of ribes. (Blister Rust Control, U. S. Forest Service, Region One.)

Possibilities for controlling ribes and sod-forming plants simultaneously with spray by combining 2,4,5-T and Dalapon. Moss, V. D. Before ribes control is established on prescribed broadcast burns - a prerequisite for planting western white pine - sodding of grasses, sedges, and rushes often makes planting costly and difficult. The interval between burning and planting usually varies from three to five years. From two to three years after burning are required for completion of ribes seed germination before spraying. Another one or two-year period is necessary for removal of any surviving ribes by hand pulling methods before planting western white pine.

Previous research has failed to uncover an effective and economical herbicide for sod control that could be simultaneously applied with 2,4,5-T in establishing ribes control. In 1954, 2,2-dichloropropionic acid (Dalapon), a 78 percent sodium salt containing an anionic wetting agent, was supplied by the Dow Chemical Company for experimental sod control tests on forest lands. Plots 1/10-acre in size were established in the Kaniksu National Forest on a densely sodded clearcut and burned area which included most of the principle sod-forming plants of the white pine type. Volume of spray per acre was 200 gallons, an amount normally applied in spraying ribes with 2,4,5-T. Spray dates, Dalapon dosage rates, and percent frequencies of grasses and forbs before and one year after spraying are shown in the table below.

Frequency of grasses and forbs before and one year after spraying with Dalapon 1/.

Spray dates	lbs a.e./A	Percent frequency			
		Before spraying		One year after spraying	
		Grasses 2/	Forbs	Grasses	Forbs
June 14 and 15	20	80.5	14.0	14.5	30.0
	16	63.5	32.0	22.0	40.5
	12	73.5	20.5	34.5	35.0
	8	78.5	14.5	44.5	33.0
	4	82.0	11.0	39.0	53.0
	check	76.5	17.5	76.5	16.0
July 20 and 21	20	84.5	11.0	49.0	31.0
	16	72.0	19.5	58.5	28.5
	12	64.5	27.0	53.0	32.5
	8	68.0	17.5	54.5	32.0
	4	74.0	13.5	58.0	34.0
	check	69.0	25.5	69.5	26.5

1/ Frequency of grasses and forbs was determined by wire-loop (3/4-inch dia.) counts at each link and relates to the number of link loops occupied in relation to the number of total links (200) in two 1-chain permanent sample strips in each 1/10-acre plot.
2/ Includes grasses, sedges, and rushes.

To study survival and growth, plots were each planted with 100 3-year-old western white pine seedlings on May 24 and 25, 1955. Most desirable conditions for planting were obtained by the mid-June Dalapon dosages of 12 pounds or more, acid equivalent per acre. A uniform kill and rapid deterioration of roots facilitated operating the hand planting tool and tamping of soil about seedlings. New seedlings accounted for most of regrowth. Predominant grasses included (Agrostis alba & scabra), (Poa palustris), (Phleum pratense), and (Agropyron repens). In the western white pine type, Dalapon should be applied in May and June when weather is cool and soil is moist. (Blister Rust Control, U. S. Forest Service, Region One.)

Additional results from herbicide tests on ribes in California. Quick, C. R., and Burrill, W. S. Treatments of Ribes roezli Regel, the Sierra Nevada gooseberry, made in June, 1952 with CMU (now "Karmex") at rates of 256 and 128 pounds/acre show 100% kill (1955). Treatments made in September 1952 show 100% kill for the 256 pounds/acre rate, but not for the 128 pounds/acre rate. The kill from lesser dosages (64, 32, 16, and 8 pounds/acre) taper off rather consistently.

Sixteen foliage-spray tests with a brush-killer mixture containing butoxyethanol esters of 2,4-D and 2,4,5-T (Weedone BK-64) in a 2:1 ratio, respectively, were started in June, 1954. Old, decadent Ribes roezli were treated on Mooreville Ridge, Plumas National Forest. Concentrations of 300, 500, 800, and 1200 ppm a.e. were tested. One percent by volume of diesel oil, summer spray oil, and an experimental emulsive oil were added as amendments to the aqueous spray solution. A control in which no oil was used was included. The addition of diesel oil and summer spray oil appeared to be generally desirable. The best kill (83 percent) was obtained with the treatment using 300 ppm a.e. and the addition of one percent diesel oil.

An experiment established in June, 1954 tested various amendments to aqueous foliage sprays. A sodium salt was used in all cases at concentrations 200, 300, 500, and 800 ppm a.e. Eight to ten-year-old gooseberries were treated on Woods Ridge, Stanislaus National Forest, California. The average percentage of plant kill for the four concentrations was as follows:

Amendment	Percent plant kill
None	91.9
1 percent cottonseed cooking oil (plus enough multifilm-L to effect emulsification)	92.3
1 percent emulsive spray oil	90.3
3 gm/gal Titanox A-WD (paint pigment marker)	85.4
1 percent Multifilm-L	66.7

The mean plant kill of the last two items was lowered by poor results from the 200 ppm tests.

An acid formulation of 2,4-D (Weedone 638) was applied in June, 1954 and again in August, 1954 at the same four concentrations listed for the sodium salt tests. No amendments were added. Average plant kill was 97.1 percent for the June application and 87.5 percent for the August application.

A formulation of 2,4,5-T propionic acid ("Kuron"), without amendment, applied on Woods Ridge in June 1954 at 200, 300, 500, and 800 ppm a.e. killed all gooseberries, but in August killed none at 300 and 500 ppm. Plant kill in August from the 800 ppm spray was 10%, and from the 1200 ppm spray, 50%. Perhaps the seasonal effect of 2,4,5-TP on Ribes roezli is more marked than that of 2,4-D or 2,4,5-T.

Small, dry pellets of industrial clay impregnated with the volatile methyl ester of 2,4-D successfully killed 8-year-old gooseberries on Woods Ridge when applied at rates of 20 to 36 grams a.e. 2,4-D per bush.

A block of 10 basal-stem tests, started in early September, 1954 on the Plumas N.F., compared isopropyl-ester and butoxyethanol-ester formulations of 2,4-D and 2,4,5-T, and mixtures of the two. All test solutions were diluted with Diesel oil, and all contained 2.5% total a.e. Proportions in the mixed formulations (2,4-D:2,4,5-T) were 2:1, 1:1, and 1:2. No noteworthy differences in results could be ascribed to formulation. The 2:1 treatment was the only one which gave 100% kill. Differences in kill between the various proportions of 2,4-D and 2,4,5-T, however, were relatively small.

Some 230 new plots were initiated on ribes in 1955. (Forest Service, U. S. D. A., Berkeley, California.)

PROJECT 4. ANNUAL WEEDS IN CEREALS AND FORAGE CROPS

William O. Lee, Project Leader

SUMMARY

Eight individual reports were received from seven investigators doing research work in five different states. Of the eight reports received, five were concerned with weed control in cereal grains, two with control in forage crops, and one with crabgrass control in lawns.

Cereal Grains

In work reported from Montana eight substituted phenoxy (acetic and butyric) acid compounds and amino triazole were tested on Park oats. Two rates of application were made at the boot stage. Weeds were effectively controlled by all chemicals tested except the sodium salt of MCP and amino triazole. Significant yield reductions occurred from the 2,4-D ester formulations and some amino triazole rates.

In work reported from Washington, three volumes of application and five carriers were compared in applying 2,4-D to winter wheat. No significant differences among treatments were found for weed control or injury to the wheat. There were highly significant differences in weed control between the untreated check and all treatments. In another test two carriers were used in applying 2,4-D at three stages of wheat development. Results showed highly significant differences in wheat yield attributed to stage of development at the time of treatment. In this test the carrier used also caused significant differences in wheat yield.

In other work reported from Washington, 18 herbicidal materials were compared in two separate tests for control of gromwell in winter wheat. In both of these experiments it was found that various 2,4-D esters were more effective in controlling gromwell than any other 2,4-D formulation or related compound tested. Yields of winter wheat were not affected by any of the compounds tested.

Wyoming reported that combined treatments of Dalapon and 2,4-D gave satisfactory chemical weed control in wheat fallow. Water intake on the chemical fallowed land was much greater than on mechanical fallowed land when tests were conducted with a truck mounted infiltrometer.

Work reported from Oregon showed that trichlorobenzoic acid and various urea compounds gave weed control in field corn which was equal to or better than standard treatments now recommended. There was no reported injury to the corn at the rates necessary for weed control.

Grasses

Nine commercial crabgrass killers were evaluated in Colorado tests for control of crabgrass in bluegrass lawns. Each chemical was applied according to manufacturers recommendations. Of the materials tested disodium methyl arsonate (Weedone LD-850) gave the best results with the other chemicals giving a lesser degree of control. In all cases, results were better when the herbicide was used in combination with nitrogen fertilizer. Also tested was the ability of several grass species to resist infestation by crabgrass. Annual bluegrass proved to be the most resistant to invasion.

Oregon reported that under their conditions 3-(3,4-dichlorophenyl) -1, 1-dimethylurea (Karmex DW) shows considerable promise for control of annual weeds, both broadleaved and grasses growing in seedling year, Alta fescue, creeping red fescue, and Merion bluegrass seed crops. When applied at rates of two to three pounds per acre, this chemical gave weed control better than the standard IPC or CIPC treatment now in use with much less injury to the grass crop.

Legumes

Karmex DW, Dalapon, and MCP appear to have promise for control of weeds in established stands of <u>Lotus corniculatus</u>. In work conducted in Oregon, Karmex DW controlled seedling broadleaved weeds and grasses, Dalapon controlled perennial and annual grasses, and MCP controlled all broadleaved weeds. Thus, a combination of these chemicals might be used to handle any weed problem that develops. None of the chemicals caused permanent injury to the lotus.

The effect of various herbicides on Park oats. Baker, Laurence O. Several substituted phenoxy (acetic and butyric) compounds and amino triazole (3-amino-1,2,4-triazole) were tested on Park oats at two rates applied at the early boot stage. At the time of application growing conditions were ideal. Water was used as the carrier at a rate of 20 gallons per acre. Treatments were applied to four replications in a randomized block design.

The area was relatively free from weeds. Of the weeds present, rough pigweed was the predominant species. Weeds were controlled effectively by all 2,4-D and MCP formulations except for MCP sodium salt and amino triazole, which were less effective.

Significant yield reductions occurred only from the 2,4-D ester formulations and from certain of the amino triazole rates. Treatments and average yield results follow:

Treatment	Rate (pounds)	Yield (bushels)
Check (hand weeded)	----	119.9
ACP-L-898 2,4-D amine	.38	114.6
2,4-D alkanol amine	.5	124.6
2,4-D isopropyl ester	.5	85.1
2,4-D butoxy ethanol ester	.5	94.8
MCP sodium salt	.5	118.4
MCPB* sodium salt	.5	121.3
MCP amine	.5	118.4
MCP butoxy ethanol ester	.5	116.6
ACP-L-898 2,4-D amine	.56	106.8
2,4-D alkanol amine	.75	120.4
2,4-D isopropyl ester	.75	68.9
2,4-D butoxy ethanol ester	.75	80.7
MCP sodium salt	.75	125.2
MCPB* sodium salt	.75	124.6
MCP amine	.75	127.1
MCP butoxy ethanol ester	.75	126.0
Amino triazole**	.5	95.6
Amino triazole	1.0	107.7
Amino triazole	1.5	104.6
Amino triazole, liquid formulation	.5	97.2
Amino triazole, liquid formulation	1.0	114.7

LSD (P_{05}) ...17.8 bushels, $s_{\bar{x}}$ = 12.9 bushels, C. V. = 11.7 percent

* 2-methyl-4-chlorophenoxybutyric acid

** 3-amino-1,2,4-triazole

Amino triazole caused a burning of the top leaves shortly after application. This effect was noticeable for several days, but eventually it disappeared, however, yield was slightly reduced. (Montana Agricultural Experiment Station, Bozeman)

Low volume application of 2,4-D spray in various carriers for the control of weeds in wheat. Probandt, George F., and Rasmussen, Lowell W. The object of this study was to determine the relationship of 2,4-D spray volumes and carriers to herbicidal action and selectivity.

The volumes used in this study were one, three, and five gallons per acre. The carriers used were water, diesel oil, water plus urea, water plus sugar, and water plus multifilm L. Urea was used as an additive for the beneficial effect of its nitrogen, the sugar in an effort to increase the effectiveness of the 2,4-D and the multifilm L to reduce the surface tension. A low volatile ester of 2,4-D was used at the rate of 3/4 pound per acre in all the field tests.

Treatments were applied with a hydro-pneumatic plot sprayer using 30 pounds per square inch pressure for the water carriers and 20 pounds per square inch for the diesel oil. Application of the specific volumes was achieved by varying nozzle tips and the speed of travel.

In one experiment all five carriers were applied at the three volumes. Also included was a check treatment on which no 2,4-D was applied. The plot size was 10 x 30 feet. This experiment (test A) was laid out in two locations, one a weed free field of winter wheat on the college farm and the other in a winter wheat field near Rockford, Washington, having a uniform infestation of gromwell (*Lithospermum arvense*). In both areas the 16 treatments were randomized and replicated three times. At the Rockford location, weed counts were made five weeks and eight weeks after treatment. Samples of the weeds in each plot were taken for hydration ratio determinations. The plots were harvested on August 10, and yield and plant heights were recorded. At Pullman, hydration ratios and respiration rates were determined on the wheat plants starting one week after treatment and discontinuing six weeks after treatment. Yield and plant heights were recorded on August 19.

A second experiment (test B) was designed to test the effect of two carriers applied at three stages of wheat development. The carriers were water and diesel oil, and they were applied at one, three, and five gallons per acre. Stages of wheat development at treatment time were stooling, stemming, and boot. The experiment was designed as a split plot in which the stages of growth were the main plots, the carriers the sub-plots, and the volumes the sub-sub-plots. The main plots were replicated six times. Yield and plant heights were recorded on August 19.

In the A test, there was no significant difference among the treatments, including the control, in either yield or plant height. There was a highly significant difference in weed control between the check plot and all treatments, but no significant difference in weed control among treatments. There was no significant difference in hydration ratios or respiration rates. The competition between the gromwell and the wheat was not severe enough to result in an increased wheat yield when the weeds were controlled.

In the B test, there was a highly significant difference in wheat yield attributed to stage of development at spraying. When the wheat was sprayed in the stooling stage the yield was 65.8 bushels/acre, when sprayed in the stemming stage 48.5 bushels/acre and when sprayed in the boot stage 56.4 bushels/acre. When diesel oil was used as the carrier, the yield of wheat was 54.8 bushels/acre. When water was used as the carrier, the yield of wheat was 59.0 bushels/acre. This was a significant difference. There was no significant difference among volumes. In all tests the five gallon volume of diesel oil caused noticeable burning of the wheat.

At present, greenhouse experiments are in progress to study further the effect of low volume application of 2,4-D in relation to herbicidal effect. (Washington Agricultural Experiment Station)

The performance of several growth regulating type herbicides for the control of gromwell in winter wheat. Rasmussen, L. W. An evaluation of growth regulating type herbicidal compounds for the control of annual weeds in wheat is essential to answering the questions of users. It also provides information relative to compound effectiveness frequently useful to manufacturers in determining uses and limitations for materials. Each year 10 to 15 compounds were included in the tests which have been carried out in wheat fields infested with gromwell (*Lithospermum arvense*). This weed species is somewhat resistant to 2,4-D and shows distinct differences in response to compounds. Some materials cause good kills while many compounds fail to produce measurable killing effects.

In 1955 ten materials at rates of one-half and one pound per acre were included in one test. A second test included eight materials at one-half and one pound per acre rates. The materials were each applied as a water spray using a plot sprayer with a 12-foot boom, operated at 30 pounds per square inch, and at a speed of four feet per second. The plots were 12 x 20 feet in size and the spraying was accomplished by one pass over a plot. All treatments were replicated three times.

The criteria of effectiveness included a visual rating of response about one month after treatment, a second rating about two months after treatment, at which time also weed coverage estimates were made; finally wheat yield was determined by harvesting samples from each plot.

The ten materials in the one test included three low volatile esters of 2,4-D, an acid formulation of 2,4-D, and three amines of 2,4-D plus the 2,4-D isopropyl ester for reference. Two of the amines were applied both with and without a non-ionic surfactant additive. By all criteria used, the differences among the three low volatile esters were non-significant. The difference between the performance of these low volatile esters and the isopropyl ester was non-significant.

The acid formulation was much less effective than the esters for the control of gromwell. The amines also were much less effective than the esters and no advantage was measurable for the addition of the surfactant.

The other test included the sodium salt of 2,4-D, a 2,4-dichlorophenoxybutyric acid formulation, a 2-methyl, 4-chlorophenoxybutyric acid formulation, and 2,3,6-trichlorobenzoic acid and its sodium salt formulations plus the isopropyl ester of 2,4-D for reference. None of these materials except the isopropyl ester of 2,4-D gave satisfactory control of gromwell. Under the prevailing environmental conditions the yield of wheat was not affected by any of the materials regardless of weed control. The trichlorobenzoic materials caused a reduction in wheat plant height of three to six inches but did not reduce the yield, compared to 2,4-D isopropyl ester. (Washington Agricultural Experiment Station)

Dalapon and 2,4-D for chemical fallow. Alley, Harold P. An experiment was initiated in 1954 and enlarged in 1955 to determine the effect of chemical summer fallow upon water intake and retention as compared to mechanical fallowed land. In 1955 comparisons were made on 1/10-acre plots at the Sheridan Agricultural Substation, whereas in 1955, 5-acre plots were established in cooperation with wheat growers in the southeastern part of Wyoming.

Dalapon (sodium 2,2-dichloropropionate) was applied at the rate of five pounds acid per acre in early spring (1954-1955) to control the grassy weeds. 2,4-D ester was applied at 3/4 pound per acre three times during the 1954 season and at 3/4, 1, 1-1/2, and 2 pounds as initial application in 1955 for broadleaved weed control. The grassy weeds consisted of mainly foxtail grass (Setaria spp), barnyard grass (Echinochloa crusgalli), cheatgrass (Bromus tectorum), and volunteer wheat. The broadleaved weeds were rough pigweed (Rumex crispur), kochia (Kochia scoparia), and Russian thistle (Salsoli kali).

A truck mounted infiltrometer was used to determine the ability of the soil to take up water under simulated rain of approximately 2.5 inches per hour. Moisture samples were taken to determine the amount of moisture in chemical fallowed land as compared to mechanical fallowed.

Plots in southeastern Wyoming indicate that Dalapon at five pounds per acre and 2,4-D at 3/4 pound per acre effectively controlled the weeds present at the time of the initial application. Additional treatments of one pound of 2,4-D appear necessary to control weeds emerging later in the season. No additional Dalapon need be applied for grass control if the chemical is applied early in the season when the volunteer winter wheat and cheatgrass plants are seedlings. 1955 test plots using Dalapon at five pounds and 2,4-D at two pounds acid per acre as initial application appeared more satisfactory than lower rates of 2,4-D and one application proved sufficient for the entire season for broadleaved weed control. Water intake from 1954 data showed that chemical fallowed land took in over twice as much water during the second 30 minutes of an hour run as the mechanical cultivated land. Moisture samples in all areas in 1955 indicated that there was very little difference in the amount of moisture in the chemical summer fallow plots compared to those that had been clean cultivated. (Wyoming Agricultural Experiment Station)

The use of substituted urea herbicides and trichlorobenzoic acid in comparison to dinitro amine and 2,4-D amine for weed control in field corn. Chilcote, D. O., and Furtick, W. R. The sodium salt of 2,3,6-trichlorobenzoic acid and urea compounds, Karmex W ((3-(p-chlorophenyl)-1, 1-dimethylurea)) and Karmex DW ((3-(3,4 dichlorophenyl)-1, 1-dimethylurea)), gave favorable weed control when compared with the standard weed control treatments for field corn. Results of a trial initiated in the spring of 1955 showed that these two compounds gave excellent weed control as compared to dinitro (alkanolamine salts of dinitro-o-secondary butyl phenol) and 2,4-D (2,4-dichlorophenoxyacetic acid) amine. The trial was established on an irrigated sandy loam soil. Plantings of corn were made May 14. The corn was planted in hills with rows forty inches apart. Pre-emergence applications were made May 16, with postemergence applications applied on July 14, 1955. The first irrigation was made on June 20. Before this time rainfall had occurred in small amounts. Ratings were made June 29, 1955, on crop injury and percent weed control. Results indicated the one, two, and three-pound rates of trichlorobenzoic acid were more effective than 2,4-D or dinitro amine for pre-emergence weed control. Indications were that the residual life was much longer for trichlorobenzoic acid. The three-pound rate gave almost complete control. The urea compounds, Karmex W and Karmex DW, were applied at one, two, and three pounds per acre. Indications were that Karmex W was more effective for selective weed control in field corn. It appeared that the three-pound per acre rate was necessary for adequate weed control under conditions of this trial. The lower rates were partially effective but did not compare with dinitro amine for weed control. The three-pound per acre rate was much more effective and gave a longer residual life than dinitro amine. Benzoic acid appears highly promising for selective pre-emergence weed control in field corn. Yield data indicated none of these materials reduced yield.

Post emergence applications of trichlorobenzoic acid were compared with 2,4-D amine. In this test it appeared that benzoic acid was not as effective a post emergence treatment as 2,4-D. (Oregon Agricultural Experiment Station)

Results of crabgrass control experiments, 1955 season. Fults, Jess L. Nine chemicals were evaluated for the control of smooth crabgrass (Digitaria ischaemum) in bluegrass lawns at Fort Collins. Rates used were manufacturers' recommendations. A single application of chemical was made. Results indicated that all chemicals tested gave some degree of control. In their ability to reduce crabgrass populations the chemicals ranked as follows: disodium methyl arsenate (Weedone LD-850); 3-(3,4-dichlorophenyl)-1-methyl-1-n-butylurea (Du Pont Pre-emergence Crabgrass Killer No. 1); chlordane (Manco crabgrass killer); potassium cyanate (Weedone KOCN); phenyl mercuric acetate (Tat-C-Lect); lead arsenate and fertilizer (PAX); N-1-naphthyl phthalamic (Alanap 1-F); sodium 2,4-dichlorophenoxy ethyl sulfate (Crag No. 1); and 2,4-dichlorophenoxy ethyl benzoate (Sesin). In all cases better results were secured as far as improvement of the bluegrass turf where the herbicide application was used in combination with a nitrogen fertilizer (ammonium sulfate or ammonium nitrate) at a rate of one pound of "N" per 1000 feet applied in early May and early September.

Tests of the resistance of several kinds of pure grass species to invasion by smooth crabgrass were made. Ranked in the order of their resistance were annual bluegrass, seaside bent, Merion bluegrass, Kentucky bluegrass, perennial ryegrass, native ryegrass, chewings fescue, red fescue, and buffalo grass (year-old spaced sods).

In cooperation with the Velsicol Corporation of Chicago, Illinois, a number of fractions of agricultural grade chlordane have been compared with pure crystalline chlordane and certain of its isomers and other pure related compounds for crabgrass control. Results secured by closely controlled greenhouse tests and by paper chromatographic analysis have been very promising. It is definitely known that the selective action of the agricultural grade chlordane is due to an impurity and not the chlordane itself. Positive clues as to the nature of the impurity have been secured and are being further tested. (Colorado Agricultural Experiment Station)

Winter weed control in seedling year stands of Alta fescue, creeping red fescue, and Merion bluegrass. Furtick, W. R. and Chilcote, D. O. One of the major problems in the production of forage and turf grass seed is the encroachment of weedy annual grasses and various broadleaved types that produce seed which contaminates the seed marketed from the forage or turf crop. This problem is unusually serious in areas with mild winters where weed growth can continue throughout the year. The standard commercial practice used by grass seed crop growers in western Oregon has been to treat the fields in October with IPC or Chloro IPC. This treatment does not control broadleaved type weeds and has a narrow safety margin on the grass seed crops. An additional disadvantage is that seedling year stands are injured by these chemicals.

Previous work indicated the urea herbicides were promising for controlling weeds selectively in established stands of the various grass seed crops grown in Oregon. In order to determine the tolerance of seedling year stands, trials were established in the fall of 1954 on row stands of Merion bluegrass, Alta fescue, and creeping red fescue planted in May. Each of these grass seed crops were treated with IPC (isopropyl N-phenyl carbamate) at the rates of three, four, and five pounds per acre; Chloro IPC ((isopropyl N-(3-chlorophenyl) carbamate)) at the rates of two, three, and four pounds per acre; Karmex W ((3-(p-chlorophenyl)-1, 1-dimethylurea)) at the rates of two, three, and four pounds per acre; and Karmex DW ((3-(3,4-dichlorophenyl) -1, 1-dimethylurea)) at the rates of two, three, and four pounds per acre. These treatments were made October 29, 1954. All of these treatments gave complete control of weedy annual grasses, primarily ryegrass (Lolium multiflorum) and rattail fescue (Festuca myuros). The urea herbicides also gave complete control of broadleaved type weeds, primarily groundsel (Senecio vulgaris). The check plots were extremely weedy, even though they were cultivated prior to the application of the herbicides in October and were again cultivated the early part of April, 1955. The area in the row was so weedy that it was impossible to obtain seed yield from Merion bluegrass check plots. The harvested seed from the creeping red fescue, even after thorough cleaning, contained nearly fifty percent weed seeds. The Alta fescue was tall enough that it was not seriously affected from competition by the weedy grasses. However, purity determination on the seed from the check plots indicated twelve to fifteen percent weed seeds even after cleaning. All rates of IPC and Chloro IPC seriously reduced the seed yield and stand of all three grasses. The seed yield was reduced over fifty percent in all cases. The high rates of these two compounds eliminated seed yield and nearly killed the stands completely.

Karmex W was more injurious than Karmex DW on all three grass species. Yield was reduced only at the four-pound rate of Karmex W on Alta fescue and this was only approximately fifteen percent. Both materials appeared to be about equally injurious to creeping red fescue. The two-pound rates did not give sizable seed yield reduction on a pure seed basis. The reduction was approximately twenty percent with both materials. The higher rates seriously reduced yield.

Yield data was not collected from the Merion bluegrass due to lack of uniformity in stand; however, there was no detectable injury from Karmex DW at the two and three pound rates, and only slight injury at the four pound rate. Compared to Karmex DW, the seed yield on the Karmex W treated plots appeared to be reduced approximately fifty percent. Excellent stands and seed set resulted where two and three pound rates of Karmex DW were used. The check plots were so weedy that the Merion bluegrass was almost completely smothered out. Because of the excellent weed control obtained even at the two pound rate it would appear profitable to explore the use of Karmex DW at lower rates. This material would appear promising for weed control in seedling stands of Merion bluegrass and Alta fescue and at lower rates for weed control on creeping red fescue. (Oregon Agricultural Experiment Station)

<u>Weed control in established Granger Lotus</u>. Furtick, W.R., and Chilcote, D. O. A three year old stand of Granger strain of <u>Lotus corniculatus</u> was sprayed March 18, 1955, with Karmex DW ((3-(3,4-dichlorophenyl)-1, 1-dimethylurea)) at the rates of one, two, and three pounds per acre; Dalapon (2,2-dichloropropionic acid) at the rates of four, six, and eight pounds per acre; trichloropropionic acid at the rates of four, six, and eight pounds per acre; and sodium MCP (2-methyl-4-chlorophenoxyacetic acid) at the rates of three-fourths and one pound per acre. The stand of lotus was heavily infested with hawksbeard (<u>Crepis capillaris</u>), bull thistle (<u>Cirsium lanceolatum</u>), rattail fescue (<u>Festuca myuros</u>), ripgut brome (<u>Bromus rigidus</u>), and velvet grass (<u>Holcus lanatus</u>). The lotus was starting spring growth and was about three inches tall at the time applications were made. The two and three pound rates of Karmex DW effectively controlled the hawksbeard, rat's-tail fescue, and velvet grass. It was not effective on the ripgut brome and bull thistle. Dalapon effectively controlled all of the grass species but was ineffective on bull thistle and hawksbeard. The trichloropropionic acid did not have any measurable effect on the weed species present. MCP effectively controlled both the hawksbeard and the bull thistle. None of these materials gave any detectable injury to the lotus other than a slight distortion from the MCP for a few weeks after treatment.

Karmex DW would appear to be an effective means of controlling both seedling grasses and broadleaved weeds. Dalapon would appear to be effective for controlling both perennial and annual grasses and MCP appears to be an effective means for controlling broadleaved weeds selectively in lotus. Trichloropropionic acid does not appear to be effective under cool spring conditions. (Oregon Agricultural Experiment Station)

PROJECT 5. WEEDS IN FRUITS, VEGETABLES, AND ROW CROPS

E. R. Laning, Jr., Project Leader

SUMMARY

General

Greenhouse evaluation tests have indicated that some of the newer chemicals, CDAA, CDEC, and CDEA, compared favorably in the control of watergrass and pigweed with such herbicides as CIPC, DCMU, and 2,4-D. Evidence of selectivity toward cotton, rice, and sugar beets was found for these materials depending on time and rate of application.

In crops known to be quite sensitive to the plant growth regulator type herbicides morning glory has been controlled with 2,4-D through the practice of using shielded sprayers. Small shields protect the crop while canvas drapes prevent drift of the 2,4-D. The object of this practice is to eventually control morning glory rather than an attempt to eradicate it immediately.

Vegetables

Pre-emergence herbicidal applications in table or red beets, cantaloupes, onions, and green peas indicate promise of effective weed control in these crops. Post-emergence treatments were not reported.

In one experimental trial NaTCA did not reduce beet stand but did reduce total yield while the opposite was true of another test. Endothal did not live up to expectations as a herbicidal agent. Dalapon appeared to provide adequate weed control without causing a reduction in table beet yield.

In cantaloupes the sodium salt formulation of Alanap effectively controlled the broadleaf weeds under study without injury to crop stand. Yield data were not obtained nor were grasses a problem in this experiment.

Treatment of the soil surface with Stoddard Solvent, KOCN, DNOSBP @ 2 ppa, and CIPC @ 2 ppa prior to transplanting onions which were started in the greenhouse resulted in no injury to the crop stand or yield. Higher rates of DNOSBP and CIPC as well as all rates of CMU and NaTCA tested reduced stand and yield.

Green pea yield was severely reduced by Alanap and 2,4-D, and slightly lowered by CIPC. DNOSBP, KOCN, or IPC did not influence yields.

Fruits

Considerable promise was found for the utilization of low rates of CMU and DCMU in black and red raspberries for the control of annual grasses and broadleaf weeds. Higher rates which in part at least control quackgrass did not cause injury to the cane berries in sufficient degree to reduce yields during the year after treatment.

Some degree of variation in degree of tolerance to high rates of Dalapon is shown by different grape varieties. Low rates in split applications seemed to do a better job of controlling Johnson grass than did the usual oil application. At the lower rates more selectivity is obtained.

Field Crops

Field beans were treated with pre-emergence applications of several chemicals after which a crust breaker was used to incorporate the materials into the moist soil under the surface. Satisfactory weed control was obtained with CDAA, CDEA, Alanap, and CIPC without injury to the beans. CMU, DCMU, and Geigy 444E caused severe injury while producing good control of the weeds. Post-emergence treatments with four chlorophenoxy butyric acids gave evidence of being more selective than 2,4-D toward field beans. The sodium and amine salts of 4(MCPB) gave the best results.

Under conditions of a moist soil surface pre-emergence applications of CIPC, Alanap, DCMU, and CMU produced effective watergrass control in cotton without discernible injury to the crop.

Although various methods of cultivation and other cultural practices were utilized to advantage, it was indicated that some herbicides are more effective and economical as post-emergence treatments than are other means of weed control. It appears that from the time of the first irrigation until "layby" applications of CMU, DCMU, or Alanap do a good job of controlling weeds if moisture at the soil surface is available at or soon after treatment. CMU usually causes more temporary chlorosis than does DCMU, but at low rates neither seems to permanently injure the cotton. Generally an application sometime later than the first irrigation is needed to carry the weed control through to the end of the season.

Generally Dalapon as a pre-emergence treatment does not have a wide enough safety factor for use on sugar beets. As a post-emergence application considerable promise is shown in some instances and a lack of safety range is in evidence in other tests.

Lawns

Excellent crabgrass control in Bermuda grass lawns was obtained through the use of low rates of CMU and DCMU. Temporary chlorosis was followed by full recovery of the Bermuda grass.

Greenhouse evaluation of herbicides applied as pre-emergence sprays to crops and weeds. Sheets, T. J., and Crafts, A. S. This test was conducted during August and September of 1955. One row each of four crop plants including cotton (Gossypium hirsutum L., Acala), rice (Oryza sativa L.), alfalfa (Medicago sativa L.), and sugar beets (Beta vulgaris L.) were seeded per flat. Watergrass (Echinochloa crusgalli L.) was broadcast over one half of the flat and rough pigweed (Amaranthus retroflexus L.) over the other half. All seeds were covered with one half inch of soil (fine sandy loam), and the spray solutions applied to the soil surface immediately following planting.

Three herbicides, CDAA (alpha-chloro-N,N-diallylacetamide), CDEA (alpha-chloro-N,N-diethylacetamide), and CDEC (2-chloroallyl diethyldithiocarbamate) were each applied at 2, 4, and 8 pounds of the active ingredient per acre. For comparative purposes 2 pounds per acre of 2,4-D (2,4-dichlorophenoxyacetic acid, alkanolamine salts formulation), 6 pounds per acre of CIPC (isopropyl-N-(3-chlorophenyl)carbamate), and 1.5 pounds per acre of DCMU (3-(3,4-dichlorophenyl)-1,1-dimethylurea) were included. There were 3 replications.

The flats were sub-irrigated immediately following treatment. Additional water was supplied by this method throughout the course of the test. Approximately one month after treatment general vigor ratings, plant counts, and height measurements were taken on all treatments. The flats were discarded following these recordings.

Marked selectivity was exhibited in this test by CDAA, CDEA, and CDEC. Although CIPC reduced the counts and the vigor of watergrass more than any other herbicide used, the highest two rates of CDAA, CDEA, and CDEC also greatly reduced the vigor and counts of this plant. CDAA and CDEC at 8 pounds per acre were only slightly less effective than CIPC.

Some reduction in number of pigweed plants was produced by all treatments. DCMU and the high rate of CDEC were most effective, giving almost complete control. CDEC at 2 pounds per acre was slightly less effective than the same rate of 2,4-D; the 4-pound rate of CDEC was more effective.

Cotton apparently was not injured by any of the chemicals. Rice was tolerant to all of the materials with the exception of 2,4-D, the 4- and 8-pound rates of CDEA, and the 8-pound rate of CDAA; these treatments reduced plant counts slightly. Thus watergrass was almost completely eliminated by CIPC and the high rate of CDEC; rice was tolerant to these treatments. A similar test conducted earlier gave the same results with the exception that some injury to rice appeared following emergence at the 8-pound rate of CDEC and CDEA; however, counts were not reduced.

Alfalfa and sugar beets were injured by most treatments. Alfalfa appeared tolerant to the low rate of CDEA; sugar beets to the low rates of CDEA and CDEC. (Field Crops Research Branch, ARS, USDA, and California Agricultural Experiment Station, cooperating)

Control of morning-glory in lima beans and other crops. Stevenson, E. E. The shielded-spray method of applying 2,4-D to control morning-glory in beans and other row crops continues to give satisfactory weed control with a minimum of damage to the crop being treated and practically none to nearby crops. This practice has been used by local lima bean growers for the past eight or nine years and is now spreading to other crops and into other areas of California. In addition to lima beans, crops which have been treated successfully are red kidney, pink, blackeye, and string beans (all of which are more sensitive to 2,4-D than lima varieties), row-planted alfalfa (for seed), roses, and various flower crops.

Most local growers have continued to use from one to one and one half pounds of an amine formulation of 2,4-D in 10 to 20 gallons of water per acre. In other areas, MCP has been used because of the greater safety provided for both the crop being treated and adjoining crops.

Cultural and seeding operations are scheduled to provide maximum growth of morning-glory when the bean plants are two to four inches tall, at which time the single application is made. (A few farmers use a pre-planting treatment prior to this application.) The crop is protected by "shields" or inverted troughs about six inches wide and six or eight inches high. The area between the plant rows is sprayed with a boom arrangement which is enclosed with canvas drapes to prevent spray drift. The spray boom covers four rows at a time and is mounted on the tractor tool bar.

Results

Most morning-glory plants are not "killed" by one application, though the tops die back in a few weeks. By the time new shoots are sent up, the plants have covered the ground and the weeds remain spindly, causing little or no trouble with cultivating or harvesting. After several years of treatment, morning-glory patches have been thinned out considerably.

An evaluation of this treatment shows that:

1. The spread of morning-glory has been stopped.

2. Yields which were quite low have jumped back to normal.

3. Costly and bothersome cultural controls have been eliminated.

4. Harvesting has been made easier and cheaper.

5. Spraying has been very reasonable (materials $1.00-$1.75/A and application cost about $1.00-$1.50/A).

6. 2,4-D breaks down in a few weeks in warm, moist soils so no injurious residues will be left for future crops.

Tolerance of red beets to herbicides applied as pre-emergence sprays. Barnard, E. E. Perfected Detroit red beets were planted in a silt loam soil on June 13, 1955, and on June 15 the following pre-emergence sprays were applied: IPC, CIPC, and Dalapon, all at 2, 4, and 6 pounds per acre, and TCA at 5 and 10 pounds per acre. All materials were applied in water at 50 gallons per acre under 25 psi. Treatments were replicated three times.

All weeds surviving the treatments were suppressed throughout the test by mechanical cultivation. Soil moisture was maintained by overhead irrigation. Beets were harvested as bunching beets on August 30.

Stands were not affected by any but the CIPC treatments. All plots treated with CIPC showed reductions in stands with the 2-pound rate showing slight reduction, 4-pound rate showing greater and significant reduction, and the 6-pound rate showing greatest and highly significant reduction. Stands of all other treatments approximated the check. However, the stands of the IPC plots showed a trend towards reduction as the rate increased, although not significantly so.

Yields of the check exceeded yields of all treatments. Yields of plots treated with the 2-pound rate of IPC, and both rates of TCA were slightly reduced. Yields of plots treated with Dalapon were more severely reduced. None of the reductions were significant. The 4-pound rate and the 6-pound rate of IPC caused significant reductions and all three of the CIPC rates caused highly significant reductions. At the high rate of CIPC there was a virtual elimination of yields. (Contribution of the Montana Agricultural Experiment Station)

Chemical weed control in table beets. Laning, E. R., Jr. Preliminary trials conducted during the past two years indicated that Endothal or NaTCA may have promise as pre-emergence applications for weed control in table beets.

In 1955 a trial was established using these two materials at rates of 5, 7.5, and 10 pounds per acre on Detroit Dark Red Table Beets. These treatments were made six days after planting and three to four days prior to crop emergence. The soil surface was quite moist at the time of application and a gentle rain fell the following day.

The weeds in the plots were pigweed, lambsquarter, wild turnip, and dead nettle.

During the first two weeks after treatment fair to good weed control was noted in the Endothal plots while good to excellent control was in evidence in the NaTCA plots. No injury could be discerned in the Endothal plots, but considerable injury was noted in all NaTCA plots with the most severe symptoms due to the 10 ppa rate. The weed control effectiveness diminished and many of the injured beets seemed to recover as the season progressed.

Weed control and beet injury ratings were made five weeks after treatment (Table I) after which all plots were cultivated and hoed whenever necessary. The ratings were based on a scale of 0 to 4. A zero rating indicated no weed control or no injury whereas 4.0 indicated complete weed control or complete crop kill.

The table beets were harvested and graded according to the diameter of the individual roots. These data are presented in Table II.

It would appear that the initial control in the treated plots may have given these beets a better start than was obtained by the beets in the control plots thus resulting in higher yields. It is more likely, however, that the stand was reduced more than was apparent when the ratings were made and the beets in the treated plots had more room in which to grow thus producing larger beets which resulted in higher yields. These larger beets are not acceptable for processing in the Willamette Valley of Oregon. (Oregon Agricultural Experiment Station)

Table I. Weed control and table beet injury five weeks after treatment as influenced by pre-emergence herbicidal applications.

Treatment	Rate ppa	Weed Control*	Beet Injury**
Endothal	5.0	0.6	0.2
	7.5	1.8	0.2
	10.0	1.5	0.2
NaTCA	5.0	2.4	1.2
	7.5	2.4	1.5
	10.0	3.2	1.8
Control	-	0.0	0.0

* 0 = no control; 4 = complete control. Average of 5 repl.
** 0 = no injury; 4 = complete kill. Average of 5 repl.

Table II. Table beet yield in pounds per plot as influenced by Endothal and NaTCA as pre-emergence applications.

Treatment	Rate ppa	Diameter of Table Beet Roots 0-1 in.	1-2 in.	2-3 in.	3-4 in.	Total
Endothal	5.0	0.35*	9.70	15.70	9.10	34.85
	7.5	0.30	8.70	19.45	9.85	38.30
	10.0	0.80	10.65	15.75	7.90	35.10
NaTCA	5.0	0.30	8.40	16.55	13.80	39.05
	7.5	0.40	10.00	15.65	10.90	36.95
	10.0	0.30	7.40	17.90	12.95	38.55
Control	-	0.55	10.15	11.10	5.98	27.78

* Average of 5 replicates. Harvested 2 center rows of four 25-foot rows.

Weed control in cantaloupes. Campbell, C. Harvey, Jr. Pre-emergence tests conducted with Alanap-3 (Sodium N-1 naphthyl phthalamate) in open planted cantaloupes have shown to give good to excellent weed control. Weeds controlled include lambsquarter (Chenopodium album), nettleleaf goosefoot (Chenopodium murale), London rocket (Sisymbrium Irio), the most serious annual weeds in cantaloupes. Puncture vine (Tribulus terrestris) is not controlled with this treatment.

Applications of Alanap-3 were made after planting and before irrigation of the beds. Rates of 4, 6, and 8 pounds per acre in 100 gallons of water were used. The material was applied in a 2-foot band over the planted area and the irrigation was continued until the entire treated area was wetted.

Reduction of weed stand in all the treatments was significant at the 1 per cent level. There was no significant difference in stand of cantaloupe seedlings between all treatment rates and the checks. (Imperial County Agricultural Extension Service)

Tolerance of onions to herbicides applied as pre-transplanting sprays. Barnard, E. E. Yellow Sweet Spanish onions were planted in the greenhouse on March 25, 1955. On May 17, the following treatments were applied to a silt loam field plot: DNOSBP and CIPC at 2, 4, and 6 pounds per acre, TCA at 3.5, 5.3, and 7 pounds per acre, KOCN at 10 and 20 pounds per acre, CMU at 1 pound per acre, and stoddard solvent at 40, 60, and 80 gallons per acre. All materials were applied in 50 gallons of water per acre except stoddard solvent which was applied undiluted. All materials were applied at 25 psi and the treatments were replicated four times. On May 19 the onions were transplanted in the plots using ordinary hand transplanting procedures. All weeds surviving the treatments were suppressed throughout the test by mechanical cultivation. Soil moisture was maintained by overhead irrigation. Onions were harvested as dry onions on September 13.

Stands were not affected by stoddard solvent or KOCN at any rate or by the 2-pound rate of DNOSBP or the 2- or 4-pound rates of CIPC. They were reduced by 1 pound of CMU though not significantly, by all rates of TCA significantly, and by the 4- and 6-pound rates of DNOSBP and the 6-pound rate of CIPC highly significantly.

The plots treated with KOCN, stoddard solvent, the 2-pound rate of DNOSBP, and the 2-pound rate of CIPC approximated or exceeded the check as regards yields. Yields of the plots treated with 1 pound of CMU or 4 pounds of CIPC were reduced but not significantly. The 4-pound rate of DNOSBP and the 3.5-and 5.3-pound rates of TCA caused significant reductions. The 6-pound rate of DNOSBP, the 6-pound rate of CIPC, and the 7-pound rate of TCA caused highly significant reductions in yields. (Contribution of the Montana Agricultural Experiment Station)

Tolerance of peas to herbicides applied as pre-emergence sprays. Barnard, E. E. Dark Green Perfection peas were planted in a silt loam soil on June 13, 1955, and on June 15 the following pre-emergence treatments were applied: DNOSBP at 2, 4, 6, 8, and 10 pounds per acre; KOCN at 10, 15, 20, 25, and 30 pounds per acre; IPC and CIPC at 2, 4, and 6 pounds per acre; Alanap at 4, 6, and 8 pounds per acre, and 2,4-D at ½, 1, and 1½ pounds per acre. All materials were applied in water at 50 gallons per acre under 25 psi. Treatments were randomized four times. All weeds surviving the treatments were suppressed throughout the test by mechanical cultivation. Soil moisture was maintained by overhead irrigation. Peas were harvested at the green pod stage on August 17, 25, and 31, after which stand counts of producing plants were made and the planting was abandoned.

Stands were affected only by Alanap which caused slight reductions at all rates. However, no significance is attached to any of the differences in stands.

Yields were adversely affected by the high rates of 2,4-D, and by all rates of Alanap. 2,4-D at the 1-pound rate, caused a significant reduction in yields, and at the $1\frac{1}{2}$-pound rate a highly significant reduction. Alanap caused highly significant reductions at all rates. In fact, it virtually eliminated yields. CIPC showed an increasing tendency to reduce yields as the rate increased. At the 6-pound rate the reduction was almost significant. 2,4-D at the $\frac{1}{2}$-pound rate and DNOSBP, KOCN, and IPC at all rates very closely approximated the check. (Contribution of the Montana Agricultural Experiment Station)

Chemical weed control in cane berries. Bullock, R. M. The Arthur Hansen farm and H. J. Junker farm plots are off-station grower cooperative plots. The materials were applied in February, 1954, to fields which had heavy quack grass and other weeds in the rows. A 3-foot band of row was sprayed in each case although the chemicals are calculated on a blanket coverage rate. The yield data for the Arthur Hansen farm represents the main picking of black raspberries for the 1955 season. The yield data for the Junker farm represents two of the main season pickings of red raspberries for the 1955 season. On the plots from the experiment station plantings the materials were applied in 1955 and the yield data is from the 1955 harvest. Here again only a 3-foot band of row was sprayed. In the yield data average yields are presented on the basis of three replications used and also from replications 2 and 3, since block 1 suffered a serious infestation of symphyllids in part of the block which we feel was the main factor responsible for the low yield in part of that block. In considering only blocks 2 and 3 there is no significant difference in any of the yields. At rates used for DN General, IPC and CIPC are high rates because of a miscalculation at the time of application. These rates are the ones that were actually applied. Weed control in the off-station blocks where there was a heavy infestation of quack grass was very good at the 20-lb. rate of Karmex W and DW and was fairly good to good in the 8-lb. rates of these materials. The other materials had very little effect on quack grass control. All rates of Karmex controlled annual weeds and grasses but did not control perennial broad leaves such as Plantain. In the experiment station plots all annual weeds and grasses were controlled by all rates of Karmex W and DW throughout the summer season. Regrowth of seedling weeds was occurring in plots receiving the $4\frac{1}{2}$-lb. and the $1\frac{1}{2}$-lb. rates of Karmex W and DW by October, 1955. Annual weeds and grasses returned to the DN General, IPC, and CIPC plots during mid-summer. Infestation of quack grass was extremely spotted so that no overall lead can be given for control of this pest. However, the 9-lb. rate of Karmex W and DW and the 15-lb. rates of IPC and CIPC thinned out the quack grass stands where they occurred in these plots. Soil samples were taken to determine the Karmex residue in all Karmex plots. However, data is not available on these analyses at this time. (Southwestern Washington Agricultural Experiment Station)

SOUTHWESTERN WASHINGTON EXPERIMENT STATION

Arthur Hansen Farm, Brush Prairie

Black raspberry plots

Yield data in lbs. per plot - main picking - 1955

Material	Active dosage blanket rate	Treated	Untreated Check
Karmex W	4 lbs.	7	9
Karmex DW	4 lbs.	12	9
3 CIPC	16 lbs.	13	12
Karmex W	8 lbs.	9	13
Karmex DW	8 lbs.	8	4
3 CIPC & oil	16 lbs. + 83 gals.	4	3
Karmex W	20 lbs.	5	7
Karmex DW	20 lbs.	14	8
3 CIPC + DN Gen.	16 lbs. + 5 qts.	5	6

H. J. Junker Farm, Vancouver

Red raspberry plots - 1955

Treated in February, 1954 - total lbs. fruit 2 pickings

Material	Treated			Untreated		
	7-29	8-3	Total	7-29	8-3	Total
Karmex W 4 lbs.	7	4	11	6	4	10
Karmex DW 4 lbs.	6	4	10	8	6	14
Karmex W 8 lbs.	12	8	20	6	5	11
Karmex DW 8 lbs.	10	7	17	9	7	16
Karmex W 20 lbs.	7	7	14	7	5	12
Karmex DW 20 lbs.	9	7	16	7	6	13

SOUTHWESTERN WASHINGTON EXPERIMENT STATION

Weed Control Blocks

Red Raspberries - 1955

Material	Rate of Application Blanket Coverage	Month Applied	Yield tons per acre Block 1	Block 2	Block 3	Av. 3 reps.	Av. 2 reps Blocks 2 & 3
DN General	9 pints	2	4.5	5.5	5.1	5.0	5.3
DN General CIPC	9 pints + 15 lbs.	2	4.6	5.7	5.7	5.3	5.7
DN General IPC	9 pints + 15 lbs.	2	5.4	5.4	5.7	5.5	5.6
Karmex W	4½ lbs.	2	4.7	5.2	5.4	5.1	5.3
Karmex DW	4½ lbs.	2	4.7	4.7	5.0	4.8	4.9
Karmex W	9 lbs.	2	3.8	4.0	5.8	4.5	4.9
Karmex DW	9 lbs.	2	4.7	4.9	5.0	4.9	5.0
Karmex W DN Gen.	4½ lbs. + 9 pints	2	3.8	5.1	5.0	4.6	5.1
Karmex DW DN Gen.	4½ lbs. + 9 pints	2	3.2	5.2	4.4	4.3	4.8
Karmex W	1½ lbs.	4	5.6	4.6	5.2	5.1	4.9
Karmex DW	1½ lbs.	4	2.9	5.0	4.6	4.2	4.8
Karmex W	6 lbs.	4	2.8	5.1	5.2	4.4	5.2
Karmex DW	6 lbs.	4	3.2	5.3	5.3	4.6	5.3
Check	---	-	4.0	5.1	4.7	4.6	4.9

Notes:

1. Karmex dosages based on lbs. product (80% active).
2. IPC and CIPC dosages based on active material.
3. Knapsack pressure sprayer used at 26 lbs. pressure.
4. T-jet 8004 nozzle.
5. Only 3-ft. band of row actually sprayed - covered twice.

<u>Johnson grass control in Thompson Seedless vineyard</u>. Baranek, Paul P. This past year, it was demonstrated that Johnson grass could be controlled in vineyards with aromatic weed oil or Dalapon. In all cases, the treated areas were sufficiently free of weeds so that harvest could progress. In the check, however, the Johnson grass had to be chopped out before harvest. In general, Bermuda grass was controlled easier than Johnson grass.

The weed oil was applied on May 13, June 3, and July 12. The Johnson grass was about 8 inches high in all cases. Eighty gallons of oil was used per acre at a cost of $15.00.

Dalapon was applied as a spray on the same dates as above, but three plots receiving different treatments were established. A single application using a rate of 40 pounds per acre was made on May 13. The second test consisted of a split application, using a rate of 20 pounds per acre, on May 13 and June 3. The third test started with a 20-pound rate on May 13 and followed by a 10-pound rate of June 3 and July 12. Johnson grass was sprayed in the vine row only and the material cost was about $10.00.

The best results were obtained with the three oil sprays and the three Dalapon applications. Some evidence of damage was observed on weak vines using the 40-pound rate, single application. (Contributed by the University of California Agricultural Extension Service from Madera County)

The effect of sodium 2,2-dichloropropionate (Dalapon) on Grapes and Johnson grass. Whitworth, J. Wayne, and Long, John A. Studies were initiated to determine the effectiveness of Dalapon for the control of Johnson grass in grapes and further determine phytotoxicity of the chemical to grapes.

The experiment was located in an old vineyard containing 25 different varieties of grapes. A number of vines were low in vigor and had shown decrease in yield over the last few seasons. Past yield records on the vineyard further illustrated considerable variation between seasons on the grape yields. Johnson grass and nutgrass were uniformly distributed over the entire vineyard.

The treatments consisted of Dalapon at rates of 20, 40, and 80 pounds active material per acre applied in a volume of 80 GPA of water. One series of treatments was applied before irrigation and one series just after irrigation. Height of Johnson grass at the time of treatment ranged from 12 to 18 inches. Grape vines were in active growth when treatments were applied. A directed spray was used to prevent the chemical from contacting the foliage of the grape vines.

Growth of Johnson grass on the check plots was controlled by repeat applications of oil at a volume of 160 GPA. Plots that received the 20-pound rate of Dalapon required a repeat application 30 days later. Plots treated with 40-and 80-pound rates held growth of Johnson grass in check for the growing season. Nutgrass present in the plots was not controlled by any of the treatments.

Considerable variation was apparent among varieties to the treatments. An attempt to correlate susceptibility with the parentage of certain susceptible varieties was not successful. No definite difference was observed in treatments applied before or after irrigation. The more common symptoms attributed to Dalapon were: (1) chlorosis restricted to terminal growth, (2) definite pattern of chlorosis over most of plant, (3) marginal leaf-edge burn, (4) aborted fruit clusters, and (5) abnormal color development of fruit. Grape varieties that appeared to be relatively tolerant to medium or high rates of Dalapon were: Edna, Lenior, Black Monukka, Carman, Beacon, Mission, and Improved Concord. Varieties which developed one or more of the above symptoms in addition to a sharp drop in yields from the preceding season were: Lindley, Goethe, Catawba, Armalaga, Extra, Agawam, America, Last Rose, Ellen Scott, Pierce California Concord, Fern Munson, and R. W. Munson. (New Mexico Agricultural Experiment Station)

Control of annual weeds in dry beans by use of pre-emergence chemical treatments. Lee, W. O., and Timmons, F. L. During 1955 an extensive chemical screening test was conducted at Powell, Wyoming, in an attempt to find chemicals that could be used for weed control in dry beans. Twenty-four herbicides were compared at 2 rates each, replicated 3 times in randomized blocks.

The treatments were made on plots 15 feet long consisting of 4 rows of beans spaced 22 inches apart. Immediately after treatment, a crust breaker was run over the 2 center rows to incorporate the chemical with the surface soil. The soil at Powell is a heavy sandy clay loam.

At the time of treatment most of the beans had germinated and had sprouts $\frac{1}{2}$ to 1 inch long. None of the beans had emerged. Many weed seeds had also germinated and a few had emerged. The soil was damp at the surface and wet underneath from frequent showers which occurred just before the treatments were made. Showers of .25 and .50 inch followed 10 and 14 days after treatment.

In dry beans most of the early season weeds can be successfully controlled by cultivation. Thus, unless the chemicals controlled the late season weeds which appeared after cultivation was no longer possible, control was not considered satisfactory.

Of the 24 materials tested, only 9 gave satisfactory weed control and 3 of these caused excessive damage to the beans. CDAA (2-chloro-N, N'-diallyl-acetamide) and CDEA (alpha-chloro-N, N'diethylacetamide) at 8 pounds per acre, Alanap 3 (sodium salt of N-1 naphthyl phthalamic acid) at 3 pounds, and CIPC /isopropyl N-(3-chlorophenyl)-carbamate/ at 8 pounds gave excellent control of both broadleaved weeds and grasses without noticeable permanent injury to beans. Observations made August 4 showed the percentage control by these chemicals to be as follows: broadleaved weeds - 85, 73, 83, and 75; grasses - 93, 90, 73, and 75. In addition to the above treatments, CDEC (2-chloroallyl diethyldithio-carbamate) at 4 and 8 pounds and sodium pentachlorophenate at 30 pounds gave good control of broadleaved weeds but rather poor control of grasses. In most instances it was noted that weed control was consistently better on the center rows where the chemical was worked into the soil than on the undisturbed rows.

The chemicals which showed good weed control but caused severe injury to the beans were: CMU /3-(p-chlorophenyl)-1, 1-dimethylurea/ and DCMU /3-(3,4-dichlorophenyl)-1, 1-dimethylurea/ at 1 and 2 pounds per acre and Geigy 444E /2-chloro-4, 6-bis(diethylamino)-s-triazine/ at 8 and 16 pounds per acre.

All of the 15 other chemicals tested which included carbamates, dinitros, dichloral urea, and various chlorophenoxy compounds gave unsatisfactory control of late season weeds and some caused injury to beans. (Field Crops Research Branch, ARS, USDA, and Wyoming Agricultural Experiment Station, cooperating)

The effects of post-emergence treatments with chlorophenoxy butyric acid compounds on field beans and certain weeds. Lee, W. O., and Timmons, F. L. An exploratory experiment conducted at Powell, Wyoming, in 1955 compared four chlorophenoxy butyric acid compounds and 2,4-D when applied post-emergence to beans and weeds. The compounds tested were: 2,4-DB amine [4-(2,4-dichlorophenoxy) butyric acid], MCPB amine [4-(2-methyl-4-chlorophenoxy) butyric acid], 2,4,5-TB amine [4-(2,4,5-trichlorophenoxy) butyric acid], MCPB sodium salt [4-(2-methyl-4-chlorophenoxy) butyric acid], and 2,4-D amine. All chemicals were applied at rates of $\frac{1}{4}$, $\frac{1}{2}$, and 1 pound per acre in a uniform volume of 80 gallons per acre.

At the time of treatment the beans were in the 2 to 5 leaf stage. Weeds including lambsquarter, pigweed, wild buckwheat, and kochia were present on most plots and ranged in height from 1 to 12 inches. Volunteer alfalfa plants 8-12 inches tall from old crowns that had survived plowing out the previous year's stand were present on many plots.

Results of this experiment are shown in the accompanying table. Of the 5 chemicals tested, the amine and sodium salts of 4(MCPB) gave the best results. They showed good to excellent control of pigweed and lambsquarter and little injury to the beans. The 4(MCPB) materials gave better weed control than 2,4-D amine with much less injury to beans. The 4(2,4-DB) was slightly less effective on weeds and much more injurious to beans than were the 4(MCPB) compounds. The 4(2,4,5-TB) was much more injurious to beans and much less effective on weeds than the 4(MCPB) formulations.

Volunteer alfalfa plants showed no noticeable injury from the 4(MCPB) compounds even at the heaviest rate of 1 pound per acre. The 4(2,4-DB) and 4(2,4,5-TB) caused slight injury to alfalfa at the $\frac{1}{2}$-pound and 1-pound rates, while 2,4-D amine caused serious injury at all rates and a 90 per cent kill at the 1-pound rate. (Field Crops Research Branch, ARS, USDA, and the Wyoming Agricultural Experiment Station, cooperating).

Effect of post-emergence herbicides on beans and weeds.

Treat-ment No.	Chemical	Lbs/A (A.E.)	Beans Injury[1/]	Beans % kill	Pigweeds Injury	Pigweeds % kill	Lambsquarters Injury	Lambsquarters % kill
1	MCPB amine	1/4	2	0	9	85	9	95
2	MCPB amine	1/2	1	0	8	70	9	95
3	MCPB amine	1	3	5	9	85	9	95
4	MCPB sodium salt	1/4	1	0	4	10	5	25
5	MCPB sodium salt	1/2	1	0	7	80	9	93
6	MCPB sodium salt	1	3	8	5	40	9	88
7	2,4-DB amine	1/4	3	8	8	55	9	93
8	2,4-DB	1/2	6	28	8	60	9	73
9	2,4-DB	1	7	68	8	68	9	93
10	2,4,5-TB	1/4	4	5	3	10	3	10
11	2,4,5-TB	1/2	6	25	4	10	3	0
12	2,4,5-TB	1	8	50	7	23	5	5
13	2,4-D amine	1/4	4	25	4	5	4	10
14	2,4-D	1/2	6	40	6	40	8	80
15	2,4-D	1	8	90	8	35	8	50
16	Untreated check	0	0	0	0	0	0	0

1/ Visual estimates of injury (as expressed by height reduction, malformation, plant mortality) were made on all plots. A value of 1 to 10 was assigned according to the following scale: 0 - no visible injury; 1, 2, 3 - slight injury; 4, 5, 6 - moderate injury; 7, 8, 9 - severe injury; 10 - all plants killed.

The use of residual herbicides for the control of watergrass (Echinochloa crusgalli) in cotton - Famoso, California, 1955. Foy, C. L., and Miller, J. H. Several residual herbicides were evaluated for watergrass control in cotton on a Delano sandy loam soil. CIPC (isopropyl N-(3-chlorophenyl) carbamate), was included at three rates on the first date only (April 13). Alanap 3 (N-1 naphthyl phthalamic acid), DCMU (3-(3,4-dichlorophenyl)-1, 1-dimethylurea), and CMU (3-(p-chlorophenyl)-1, 1-dimethylurea) were each applied at three rates on the following four dates:

Date 1 (April 13) 12-inch band spray at planting. Unexpected showers of rain totalling approximately 1½ inches fell within one week after treatment. Under these conditions, all herbicides were effective in controlling watergrass for twelve weeks. At that time, the plots were hoed and flame cultivation was introduced as a uniform treatment. Satisfactory control lasted to the end of the season and there were no losses in grade of cotton due to grass. Alanap 3 was leached into the zone of germinating cotton and caused stand reductions at all rates. This injury resulted in significant yield reductions with the 9-pound per acre rate, and tended to reduce yields with the two lower rates. No other visible injury occurred in this test, and no injury symptoms were observed in any of the later experiments.

Date 2 (June 15) directed spray in 20-inch bands prior to first irrigation. Normal furrow irrigation following application of the herbicides did not satisfactorily wet the beds. Although the irrigation caused the germination of many weed seeds, the treated bands on top of the beds remained dry. Under these conditions, all herbicides failed to control watergrass. The herbicides were activated one month later by purposely sub-irrigating to the tops of the beds. This practice resulted in kills of many of the newly germinated weeds, but the earlier failure necessitated hoeing the entire field. Weed control was maintained for the remainder of the season by flame cultivation. Yields and grades of cotton were not affected.

Date 3 (July 12) directed spray in 20-inch bands prior to second irrigation. Following the application of the herbicides, the irrigation water was controlled to insure thorough wetting of the tops of the beds. With adequate moisture, all herbicides effectively controlled watergrass for the remainder of the season without causing a reduction in yield of cotton. Trash percentage appeared to be reduced, and grades of cotton were improved by using the high rate of all three herbicides, these being the only plots sampled for grade determination.

Date 4 (August 4) broadcast spray at lay-by. Weed control following herbicidal applications at lay-by was highly satisfactory for all treatments, however, weed growth in the check after August 4 was not sufficient to affect either yields or grades of cotton.

These experiments showed the strong dependency of herbicidal response upon proper moisture relationships. Adequate moisture both to germinate weed seeds and, at the same time, to activate the herbicides in the region of weed germination is required for optimum results. When these requirements were met either by unexpected rainfall or special water management, weed control was satisfactory. The fact that Alanap 3 caused injury to germinating cotton and tended to become dissipated more rapidly than other herbicides may be partially explained by the relatively more soluble nature of the compound. Only treatments made on Date 3 showed an economic advantage as measured on the basis of one season's returns. Since neither yields nor grades were increased by treatments made on Dates 1 and 4, no economic advantage was realized from the use of these herbicides, despite satisfactory weed control. However, more extensive evaluation would undoubtedly show these practices to be valuable in accomplishing long-term control. The amount of early weed germination and the rate of weed growth late in the season will determine the practicability of these methods. (University of California, Davis, and Field Crops Research Branch, ARS, USDA)

Table 1. The effect of some residual herbicides upon cotton and watergrass when applied at various dates.

A. Pre-emergence application in 12-inch bands (April 13)[1/]

Treatment	Rate lbs/A.	Cotton plants per 10 ft. of row (June 13)	Weeds per 10 ft. of row June 13	Weeds per 10 ft. of row July 7	Weed control rating[2/] Oct. 31	Pounds seed cotton/acre	Grades[3/]
1. Check	--	41.3	24.1	327.3	6.9	2455	4-M
2. Alanap 3	3	32.8	.1	46.0	7.8	2370	
3. "	6	30.0	.5	113.3	7.3	2300	
4. "	9	25.5	.1	26.0	8.4	1930	2-M+, 2-M
5. CIPC	6	41.3	2.8	31.7	8.5	2540	
6. "	9	45.8	1.1	18.0	9.1	2725	
7. "	12	44.5	1.3	17.3	9.0	2510	1-M+, 3-M
8. DCMU	1	43.5	3.5	133.7	8.5	2485	
9. "	1.5	43.8	4.3	60.7	9.1	2660	
10. "	2	42.8	2.1	79.0	9.4	2685	4-M
11. CMU	1	44.0	7.1	140.3	8.4	2655	
12. "	1.5	43.8	6.8	123.7	8.9	2665	
13. "	2	44.3	5.5	122.0	9.0	2480	4-M
L.S.D. at 5%		5.8		97.4		438	
at 1%		7.8		131.5		588	

B. Directed spray application in 20-inch bands prior to second irrigation (July 12).

Treatment	Rate lbs/A.	Weeds per 10 ft. of row (July 26)	Weed control rating (Oct. 31)[2/]	Pounds seed cotton/acre	Trash percentage	Grades[3/]
1. Check	--	880.0	2.6	2275	7.9	1-M, 3-SLM*
2. Alanap 3	3	216.8	4.8	2270	7.2	
3. "	6	108.5	6.8	2175	5.7	
4. "	9	183.8	6.6	2350	5.0	3-M, 1-SLM*
5. DCMU	1	118.3	7.3	2245	7.3	
6. "	1.5	138.5	8.8	2195	5.6	
7. "	2	70.0	8.4	2575	5.6	1-M+, 1-M, 2-SLM+
8. CMU	1	85.3	8.6	2530	7.0	
9. "	1.5	72.3	8.5	2150	7.0	
10. "	2	57.8	9.1	2335	5.2	4-M
L.S.D. at 5%		121.0	.9	Not Sig.		
at 1%		163.5	1.2			

(Continued on next page)

C. Broadcast application at lay-by (August 4).

Treatment	Rate lbs/A.	Weed control rating (October 31)[2]	Pounds seed cotton/acre	Grades
1. Check	--	5.9	2510	1-M+, 3-M
2. Alanap 3	3	8.6	2525	
3. "	6	9.0	2565	
4. "	9	9.1	2375	4-M
5. DCMU	1	9.0	2295	
6. "	1.5	9.1	2515	
7. "	2	9.4	2390	2-M+, 2-M
8. CMU	1	6.9	2290	
9. "	1.5	7.4	2295	
10. "	2	8.8	2595	1-M+, 3-M
L.S.D. at	5%	2.1	Not Sig.	
at	1%	2.8		

1/ All plots were hoed and uniformly flame cultivated after July 12.

2/ Numerical ratings denote the following: 10 - weed-free, 9 - excellent, 8 - very good, 7 - good, 6 - fair, 5 and below - poor.

3/ Code for final grades: M - middling, SLM - strict low middling, plus designation - premium above grade, asterisk - reduction of one grade due to grass.

<u>The effect of flame cultivation and various cultural and chemical weed control practices upon watergrass and cotton.</u> Miller, J. H., and Foy, C. L. A detailed experiment was conducted in 1955 to evaluate the various treatments listed in Table 1 for the control of annual grasses in cotton. The area chosen for the test was a Delano sandy loam soil, heavily infested with watergrass (<u>Echinochloa crusgalli</u>). Under normal conditions, some weeds emerge early in the season, however, most watergrass seeds do not germinate until after the first irrigation.

One objective of the experiment was to investigate substitute practices for directed oil spraying during the period when cotton plants are too small to tolerate flame cultivation. The hoeing time recorded June 13 compares the various practices for early weed control (Table 2). Because of the early spring rains, the plot which received a pre-emergence herbicide required significantly less time to hoe than any other plot. This weed control continued following first irrigation, as evidenced by weed counts recorded June 30. The wide differences in weed control indicated by final ratings on October 31 were largely due to flame cultivation. Plots which were not flamed (Plots 1, 2, and 3) were thoroughly infested with mature watergrass at the end of the season. Hoeing showed a significant advantage in Treatment 6 only. This was due to the fact that, with the low bed planting, early dirting in cloddy soil did not satisfactorily cover small weeds and left the row profile in such a condition that the first flaming had to be omitted.

The differences in final weed ratings were reflected in the trash content of machine-picked cotton.

Neither cotton stands, picker efficiency, nor yields of seed cotton showed significant differences due to treatment. Although yields were not reduced in Plots 1, 2, and 3, grass caused reductions of one grade in 23 out of 24 classing samples. By contrast, only 8 out of 48 samples were classified as grassy in the six treatments which were flame cultivated. The losses due to grade reductions ranged from .44 to 1.94 cents per pound of lint cotton or from \$2.20 to \$9.70 per bale. (Field Crops Research Branch, ARS, USDA, and University of California, Davis)

Table 1. Various weed control treatments applied to watergrass - infested cotton - Famoso, California - 1955.

Treat-ment	At Planting (12 April)	1st (11 - 12 May)	2nd (25 - 27 May)	3rd (1 June)	4th (8 June)	5th 1/ (13-14 June)	6th 3/ (1-5 July)	7th (8-12 July)	8th (29 July)	Total No. Weeding Operations
1	Low Bed	Rotary hoe in row, beet knives at 6' plus sweeps	Rotary hoe in row, plus sweeps	Same ←	Same ←		Sweeps		22" Sweeps	6
2	High Bed	"	"	Same ←	Same ←		"		"	6
3	High Bed	Beet knives at 8", plus sweeps	Oiled 10" band plus sweeps	Same ←	Same ←		"		"	6
4	High Bed	"	"	Same ←	Same ←	Flame in row, plus sweeps	Same ←	Same ←	Flame in row 4/ plus 22" sweeps	9
5	High Bed	"	Row shielded 8" band, plus sweeps	Same ←	Same ←	"	Same ←	Same ←	"	9
6	Low Bed	Disc Hillers at 5" plus sweeps	Dirting by sweeps with shields raised	Same ←	Same ←	2/	Flame in row, plus sweeps	Same ←	"	8
7	Low Bed	Rotary hoe in row, beet knives at 6" plus sweeps	Rotary hoe in row, plus sweeps	Same ←	Same ←	"	Same ←	Same ←	"	9
8	High Bed	"	"	Same ←	Same ←	"	Same ←	Same ←	"	9
9	High Bed, Alanap 3 at 6#/A in 12" band	Beet knives at 10", plus sweeps	Same ←			Same ←		Flame in row, plus sweeps	Same ←	7

1/ Two rows of all four-row plots were hoed, and hoeing time recorded 13 June.
2/ First flaming omitted. Cotton was too short in cloddy ground due to early dirting after planting low in bed.
3/ First irrigation - 18 June.
4/ Plots were flamed <u>twice</u> at lay-by.

Table 2. The effect of flame cultivation and various cultural and chemical weed control practices upon watergrass and cotton. Famoso, California - 1955.

Treatment		Watergrass: Hoeing time hours/acre 1/ (June 13)	Watergrass: Plants per 10 ft. of row (June 30)	Watergrass: Final rating 2/ (Oct. 31)	Cost of weed control practices $/acre 3/	Cotton: Trash percentage	Cotton: Grades 4/	Cotton: Value $/cwt lint
1	A	8.75	1609	2.9	15.21	9.2	1 -M,3-SLM*	33.71
	B	-	-	1.9	6.90	9.4	4 -SLM*	33.08
2	A	6.67	1612	1.4	13.24	8.4	4 -SLM*	33.08
	B	-	-	1.3	6.90	8.6	4 -SLM*	33.02
3	A	7.50	1614	1.8	18.52	7.8	4 -SLM*	33.02
	B	-	-	1.4	11.40	10.0	4 -SLM*	33.02
4	A	7.08	1614	8.8	24.08	6.1	1 -M+,2-M,1-SLM*	35.20
	B	-	-	8.4	17.35	7.8	1 -M+,1-M,2-SLM*	34.51
5	A	9.17	1624	8.8	21.56	6.7	4 -M	35.77
	B	-	-	8.0	12.85	6.6	4 -M	35.77
6	A	8.33	1611	8.0	19.11	5.8	4 -M	35.77
	B	-	-	4.0	11.20	7.8	1 -M,1-M*,2-SLM*	34.15
7	A	7.50	1610	7.9	19.98	5.2	2 -M,1-SLM+,1-SLM*	34.77
	B	-	-	7.4	12.85	5.2	2 -M,1-SLM+,1-SLM*	34.77
8	A	6.67	1614	8.4	19.19	5.6	1 -M+,2-M,1-SLM+	35.51
	B	-	-	8.3	12.85	6.7	3 -M,1-SLM	35.33
9	A	2.92	93	7.3	16.37	5.5	1 -SM,3-M	35.96
	B	-	-	8.5	13.60	5.5	4 -M	35.77
L.S.D. at 5%		2.60	-	1.4	-	1.9		
L.S.D. at 1%		3.60	-	1.8	-	2.6		

1/ Two rows (A) of all four row plots were hoed June 13. The weeds hoed represented only a small percentage of those which emerged following the first irrigation on June 18.
2/ Numerical ratings represent an average of 8 observations, ie., 4 replications each rated independently by two persons on an arbitrary scale of 0 (no control) to 10 (perfect control).
3/ Weed control costs were computed as follows: cultivations - $1.15 each; hoeing - $0.95 per hour; oilings - $1.50 each; flame fuel - $0.50 per flaming. (Equipment costs are not included).
4/ Final grades are coded as follows: SM- strict middling; M-middling; SLM-strict low middling; "plus" designation - premium above grade; asterisk - reduction of one grade due to grass.

Control of annual weeds in cotton using CMU applications in combination with various cultivation practices. Hamilton, K. C., and Arle, H. F. To determine the effectiveness of CMU treatments when used in combination with other weed control practices, this herbicide was applied at lay-by to Acala-44 cotton grown under the following types of cultivation:

A. Normal cultivation (seven cultivations).
B. Normal cultivation, plus using rod weeders on the drill row.
C. Normal cultivation, plus three flame cultivations.
D. Normal cultivation, plus three flame cultivations, plus two early flamings with an "Arkansas burner."

The cultivation treatments were replicated six times in a randomized complete block design on plots four rows wide and 1320 feet in length. Paired plots, 60 feet in length, were established in each cultivation plot, and on July 30 CMU was applied to one of the paired plots at the rate of $1\frac{1}{4}$ pounds per acre.

The degree of weed control was evaluated in August and November. All plots to which CMU had been applied remained free of annual weeds (principally *Ipomoea hirsutula*, *Leptochloa filiformis*, and the seedlings of *Sorghum halpense*) from the time of treatment to the end of the growing season. The plots which received only mechanical cultivation and flaming had significantly fewer weeds than the plots receiving only mechanical cultivation. The degree of weed control, however, resulting from the mechanical cultivation and flaming was inferior to the weed control produced by the application of CMU.

The data showed that cotton given normal cultivation yields significantly greater amounts of seed cotton on the plots treated with CMU, this yield being 174 per cent of the untreated plots receiving normal cultivation. The yield of cotton on plots receiving normal cultivation plus flaming was not influenced by CMU treatments. (Arizona Agricultural Experiment Station and Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture, cooperating)

The effect of several substituted urea compounds in the control of annual morning glory and annual grass growth in cotton. Arle, H. Fred, and Hamilton, K. C. During the past five years considerable work has been done with CMU; 3-(p-chlorophenyl)-1, 1 dimethylurea for the control of several annual weeds in cotton. During the past two years DCMU; 3(3,4-dichlorophenyl)-1, 1 dimethylurea and PDU; 3-phenyl-1, 1-dimethylurea have been included in the research program. These materials have been applied at rates ranging from .75 - 2.0 lb/A. Most applications have been made at "lay-by" time, just prior to the final cultivation. During the past season, applications of CMU and DCMU have also been made earlier in the growing season to determine the possibility of gaining early weed control, but retaining sufficient toxicity to prevent weed growth after "lay-by" time.

In one field, which was heavily infested with annual morning glory, applications of CMU at 1.25 lb/A. and DCMU at 1.0, 1.25, and 1.50 lb/A. prior to the first irrigation in early June resulted in very good control throughout the entire season. In another field, annual grasses were an accompanying problem. Annual grasses were best controlled by the higher rates of DCMU; however, some grass was able to establish itself on the plots treated early in the season. "Lay-by" time applications of DCMU gave almost complete control of annual grasses throughout the balance of the season while similar rates of CMU were much less effective. Symptoms of injury evidenced in the form of chlorotic cotton foliage were most pronounced with applications of CMU. Applications of 1.0 lb/A of CMU usually caused more extensive chlorosis than did 2.0 lb/A of DCMU. The yellow appearance persisted for 3-4 weeks following the first irrigation after application. In spite of these early differences in apparent toxicity, there are no definite trends toward yield differences. Increased yields ranging from 20-40 per cent have been measured where morning glory control has been maintained.

Another experiment has been established to determine the possibility of building up a cumulative toxicity through annual applications of CMU, DCMU, and PDU. Each of these materials is being applied annually to permanent plots at rates of 1.0 and 2.0 lb/A. Applications made in 1954 had no apparent effect on germination or early development of cotton planted on these plots in 1955. During both years, plants treated with PDU became severely chlorotic following treatment. Plants on these plots continued to be somewhat less vigorous than those receiving other treatments. There is also a definite tendency toward reduced early yields although these differences are somewhat minimized by later picking.

Newly formed bolls were tagged on these plots two weeks, one month, and two months following treatment. These bolls were harvested upon maturity and subjected to various tests of fiber analysis. Regardless of tagging date, chemical, or rate of treatment, there were no significant differences in lint weight, seed weight, fiber length, fiber strength, or fiber fineness. (Contributed by the Field Crops Research Branch, Agricultural Research Service, USDA, and the Arizona Agricultural Station, cooperating)

The effect of rate and date of application of CMU on cotton. Hamilton, K. C., and Arle, H. F. The study of factors influencing CMU when used to control weeds in cotton was continued in 1955. To determine the effect of rate of application, CMU was applied at rates of 0, .75, 1.0, 1.25, 1.50 and 2.0 pounds per acre prior to the "lay-by" cultivation on July 14. The treatments were replicated six times in a randomized complete block design.

To study the effect of date of application, plots were treated with $1\frac{1}{4}$ pounds per acre of CMU prior to the first, second, third, fourth, or first and fourth irrigation. In both tests the chemicals were applied in water equivalent to 40 gallons per acre. The plots were eight rows, 40.5 feet in length.

The yield data showed that none of the CMU treatments in either test reduced the amount of lint cotton produced. Boll samples were collected from each of the plots and certain boll components; boll weight, lint weight, seed weight, per cent lint, and seeds per boll, and fiber properties; length, strength, and fineness were analyzed. With one exception, these analyses showed that the applications of CMU had no effect upon the fiber properties and boll components studied. The double application of CMU at the first and fourth irrigation reduced fiber length significantly. (Arizona Agricultural Experiment Station and Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture, cooperating)

Response of cotton lines to CMU applied to the soil at "lay-by" time. Hamilton, K. C., Fisher, W. D., and Arle, H. F. The use of CMU (3-(chlorophenyl)-1,1-dimethylurea) in Arizona for the control of annual weeds after the "lay-by" time cultivation has increased for the past three years. It was deemed necessary to test several lines of cotton in order to determine if varieties might differ in their responses to CMU treatment.

In 1955 six lines of cotton, all Acala types, were tested: A-44, A-124-67, A-124-68, A-29-76-16, A-4-42-WR, and C-68. The test area received the average amount of mechanical cultivation. CMU was applied on July 14 to the treated plots prior to the "lay-by" time cultivation at the rate of $1\frac{1}{4}$ pounds per acre in water equivalent at 40 gallons per acre. The cotton lines were arranged in a 6 x 6 latin square with a split plot for the chemical treatments. The plot size was 3 rows, forty feet in length.

Within a few weeks after the application of CMU, a typical yellowing of the leaves developed on the treated plots. On August 2, the degree of yellowing was estimated. A-44 and the A-124 lines showed the greatest amount of yellowing. A-29-76-16 and A-4-42-WR had the least yellowing. Of the lines in this test, those that developed the greatest yellowing were lines which are susceptible to Verticillium Wilt. The lines which developed the least yellowing were lines which are relatively tolerant of wilt.

Lines	Degree of leaf yellowing*	Yield of Lint Cotton $\frac{\text{Treated Plots}}{\text{Untreated Plots}} \times 100$
A-44	5.0	102.20
A-124-68	4.0	98.90
A-124-67	3.7	98.48
C-68	3.5	101.15
A-29-76-16	2.0	99.10
A-4-42-WR	1.6	98.93

* 0 = No yellowing of foliage.
10 = Complete yellowing of foliage.

The data showed that CMU had no effect on the yields of lint cotton. Statistically significant interaction occurred between lines and CMU treatment. The extent of the interaction, however, was not great enough to be of economic importance. A-44, which exhibited the most severe yellowing, was a line in which yield increased. A-4-42-WR, which exhibited little yellowing, was among the lines that showed a decrease in yield with CMU treatment. (Arizona Agricultural Experiment Station and Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture, cooperating)

The evaluation of pre- and post-emergent chemical treatments for weed control in sugar beets. Hodgson, Jesse M. Several chemicals were applied to field planted sugar beets in 1955. Pre-emergence treatments were made April 28, six days after planting. Early post-emergence treatments were made May 19 when beets varied from just emergent to the four leaf stage of growth. Rainfall during the period immediately following planting was ample for beet and weed germination and growth. Individual plots were eight feet wide (four rows) and 38 feet long. A bicycle push type sprayer was used to apply the treatments in 40 gallons of water per acre. Treatments were randomized and replicated four times. The soil in the plot area was a heavy clay loam.

Sugar beet yields were obtained by harvesting two center rows 33 feet long on each plot. Yield of weeds was obtained on an area two feet by eight feet in the center of each plot. Weeds were harvested June 16 and 17 and sugar beets were harvested September 26 and 27.

The treatments are listed and results summarized in the following table:

Treatments	Lbs. Per Acre	Beet Yield**		Weed Yield in Grams*			
				Grasses		Broad-Leaved	
		Pre	Post	Pre	Post	Pre	Post
1. Sodium-2,2-dichloro-propionate (DPA)	4	117.1	112.83	.55	1.60	17.7	41.02
2. Sodium-2,2-dichloro-propionate (DPA)	6	119.91	108.42	.40	.65	19.4	33.62
3. Sodium-2,2-dichloro-propionate (DPA)	10	114.67	91.69	.25	0.00	10.7	10.40
4. Ammonium sulfamate	20	108.93	108.09	14.90	3.57	13.0	9.12
5. 2-(2,4,5-trichlorophenoxy)-ethyl-2,2-dichloropro-pionate (2,4,5T,DPA)	6	115.94	107.48	1.00	2.10	13.2	10.45
6. " " " "	10	93.93	93.13	0.00	.39	3.5	8.77
7. " " " "	20	85.92	68.36	.10	0.00	4.2	.50
8. A-chloro-N,N-dialylacetamide (CDAA)	6	110.55	99.12	.54	.25	9.1	3.45
9. A-chloro-N,N-diethylacetamide (CDEA)	6	77.07	64.23	.05	.03	3.0	22.65
10. 2 chloroallyl-diethyl-dithiocarbamate (CDEC)	6	117.05	100.68	14.80	6.05	16.7	10.70
11. Hand weeded - control		120.92	121.79	0	0	0	0
12. Non-weeded		97.53	102.79	18.2	18.9	29.1	44.73

* Oven-dry

** Pounds on plot 4 ft. x 33 ft.

The predominate grassy weeds were green fox tail with a small amount of wild oats. Broad-leaved weeds consisted of wild buckwheat, rough pigweed, lambs quarter, and Kochia scoparia. The sugar beets were more tolerant of these chemicals applied as pre-emergence treatments than when applied post-emergence.

DPA effectively controlled the grasses at all three rates. The ten-pound-per-acre rate caused some yield reduction of the sugar beets. Broad-leaved weeds were not controlled by treatments.

The 2,4,5T-DPA at six pounds per acre gave good control of grasses but caused some reduction in yield of sugar beets. The ten- and twenty-pound rate of this chemical gave good control of all weeds but were quite toxic to sugar beets.

The most promising treatments for further consideration appeared to be 2,4,5T,DPA at a lower range of rates, DPA, CDEC, and CDAA. (Field Crops Research Branch, U.S.D.A., A.R.S., and the Montana Agricultural Experiment Station cooperating)

Effectiveness of Dalapon for weed control in sugar beets. Alley, Harold P. During the past three years experiments have been conducted to determine the effect of Dalapon (alpha, alpha dichloropropionic acid) upon sugar beets when used as a pre-emergence and post-emergence weed control chemical. The plots were randomized and replicated and each plot four rows wide and 25 feet long. To insure good stands of grassy weeds in the experimental plots, a mixture of tame oats and warm season grasses (mainly Setaria viridis L. and Echinochloa crusgalli L.) were sown in every other beet row. The pre-emergence treatments were made at time of planting the beets and the post-emergence when the sugar beets were in the two to four leaf stage of growth.

Three years' data shows that Dalapon when applied as a pre-emergence treatment cannot be used at sufficiently high enough rates to give good weed control without reducing beet stand and yield. All rates over 3 pounds acid per acre reduced the beet stand and yield to a point where Dalapon was not practical as a pre-emergence treatment.

Comparison of Dalapon applied at six rates as a post-emergence treatment show a greater percentage of weed control with each increased amount of Dalapon. However, all concentrations above the six-pound rate caused a reduction in beet stand and yield; the six-pound rate gave good weed control without reducing yield and may be expected to control four-fifths of the grassy weeds and one-third of the broad-leaved weeds. The yield of sugar beets in tons per acre was as high or superior to the check when six pounds of Dalapon was used. Higher rates than the six pounds caused considerable damage and appeared too toxic as a post-emergence treatment in Wyoming. (Wyoming Agricultural Experiment Station)

Table 1. Effect of Dalapon as a post-emergence chemical weed control, beet stand and yield[1/]

Treatment	Lbs. Acid Per Acre	Percentage Control								Sugar Beets				
		Grass				Broad Leaves				Per cent Stand				Tons Acre Yield[2/]
		1953	1954	1955	Ave.	1953	1954	1955	Ave.	1953	1954	1955	Ave.	
Dalapon	4	-	-	72.0	72.0	9.0	-	-	9.0	-	-	74.0	74.0	19.8
Dalapon	5	60.0	-	-	60.0	33.0	-	-	33.0	87.0	-	-	87.0	21.2
Dalapon	6	-	53.0	84.0	68.5	-	36.0	20.0	28.0	-	99.0	95.0	97.0	22.7
Dalapon	10	87.0	71.0	90.0	82.7	42.0	62.0	40.0	48.0	80.0	84.0	74.0	79.0	18.2
Dalapon	15	87.0	-	-	87.0	50.0	-	-	50.0	70.0	-	-	70.0	13.8
Dalapon	20	92.0	89.0	-	90.5	58.0	80.0	-	69.0	63.0	42.0	-	47.5	15.3
Check	-	0	0	0	0	0	0	0	0	100.0	100.0	-	100.0	20.0
L.S.D. .05					20.1				33.4				31.2	
L.S.D. .01					28.6				47.5				44.4	

1/ Data average of 4 replications each at 3 locations; Torrington, Powell, and Laramie, Wyoming, 1954, and 4 locations; Torrington, Powell, Laramie, and Sheridan, Wyoming, in 1955. All data computed as a per cent of the untreated check for the year tested.

2/ Yield average of three years' data.

The control of annual grass weeds in sugar beets by sodium 2,2-dichloropropionate (Dalapon). Fults, Jess L., Blouch, Roger, and Gaskill, John O. One of the most critical weed problems in the growing of sugar beets in northern Colorado is that of pigeon grass (*Setaria viridis*) which often germinates and grows at the same time as the crop. Volunteer small grain, wild oats, and miscellaneous broad-leaved weeds also may be serious. The development of mechanical "down-the-row" thinners has helped a great deal but there still is need for an effectual, safe herbicide to lessen further the labor requirements of weed control. This problem apparently can be attacked successfully between the time of emergence of the crop and the time of blocking and thinning. Weeds emerging after blocking and thinning appear to be of secondary importance.

Tests with Dalapon which first were conducted in 1954 have been continued during the 1955 season. Broadcast spraying immediately following emergence of the crop at a chemical rate of 7 to 9 pounds per acre, in 100 gallons of water, gave good to excellent control of volunteer grain and pigeon grass. Growth of the sugar beets was depressed slightly by such applications, for a period of about 3 weeks with recovery soon after blocking and thinning. At harvest time the plants in the treated plots were as large and vigorous as in the untreated controls. Yield and sucrose determinations were made for the 1955 crop, as in 1954, but a critical analysis of the results is not yet available. Field tests are planned for the 1956 season. (Contribution of Colorado Agricultural Experiment Station)

Control of crabgrass in Bermuda grass lawns with CMU and DCMU. Hamilton, K. C., and Arle, H. F. The invasion of crabgrass (*Digitaria sanguinalis* and *D. Ischaemun*) in Bermuda grass lawns is considered as a serious problem. When crabgrass dies in the fall, its leaves and stems may shatter under heavy usage leaving bare ground exposed through the winter. At different intervals during the 1955 growing season, CMU (3-(p-chlorophenyl)-1,1-dimethylurea) and DCMU (3-(3,4-dichlorophenyl)-1,1-dimethylurea) were applied to Bermuda grass sods to determine the value of these chemicals for controlling crabgrass. The chemicals were applied at rates of 3/4 to 2 pounds in water equivalent to 40 or 80 gallons per acre. All treatments were replicated either 2, 3, or 4 times. The stand of crabgrass in the untreated check plots increased from about 35 per cent ground cover in June to 95 per cent in September.

Applications of either CMU or DCMU resulted in excellent control when the crabgrass was young. The June 14 applications were made about five weeks after the crabgrass emerged. The DCMU treatments made on July 29, when the crabgrass was more mature, produced excellent control whereas CMU was not effective. The applications of DCMU made on September 29 failed to control the crabgrass which had started to set seed.

Applications of CMU and DCMU, at the rates used, often caused a temporary yellowing of the Bermuda grass, but normal color was regained within a few weeks. Its vigorous new growth covered the spots of bare ground which had resulted from the death of the crabgrass.

Date Applied	Treatment Chemical	Rate Lbs./A.	Estimated per cent crabgrass in Bermuda sod Weeks after treatment 2	4	8
June 14	DCMU	2	0	0	0
June 14	CMU	2	0	0	0
July 20	DCMU	2	0	8	5
July 20	CMU	2	15	42	35
August 22	DCMU	1	0	0	0
September 29	DCMU	1	85	80	Frosted

The spread of Bermuda grass into bare areas was slow where it had been subjected to the competition of a dense stand of crabgrass. To determine whether the previous competition or the herbicide application had affected the Bermuda grass, a severe infestation was selected and the crabgrass was hand-weeded from two-foot square quadrants. Where crabgrass was removed in July, the Bermuda grass covered the bare areas within a few weeks. When Bermuda grass was subjected to competition until September, an elapse of four to five weeks occurred before the bare areas were covered. (Arizona Agricultural Experiment Station and Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture, cooperating)

PROJECT 6

AQUATIC WEEDS; SUBMERSED AND EMERGENT

H. Fred Arle, Project Leader

SUMMARY

A total of eight abstracts were received from five contributors. Four pertained to the control of cattails, three regarded the control of submersed waterweeds and one pertained to algae control.

During previous years it was determined that cattails were effectively controlled by a mixture of 2,4-D (heavy esters) plus diesel or summer oil and an emulsifying agent. This treatment cannot be used in areas where 2,4-D sensitive crops are grown. Research is now concerned with discovering methods for controlling cattails in these areas. Promising results with DPA and ATA are reported from California, Wyoming and Montana. In most experiments it is indicated that at least one re-treatment is necessary. In one experiment excellent control of cattails was obtained when CMU was applied at 80 lb/A.

The use of aromatic solvents for the control of submersed aquatic weeds has been accepted by Water Users Districts in many of the western states and this line of research has essentially been discontinued. There appears to be somewhat increased interest in the control of waterweeds and algae in ponds and reservoirs.

The use of sodium arsenite, commercial fertilizer, RADA, Polyrad 0200 and Dichlone are being used experimentally and have usually indicated effective control under conditions of ponded water.

Control of cattail by various chemical treatments. Lee, W. O. and Timmons, F. L. Experiments conducted at Logan, Utah, during 1949 to 1953 and reported in previous Research Progress Reports showed that broad-leaved cattail (*Typha latifolia*) can be controlled satisfactorily by chemical means. The most effective and least expensive treatment in these earlier experiments was to spray 3 or 4 times during a 2-year period with 200 gallons per acre of a solution consisting of 6 pounds of 2,4-D as the low volatile ester, 10 gallons of diesel oil or fuel oil, and .5 gallon of a good emulsifier. However, such a treatment is hazardous in areas where grapes, cotton, or other crops sensitive to 2,4-D are grown. Therefore, the search was continued for an effective chemical treatment of cattail that would be less hazardous to such crops.

An experiment begun in 1954 tested Amizol (3-amino-1,2,4-triazole) and Dalapon (sodium salt of 2,2-dichloropropionic acid) alone and in combination with 2,4-D. Silvex [an ester of 2-(2,4,5-Trichloropropionic acid)] plus diesel oil was also tested in comparison with 2,4-D plus diesel oil and 2,4-D plus TCA (sodium salt of trichloroacetic acid). The butoxy ethanol ester of 2,4-D was used in all treatments containing 2,4-D. All treatments included a nonionic emulsifier-spreader at 0.5 gallon per acre. All chemicals were applied in water at a total volume of 200 gallons per acre.

The original spray applications were made June 23 when cattail was just beginning to head. Retreatments at the same rates were made September 9 on small cattail regrowth and any mature growth not killed by the original treatment in June.

Table 1 outlines the eight treatments in this experiment and summarizes the result data. Topkill in 1954 indicated that the combination treatments with 2,4-D were more effective than Amizol alone, Dalapon alone, or Silvex plus diesel oil. However, regrowth data recorded in July 1955 showed all of the treatments except Silvex to be about equally effective with only a trace to 4 percent of cattail regrowth remaining. Silvex was much less effective with 35 percent survival of cattail.

Both Amizol and Dalapon gave excellent results when used alone and appear to justify extensive testing for cattail control, particularly in areas where use of 2,4-D is hazardous to sensitive crops. (Field Crops Research Branch, ARS, USDA, and Utah Agricultural Experiment Station, cooperating).

Table 1. Effects of chemical treatments on cattail

Treatment No.	Chemical and rate per acre	Percent topkill: 7-19-54	Percent topkill: 9-9-54	Percent regrowth: 9-9-54	Percent regrowth: 7-2-55
1	Amizol at 10 pounds	33	73	5	1
2	Dalapon at 20 pounds	43	80	3	Tr
3	2,4-D at 6 pounds plus Amizol at 5 pounds	87	96	2	4
4	2,4-D at 6 pounds plus Dalapon at 10 pounds	96	98	1	1
5	Untreated check	0	6	5	82
6	2,4-D at 6 pounds plus TCA at 30 pounds	94	98	2	2
7	2,4-D at 6 pounds plus diesel oil at 10 gallons	85	91	3	4
8	Silvex at 6 pounds plus diesel oil at 10 gallons	6	58	8	35

Control of pondweeds with fertilizer. Baranek, Paul P. This past year excellent results were obtained controlling submersed pondweeds with fertilizer. The work was done on a farm pond consisting of four surface acres. The pond wasused for stock watering and for the production of fish for recreation.

The first application was made on March 13th and the ninth and last application was made on November 11th. A total of 2600 pounds of fertilizer was used during the season at a cost of one hundred dollars.

Two materials were tried but the best results were obtained using a pelletted 10-10-10. It was easier to apply and it created an excellent algae blanket with very little scum. The algae blanket shaded out the pond weeds on the bottom.

Results were very good compared to untreated ponds and to the conditions in this pond in 1954. The water level in this pond at the end of the 1955 season was about two feet higher than the height in 1954, whereas the water level in untreated ponds was lower in 1955 than in 1954. The pondweeds were controlled at least 80 percent and at no time during the season was fishing hindered because of weeds. (Contributed by the University of California Agricultural Extension Service from Madera County.)

The effect of several herbicides on Algae. Arle, H. Fred. During 1955 several experimental applications of chemicals were made to determine their effectiveness in controlling algae. These materials were applied to canal water and to irrigation water storage sumps.

Rosin Amine D Acetate (RADA) was applied in a lined canal to water carrying a high soluble salt content. Algae (probably Oscillatoria sp.) had formed a thickened mat over the sides and bottom of the canal. Both formulations of RADA, the 70 percent paste and the 50 percent solution were applied at a concentration of 5 ppm. maintained for 30 minutes. These materials appeared to be insoluble from the water obtained from one well. As the RADA was applied, flakes of a white material were formed immediately. These collected in small resinous masses and floated off on the water surface. There was no control of algae.

At a later date, a quantity of the 70 percent material was placed in a burlap bag, suspended in the flow and given vigorous agitation. The paste dissolved slowly and remained in solution. Algae became discolored and in approximately two days 90 percent had been cleared from the canal. Regrowth was rapid and algae reached the original degree of infestation in about 10 days. An application of Polyrad 0200, a similar material, but more soluble in saline waters was also made at 5 ppm. for 30 minutes. Although the material remained in solution there was no indication that algae were affected.

An application of 2,3 dichloro-1,4-napthoquinone (Dichlone) in the same canal at 1 ppm. was also noneffective. In another canal, Dichlone at 1 ppm, effectively controlled filamentous green algae (Spirogyra sp.). Within 24-48 hours the algae had lost its normal green color and was sloughing off. Maximum results were evident about 4 days following treatment with only about 10 percent of the original infestation remaining. Regrowth was very rapid and 10 days later there was no further evidence of control.

An application of 50 percent RADA to an irrigation water storage sump effectively controlled filamentous algae at a concentration of 5 ppm. Algae turned greyish-white within several hours and apparently sank to the bottom within 24 hours. This reservoir had previously been stocked with large mouth bass and bluegill. There was no apparent effect to the bass; however, numerous dead bluegill, 4-5 inches in length were noted several days later. Algae were controlled until additional water was added to the reservoir.

At a later date, this sump was treated with Dichlone at a rate of 1.0 lb/A of water surface. Good control of algae was obtained in 4-5 days. It was also noted that the foliage of Sago pondweed (Potomogeton pectinatus) was turned brown. There were no evident effects on fish or other water life. (Contributed by the Field Crops Research Branch, Agricultural Besearch Service, USDA, and the Arizona Agricultural Experiment Station, cooperating.)

Soil treatment with CMU for control of cattail and willows. Baranek, Paul P. Many farm ponds in Madera County have become choked along the shore line with growths of cattail and willows, making it impossible to fish from the shore. To solve this problem, a test was made using CMU.

First, all cattail and willows were cut and removed from the plot area. Then, on November 24, 1954, a wettable powder of CMU was applied at the rate of 80 pounds per acre as a spray. By January 1, 1955, the treated area was completely submerged and remained so until May, 1955. As much as 5 feet of water covered some of the area. During the summer months the water level dropped again exposing the treated area. A 100 percent kill resulted. The plot was replicated three times.

No harmful effects were noted to fish life or to livestock. Control was obtained three feet beyond the treated area.

This work has been repeated for the 1956 season. (Contributed by University of California Agricultural Extension Service from Madera County.)

The effect of chlorinated benzene on submersed aquatic weeds. Arle, H. Fred. A mixture containing one third trichlorobenzene and two thirds of a commercial aromatic solvent waterweed killer was applied in an irrigation canal at a concentration of 740 ppm (10 gal/cfs.) for 30 minutes. Weed growth consisted primarily of sago pondweed (Potomogeton pectinatus) and occasional plants of water stargrass (Heteranthera dibia). Within three hours following treatment, the pondweed had turned a dark brown and stargrass foliage was becoming white. Five days later approximately 95 percent of all growth appeared dead and was being sloughed off. Three weeks later all old growth was gone, however, heavy regrowth was evident. This mixture effected much better control than previous applications of the commercial waterweed killer at the same concentration.

At a later date the same canal was treated with O-dichlorobenzene at a concentration of 370 ppm. (5 gal./cfs.) for a 30 minute period. An emulsifier, "Nopco 1219 A", was added at a concentration of 5 percent by volume. Water in the canal was carrying a considerable silt content and may have had an adverse effect on results. While the application was in progress it was noted that sago pondweed was becoming a deep brown, but stargrass showed no immediate effect. Eventually stargrass showed only a minimum of injury and complete recovery followed very quickly. Practically all foliage of sago pondweed was sloughed off, however, the main stem remained intact. Four weeks after treatment much new foliage was formed on the old stems. Treatment failure was apparently due to the high silt content or to insufficient concentration. (Contributed by the Field Crops Research ranch, Agricultural Research Service, USDA, and the Arizona Agricultural Experiment Station, cooperating.)

Cattail control in 2,4-D hazardous areas. Baranek, Paul P. In much of the San Joaquin Valley where cotton and grapes are grown, 2-4-D cannot be used for cattail control during the growing season. This past year amino triazole was compared with a low volatile 2,4-D ester in control of cattail. The results are very encouraging for use of amino triazole for control of cattail in 2,4-D hazardous areas.

Amino triazole was used at the rate of 4 pounds (50 percent material) per 100 gallons of water for cattail control. It was applied as the seed stalk was emerging. Three hundred gallons per acre was applied in all cases. The addition of one quart of kerosene per 100 gallons of water gave a better kill.

The results compared very favorably with results obtained using a low volatile ester of 2,4-D at the rate of 2 pounds per 100 gallons of water plus 2 quarts of kerosene. Material was applied as a drenching spray at the rate of 300 gallons per acre.

Kills of 70 to 100 percent were obtained with one application in the trails. (Contributed by University of California Agricultural Extension Service from Madera County.)

Preliminary results pertaining to aquatic weed control with Atlas A. Crowley, G. R. and Mollenhoff, H. H. On October 20, 1955 a pond of approximately nine and a half acre feet of water was treated with Atlas A (Sodium Arsenite) in an attempt to eliminate three species of Potamogeton. It was observed that the plants had set seed and the joints of the stems had swollen with winter storage. One species was forming a thick mat along the bottom of the pond approximately one foot in thickness.

The Atlas A was applied at the rate of 10 ppm and another 10 ppm to be applied in mid-spring of 1956. It was felt that a split application would greatly reduce the amount of foliage, possibly lower the viability of the many seed and that the decaying material would add "bloom" to the water cutting down the light intensity for those plants not completely killed. The water at time of application was crystal clear and there had not been any survival of fish for a considerable length of time.

Analysis of the water showed total soluble salts to be 644 ppm with a pH of 9.5.

Observations made November 23, 1955 indicated that a considerable amount of the upright growth was in a state of decay as well as about two inches of the top of the mat on the bottom. The downwind side of the pond had considerable scum of decaying algae and the remainder of the pond water had darkened up. By this time of year water temperature had dropped to the point where decomposition probably will have ceased until spring. (Contributed by Chipman Chemical Co., Inc. and Soil Conservation Service, USDA., Phoenix, Arizona.)

Cattail control with chemical foliage treatments. Hodgson, Jesse M. An experiment to determine the effectiveness of several chemical sprays for control of cattil was begun in June 1954. The cattails were rapidly growing and flower heads were just emerging when the treatments were applied. All treatments were made in 160 gallons of water per acre. Plots were located in a deep drain and were one rod wide and two rods long.

The survival of cattail was estimated in July 1955 with the follow-results:

1. Sodium-2,2-dichloropropionate (DPA) was applied in June at ten pounds per acre. A re-treatment of the same rate was applied to regrowth in August. Only 12 percent of the cattail was present in July 1955.

2. DPA at 30 pounds per acre, applied in the same manner as the ten pound rate, also had a survival estimate of 12 percent in 1955.

3. DPA at ten pounds per acre plus four pounds of a heavy ester of 2,4-D, applied in June and on regrowth in August, resulted in a survival of cattail of only seven percent.

4. 3-Amino-1,2,4-triazole was applied at 5 and 20 pounds per acre only once during 1954. The five-pound rate caused no noticeable reduction in stand the following year, whereas plots treated at the twenty-pound rate had only 20 percent as much cattail the following year.

5. The heavy ester of 2,4-D at four and eight pounds per acre gave practically no reduction in cattail the following season.

6. The PGBE ester of 2,2,4,5,-trichlorophenoxy propionic acid at four and eight pounds per acre was somewhat less effective than 2,4-D. 4 Chlorophenoxyacetic acid at four and eight pounds per acre was somewhat more effective than 2,4-D. (Field Crops Research Branch, U.S.D.A., A.R.S. and the Montana Agricultural Experiment Station Cooperating.)

PROJECT 7. CHEMICAL AND PHYSIOLOGICAL STUDIES

Herbert M. Hull, Project Leader

SUMMARY

A total of 14 project reports dealing with chemical and physiological studies were received from 13 investigators. The states of Arizona, California, Oregon and Washington were represented.

There is a great need for further chemical and physiological work in weed control investigations. Certain phases of research in this field have been touched but very lightly, if at all. It is hoped that many of the 55 workers contacted for contributions to Project 7, but who did not reply, will submit results of their investigations for the 1957 report.

Studies in California have demonstrated that penetration of radioactive 2,4-D and amino triazole from the leaves of Zebrina pendula is not a linear function of concentration, and that a certain minimum concentration must be exceeded before significant penetration is achieved. At low concentrations 2,4-D penetrated more readily than amino triazole, and both compounds penetrated to a markedly greater degree at low concentrations from the lower leaf surface than from the upper. Penetration in Zebrina has also been investigated by means of fluorescent dyes. Cuticular penetration of the upper non-stomatal surface was determined in this manner, but again greater penetration was obtained through the lower surface. Stomatal entry was not indicated because dye patterns appearing in the cell walls held no relation to stomatal distribution.

The possible relationship between indole-3-acetic acid content of Arizona burroweed and its susceptibility to herbicides is under investigation. A technique for extracting the auxin has been developed, and future work will involve the establishment of seasonal variation in auxin content and correlation with herbicidal sensitivity at various periods.

Soil adsorption of amino triazole was considered as one of the possible causes of variable results achieved from pre-emergence treatments with this compound. Adsorption was not a linear function of concentration of solution applied, but was nevertheless considerable in the soil used.

Research in Washington on Canada thistle has shown the sucrose content of the roots to remain stable at various intervals after foliar treatment with 2,4-D. Reducing sugars were constantly depleted in the treated plants, but not to the degree they were in the non-treated controls. Conversely, dextrins and levulins increased with time, even to some extent in the treated plants, thus suggesting a translocation from deeper root levels. Related studies on bindweed roots showed a decrease in weight between the 28th and 56th days after application of 2,4-D at 1 and 2 lb. rates. This was followed by a weight increase - an apparent indication of recovery. Of plants grown under 4 combinations of soil moisture and nitrogen level, those with the high nitrogen-low water combination showed the greatest reduction in root weights.

Experiments with kidney beans have demonstrated that the addition of certain chlorinated acids or unsubstituted carboxylic acids to amino triazole results in decreased chlorosis development in primary leaves, but increased chlorosis in growth above the primary leaves. Further work of this nature was carried out on barley.

Some interesting reports have come from Oregon. A new analytical method for the determination of isopropyl-N-phenyl carbamate utilizes a color reaction, the optical density of which is measured at 580 mμ.

A method of evaluating the herbicidal activity of chemicals by the Ferguson principle has been presented. It is based on the ratio of concentration required for production of a given response to solubility at a given temperature. Reaction rates of halogen-substituted acids with glutathione, a tripeptide containing the SH group, were shown to be quite variable - a possible explanation for differences in physiological activity among chemicals.

A number of carefully determined physical properties of herbicidal chemicals was reported. These included density, solubility, ionization and surface tension. In addition, the partial molar volume of several chloro alkyl acids was determined and compared with the molar volume. It was considered that the relation of these values to one another may in turn be related to biological activity.

Penetration of 2,4-D and amino triazole from the upper and from the lower surfaces of the leaves of Zebrina pendula. Yamaguchi, Shoga and Crafts, A. S. The factors of penetration of herbicide chemicals are numberous and variable. There is no ideal experimental plant for the study of these factors. Nevertheless, in *Zebrina pendula* some of the variables are reduced to a minimum. The plant is readily propagated from cuttings and genetic variability is obviated. Also, the upper surface of the leaves is devoid of stomates and interpretation of results need not be confounded by whether or not the applied solution had moved into stomatal cavities by capillary movement.

Plants which have been spot-treated on the leaves are quick-frozen with dry ice and vacuum-dried at -7 degrees C. By this method all movement of the radioactive chemicals in the plant is stopped almost instantly and no further movements occur. Radioautographs of these plants serve as a source of our information.

Penetration is not a linear function of the concentration. Both 2,4-D and amino triazole appear to have certain minimum concentrations below which penetration is nil. 2,4-D has repeatedly failed to penetrate the upper surface of *Zebrina* leaves to any extent with concentrations of 500 ppm. or lower. At 2500 ppm. or higher it readily penetrates. In fact, penetration is about as rapid as it is from the lower surface, which has stomates. The amount, however, which can penetrate from the upper surface may not equal that from the lower surface. The lower surface has permitted penetration of 2,4-D even at 100 ppm.

Amino triazole has shown a similar concentration effect on this plant. At 2500 ppm. and lower, penetration was very limited. At 12,000 ppm. penetration into the leaf was extensive. We have evidence that the lower effective concentration of amino triazole for penetration through the upper surface is about 5000 ppm. On the other hand, penetration from the lower surface was extensive with 2500 ppm.

The concentration of 2,4-D for effective penetration from the upper surface of the leaves of *Zebrina pendula* is between 15 and 25 times that for the lower surface. The concentration differences with amino triazole is about five times. This discrepancy is probably explained by the fact that, whereas the amino triazole is dissolved in water alone, the 2,4-D is dissolved in 50 percent alcohol and 0.1 percent surfactant (Nonic), which facilitates flow into stomatal cavities.

The first evidence of penetration into the leaf is usually the spreading of the radioactive chemical through the veins from the point of application to other areas of the leaf blade. Then movement of the chemical out from the leaf and into the stem via phloem becomes prominent. All this occurs within two hours. When the concentration is low and penetration occurs, the radioactive chemical is moved out from the leaf about as readily as it is moved toward the edge or the tip of the leaf. In this case the amount penetrating the leaf surface is but a trace. (Department of Botany, University of California, Davis.)

<u>A fluorescence method in foliar penetration studies.</u> Dybing, C. D. and Currier, H. B. The relative importance of cuticular versus stomatal entry is an unanswered problem in the foliar penetration of solutions. Once in the cell walls or intercellular spaces, there remain the questions of protoplasmic uptake and movement, a movement that may be both in walls (apoplastic) and from protoplast to protoplast (symplastic).

In addition to radioactive solutes, fluorescent dyes are useful tracers in investigating leaf penetration. The two methods tend to be complimentary. Promising results have been obtained with solutions of trisodium 3-hydroxy-5,8,10-pyrenetrisulfonic acid. For <u>Zebrina pendula</u> leaves, cuticular penetration of the upper non-stomatal surface was evidenced by staining of epidermal cell walls. On the lower surface, vacuum infiltration caused rapid filling of substomatal air chambers with bulk solution. Immersion and application of droplets produced no such result in short treatments. After 12 hours immersion, however, stomatal entry had occurred. There was greater penetration of the lower surface than of the upper in all cases. This is believed due in part to a thinner and/or more permeable cuticle on the lower epidermis, since the dye appeared first in the cell walls, in patterns unrelated to the distribution of stomata.

Adding a surfactant to the solution generally resulted in a greater penetration, regardless of type of treatment.

Results so far agree with observations on the same plant by Yamaguchi and Crafts, who employed radioactive tracers. (Department of Botany, University of California, Davis.)

<u>The relationship between free auxin content and susceptibility of burroweed to systemic herbicides.</u> Schmutz, Ervin M., Turner, Raymond M. and Harris, Robert M. Work during the past year has involved perfection of a technique for extracting indole-3-acetic acid (1AA) from burroweed (<u>Haplopappus</u> <u>tenuisectus</u>). This technique includes the following steps:

1. Collect tissue and freeze immediately in absolute alcohol.
2. Extract in absolute alcohol for 12 hours at -10° C.
3. Filter and evaporate alcohol from filtrate.
4. Dissolve the filtrate which remains in glass-distilled peroxide-free ether.
5. Wash ether-filtrate solution with aqueous 1/10 saturated $NaHCO_3$. Discard ether.
6. Acidify aqueous solution to pH 2.8 using 15% tartaric acid.
7. Shake with glass-distilled peroxide-free ether. Discard aqueous fraction.
8. Chromatograph ether extract using distilled water as solvent.
9. Elute paper with ether and make quantitative determination by Avena curvature test.

During 1956, small plots are to be sprayed at intervals of one to two weeks, and tissue samples will be obtained from plants in adjacent unsprayed area. These tissues will be analyzed to determine their 1AA content. In this manner any relationship between herbicidal susceptibility and 1AA content at different times of the year can be determined.

Certain environmental conditions are to be studied to facilitate interpretation of the results. Among these conditions will be precipitation, soil moisture, and air and soil temperature. Detailed notes will be taken on the phenology of burroweed. (Arizona Agricultural Experiment Station, Tucson.)

Soil adsorption of amino triazole. Freed, V. H. and Montgomery, M. The reported variability in the pre-emergence behavior of 3-amino-1,2,4-triazole suggests a strong interaction with soil. In addition, the chemistry of this material would indicate the possibility of considerable adsorption.

As a study preliminary to the determination of the adsorption bond energy, the adsorption isotherm was run. A sandy soil known to be a relatively poor adsorber was used. Varying concentrations of amino triazole solution were used to treat a standard amount of soil. The amount of amino triazole adsorbed per gram of soil was determined by a recently developed analytical method. The amount of amino triazole adsorbed from solutions of different strength are recorded below.

Concentration of amino triazole, ppm.	Amino triazole adsorbed, µg/g. soil
25	35
50	65
100	100
200	160
400	230
800	290
1600	330

It may be noted that the amount of CMU adsorbed by this soil is only 72 µg/g. soil, indicating the very ready adsorption of amino triazole. (Agricultural Chemistry Department, Oregon Agricultural Experiment Station, Corvallis.)

The effect of 2,4-D foliar spray on the weight and carbohydrate content of Canada thistle roots. Rasmussen, L. W. A uniform, heavily infested area of Canada thistle was selected in the spring of 1954 for this study. Plots 15 x 20 feet were laid out and the treatments were applied when the plants were in the early bud stage. The treatments included 2,4-D ester at 1, 2, and 4 pounds per acre and an untreated check. Treatments were randomized and replicated four times. Root samples of approximately 200 grams were taken from each plot 28, 42, 49, 56, 63 and 77 days after treatment. These roots were taken from the region of 6 to 18 inches below the soil surface. The roots were taken into the laboratory, washed, blotted free of surface water and 50-gram portions were weighed out, killed, and later extracted in 80 percent ethyl alcohol.

During the sampling period the dry weight of roots from the untreated checks showed a straight line increase. A similar but lower level change was shown for the one pound treatment. No changes were shown in the dry weights of roots from the two and four pound treatments. The comparison of treatment effect showed a highly significant difference between the check and the mean of the treated plots. The comparisons among treatments showed a linear relationship with rates of 2,4-D application. The one pound treatment showed the highest dry weight of roots, the two pound rate was intermediate and the four pound rate had the lowest level. The content of reducing sugars was higher in the roots from treated plots than in those from the check. Over the sampling period the reducing sugars decreased in all treatments and in the check. The trends were linear with time. The sucrose content was not affected significantly by treatment with 2,4-D and no change in the content of this component occurred throughout the sampling period.

Dextrin and levulin constituted the principal polysaccharide reserves. The level of these reserves increased in all roots throughout the sampling period. In general, the increases were linear and in all cases the change in level was statistically significant. The content of reserve carbohydrates was significantly higher in the untreated check than in the treated roots.

The level of carbohydrates and particularly the increase in the reserve forms indicates the capacity of the roots to survive treatment. It is suggested by the data and observations that many roots die at least in the area sampled, even though the carbohydrate content appears favorable to survival. The quantity of roots in each plot was not determined but in digging samples it was obvious that many roots were killed by the two and four pound treatments. Consequently, death of the roots resulted from some condition or effect other than a change in carbohydrate content. Roots which appeared to be alive were found to contain ample carbohydrates for continued life processes. The observed increases in reserve carbohydrates was undoubtedly due to translocation from deeper levels of the roots inasmuch as treatment killed the top growth and hence stopped photosynthesis. (Washington Agricultural Experiment Station, Pullman.)

<u>The effect of 2,4-D on volume and composition of bindweed roots.</u> Weis, Maurice E. and Rasmussen, Lowell W. This study was designed to measure certain effects of 2,4-D on the complete root system of bindweed plants (<u>Convolvulus arvensis</u>).

Seeds were germinated and then planted in individual gallon containers provided with drainage. Initial growth was made in the greenhouse; the plants later were moved outside. The containers were buried in the soil with their tops flush with the soil surface.

Three separate tests were designed. Test I included 0, 1/2, 1, and 2 pounds of 2,4-D per acre replicated 6 times for each of 6 sampling dates for a total of 144 containers. Test II included high and low nitrogen levels, high and low water levels, and rates of 2,4-D at 0 and 1 pound per acre for each of the 4 different combinations of water and nitrogen levels. This test was replicated 4 times for each of 5 sampling dates for a total of 160 containers. Test III included shade and non-shade grown plants treated with 0 and 1 pound of 2,4-D per acre. This test was replicated 5 times for each of 5 sampling dates for a total of 100 containers.

All 2,4-D treatments were applied by means of a plot sprayer with a 4 foot boom. Shields were used to prevent drift. The spray volume was equivalent to 52.5 gallons per acre and the pressure was 30 psi. Test I was treated on July 21 and tests II and III were treated on August 1.

In test I, the sampling intervals were at 7, 14, 21, 28, 56 and 84 days after treatment. In test II and III the sampling intervals were at 7, 14, 21, 28 and 84 days after treatment. At each sampling date one container was removed from each treatment in each replicate. All of the roots from each container were carefully washed out and collected. The fresh and dry weights of the roots from each container were recorded and notes were taken on the condition of the top growth of each plant at the time of sampling.

In test I, the treated and check plants showed increases in fresh and dry weights of roots up to 28 days. At 56 days after treatment the plants treated at the 1 and 2 pound rates showed a decrease in fresh and dry weights of roots while the 0 and 1/2 pound rates maintained a constant level. At 84 days after treatment the plants treated at the 1 and 2 pound rates showed an increase in fresh and dry weights of roots over that at 56 days indicating some recovery. All plants showed regrowth of shoots at 84 days after treatment.

In test II, 2,4-D treatment caused the greatest reduction in fresh and dry weights of roots when applied to plants grown under a high nitrogen and low water combination. The hydration ratios of the roots from these plants were also greater than those of treated plants grown under the other combinations of water and nitrogen levels.

In test III, the plants grown in shade showed a much greater decrease in fresh and dry weights of roots when treated than those grown under full sunlight.

The data obtained indicate that 1 and 2 pound rates of 2,4-D cause measurable decreases in the fresh and dry weights of bindweed roots. However, all treated plants were capable of regrowth and subsequent recovery. A high nitrogen level appears to be a more important factor than a high water level in maintaining bindweed in a condition susceptible to 2,4-D. Shaded plants show greater reduction in root growth when treated with 2,4-D as compared to those plants grown in full sunlight.

The recovery of all treated plants leads to some speculation. Either the quantity of 2,4-D applied was insufficient or the quantity which entered and translocated into the root system was insufficient. The latter condition of course, could have been due to the insufficient application or to plant resistance. The remaining question is - can a bindweed plant that has reached full bloom stage be killed with one application of 2,4-D? (Washington Agricultural Experiment Station, Pullman.)

<u>The response of kidney beans and barley to mixtures of amino triazole and several chlorinated acids, sodium salts of chlorinated acids, and unsubstituted carboxylic acids.</u> Sheets, T. J. and Leonard, O. A. Kidney beans (<u>Phaseolus vulgaris</u> L.) were seeded in 4-inch pots, thinned to two plants per pot, and treated when the primary leaves were expanded. Barley plants (<u>Hordeum vulgare</u> L.) were treated when approximately 6 inches high; each treatment consisted of ten plants contained in 4-inch pots. The chemicals were dissolved in water and the solutions applied at the rate of 40 gallons per acre.

The addition of the sodium salt of 2,2-dichloropropionic acid (DPA) to 3-amino-1,2,4-triazole (amino triazole) solutions, at sublethal doses of the chemicals, decreased chlorosis development in primary leaves of beans treated with such mixtures and tended to increase the total chlorosis development in the growth above the primary leaves. This effect was evident when the molarity of the sodium salt of DPA in the solution approached or was greater than the molarity of the amino triazole. Several chlorinated acids and sodium salts of chlorinated acids including 2,2-dichloropropionic acid, TCA (trichloroacetic acid), sodium TCA (sodium trichloroacetate), 2,2,3-trichloropropionic acid, and E.H. 6249 (sodium 2,2,3-trichloropropionate) when mixed with amino triazole produced similar results. Bean plants responded similarly to mixtures of sodium MCA (sodium monochloroacetate) and amino triazole; however, contact injury of the primary leaves occurred at lower rates of sodium MCA than with the other materials. Although mixtures of amino triazole with these chemicals at equal molarities usually reduced growth below either used alone, there appeared to be no more than additive effects and perhaps less.

There was apparently no more than additive effects on weight reductions of barley from mixtures of amino triazole and sodium DPA. Similar results were obtained with sodium MCA, sodium TCA, or 2,2-dichloropropionic acid, when mixed with amino triazole in equal molar amounts.

Unsubstituted carboxylic acids of the series from acetic through heptanoic were mixed at equal molar amounts to one-half and to one pound-per-acre rates of amino triazole and the solutions applied to beans and barley as described above. A mixture of sodium DPA and amino triazole was included for comparison.

The carboxylic acid-amino triazole mixtures had little or no effect on the chlorosis of the treated primary leaves of beans. They increased the percent chlorosis in the growth above the primary leaves but were slightly less effective than sodium DPA in this respect. Addition of these acids to amino triazole reduced the weight of the growth above the primary leaves but, again, were not as effective as sodium DPA. Weights of barley were reduced at the high rate of all carboxylic acid-amino triazole mixtures, except the one containing butyric acid.

Sodium DPA alone at the high rate reduced weights whereas the acids alone either increased or had no effect on weights of barley and beans. Since the carboxylic acids apparently have no herbicidal activity, particularly at these rates, it is possible that penetration and/or translocation of amino triazole is increased by inclusion of the acids in the herbicidal solutions. (Field Crops Research Branch, ARS, USDA, and California Agricultural Experiment Station, cooperating.)

<u>An analytical method for isopropyl-N-phenyl carbamate (IPC)</u>. Freed, V. H., Montgomery, M. and Burschel, P. In the course of study with isopropyl-N-phenyl carbamate (IPC), it was realized that a more direct and simplified method of analysis of the chemical was needed. It was found to be feasible to use basic hydrolysis to form aniline from which color could be developed.

The reagents and procedure used are as follows:

Reagents:

NaOH	- 20 percent weight/volume
HCl	- 1 normal
Dye	- 2 percent N-1-naphthyl ethylene-diamine dihydrochloride
Aniline	- Eastman white label - redistilled 99.9+ percent pure - 10.0 milligram/liter
IPC	- 99.2+ percent purity - 100 milligram/liter
$NaNO_3$	- 2 percent
NH_2SO_3H	- 10 percent

The standard curve is prepared by adding known quantities of aniline to a 50 milliliter volumetric flask. One ml. of 2 percent $NaNO_3$ is added. After 20 minutes 1 ml. of 10 percent sulfamic acid is added. Next, after 15 minutes, 5 ml. of dye is added and after 90 minutes for color development, the color intensity is determined at 580 mµ.

In determining IPC, 100 micrograms are placed in a 500 ml. flask and 100 ml. of 20 percent NaOH is added. The contents are refluxed for 4 hours. After a double condenser has been assembled, distill at the rate of 7-10 ml. per minute until 50 ml. of distillate is received. Catch the distillate in 3 N HCl. A 20 ml. aliquot is taken for color development. One microgram of aniline is equal to 1.923 micrograms of IPC. Recoveries of 99.0 - 100 percent have been obtained, using highly purified IPC.

This method has been found equally applicable to Isopropyl-N-(3 chlorophenyl)-carbamate (Cl - IPC). The method has been successfully applied to residue determinations in both crops and soil. (Agricultural Chemistry Department, Oregon Agricultural Experiment Station, Corvallis.)

<u>The application of the Ferguson principle in evaluating herbicidal activity</u>. Freed, V. H. and Montgomery, M. It has been found that application of the Ferguson principle can be of great use in evaluating herbicidal activity of chemicals. The basis of this principle is in the establishment of a thermodynamic partition equilibrium. When the chemical is evaluated at several dosages, the concentration required to give a predetermined response - usually the 50 percent level - may be used to compute the activity potential. This is the ratio of the concentration required to produce a given response and the maximum solubility or pressure at the given temperature. By means of this constant, it is possible to ascertain the nature of the action of the chemical and to make a quantitative evaluation of the influence of structure on activity.

Several herbicides were evaluated by application of this principle. Corn seeds were germinated in a dark chamber for two days. The roots were measured and the seed placed in a petri dish between filter papers. To this was added 10 ml. of a known concentration of the solution of the chemical. After an additional two days growth, the roots were again measured. Plots of the transformed data permitted determination of the concentration of chemical required to give 50 percent growth inhibition. From this data and the data on the solubility of the compound, the Ferguson activity was calculated. The following table presents this information for a few herbicides:

Compound	Ferguson "activity"
2,4-D (acid)	0.0017
2-Methyl-4-chlorophenoxy-acetic acid	0.00095
2,4,5-T (acid)	0.0043
Isopropyl N-phenylcarbamate	0.065
Indole-3-acetic acid	0.0092
Maleic hydrazide	0.028
Malonic acid	0.0034
Amino triazole	0.0018

It is very apparent on the basis of these data that there exists differences in the activity of many of these compounds. However, in all cases, there is evidence for specific action on the organism. (Agricultural Chemistry Department, Oregon Agricultural Experiment Station, Corvallis.)

<u>The reaction rates of halogen-substituted acids with glutathione</u>. Freed, V. H., and Montgomery, M. It has been shown that compounds of the type structure R-CHCl-COOH react with sulfhydryl groups of living systems. It is in this manner that iodoacetic acid exerts its toxic action.

The reaction of halogen substituted alkyl acids with sulfhydryl groups is a typical second order reaction i.e. the rate is dependent on the concentration of both reactants. It obeys the typical second order reaction equation:

$$\frac{dx}{dt} = k\ (a-x)\ (b-x)$$

where a and b are the reactants and x is the product.

It became of interest to compare the rate of reaction of several halogen containing alkyl acids and their derivatives with a sulfhydryl compound. The ubiquitous physiologically active compound glutathione was selected for study.

Equimolar amounts of glutathione and the desired acid or its derivative were added to a flask in 0.04 molar sodium bicarbonate buffer at pH 7.4. The system was kept under an atmosphere of nitrogen. After varying lengths of time, aliquots of the reaction were analyzed for the disappearance of sulfhydryl groups of glutathione. This was done by use of the nitroprusside method for sulfhydryl groups.

The following table presents the information thus obtained:

Compound	Reaction constant k (liters per mole per second)
Trichloroacetic acid	0.77
2,2-dichloropropionic acid	0.49
2-chloro-N,N-diethylacetamide	3.48
2-chloro-N,N-diallylacetamide	2.68

It is possible that the wide differences in reaction rates may account in part for differences in physiological activity between chemicals. Differences in absorption rates are probably a factor also. (Agricultural Chemistry Department, Oregon Agricultural Experiment Station, Corvallis.)

The physical properties of some of the phenoxyacetic acids. Montgomery, M. and Freed, V. H. In the course of investigation of the physiological action of a chemical, it is often important to have exact information on certain of the chemical's properties. Often of particular importance will be th water solubility and its ionic behavior. In the course of certain studies, it was necessary to have a more accurate value for some of these properties than are found in the literature.

Accordingly, highly purified samples of the phenoxyacetic acids were synthesized and recrystallized several times until the melting points agreed to within ± 0.1 degree and analyses showed a purity of at least 99.9 percent. All values reported were obtained by conventional methods and are an average of two or more separate determinations. The values are all for 25 degrees C ± 0.2 degrees C.

Acid	Density	H_2O sol. ppm.	K (ionization)	pK
Phenoxyacetic		10,202	9.21×10^{-4}	3.026
o-Chlorophenoxyacetic		633	16.6×10^{-4}	2.780
p-Chlorophenoxyacetic		381	43.3×10^{-4}	2.364
2,4-Dichlorophenoxyacetic	1.56 ± .038	725	4.91×10^{-4}	3.309
2,4,5-Trichlorophenoxyacetic	1.72 ± .054	280	7.35×10^{-4}	3.135
2,4,6-Trichlorophenoxyacetic		58	3.66×10^{-4}	3.347
Indoleacetic		1,645		

(Agricultural Chemistry Department, Oregon Agricultural Experiment Station, Corvallis.)

The surface tension of aqueous solutions of some herbicides. Freed, V. H. and Montgomery M. It is a well established fact that the surface tension of a solution or its wettability is important in herbicide application. Since information on the surface tension of solutions of herbicides is not readily available, the measurements for a few of these materials are recorded here. These values are composite averages of a number of determinations on several different commercial samples. An attempt was made to have all dilution within the range that might be encountered in the field.

Material	Dilution pounds/gallon	Surface tension dynes/cm.
Ammate	1.0	71.3
Amino triazole		
50%	.2	56.8
80%	.12	50.4
CMU	.1	51.3
Dinitro general	2 qts/100 gallons	36.5
Dinitro amine	.03	45.0
Dalapon	.2	36.5
IPC	.2	37.9
Maleic Hydrazide (amine)	.03	67.1
2,4-D		
Triethanolamine	.1	54.3
Dimethylamine	.1	49.6
L.V. ester	.1	36.9
2,4,5-T		
L.V. ester	.1	42.6
Brush Killer ester	.1	40.1
Crag Herbicide #1	.1	57.7
Sodium Chlorate	1.0	69.3
Water		71.97

(Agricultural Chemistry Department, Oregon Agricultural Experiment Station, Corvallis.)

<u>The partial molar volumes of chloro alkyl acids.</u> Freed, V. H. and Montgomery, M. The relationship of the structure of a compound to its biological activity is very complex. It involves not only the chemical structure but the three dimensional structure as well. Among other things that have been suggested, is the molecular volume. Since the toxicant in a biological system is in an aqueous phase, it was adduced that the partial molar volume might be pertinent to this relationship. The partial molar volume is the volume contribution of the constituent at infinite dilution.

The partial molar volumes of several chloro alkyl acids were determined and compared to the molar volume. These data are recorded below.

Acid	Molar volume	Partial molar volume
Monochloroacetic	59.8 cc	65.0 cc
Trichloroacetic	101.1 cc	97.5 cc
2,2,3-Trichloropropionic	118.9 cc	131.0 cc
2,2-Dichloropropionic	102.2 cc	102.2 cc

It appears significant that the dichloropropionic acid, a systemic material, is the only one showing no appreciable volume change in solution. The other materials show a volume change and possess partial molar volumes that are fractional multiples of that of monochloroacetic acid. (Agricultural Chemistry Department, Oregon Agricultural Experiment Station, Corvallis.)

PROJECT 8. RESEARCH TECHNIQUES

J. W. Whitworth, Project Leader

SUMMARY

Only three individuals contributed reports to project 8. Information on research techniques is either highly confidential or so well known that it does not require publication.

Colorado submitted a paper on methods used in making a detailed weed survey of an area to be included in a proposed pest control district. With aerial photographs as a guide, weedy species, crops, and ecological features were charted. Such a survey should permit intelligent commitment of forces and eliminate shadow boxing with a phantom problem as sometimes happens. The survey indicated that the problem centers around three weedy species: bindweed (Convolvulus arvensis), Canada thistle (Cirsium arvense), and wild oats (Avena fatua).

Washington described a highly satisfactory light weight plot sprayer for the accurate application of various rates of herbicides. But more important, an outline is presented for a method for making a rapid, accurate, and systematic evaluation of the effects of such applications. Information is also included on how to make a valid analysis of the data collected by this method.

The effectiveness of techniques for the control of experimental error associated with soil variability in cotton fields treated with herbicides for the control of annual weeds were evaluated by New Mexico. Methods of covariance and stratification based on paired check plots and initial weight of cotton plants pulled at thinning time made possible significant reductions in the error term.

REPORTS OF INDIVIDUAL CONTRIBUTORS

Some techniques for making a detailed weed survey in northern Colorado. Klein, William M., Harrington, H. D., and Fults, Jess L. Before effective community control measures can be initiated in a weed control district it is necessary to have detailed information concerning the location and extent of infestations. This information can be secured from a 'weed survey' that delineates the location of specific weeds.

In northcentral Colorado, near Fort Collins, such a weed-survey has been started. In this area portions of both foothills and shortgrass plains are found and on these plains are large acreages of irrigated cropland. For the purposes of this study this area has been subdivided into two regions which will be surveyed with different intensities. In the vicinity of a proposed Pest Control District, near Loveland, an intensive survey will be made and a more generalized survey on the remainder of the area.

In order to conduct an intensive examination of the proposed pest control district (an area of approximately 23 sections) aerial photographs were secured. These were of the scale of eight inches to the mile and were reprints of pictures taken in 1950. The procedure followed was to take these photographs out into the field and map the land divisions directly on them. These were division lines between different crops and the included area was assigned a number. This number was cross-referenced to a write-up sheet upon which notes were taken. These contained information on the crop, the weedy species represented and ecological features. The Colorado primary and secondary noxious weeds were plotted directly upon the photographs and their extent recorded on their respective write-up sheets.

On the problem area outside of the proposed pest control district county road maps have been used supplemented with topographic maps made by the U. S. Geological Survey. The procedure followed was to cover the area systematically in a car and to keep 'running' notes on the weed infestations as they were observed from the roads. In these observations the mileage and also a brief description of the infestation was recorded and from this information maps were drafted.

Preliminary results from data secured in the summer of 1955 indicate the most common perennial weed to be bindweed (*Convolvulus arvensis*). Canada thistle (*Cirsium arvense*) seems to be the cause for greatest concern among farmers. Judging from the large numbers of small patches and single plants along ditchbanks, it is spreading rapidly throughout the entire area. Kochia (*Kochia scoparia*) is by far the most frequently occurring annual plant. Interviews with farmers indicate little concern about it. The annual grass which seems to be causing the greatest amount of trouble, particularly in the Loveland area, is wild oats (*Avena fatua*). (Colorado Agricultural Experiment Station)

Herbicide application and evaluation. Rasmussen, L. W. The field testing of herbicides requires precise and timely application. It is essential, therefore, that the application be made with equipment which will deliver an exact quantity of spray uniformly over a plot in a short time.

A plot sprayer which has proved efficient in our tests has been developed over a period of several years. It consists of an air supply container, a spray solution container, and a pressure regulator mounted on a frame over two bicycle wheels. It is planned, however, to replace these wheels with cart wheels which have heavier axles and timken bearings. An aluminum boom is also supported by the framework. The boom consists of an aluminum frame supporting an aluminum tube (1/2 in. O.D.) on which are mounted Teejet eyelet nozzles spaced 18 inches. The boom has three sections and is hinged to permit folding for transport. The center section contains four nozzles and each wing section contains three nozzles, making a total of ten nozzles. The full boom will spray a width of 15 feet. By plugging some nozzles or by shutting off one or two wing sections, swath widths of 15, 12, 10.5, or 6 feet can readily be achieved. A portable air compressor is used to supply the air tank and the pressure is regulated to the desired level for spray applications.

The nozzles are calibrated on the sprayer. Selection of nozzle orifice size and regulation of speed of travel has made possible the application of spray volumes ranging from 1 to 50 gallons per acre. Higher volumes are, of course, possible. Volumes equivalent to 15 to 20 gallons per acre have been used in most of our tests. A pressure of 30 psi at the nozzles and a speed of four feet per second have proved desirable. The speed can be maintained accurately by timing with a stop watch.

Generally, a plot width has been used which could be sprayed with one pass over the plot. The chemical sprays can be prepared in the laboratory ahead of spraying time. The spray solution container has a capacity of three gallons and, for most tests, enough solution can be put in at one time to treat all of the replicate plots of a treatment without refilling. This practice saves much valuable time when spraying conditions are favorable and many plots must be sprayed.

Weed stand evaluation techniques have been studied for several years. A method which has been satisfactorily used for small weeds before treatment consists of counting weed-containing squares in a small frame. The squares are 2-1/2 x 2-1/2 inches in size, and the frame contains two rows of 16 squares or a total of 32. For evaluating larger weeds in wheat after treatment, a frame with inside measurements of 5 x 60 inches divided into five 12-inch long sections has been found suitable. It can be placed between the drill rows. The portion of each section containing weeds is estimated. Another frame used for large weeds contains five one-foot square sections, the entire frame measures 1 x 5 feet inside. The weed-covered area of each section is estimated.

The weed-coverage estimates are made on a wide scale basis which facilitates the decision and achieves good agreement among persons and over periods of time. The scale that has been found satisfactory is: No weeds, 0; trace to 1/10th cover, 5; more than 1/10 but less than 1/4, 15; 1/4 but under 1/2 cover, 30; 1/2 cover, 50; over 1/2 but less than full, 70; full cover, 100. This division requires only seven values to be considered and the two extremes 0 and 100 are readily seen. Therefore, a person only has five categories to be decided upon. By estimating many sections within a plot the over- and underestimates tend to average out and a reasonably reliable figure for weed coverage is obtained. If it is desired to analyse statistically weed coverage data obtained by the methods described here, a frequency distribution should be prepared first because such data are seldom normally distributed. Some appropriate transformation of the data is usually required to validate the use of analysis of variance. Contribution Washington Agricultural Experiment Station)

Techniques for the control of experimental error associated with soil variability. Whitworth, J. W. Extreme soil variability in some areas makes difficult the accurate measuring of the effect of herbicides on crop yields. Under such conditions, covariance and stratification can be advantageously used to obtain more dependable data, table 1.

Table 1. Effectiveness of methods for reducing the error associated with yields of cotton from plots on highly variable soils treated with herbicides to control annual weeds.

DESCRIPTION	TEST No. 1	TEST No. 2	TEST No. 3	TEST No. 4
METHOD	Covariance	Covariance	Covariance	Stratification
DEPENDENT VARIABLE	Paired check plots	Paired check plots	Initial wt. of plants	Initial wt. of plants
SOIL:				
Variability	moderate	moderate	moderate	EXTREME
Verticillium wilt	light	HEAVY	light	light
REGRESSION COEFF.	.82	.05	.58	.73[1]
LSD, 5%, TREAT.:				
Uncorrected	.68 bale/A	.94 bale/A	.36 bale/A	.72 bale/A[2]
Corrected	.41 bale/A	.94 bale/A	.30 bale/A	.53 bale/A
COEFF. OF VARIATION:				
Uncorrected	19%	20%	15%	29%
Corrected	11%	20%	12%	19%
NO. OF REPLICATIONS	3	4	10	6
DESIGN	Randomized Block	Randomized Block	Randomized Block	Factorial Stratified

[1]Calculated on strata or replications since some of treatments reduced yield by approximately the same amount in each strata.

[2]Based on error term before accounting for variation removed by strata.

Test No. 1 was laid out as a randomized block experiment with three replications. Alternating and adjacent to each plot was an untreated check plot that served as the dependent variable in making the covariance analysis. This method was used in test No. 1 and No. 2.

In test No. 1 it proved very effective, reducing the C. V. (coefficient of variation) from 19 to 11 percent, but was completely ineffective in test No. 2 where the soil was infested with verticillium wilt, a severe disease that makes an erratic patchwork of stands and yields of cotton. Eight replications would have been required in test No. 1 to obtain the same efficiency if this method of covariance had not made possible the reduction in the C. V. The effect of this correction on the LSD at five percent (least significant difference) between means showed an improvement of from .68 bales/A to .41 bales/A.

In tests No. 3 and No. 4, plots were laid out on a two acre field of cotton relatively free of verticillium wilt. The cotton came up to a beautiful stand and as it grew, an erratic patchwork of soil fertility and impermeable subsoil became apparent when a heavy rain followed on the heels of a heavy irrigation. This erratic pattern was similar to the one in test No. 2 where the design using alternate check plots failed to reduce the error. Therefore, this design was not used. At thinning time, the excess plants on the plots were pulled, counted, and weighed. This information was used in test No. 3 to lay out ten blocks, and the treatments of seedling-toxicant herbicides were assigned at random in each block. Therefore, block effect removed some variation and in combination with a covariance analysis that showed a regression coefficient of .58, the C. V. was reduced from 15 to 12 percent and the LSD at five percent from .36 to .30 bales/acre. Twenty replications would have been necessary to obtain the same efficiency if this covariance method had not made possible the reduction in the coefficient of variation.

Original plant weight was used as a basis to stratify the plots in test No. 4 into six groups or replications prior to the application of the hormone type herbicides since it was known that they would destroy the relationship between original plant weight and final yield. The stratification proved very effective with a regression coefficient of .73 calculated on the strata. This removed enough variation to reduce the C. V. from 29 to 19 percent and the LSD at five percent from .72 to .53 bales/A. (New Mexico State Agricultural Experiment Station)

PROJECT 9. ECONOMIC STUDIES OF WEED PROBLEMS AND CONTROL

D. C. Myrick, Project Leader

SUMMARY

Three abstract reports on economic studies were received. Two of these are based on experimental work still in progress, and the other is a summary of a survey of cost items and weed problems in cotton producing areas in California. These studies are just beginning to open up the wide field of study which can evaluate the weed problem, and demonstrate the economic feasibility of control practices.

In economic studies of tarweed control in wheat in Eastern Oregon, one phase was devoted to study of the injurious effects on wheat of 2,4-D applied at times and rates used in tests of control of tarweed. Fall applications at heavy rates caused more injury than spring applications. These findings are basic to appraising the results of treatment in infested wheat. Treatment of infested wheat has indicated that esters are more effective in controlling tarweed than the amine formulations of 2,4-D. Yield results showed no significant differences due to treatment as compared to the checks, which may possibly be attributed to the conditions of the experiment. The conclusion is that more research in this area is needed.

A mail survey was directed to cotton growers in the seven major cotton producing counties in California. Returns indicate that 12 percent of the land was infested with annual grasses, watergrass accounting for 11 percent. Annual broadleaved weeds infested 13 percent of the land, with pigweed accounting for 8.5 percent. Twelve percent was infested with perennial weeds, with Johnson grass accounting for 4.5 percent. Johnson grass and watergrass were considered the most difficult problems in California cotton production. Growers spent as a mean value $14.28 per acre for weed control above normal cultivations. There was a wide range in reported costs, but 50 percent were between $10.00 and $20.00 per acre, and 98 percent were $50.00 per acre or less. Despite control measures, four to six percent of California's cotton was lost to weeds.

Canada thistle control studies both in experimental plots and field surveys in Montana show a consistent pattern in the relationship between degree of infestation and yield. With the degree of infestation selected for analysis and a level of yield between that observed in the plots and a given field situation, the returns from one treatment (3/4 pound 2,4-D per acre) is extremely high in relation to the cost of treatment. A treatment the second year to control residual infestation returns a significant margin above the cost. The return from treatment the third year was near the margin but was still profitable. Data are not available with which to attempt analysis of the value of control in relation to progressive intensification of infestation, rate of spreading of infested areas, and rate of recovery of an infestation after treatment.

REPORTS OF INDIVIDUAL CONTRIBUTORS

Economic studies of tarweed control in eastern Oregon. Swan, Dean G., Chilcote, D. O., Furtick, W. R., and Mumford, D. Curtis. A series of trials were initiated the fall of 1954 to determine the effect of 2,4-D at one-half pound and one pound per acre on winter wheat and tarweed (Amsinkia intermedia) using fall and spring applications. A total of eight replications were used in an attempt to pick up small differences in yield. The 2,4-D formulations used in this trial were the isopropyl ester, amine, and low volatile ester. This trial was established in two different areas: (1) the Pendleton area (Umatilla County) on a clean stand of wheat so that information could be gathered as to the effect of the various materials on growth and yield of winter wheat; (2) the Moro area (Sherman County) which had a severe infestation of tarweed in the winter wheat planting.

In the Moro area fall applications were made December 13, 1954 using eighty gallons of water as a carrier. The wheat was in the three leaf stage and the tarweed was approximately two inches in diameter. Spring applications were applied March 31, using forty gallons of water as the carrier, applied when the wheat was four to five inches tall and in the tiller stage. At this time the tarweed was four to five inches in diameter. Harvest data were obtained from the Moro area on July 25.

The fall applications in the Pendleton area were made December 10, 1954, using eighty gallons of water as the carrier. The wheat was in the five leaf stage at the time of the fall applications. Spring applications were made April 6, at which time the wheat was four to five inches tall and in the tiller stage.

Information obtained from the trial established in the Pendleton area indicated fall treatments at the one pound per acre rate were somewhat more injurious to yield than the spring applications. Estimations obtained prior to harvest indicated that all fall treatments were somewhat damaging to wheat growth. Results indicated that spring applications of 2,4-D isopropyl ester were deleterious to the yield of wheat, especially at the one pound per acre rate.

Results from the trial established in the Moro area indicated the 2,4-D isopropyl ester and the 2,4-D low volatile ester (propylene glycol butyl ether ester) to be somewhat more effective when compared with the 2,4-D amine for the control of tarweed. The yield results did not present any significant difference between the various treatments and the untreated checks. This may possibly be attributed to the lack of uniformity of the wheat stand.

It appears from the results of these trials that more information is needed as to the economics of 2,4-D spray applications for the control of tarweed and other weeds in wheat. Where rates of 2,4-D exceed one-half pound per acre it is possible that more damage may be obtained by spraying for weed control than would be caused by the competitive effect of the weeds. (Oregon Agricultural Experiment Station, Corvallis)

A survey of weed problems associated with California cotton production. Foy, C. L., and Miller, J. H. Through the cooperation of the County Farm Advisors and the Agricultural Extension Service, a standardized questionnaire was sent to the cotton growers of seven major cotton producing counties in California. Information requested included (1) grower's name, location and acres farmed; (2) approximate acres infested with each of 12 major weed species, and others; (3) approximate cost of weed control in cotton above normal cultivation; (4) troublesome weeds along ditch banks, road sides, fence lines, etc., and the approximate cost of control; and (5) the most serious overall weed problem, and in what crop.

A total of 1,443 growers, or about 22 percent of the growers contacted, replied to the questionnaire. These growers operated 757,638 acres of land or about 19.5 percent of all the cultivated land of the seven counties. Their replies indicated that as a mean value they spent $14.28 per acre per season for weed control above normal cultivation. When the data were classified into frequencies, they showed that 50 percent of the replies indicated their costs to be between $10.00 and $20.00 per acre; 79 percent, between $5.00 and $25.00; 96 percent, $30,00 or less; and 98 percent, $50.00 per acre or less.

Based upon contacts with the cooperating Farm Advisors and prominent growers, it was estimated that as a mean value each cultivation cost $1.15 per acre, and that the number varied from four to seven. All or most of this expense may be assigned to weed control. Soil types was mentioned as an important factor influencing the number of cultivations. This governs the irrigation schedule, which in turn, governs to a large extent the emergence of annual weeds.

The addition of the weeding costs gave mean values varying from $18.88 to $22.33 per acre season. These values represent the typical situation. Stratification of the data showed that the weed costs of the lowest 25 percent ranged from $8.40 to $11.85 per acre per season, while those of the highest 25 percent ranged from $35.94 to $39.39 per acre per season. In spite of these expenditures for weed control, four to six percent of California's cotton crop was lost, either directly or indirectly, because of weeds.

Table 1 shows the estimated weed control costs and losses due to weeds in California cotton in 1954.

Both arithmetic means and modal values were recorded; however, because of the indicated bias in the data (the tendency for estimates to fall in muliples of five), the arithmetic means shown herein perhaps represent the more accurate values.

Weed control costs on ditch banks ranged from zero to $500.00 per mile per season. The mean expenditure for the seven counties was $81.60 per mile per season. Non-selective oils and mowing were the weed control measures used for the most part.

In reply to the question as to what weed species were most troublesome, the growers indicated that 12 percent of their land was infested with annual grasses. Among these, watergrass (Echinochloa crusgalli) accounted for 11 percent. The other annual grasses mentioned most frequently were crabgrass (Digitaria spp.), lovegrass Eragrostis spp.), and sandbur (Cenchrus pauciflorus). Thirteen percent of the land was infested with annual broadleaved weeds, of which pigweed (Amaranthus spp.) accounted for about 8.5 percent. Other annuals mentioned most frequently were lamb's-quarters (Chenopodium album), puncture vine (Tribulis terrestris), and purslane (Portulaca oleracea).

Twelve percent of the land was infested with perennial weeds. Percentage wise, Johnson grass (Sorghum halepense) accounted for 4.5 percent; bermuda grass (Cynodon dactylon) for 2.0 percent; nutgrass Cyperus spp.) for 1.5 percent; field bindweed (Convolvulus arvensis) for 1.5 percent; Russian knapweed (Centaurea repens) for 1.0 percent and white horse nettle (Solanum elaegnifolium) for 0.5 percent.

In all counties, Johnson grass and watergrass were considered to be the most difficult weed problems associated with California cotton production.

Table 1. Estimated weed control costs and losses due to weeds in California cotton - 1954.

	Low 25%	Typical	High 25%
Weed control costs in cotton (dollars/acre) — Arithmetic means			
Above cultivation	3.80	14.28	31.34
Cultivations (4-7)	4.60 - 8.05	4.60 - 8.05	4.60 - 8.05
Total	8.40 - 11.85	18.88 - 22.33	35.94 - 39.39
Losses due to weeds in cotton (Percentage of crop)	0 - 2	4 - 6	8 - 10
Weed control costs on irrigation ditch banks (dollars per mile per season)		81.60	

(University of California, Davis, and Field Crops Research Branch, ARS, USDA).

<u>Economic consequence of 2,4-D application in controlling Canada Thistle in the Gallatin Valley of Montana</u>. Baker, Chester B., and Infanger, Carl. Additional data from the plots described in the 1955 report plus data from field sampling provide material for further economic analysis of the control of Canada thistle in spring wheat. The minimum infestation of Canada thistle in which it will pay a farmer to attempt some control measure depends on (1) yield loss associated with the infestation, (2) the price of the crop being produced, (3) the rate at which the infestation can be reduced by the control measure, (a) this year and (b) in succeeding years, (4) the cost of the control measure, and (5) the rate at which an infestation will spread and/or intensity if unchecked, or recover after treatment. Point (5) is a significant part of the problem, but time and resources preclude study of it at this time.

In this experiment 3/4 pound 2,4-D in heavy ester or amine compound applied at the prebud stage, reduced the thistle count by about 90 percent. Preliminary evidence indicates this application will reduce a thistle-free crop yield by about 8.3 percent. The net effect on yield depends on the relative strength of these two opposing effects.

The relationship between degree of infestation and crop yield was remarkably consistent from experiments and from field survey. The experimental data are plotted in the top curve in Figure 1, and an example of the field survey data in the bottom curve. The slopes of the curve are 1.19 and 1.1, respectively. The middle curve is, at each point, vertically, the arithmetic mean of the other two. Since no particular farm situation is likely to be identical with either the experimental one or with the surveyed one, the middle one was purposely selected.

Table 1 shows results of various 2,4-D spray programs in terms of (1) thistle count, and (2) wheat yield. Because the crop and thistle growth are so far advanced at time of treatment, the major control effects and hence effects on yield are observed in the following year. The thistle count is shown before the slant (/) and the wheat yield immediately after, in each "cell" of the table.

The value of the four-year increment in spray treatments - first year only over no spray, first and second over first year only, and for three years over the first two - is given in Table 2, over a wide array of selected wheat prices. These results are all based on a beginning thistle infestation of 25 shoots per 16 square feet, yielding 42 bushels of wheat per acre. Each of the "cells" indicates the cost one could afford to incur in selecting the particular spray treatment indicated at the left of the row. If a single application costs $2.00 per acre, as long as wheat brings $2.00 or more per acre, it appears feasible to spray for at least three consecutive years.

Figure 2 shows graphically the break-even points. For the first year, the line OA passes off the chart before reaching 50 cent wheat. For the second year, line OB, we can afford $4.70 for the treatment with wheat at only $1.00 per bushel. Along line OC we find for the third year that with wheat at $2.00 we can afford $2.20 for treatment. (Montana Agricultural Experiment Station, Bozeman)

Table 1. Effect of 2, 4-D on count of Canada thistle (per 16 square feet) and spring wheat yield; annual and four-year total.

Treatment		Thistle count/wheat yield in year 1	2	3	4	Total bu. of wheat	Increment of wht.
3/4 lbs 2, 4-D applied	none	25/42	30/40.5	42.5/35.5	51.3/32.0	150.5	
	first year	25/42	2.5/51.5	3.0/51	4.3/50.5	195.0	44.5
	first & sec. yr.	25/42	2.5/51.5	.88/53.3	1.1/52.9	199.7	4.7
	first, second and third year	25/42	2.5/51.5	.88/53.3	0.6/54.0	200.8	1.1

Table 2. Value added over a four-year period from selected spray treatments at various prices for wheat.

Treatment		Value of Wheat Increment with wheat priced at (per bu.)							
3/4 lbs 2, 4-D applied	price of wheat	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25
	first year	22.25	33.38	44.50	55.63	66.75	77.88	89.00	100.13
	first & sec. yr.	2.35	3.53	4.70	5.88	7.05	8.23	9.40	10.58
	first, second and third year	0.55	0.83	1.10	1.38	1.65	1.93	2.20	2.48

Figure 1.

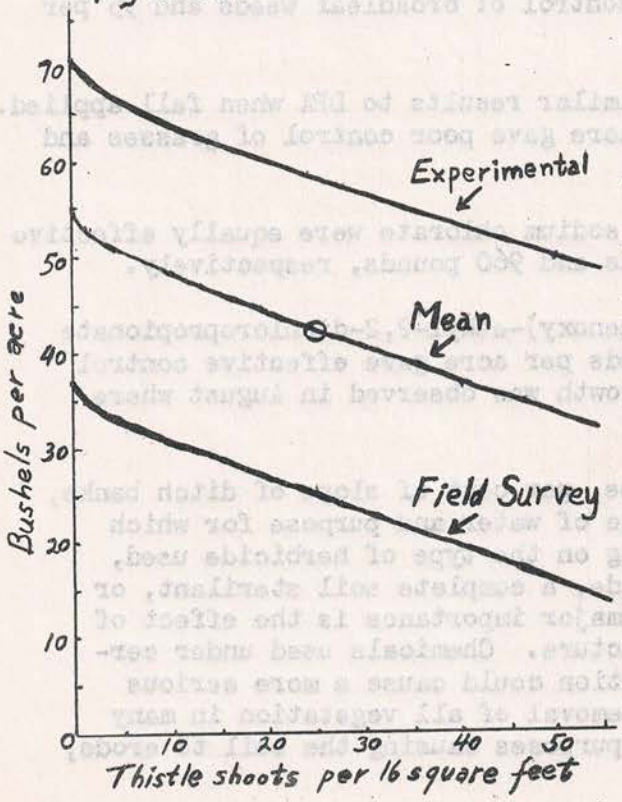
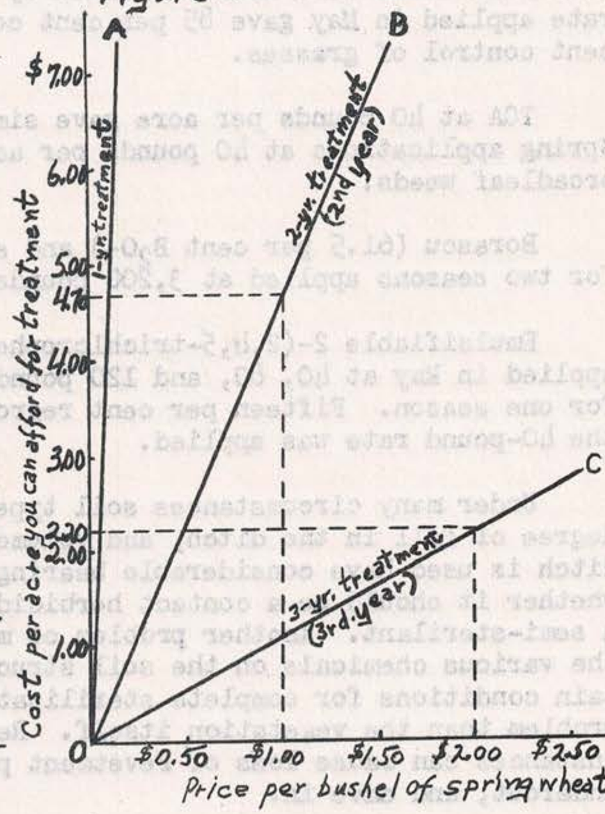


Figure 2



PROJECT 10. VEGETATION CONTROL ON RIGHTS-OF-WAY AND INDUSTRIAL SITES

J. R. McCambridge, Project Leader

SUMMARY

A total of nine reports were received from six investigators from three states.

Chemical control of ditchbank vegetation. This problem needs considerable attention by investigators throughout the western states as vegetation on ditch banks causes serious water delivery problems, evaporation losses, seepage, ditch breaks, and dissemination of noxious weeds in agricultural lands as well as distribution of secondary weed pests.

In ditchbank vegetation control trials where smooth brome, orchard grass, Kentucky bluegrass, timothy, goldenrod, sweetclover, and sunflower were the dominant species, 40-and 80-pound per acre rates of CMU applied in the fall gave complete control for two seasons. PDU at the same rate was not as effective as CMU the second season but gave equal control for the first season.

DPA was applied at 20 and 40 pounds per acre in the fall and spring. Grasses were 80 per cent controlled the first season at the 20-pound rate and 95 per cent controlled at the 40-pound rate at both dates of application. Broadleaf weeds were not controlled by the fall application. The 40-pound rate applied in May gave 85 per cent control of broadleaf weeds and 95 per cent control of grasses.

TCA at 40 pounds per acre gave similar results to DPA when fall applied. Spring applications at 40 pounds per acre gave poor control of grasses and broadleaf weeds.

Borascu (61.5 per cent B_2O_3) and sodium chlorate were equally effective for two seasons applied at 3,200 pounds and 960 pounds, respectively.

Emulsifiable 2-(2,4,5-trichlorophenoxy)-ethyl-2,2-dichloropropionate applied in May at 40, 80, and 120 pounds per acre gave effective control for one season. Fifteen per cent regrowth was observed in August where the 40-pound rate was applied.

Under many circumstances soil type, per cent of slope of ditch banks, degree of fall in the ditch, and volume of water and purpose for which ditch is used have considerable bearing on the type of herbicide used, whether it should be a contact herbicide, a complete soil sterilant, or a semi-sterilant. Another problem of major importance is the effect of the various chemicals on the soil structure. Chemicals used under certain conditions for complete sterilization could cause a more serious problem than the vegetation itself. Removal of all vegetation in many instances can cause loss of revetment purposes causing the soil to erode, undercut, and cave in.

Other problems which need to be solved in respect to this subject are the toxic effect of the various chemicals used to the crops to which the ditch will supply water, the stability of the compounds in the soil, and the parts per million of the chemical which could be expected to carry out of the ditch and into the field causing possible crop damage.

Control of vegetation in public utility substations. This program has considerable appeal to public utilities: (1) safety to personnel, (2) fire prevention, (3) aesthetic value for community and public relations, and (4) economics of maintenance.

Three prime requisites of a herbicide for this type of work are that the compound be non-poisonous, non-inflammable, and non-corrosive to the underground grids.

Telvar W and Telvar DW are being used by public utilities for vegetation control at the rates of 15 to 60 pounds per acre, depending on soil type, vegetation present, and total annual precipitation. In areas where annual precipitation is below 30 inches applications are generally made in the fall of the year when there is still adequate moisture to aid penetration. In areas of high precipitation, 30 inches and above, application is usually made in the early spring to prevent heavy rains from moving the material off of the treated area. Movement of Telvar by surface water runoff has caused damage to lawns, shrubs, and trees adjacent to power installations. Both power sprayers and backpack sprayers are used to apply Telvar W and Telvar DW at the rate of 100 gallons solution per acre.

Chlorate-borate formulations are being used by public utilities as a soil sterilant at the rate of 2 to 4 pounds per 100 square feet. In most instances the application is made dry with a mechanical spreader.

Public utility transmission line rights-of-way. The low volatile formulation of the commercial brush killers, which contain 2 pounds acid equivalent of 2,4-D and 2 pounds acid equivalent of 2,4,5-T, have been found most successful for brush work. Applications are made for foliage, basal, and stump treatment. In the Northwest, foliage applications have been most successful when the brush species have completely leafed out, and are most effective on alder, willow, and cottonwood. Basal treatment has been found to be effective on nearly all species, including those resistant to the foliage sprays. Girdling the larger trees seems to improve performance. Stump treatment is normally performed one growing season following cutting to get best results.

The recommendation for foliage spraying is three quarts of brush killer in 100 gallons of water applied by power sprayer to give thorough coverage. For basal and stump treatment, a solution containing 5 gallons of brush killer and 95 gallons of diesel oil is applied with both power and backpack spray equipment.

Highway rights-of-way. Maleic hydrazide is being tested as a growth inhibitor on grasses for areas where it is desirable to maintain soil cover but to chemically suppress the grass to replace mowing. Application date of May 2 in the Willamette Valley of Oregon at the rate of 6 pounds per acre appeared to be most effective in one trial as compared to a December and February application at the same rate.

Kuron, 2,4,5-T low volatile ester, 2,4-D low volatile ester, solubilized 2,4-D, and solubilized 2,4,5-T, in oil alone and in combination with oil and water as the carrier, were compared with Dalapon and Amino Triazole for the control of lodgepole pine seedlings. Rates of 4 to 8 pounds of the hormone compounds per 100 gallons were compared with 20 to 40 pounds of Dalapon and 4 to 8 pounds of Amino Triazole per 100 gallons. Generally the 8-pound rate of the hormone spray was significantly better than the 4-pound rate, and oil as the carrier was consistently superior to the combination of oil and water. Indications are that 2,4-D is just as effective as 2,4,5-T on lodgepole pine seedlings. Neither Dalapon nor Amino Triazole were as effective as the hormone compounds in oil, but at the higher rate of each they did compare favorably with the hormones in the combination oil and water sprays.

Telvar W at Moro, Oregon, applied November 17, 1954, at the rate of 25 pounds in 125 gallons of water per acre gave 95 per cent control of all vegetation on highway shoulders as compared to a 90 per cent kill with 488 pounds of Chlorax "40" applied in 97½ gallons total solution per acre on March 8, 1955. Chlorea in this same demonstration at Moro applied March 8, 1955, at the rate of 405.4 pounds in 108 gallons total solution gave 95 per cent control.

At Pendleton, Oregon, Chlorax "40" applied at the rate of 616.25 pounds in 123.3 gallons total solution per acre March 10, 1955, gave 80 per cent control. Chlorea on the opposite side of the road at 307.33 pounds in 82 gallons total solution per acre applied in the same date gave 90 per cent control.

Telvar W is used by the California State Highway System at the rate of 26 pounds per acre in 100 gallons of water for the original application. The second year the rate is reduced to 20 pounds and then treatment is skipped until vegetation determines need for further treatment. The California Highway personnel have found that 4 to 6 pounds per acre applied in February do an excellent job of selectively weeding annual grasses out of ice plant, which is used for ground cover, without damage to the ice plant. In some areas where Telvar W is used adjacent to trees and shrubs, serious damage is occurring and operators are discontinuing its use where these problems exist.

Baron has been applied in two counties in California for roadside vegetation control at the rate of 15 gallons in 85 gallons of water per acre. Poison oak, mullein, sunflower, pigweed, nutgrass, and Russian thistle were not completely killed and the latter three grew in abundance but not enough to create a fire hazard. Treatments on previously graded areas were not as outstanding as on areas which had not been graded.

December application in Los Angeles County of 15 pounds of Baron in 85 gallons of water gave good results, where a February application at the same rate was unsatisfactory. Baron at 15 gallons per acre is being used in those areas where the use of Telvar W has been precluded due to damage to trees and shrubs.

Under trees and outside of oleander basins, Baron is being used at 15 gallons per acre. An application in December, 1954, was effective for the 1955 season. Baron is being tested at 5 gallons per acre within the oleander basins to determine its selective action in removing weeds and grasses without damage to the oleanders.

Dalapon shows promise as a selective herbicide to remove grass from ice plant ground cover up to 30 pounds per acre. Dalapon at 30 pounds per acre is being used in oleander basins for the control of Bermuda grass. Dalapon looks favorable for the control of tules and cattails at 40 pounds per acre.

Sodium chlorate and chlorate-borate combinations have been used extensively by highway maintenance departments and have been found to be excellent sterilants for firebreaks and maintenance area clean-up. There is a tendency for these compounds to lose their attractiveness because of low solubility. To apply 600 pounds of sodium chlorate per acre requires a total gallonage of 600 as compared to using Dalapon, Baron, and Telvar W which can be applied at the recommended rate in 100 gallons total solution per acre. The difference, aside from time saved in filling, is 40 roadside miles sprayed per tanker with low dosage materials as compared to 7 miles with the less soluble chlorates and chlorate-borate materials.

Evaluation and demonstration trials have been set up using Chlorea dissolved at the rate of 4 pounds in .8 gallon water bringing it up to 1 gallon volume and applied at the rates of 172.5 to 689.9 pounds per acre to be compared with Telvar W at the rates of 13.36 to 50 pounds per acre, Baron at 6.395 gallons per acre, and Polybor chlorate (25 per cent) at 721.1 pounds per acre. These demonstrations were put out this fall in southern California and others will be put out according to geographical location in relation to total annual precipitation. The purpose of these trials is to demonstrate the high solubility and low gallonage application of Chlorea as compared with the old chlorate-borate formulations, to observe its contact action on emerged vegetation, and to determine its effectiveness in comparison with Telvar W, Dalapon, Baron, and Polybor chlorate. These demonstrations will be evaluated as the season progresses.

Chemical control of ditchbank vegetation. Hodgson, Jesse M. Ideal growing conditions for many plants are provided on ditch banks. On smaller type ditches that farmers use intermittently, plants grow vigorously throughout the bottom as well as on the banks, creating a serious water delivery problem.

Experimental applications for control of plant growth on ditch banks were made in October, 1953, October, 1954, and May, 1955. The plots treated in May were sprayed about three weeks or more before any water was delivered in these ditches. Seven different ditch banks were used. All ditches had a capacity of one to three cubic feet per second. These ditches carried water about four days out of each fourteen and were used about four to six times per season. A mixture of plant species was present. Those most prevalent were smooth brome (Bromus inermis), orchard grass (Dactylis glomerata), Kentucky bluegrass (Poa pratensis), timothy (Phleum pratense), goldenrod (Solidago sp.), sweetclover (Melilotus sp.), and sunflower (Helianthus sp.).

1. CMU, 3-(p-chlorophenyl-1,1-dimethylurea) and PDU (3-phenyl-1, 1-dimethylurea) were equally effective the first season. Twenty pounds per acre applied in October effectively controlled all growth for the next growing season. The 40- and 80-pound rates of CMU have given complete control for two seasons to the present time. PDU was not as effective as CMU the second growing season.

2. DPA (sodium-2,2-dichloropropionate) was applied at 20 and 40 pounds per acre in October and May. Grasses were 80 per cent controlled the following season at the 20-pound rate and 95 per cent by the 40-pound rate at both times of application. Broad-leaved weeds were not controlled by the fall applications of DPA, but 40 pounds per acre in May gave 85 per cent control of broad-leaved weeds and 95 per cent control of grasses.

3. TCA (trichloroacetate) gave results similar to DPA when applied in the fall. May applications of 40 pounds per acre of TCA gave little control of either grasses or broad-leaved weeds.

4. Borascu (61.5 per cent B_2O_3) at 3,200 pounds per acre and sodium chlorate at 960 pounds per acre gave equally effective control for the first two seasons.

5. Emulsifiable 2-(2,4,5-trichlorophenoxy)-ethyl-2,2-dichloropropionate applied in May, 1955, at 40, 80, and 120 pounds per acre effectively controlled plant growth for the season. There was about 15 per cent regrowth in August where 40 pounds per acre was applied. (Field Crops Research Branch, USDA, ARS, and the Montana Agricultural Experiment Station, cooperating)

Control of vegetation in rights-of-way and maintenance areas of a public utility. Wetsch, Arthur F. Telvar W, 3-(p-chlorophenyl-1, 1-dimethylurea), has been used for more than two years for controlling weeds in substations and around tower structures and material yards. Borax and borax-chlorate mixtures have also been used for the same purpose but to a lesser extent. Telvar W is applied at the rate of 20 to 60 pounds per acre, depending on weed species, density of weed growth, and location. The soil sterilant is generally applied in the spring of the year after plant growth has begun. 2,4-D is added to the spray mixture, which enhances the results and at the same time permits a reduction in the amount of soil sterilant normally applied. Application is normally made by means of a mechanically-agitated power sprayer, although in small isolated areas application may be made by back pump.

The low volatile esters of 2,4-D - 2,4,5-T (brush killer), 2 pounds parent acid of each per gallon, are used for brush control work on transmission line rights-of-way. Foliage, basal, and stump treatments are the methods normally employed. Foliage sprays at the rate of 3 quarts of brush killer in 100 gallons of water have been found to be most effective on alder (Alnus sp.), willow (Salix sp.), and cottonwood (Populus sp.), results being dependent on thoroughness of coverage. Applications are made with power sprayers.

Basal and stump treatment have been found to be effective at the rates of 5 gallons of brush killer in 95 gallons of diesel oil on nearly all species, including those resistant to foliage sprays. Applications are made by power sprayer or back pumps. The larger trees, 2 inches and up, are girdled before applying the basal treatment, although excellent results have been achieved during the summer months without girdling. However, to insure positive control and to make allowances for poor application, bad weather, and other unknown factors, girdling is recommended prior to spraying. Stump treatment is normally performed one growing season following cutting to give best results. (Bonneville Power Administration, Portland, Oregon)

Nonselective control of weeds and grasses in a utility substation. Rowse, R. Larry. Weeds and grasses infesting utility substations, power plants, and pole yards create serious fire hazards. Hand measures aimed toward control are laborious, costly, and wholly inadequate. It is imperative in chemical control to use noncorrosive materials when treating substations because of grounding grids. A number of soil sterilants and other materials, including contact weed killers and weed oils, have been tried with varying degrees of success. Heavy rainfall (forty inches or more annually) coupled with solubility of the materials as related to economical application rates has been the limiting factor in many cases.

Telvar W (80 per cent 3-(p-chlorophenyl)-1,1-dimethylurea) and Telvar DW (80 per cent 3-(3,4-dichlorophenyl-1,1-dimethylurea) have been most promising from a cost-control standpoint. Forty pounds Telvar W to 100 gallons water per acre applied during early April just before heavy winter rains cease gave excellent control. Maintenance following the initial treatment involved 20 pounds Telvar DW plus 4 pounds of 2,4-D amine per acre the following April; thereafter, alternate yearly applications of 15 pounds Telvar DW plus 4 pounds 2,4-D amine.

Substations are generally landscaped and often located in residential areas. Drenching rains with heavy runoff immediately following application have washed the Telvar onto adjacent property causing extensive damage to shrubs, trees, and lawns. Severe injury to trees with roots extending into the treated area has been observed. (Portland General Electric Company)

Effect of timing of maleic hydrazide on growth inhibition of roadside grasses. Kosesan, W. H. Maleic hydrazide has been found to be effective as a temporary growth inhibitor on grasses. An experiment was set up to determine the possibility of its use to replace mowing of roadside grasses in the Willamette Valley and the most favorable time of application. The 40 per cent water-soluble powder was applied on December 21, 1954, February 3 and May 2, 1955, at the rates of 2, 5, and 6 pounds active ingredient per acre. The grasses in the treated area consisted mostly of tall fescue (*Festuca elatior arundinacea*), with some Highland bentgrass (*Agrostis tenuis*), red fescue (*Festuca rubra*), orchard grass (*Dactylis glomerata*), and velvet grass (*Holcus lanatus*).

Information in the following table is based on observations made June 2, 1955:

Time of Treatment	Pounds/Acre	Height of Grass
December 21, 1954	2	16-18 inches
	4	"
	6	"
February 3, 1955	2	14-16 inches
	4	"
	6	"
May 2, 1955	2	8-12 inches
	4	"
	6	6-8 inches
Untreated	-	16-18 inches

(Oregon State Highway Department)

Experiments on control of lodgepole pine seedlings in Central Oregon. Kosesan, W. H. Lodgepole pine seedlings (*Pinus contorta*) are a serious pest along highway shoulders and rights-of-way in Central Oregon. They grow in thick stands, obscuring vision and providing hiding places from which deer may bound into the traffic lane.

Plots were established on September 23 and October 26, 1954, and July 21 and August 22, 1955. Soils in the area are predominantly pumice type. Pine seedlings were 24 inches or under in height at the time of treatment.

Table below shows the various treatments, rates, and percentage controls:

Treatment	Rate	Per cent control
Kuron, 2-(2,4,5-trichlorophenoxy) propionic acid, plus diesel oil	4#/100 gal.	80
	8#/100 gal.	85
2,4,5-T low volatile ester (Iso-octyl) plus diesel oil	4#/100 gal.	75
	8#/100 gal.	90
2,4-D low volatile ester (Iso-octyl) plus diesel oil	4#/100 gal.	80
	8#/100 gal.	90
2,4-D Cal. Spray solubilized ester plus diesel oil	4#/100 gal.	80
	8#/100 gal.	90
2,4,5-T Cal. Spray solubilized ester plus diesel oil	4#/100 gal.	80
	8#/100 gal.	80
2,4-D low volatile ester (Iso-octyl) plus diesel oil	4#/25 gal. diesel oil, 75 gal. water	75
	8#/25 gal. diesel oil, 75 gal. water	75
2,4-D Cal. Spray solubilized ester plus diesel oil	4#/25 gal. diesel oil, 75 gal. water	65
	8#/25 gal. diesel oil, 75 gal. water	75
2,4,5-T Cal. Spray solubilized ester plus diesel oil	4#/25 gal. diesel oil, 75 gal. water	70
	8#/25 gal. diesel oil, 75 gal. water	70
Dalapon (a,a-dichloropropionic acid)	20#/100 gal. water	70
	40#/100 gal. water	70
Amino triazole (3-Amino-1, 2,4-triazole)	4#/acre	30
	8#/acre	70

(Oregon State Highway Department)

Soil sterilant trials for vegetation control along highway rights-of-way. Kosesan, W. H. The use of soil sterilant materials for control of vegetation along highway shoulders, around guardrails and other structures is increasing. Economical methods of vegetation removal are necessary to meet the increased need along miles of both old and newly constructed highways.

Trials were established on several miles of state highway shoulder near Moro and Pendleton, Oregon. The chemicals used included Telvar W, 3-(p-chlorophenyl)-1,1-dimethylurea), Chlorax "40" (40 per cent sodium chlorate, 58 per cent sodium metaborate), and Chlorea (40 per cent sodium chlorate, 57 per cent sodium metaborate, 1 per cent technical Telvar W). Weeds in the treated areas consisted of Kentucky bluegrass (*Poa pratensis*), saltgrass (*Distichlis* sp.), knotweed (*Polygonum aviculare*), Russian thistle (Salsola kali), tarweed (Amsinckia intermedia), Jim Hill mustard (Sisymbrium altissimum), china lettuce (Lactuca sp.), filaree (Erodium cicutarium), cheatgrass (Bromus tectorum), bulbous bluegrass (Poa bulbosa), crested wheatgrass (Agropyron sp.), volunteer wheat (Triticum sp.), wild oats (Avena fatua), barnyard grass (Echinochloa crusgalli), green foxtail (Setaria viridis), and Elymus sp.

Observations made October 7, 1955, are summarized below:

Chemical	Location	Volume Spray/A. Gals.	Lbs./A.	Time of Application	Per cent Control	Av. Annual Precip. Inches
Telvar W	Moro	125.0	25.0	11/17/54	95	13.50
Chlorax "40"	Moro	97.5	488.0	3/8/55	90	13.50
Chlorea	Moro	108.0	405.4	3/8/55	95	13.50
Chlorax "40"	Pendleton	123.3	616.25	3/10/55	80	13.68
Chlorea	Pendleton	82.0	307.33	3/10/55	90	13.68

(Oregon State Highway Department)

Vegetative control on rights-of-way. Hellesoe, G. F.; McCoy, G. T.; and Bosworth, Horace. Chemical weed control is of prime importance in roadside maintenance to (1) eliminate hand labor such as hoeing weeds at sight and sign posts, bridges, culverts and other roadside structures, (2) to create and maintain a firebreak between the highway and adjacent fire hazardous lands in rolling country, and (3) to control weeds selectively without damage to a desired plant in ground covers or landscaped areas. Aside from these factors it is to be desired that most roadsides should have a vegetative cover to control shifting or erosion of soil and present a more natural landscape. Mowing over such areas is less expensive than spraying and does not denude the roadside.

Telvar W, 3-(p-chlorophenyl-1,1-dimethylurea) and the original CMU have been and are used as a soil sterilant for fire hazard control work along some state highways. Original application is made at 26 pounds per acre in 100 gallons of water. The application the second year is reduced to 20 pounds per acre and thereafter some areas will be skipped until more sterilant is required. Other areas will receive a lowered amount, say 10 pounds per acre. Telvar W is extremely hazardous near many trees and some shrubs. It is otherwise an excellent herbicide for control of annual grasses. Telvar W has been used successfully as a February spray at 4 to 6 pounds per acre to prevent grass growth within ice plant (Mesembryanthemum nodiflorum) ground cover plantings without damage to the ice plant.

Baron, 2-(2,4,5-trichlorophenoxy)-ethyl-2,2-dichloropropionate, was applied in late December, 1954, to roadsides in northern Sonoma County, eastern Fresno County, and eastern Los Angeles County. It was sprayed at the rate of 15 gallons Baron in 85 gallons of water per acre on dead roadside grass with a tinge of new grass showing in the first two locations and on a newly graded surface in Los Angeles County. The two northern California areas where the roadside was not cleared of old growth before spraying showed no response to the spray for nearly three weeks. Thereafter the new grass developed a chlorosis and stopped growing. A strip devoid of new growth continued throughout the remainder of 1955 with the exception of a spot of poison oak (Rhus diversiloba) in Sonoma County and minor spots of mullein (Verbascum sp.) and sunflower (Helianthus sp.) in Fresno County.

The results were not as outstanding in Los Angeles where the soil had been previously graded; however, due to traffic obstructions the spraying was not as uniformly done as in the two northern trials. New growth did not create a fire hazard; however, pigweed (Amaranthus sp.), nutgrass (Cyperus sp.), and Russian thistle (Salsola kali) did grow in abundance here. A three-mile application (1½ acres) applied adjacent to the December trial in Los Angeles was put on at the same strength in mid-February. Results were not satisfactory on this trial. A fire hazard grew regardless of the application.

Baron had been used more extensively during the December and January 1954 and 1955 spraying on roadsides where the presence of trees and shrubs precluded the use of Telvar W. It appears Baron at 15 gallons per acre has no ill effect on trees.

Baron was sprayed at the rate of 15 gallons per acre under trees and outside of oleander (Nerium oleander) basins in December, 1954, in Fresno County. This did the work for the entire 1955 season which formerly was done with repeated and unsightly oil spraying. Some Johnson grass (Sorghum halepense) and Bermuda grass (Cynodon dactylon) spots appeared.

Trials were put on in December, 1955, using Baron at 5 gallons per acre within the oleander basins to determine the value of low dosage sterilization for grasses without damage to the plants.

Dalapon (a,a-dichloropropionic acid) shows promise as a grass killer without damage to ice plant used as ground cover. Bermuda grass, Kikuyu grass (Pennisetum clandestinum), Johnson grass, and annual grasses in ice plant plantings have been damaged severely without undue effect upon the ice plant with a 30-pound per acre application. Only a surface wetting spray is applied with as little run-off as possible. September spraying has given the best results. Spring and summer application usually require a touch-up spraying in the late summer.

Dalapon is of particular value for spraying and destroying Bermuda grass and Johnson grass within the oleander basins. At 30 pounds per acre or ¼ pound per gallon of water and used as a foliage wetting spray, Dalapon seems to leave no ill effect when sprayed into the basal portion of oleanders.

Dalapon has shown promise as a tule (Scirpus sp.) and cattail (Typha sp. control where brush killers are too hazardous for use. Late July application at 40 pounds per acre in Sacramento County stopped growth for the remainder of the season in 1955.

Sodium chlorate and chlorate-borate compounds are excellent sterilants for fire hazard control work; however, the economy of applying either 20 pounds of Telvar W or 15 gallons of Baron in water to make 100 gallons for each roadside acre sprayed is most appealing compared to handling 600 pounds of the chlorates or chlorate-borates in 600 gallons of water for each roadside acre sprayed. The difference, aside from time saved at filling is 40 roadside miles of continuous spraying per tanker with the low dosage materials as against less than 7 miles for the bulky salts. (California State Department of Public Works, Division of Highways)

<u>County and state highway rights-of-way maintenance through chemical control of vegetation.</u> McCambridge, J. R. State and county road departments are plagued with vegetation in their rights-of-way. This vegetation creates many problems:

1. Fire hazards from rights-of-way into adjoining range, timber, and crop land.

2. Growth around guardrails, signposts, bridge and culvert abutments.

3. Obstruction of vision.

4. Control of noxious perennial weeds as designated by state and county weed laws.

5. Control of miscellaneous annual weeds and grasses on gravel shoulders which create blading difficulties and gravel loss.

6. Prevention of drainage from paved surface off of shoulders, causing water to stand on highways. In areas of low winter temperatures this causes frost swells and break-up of paved edges.

All of the above are serious problems encountered by highway department personnel and in the past vegetation has been controlled by mechanical and hand methods, such as scalping with shovels, mowing, blading, and slashing. There is a need for more information on a cost comparative basis of chemical maintenance versus mechanical maintenance, as to date no cost figures have been assembled. However, it appears that chemicals have a very definite place in many of these problems for the expediency of getting the job done and for the cost involved.

Borate, chlorate, and chlorate-borate combinations are the oldest of the compounds which have been used by county and state highway personnel for maintenance purposes. Borates, being insoluble and low in herbicidal toxicity per pound of material, require handling considerable tonnage of material per acre. Straight sodium chlorate is highly inflammable and presents a safety problem in use. With a solubility of approximately 1 pound per gallon, high gallonage per acre is required for application of sodium chlorate as a spray. Chlorate-borate combinations are an excellent soil sterilant herbicide, non-poisonous and non-inflammable, but due to low solubility of 1 to 1½ pounds per gallon require high volumes of water per acre for distribution.

With the advent of Telvar W, 3-(p-chlorophenyl-1,1-dimethylurea), Dalapon (a,a-dichloropropionic acid), and Baron, 2-(2,4,5-trichlorophenoxy)-ethyl-2,2-dichloropropionate, which can be applied at the rate of 100 gallons total solution per acre, it has become increasingly of interest to the maintenance personnel of county and state roads to reduce their labor in application of chlorate-borate formulations.

Chlorax "40" (40 per cent sodium chlorate, 58 per cent sodium metaborate) was developed with a solubility of 4 pounds per .8 gallon of water at 40 degrees Fahrenheit. When dissolved at the rate of 4 pounds in .8 gallon of water the weight per gallon of solution is 10.59 pounds. Chlorea (40 per cent sodium chlorate, 57 per cent sodium metaborate, 1 per cent technical Telvar W) has the same solubility as Chlorax "40" with the Telvar W in suspension. Demonstrations for evaluation purposes by the road maintenance people were set up this fall in comparison with Telvar W, Baron, and Polybor chlorate to demonstrate solubility, method and rates of application, and performance.

Los Angeles County, applied December 5, 1955.

Product	Gals. Solution/Acre	Lbs./Acre
Chlorea	207.2	689.9
Chlorea	300	600
Chlorea	155.4	517.5
Chlorea	103.6	344.9
Chlorea	51.8	172.5
Telvar W	300	50
Telvar W	300.4	32.65

California State Division of Highways, applied December 12, 1955.

Product	Gals. Solution/Acre	Lbs./Acre
Chlorea	200	400
	150	300
	100	200

California State Division of Highways, applied January 4, 1956.

Product	Gals. Solution/Acre	Lbs./Acre
Chlorea	140	561
Chlorea	82.5	330
Chlorea	73.5	294.2
Chlorea	44	176
Telvar W	--	13.36
Baron	--	6.395 gals.
Polybor chlorate (25 per cent)	--	721.1

(Chipman Chemical Company, Inc.)