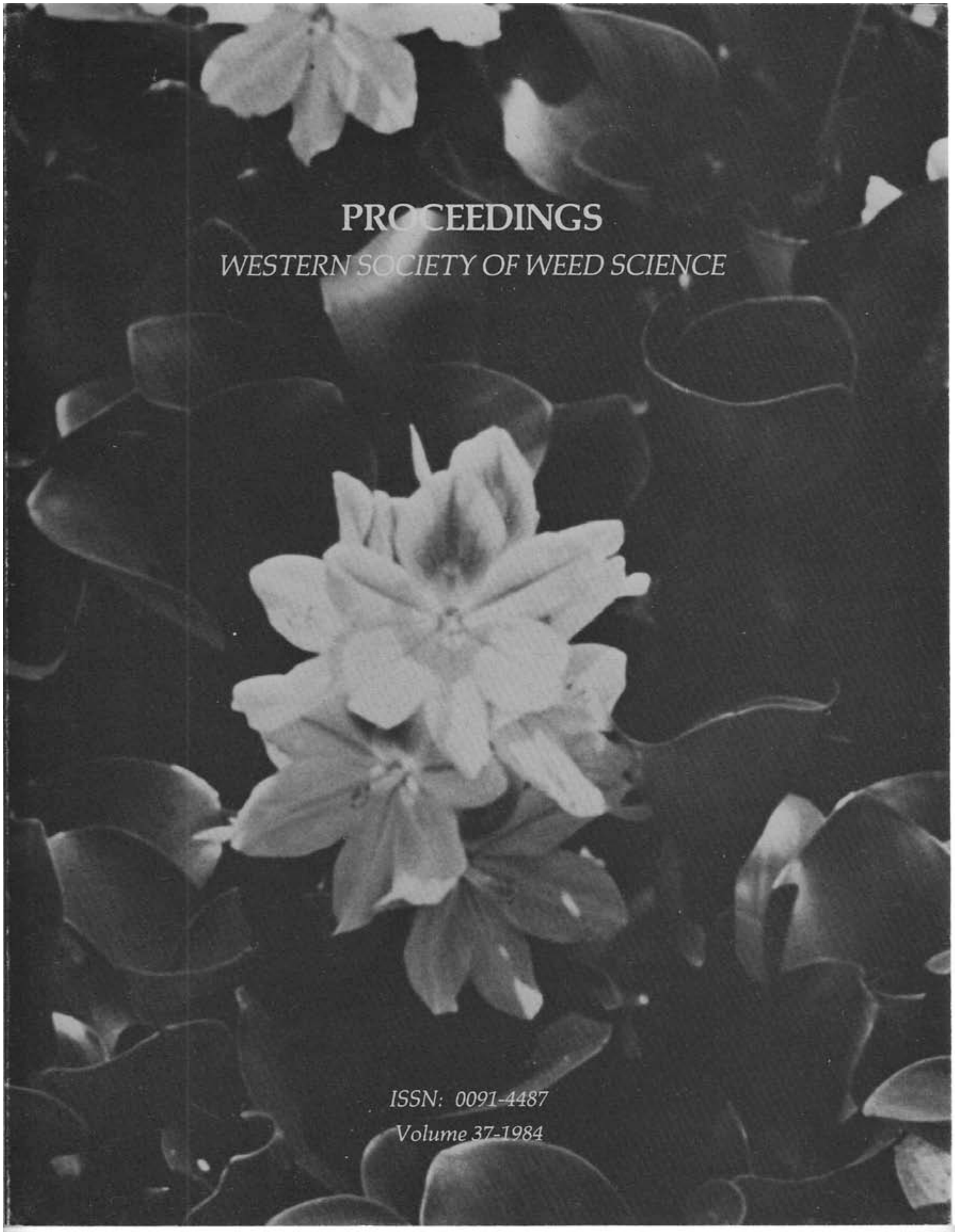

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PROGRAM AND TABLE OF CONTENTS

PESTICIDES, ALMONDS AND COMPLIMENTS

Garry D. Massey[1]

PRESIDENTIAL ADDRESS

Most of our past presidents have talked on weed control from a broad perspective. I will present this address by dividing the presentation into three parts: 1) The way the public perceives the risk from pesticides; 2) My farming experience or "the battle with perennial weeds"; and 3) How a farmer perceives pesticides, and his feelings about those who work in this field.

I. Public Perception of Pesticide Risk

In the February 1982 issue of Scientific American, (pp. 48-49), an article reported how three consumer groups ranked various risks to life. The league of women voters, college students, and business and professional club members ranked 30 potential causes of death, and their results were compared to the 30 actual causes of death.

I was alarmed at the way the three groups perceived the danger from pesticides. The league of women voters ranked them as the ninth most dangerous risk; college students ranked them fourth; and business and professional people fifteenth out of the 30 categories of things that cause death. The actual causes of death showed smoking as number one while pesticides were ranked 28th with no deaths reported in the year of the survey. This study shows us that we in agriculture are not doing a good job of informing the public of the value of pesticides. The misguided public perception of agricultural chemicals may be very hard to correct.

The editorial page of the Fruit Grower (Nov. 1983, p. 48) reported on comments from a concerned public about pesticides. The editorial follows:

> "Pesticides are present in great quantities throughout the environment, especially on commercially grown fruits and vegetables; pesticides and their residues are highly toxic and a prime cause of cancer ("natural" substances, on the other hand, are generally considered harmless); and a great cancer epidemic is sweeping the country.
>
> "This perception is not just held by a few extremists. A wide segment of the population holds these ideas to be true.
>
> "The reasons why these precepts are so universally accepted are easy to comprehend. First, people are understandably concerned about cancer, and the mass media uses their fear to boost ratings by overplaying stories on cancer. The resulting barrage further convinces people that cancer is a rapidly growing problem.
>
> "The belief that pesticides or any synthetic chemicals are bad is also easy to understand. It just makes 'sense' to most people that substances found in nature are somehow safer than ones made in a laboratory. One doesn't have to understand much about chemistry (and most people don't) to see the 'truth' of that.
>
> "It is too bad that most people will never read an article in the September 23, 1983 issue of Science magazine titled 'Dietary Carcinogens and Anticinogens' by Dr. Bruce N. Ames, the chairman of the Department of Biochemistry at the University of California, Berkely, is one of the top authorities on cancer-causing chemicals in the country.

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[1]3M Company, Fresno, California.

"While it would not calm their fears about cancer, it would come as a shock to many 'organic' believers to read that many foods contain natural compounds that are carcinogens. The long list of foods that contain such natural carcinogens includes black pepper, celery, figs, tea, herbs, honey, potatoes, and even that natural food favorite, alfalfa sprouts.

"'Our intake of these perfectly natural toxic compounds,' says Ames, 'is likely to be several grams per day - probably at least 10,000 times higher than the dietary intake of man-made pesticides.'

"'However,' continues Ames, 'little information is available about the toxicology of most of the natural plant toxins in our diet, despite the large doses we are exposed to. By comparison, our knowledge of the toxicological effects of new man-made pesticides is extensive, and general exposure is exceedingly low.'

"'The idea that cancer rates are increasing is also a misconception,' notes Ames. 'Despite numerous suggestions to the contrary, there is no convincing evidence of any generalized increase in U.S. (or U.K.) cancer rates other than what could plausibly be ascribed to the delayed effects of previous increases in tobacco usage.'

"All of this is not to suggest that pesticides never have undesired side effects or that they should be used or handled with abandon. Growers handle pesticides in concentrated form and should always wear proper masks, gloves, and protective clothing. Safety, economic, and environmental considerations dictate that pesticides should not be overused.

"What this does suggest, however, is that we know far more about the properties and safety of pesticides than we know about naturally occurring compounds. Also, it appears that the average consumer faces more health risks from the naturally occurring toxins in foods (not to mention hazardous compounds found in molds, bacteria, etc.) than from the infinitesimal traces of pesticide residue they encounter."

There are many other comments which could be made on this subject including the balance that science and, in particular, agricultural chemicals play between food abundance and famine, but I will leave that to others to discuss.

II. Almond Weed Control

Now some facts about almond farming. This is a topic with which I have gained twelve years experience on 80 acres of almonds. The crop is mechanically harvested (labor efficient), and that is one reason for its popularity in California. The trees are mechanically harvested by shaking the nuts onto the orchard floor, where they then are mechanically blown, raked and picked up. Weed control becomes crucial; for the cleaner the orchard floor, the more efficient are the blowing, raking and pick-up operations. When weeds are present, the nuts can become tangled and will be lost. The weeds can also prevent proper drying of the nuts and will tangle in the pick-up operations causing more harvest losses. The whole floor (berm and centers) must be completely free of weeds. In the final preparation of the orchard floor before harvest, I disk, harrow and then float or smooth the center of each row so they are flat. The orchard floor remains in this form for 30-60 days depending on the harvest time required. After the orchard is smooth, it is set by flood irrigation and will not be touched except for harvest equipment. It is within these conditions, then, that herbicides are used. Now keep in mind; 1) I am a week-end farmer, so I do not have time to respray often. Time is crucial to me. 2) I travel 4-6 mph with my sprayer. 3) I spray with the K 10 flood nozzle with an output of about 30 GPA.

I first tried dalapon (2,2-dichloropropionic acid) which has three disadvantages:

1) It requires precise timing for adequate control.
2) Leaching of the herbicide could cause injury to the trees.
3) It has generally provided poor weed control.

I next tried amitrole (3-amino-s-triazole) which did a fairly good job of controlling weeds but found it was illegal, and I found I was losing the weed battle.

I started using glyphosate (N-(phosphonomethyl)glycine) in about 1974-75, three years before its registration in almonds. It was the best herbicide for bermudagrass control and caused no injury to the trees. I tested glyphosate at rates of 2-4 lb/A and the 4 lb/A rate proved to be the most effective. I also found it more practical to calculate rate in concentration (4 lb/A = 2.5%). I spot spray the orchard 1-2 times per year with glyphosate.

Over the past 10 years I have also used trifluralin(a,a,a-trifluoro-2,6-N,N-dipropyl-p-toluidine) in the centers at rates of 1-4 lb/A. Although the bermudagrass has often been suppressed, I never obtained adequate control from this herbicide alone.

In 1977 I began evaluating several herbicides (prodiamine, oryzalin, trifluralin, and norflurazon) for weed control in a cooperative study with Art Lange (University of California Extension Specialist). Four treatments were applied at various rates over a three year period comparing surface application and soil incorporation (disk). These treatments were evaluated for bermudagrass and winter annual weed control. Table 1 reports the ratings taken in the final or third year (1979) of the study.

When prodiamine (2,4-dinitro-N^3,N^3-dipropyl-6-(trifluoromethyl)-1,3-benzenediamine) was applied at the 8 lb/A rate the first year and followed by reduced rates over the next 2 years weed control was excellent with incorporation being slightly superior to surface applications. This super rate provided excellent control of bermudagrass (not normally controlled by this herbicide). Once this super rate was used, then excellent control was maintained over the next 3 years no matter which herbicide (oryzalin, norflurazon, trifluralin) followed the 8 lb/A rate of prodiamine.

Oryzalin (3,5-dinitro-N^4,N^4-dipropylsulfanilamide) at recommended or near label rates of 3-4 lb/A over a three year period provided superior control to prodiamine when soil incorporated whereas prodiamine proved superior to oryzalin when surface applied.

The winter weed complex, consisting of London rocket (*Sisymbrium irio*) 40%, red stem filaree (*Erodium cictarium*) 40%, cheese weed (*Malva parviflora*) 5%, and common groundsel (*Senecio vulgaris*) 15%, showed good control (85-95%) from oryzalin and prodiamine at 3-4 lb/A while less than adequate control (63-79%) was provided from trifluralin and norflurazon at approximately the same rates.

In another cooperative and more recent incorporation test (Table 2) involving norflurazon (4-chloro-5-(methylamino)-2-(a,a,a-trifluoro-m-tolyl)-3(2H)-pyridazinone), oryzalin, and prodiamine the superior treatment was found to be a norflurazon-oryzalin combination of 4 + 2 lb/A. Winter weed control was good to excellent (95-100%) from all treatments but the most troublesome weed, burmudagrass, still remained. For this reason the combination treatment of norflurazon-oryzalin was best, as I feel 100% control of bermudagrass is essential.

I have also used simazine (2-chloro-4,6-bis(ethylamino)-s-triazine) extensively in my orchard over the past 10 years and found it to be an excellent and inexpensive herbicide and I have the greatest respect for it. However, I have found that it also has several disadvantages. 1) It can injure trees at rates of 4 lb/A and above. 2) Bermudagrass, filaree, groundsel, cheese weed and nutsedge have become resistant to simazine. Oryzalin and glyphosate now play an integral role in keeping the above and other weeds under control.

Oryzalin at 2-4 lb/A as a berm application is used twice a year. In addition, I spot spray, strip spray and broadcast glyphosate at a 2-4 lb/A rate as many times a year as required by bermudagrass escapes which continue to plague the orchard. The theme of our conference is can we afford escape weeds and, with bermudagrass, there is no compromise, I will achieve 100% or else!

Based on 12 years of experience I have formed the following conclusions about weed control in almond farming.

1. High rates of certain non-leaching herbicides (oryzalin and prodiamine) have provided excellent weed control over an extended period of time (up to 8 years) with good crop safety. Initial high herbicide rate use followed by low rates may have valid application in agriculture depending on safety or selection. Might I suggest it in some of your future work.
2. Glyphosate has proven one of the all-around superior herbicides on my farm and is central in my weed management program.
3. Combinations of oryzalin and norflurazon offer excellent control of bermudagrass.
4. Oryzalin alone provided control of many of my annual weed problems.
5. Norflurazon weakened hard to control perennials but tends to leach in my soil allowing shallow germinating annuals to reinfest the treated area and can cause stunting of young trees (at high rates).
6. I am just starting to use oxyflurofen in my orchard and find it is excellent in controlling some of my annual winter weed complex.
7. Low rates of glyphosate may select for resistant weeds and could change the weed complex of many California orchards.
8. Several of these weed control treatments, although highly effective, raise economic considerations and increased label rates before becoming useful chemical methods of weed control in California almonds.

III. A Farmer's Perception of Pesticides and of Those Who Work in This Field of Endeavor.

Pesticides are essential for my farm! They are essential for the farms of this nation! I cannot overemphasize this fact. Let me give you just two examples. When I first started farming this almond acreage, bermudagrass had taken over the farm. I could not get my almonds picked up and would eventually have had to abandon the farm or change crops because of this weed infestation.

As the second example, I have spider mites in my orchard every year. When I first started farming I tried to tolerate this insect or provide control by lowering rates and several times courted disaster. If you have ever seen a heavy mite infestation in an almond orchard, you will know what a damaging insect this can be. Spraying for mites is essential! When I hear some one say let the balance of nature (preditors) take place - I see red. I tried it. It almost killed some of my trees! Some people who are environmentally oriented say farmers are wantonly spraying chemicals. Let me inform them, you, and anyone who would pause to listen: A farmer is a businessman. He will not spray chemicals around indiscriminately. This is like going out and throwing money on the ground or spraying it into the trees; only a nut (I use the term loosely) would do that. It's not logical, it doesn't make sense! If you can show me or any other progressive farmer an effective, dependable and economical way to do a better job I will be the first to use it; as will any other good businessman (farmer).

Another thing I have learned as a farmer: Doing research and farming are two different disciplines. In research if you lose a plot, test, or a series of experiments, you have lost a year (bad enough), but you have not lost your livelihood, i.e., the way you feed and care for your wife and children. When a farmer makes a mistake, there may be no next year! There is not farmer who can take three bad years back to back. One bad year can wipe out a new farmer; two years will wipe out a farmer who is just getting his legs under him and three years will usually wipe out the best of them.

Timing is absolutely critical in farming. Timing interacts with the sequence of farming operations so it can become a very complex business. In addition, weather conditions are often beyond a farmer's control, and weather often interacts with chemical treatments. If you want to study interactions, try farming for a while. If you want to have your heart broken, spend a year of back-breaking work and then have your crop lost in a two hour frost or six hour rain. I say to you, stay in research, teaching or extension; for only a nut would stay in farming. My banker says he keeps his job to support his farming habit! I know of few promising areas of agriculture in the United States and know of many farmers who are over-extended caused by the 1979-81 tremendous increase in land prices. Today they are in trouble, as land prices have tumbled and crop prices are depressed. Costs, however, <u>have not</u> decreased.

One bright spot for us is <u>you</u> - the <u>agricultural</u> research and extension workers - may I <u>compliment you</u>! I doubt if anyone has ever stopped to tell you how you are appreciated from the standpoint of a farmer. I am probably in a unique position since I have operated on both sides of the fence but did not fully understand the degree to which we, as farmers, depend on your help! I come back to my theme - I could not operate without chemicals; I could not farm without you! I have given you examples of glyphosate saving my farm or an insecticide to control mites, or a fungicide to control disease. Gentlemen, these are essential for all of us in farming! I admire you for your dedication and perserverance in solving the never ending challenges facing agriculture. I know of the long hours you put in on your job. I know of the elements with which you deal. I have seen you sweat in the Yuma sun at 120F. I have seen you freeze in a Utah blizzard while trying to spray plots. I have seen you travel long lonely hours between experiments and I say to you - <u>God bless you</u>! You are our first line of defense in the never ending <u>challenge to provide</u> food and fiber to this blessed nation.

Table 1. Weed control - 3rd year ratings[5]. Massey Almond Orchard. Fresno, CA. 1977-1979[1].

Treatment	Rate by Year lb/A '77	'78	'79	Method App'd.	Weed Control (1979)[6] Bermudagrass	Winter Annuals
prodiamine	4	+ 3.3	+ 3[a]	Incorp.	6.0	9.0
"	4	+ 3.3	+ 3	S.A.	8.9	9.6
oryzalin	4	+ 3.3	+ 3	Incorp.	9.7	9.0
"	4	+ 3.3	+ 3	S.A.	3.0	8.6
trifluralin	4	+ 4	+ 2	Incorp.	3.0	7.0
"	4	+ 4	+ 2	S.A.	4.0	7.9
norflurazon	4	+ 4	+ 4	Incorp.	9.8	7.3
"	4	+ 4	+ 4	S.A.	9.5	6.3
prodiamine[2]	8	+ 4	+ 4[b]	Incorp.	9.9	9.8
prodiamine[2]	8	+ 4	+ 3	S.A.	9.5	9.5
prodiamine[2]	8	+ 4	+ 2[c]	Incorp.	10.0	9.9
prodiamine[2]	8	+ 3	+ 3[a]	S.A.	9.8	9.8
prodiamine[2]	8	+ 3	+ 3[a]	Incorp.	9.8	9.8
control	0	0	0	--	0	0

[1]Applied Feb. of each year. Plot size: 1320' X 15'; 2 reps.

[2]Reason for rate reduction and chemical change; lack of chemical.

[5]Cooperative test between Art Lange (U.C. Ext.) and G. Massey.

[6]Ratings: 0 = no weed control; 10 = 100% weed control.

[a]oryzalin

[b]norflurazon

[c]trifluralin

Table 2. Weed control and crop injury, Massey Almond Orchard[1]. Fresno, CA. 1982[2].

Treatment	Rate lb/A	Weed Control[3] Winter Annual[4]	Weed Control[3] Bermuda-grass[5]	Crop Injury
norflurazon + oryzalin	2 + 2	9.8	8.6	0
norflurazon + oryzalin	4 + 2	10.0	10.0	0
prodiamine	4	9.5	8.4	0
oryzalin	4	10.0	8.0	0
control	0	0	0	0

[1]Cooperative test initiated between Art Lange (U.C. Ext.) and Garry Massey.

[2]App'd. January 22, 1982. Plot size: 400' X 15'; 2 reps, trees 3 yr.

[3]Rated November 4, 1982: 0 = no control; 10 = 100% control.

[4]Winter annuals: Sencio vulgaris 90%; Erodium cicutarium 5%; Sisymbrium irio 5%.

[5]Bermudagrass moderately infested in each plot at treatment.

THE NEW WEED SCIENCE -- A VIEW OF THE 21st CENTURY

W. C. Shaw[1]

If there is a greater risk than trying to visualize the technology trends, weed science accomplishments, and weed problems of the 21st century, it is the risk of dwelling on the past and accepting the current technology for future use. Fortunately, creative scientists and scientific research do not accept the latter of these options. Nor does our projected population growth allow us to accept such a philosophy.

It took the people of the world from the dawn of time until 1830 to reach a population of 1 billion. By 1960 we reached 3 billion, and by 1980 we had a population of 4.5 billion. It is estimated that by the beginning of the 21st century, there will be about 6 billion people in the world. Just 15 years from now, it is expected that the world population will double. That means that by the beginning of the 21st century, we must produce as much food as we have produced since the beginning of history. Can we feed this many people? Most scientists believe that we can, but expanded research to develop improved technology will be required to meet the challenge (34, 35).

Weeds cause annual losses of about 10 percent in agricultural production, including crops, livestock, forests, and aquatic resources currently valued at more than $12 billion. Farmers also spend more than $8 billion to control weeds each year for total losses and costs of over $20 billion (22). It is estimated that about 30,000 species of weeds are distributed throughout the world and that more than 1,800 species cause serious economic losses each year. Cultivated crops are subject to competition from about 200 weed species. Each year 10-50 different species of weeds infest each of our food, feed, and fiber crops and cause severe damage. Unlike insects, diseases, and nematodes, weeds occur in all cultivated fields every year at population threshold levels that will cause crop failure unless they are controlled (23).

Because there are many kinds of weeds with varying periods of germination and with highly diverse life cycles, they obviously can not be controlled by a single method. Management of diverse weed population requires an integrated weed management systems (IWMS) approach that utilizes cultural, mechanical, biological, ecological, and chemical methods in a directed agroecosystem approach. The management of such diverse weed populations requires a broad spectrum of selected herbicides, mixtures of herbicides, and combination chemical treatments as key components of IWMS (4, 5, 6, 20, 25, 26).

The goal of weed scientists is to develop basic principles, technology, and systems that can be used to reduce the losses caused by weeds and the cost of their control (33). From the earliest beginnings of the development of the discipline of weed science, weed scientists have emphasized the fundamental principles of applied ecology in their research programs to solve weed problems. Using the principles of applied ecology

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[1]National Program Leader, Weed Science and Agricultural Chemicals Technology, National Program Staff, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Maryland.

to solve weed problems, weed scientists have been successful in reducing the losses caused by weeds during the period 1940 to 1960 from 20 percent to about 15 percent (22). During the period 1960 to 1980, improved technology was used to reduce the losses from about 15 percent to about 10 percent (22, 23). A goal which many believe can be achieved by the 21st century is to reduce the losses caused by weeds from 10 percent to 7 percent or perhaps even lower (35).

If we are to achieve this objective, new approaches, new strategies, and new tactics will be required. As we approach the 21st century, our weed research programs must emphasize new approaches that include the application of selective stress. Maximum stress on the weeds without stress on crops will be the objective (35). In the past, we defined our major approach to weed control as the application of the principles of ecology. In the future, our progress will be characterized by the application of the principles of selective stress on weeds without crop stress as a supplement to the principles of ecology. This approach is essential if we are to achieve the goal of reducing weed losses from 10 to 7 percent or lower.

Research Progress by ARS, State, and Industrial Scientists in 1983

Weed science research progress in 1983 was characterized by applying the principles of selective stress in a directed agroecosystem approach to weed management. In 1983, discoveries, research accomplishments, and advances in weed science technology were reported in more than 300 scientific publications. Progress included developing an understanding of the germination of weed seeds, growth, reproduction, allelopathic relationships, competitiveness with crops, and determining the vulnerability of weeds to control. The discovery of allelopathic effects and the effects of naturally occurring secondary chemicals in weeds and crops will provide new selective stress approaches for developing weed control technology (35).

More than 65 new chemicals were included in advanced evaluation research to determine their weed control effectiveness and safety in about 70 crops, aquatic sites, and rangelands. Four trends were evident in herbicide development: (a) emphasis on chemicals that control weeds at 5 to 100 grams per acre with great crop tolerance, (b) emphasis on postemergence non-selective chemicals, (c) emphasis on selective systemic herbicides without residual action, and (d) the direct application of herbicides to the seed coats of crop seeds as a new approach to control. Controlled-release technology and the use of vegetable oils as carriers for herbicides were improved in 1983. Progress in understanding the penetration, absorption, translocation, sites and mechanisms of selective action, and metabolic fate of herbicides in plants, soil, water, and the environment will increase the efficiency and safety of chemical weed control practices (35).

Several new plant pathogens were discovered as having potential for weed control and some are now registered for widescale use in rice, soybeans, and other crops. More than 20 species of insects are being evaluated for weed control in crops, rangelands, and aquatic sites (35).

Unique herbicide application equipment, such as the rope wick applicator, recirculating sprayer, endless belt applicator, and roller wipers, that reduce drift and applies herbicides to weeds in crops without getting the herbicides on crops or soils is being developed and several designs are in widescale use.

Outstanding progress was made in developing new weed control components technology that will increase the effectiveness and safety of integrated weed management and pest management systems. The development of improved and new chemical weed control practices and their use in integrated weed and vegetation management systems is enhancing revolutionary advances in reduced tillage, minimum tillage, no-tillage, conservation tillage, and crop production and soil management systems. These systems are increasing crop yields, lowering production costs, reducing the use of energy, increasing water use efficiency, and reducing soil erosion (35).

Recent Advances in Weed Science Technology and IWMS

Advances in chemical weed control technology must be assessed as a part of our total farm management production and protection technology which inlcudes: genetically improved varieties; improved crop and soil management practices; better plant and animal nutrition; improved farm equipment and mechanization practices; improved irrigation equipment, principles, and practices; and efficient control of diseases, insects, nematodes, parasites, and other pests. These production and protection practices have been integrated into high-yielding agroecosystems compatible with a quality environment. They have had far-reaching benefits (10, 16, 19, 30).

More than 90 percent of current weed control technology has been developed since 1940, and much of it since 1960. ARS, state, and industrial scientists and engineers have made major contributions to these advances. Cultural, ecological, and biological methods of weed control are used on more than 369 million acres of harvested crops each year. Moderate cultural weed control is practiced on more than 212 million acres of drill crops at a cost of about $5 to $15 per cultivation per acre per year. More than 157 million acres of intertilled row crops receive intensive tillage and cultural weed control at a cost of about $5 to $15 per acre per tillage or cultivation treatment. The intertilled row crops usually receive two to five seedbed preparation treatments and from one to as many as seven cultivations in a single growing season. Cultural weed control practices are also used on more than one billion acres of hay, pasture, and rangelands, and on millions of acres of nonagricultural lands and aquatic sites (28, 31).

Weed scientists, in cooperation with entomologists and plant pathologists, have contributed to the development of the use of insects to control Klamath weed, prickly pear cactus, and Lantana; the use of insects and fish to control several species of aquatic weeds; and the use of plant pathogens to control northern jointvetch in rice fields, several weeds in cotton and soybeans, and strangler vine in citrus orchards. These are outstanding examples of biological control of weeds. Such successes emphasize the need for expanded research to develop additional biological control methods. They can be highly cost-effective and aid in reducing total control costs. Interest in the use of biological agents to control weeds has grown rapidly in the last 20 years.

Biological agents, primarily insects and plant pathogens, are currently being evaluated for control of 75 to 100 species of weeds by biological weed control specialists throughout the world. To date, substantial to complete control has been attained by the use of biological agents on 25 to 30 weed species in various problem situations. Natural insect enemies have been found for most plants studied thus far, but whether these can provide the levels of control, specificity, and environmental safety required by today's standards remains to be determined. Likewise, the role of biological control in integrated weed management systems and the extent to which it can help in controlling the world's 30,000 weeds remains to be seen.

Chemical weed control technology has progressed greatly during the past 20 years. In 1949, herbicides were used on 23 million acres of agricultural land; in 1952, on 30 million acres; in 1959, on 53 million acres; in 1962, on 71 million acres; in 1965, on 120 million acres; and in 1981, on more than 250 million acres. The acreage treated with herbicides has more than tripled in the past 15 years.

The production and use of herbicides have grown at the rate of about 7 percent a year during the past 5 years. The domestic use of herbicides increased from 125 million pounds in 1963, to more than 800 million pounds in 1981. Currently, herbicides account for about 54 percent of the total pesticides used in the United States; and they represent about 60 percent of the value of total pesticide sales (1, 2, 12, 14). Tables 1, 2, 3, 4, and 5 summarize information on the volume and value of sales of pesticides, growth in domestic herbicide production, and the major uses of herbicides in the United States. These trends are expected to continue into the 21st century.

Important progress has also been made in the development of efficient herbicide detection, screening, evaluation systems, and equipment. Use of these techniques has given impetus to the industrial discovery and development of new herbicides. In 1950, we had about 15 basic herbicides. Today we have more than 180 basic herbicides and about 6,000 formulated products. Two trends characterize current experimental herbicides. First is the trend toward herbicides with great crop tolerance that are broadcast applied as postemergence sprays and control weeds at 5 to 100 grams per acre. Second is the trend toward the development of systemic nonselective herbicides that do not have residual action. These are particularly valuable for use in conservation tillage and multiple cropping systems. Emphasis continues on the use of mixtures of herbicides and combination treatments (1, 2, 7, 8, 12, 14, 23, 28).

ARS, state, and industrial scientists have contributed to the development of new IWMS techniques that have improved the effectiveness and safe use of the herbicides. These approaches include versatile preplanting treatments; preemergence and other soil application and incorporation methods; controlled-release formulations; granular formulations; herbicides applied to the seed coats of crop seeds; low-pressure, low-gallonage application techniques; recirculating spray applicators, herbicide rope wick and wipe-on applicators; and technology for improved distribution and deposit of sprays and low-drift formulations. However, application technology has not kept pace with advances in herbicide development and use. Other significant advances were the development and use of cultural, ecological, bio-environmental, and mechanical methods in an agroecosystems approach that included herbicide mixtures and crop-herbicide rotations. These are key component technologies for use in IWMS.

Table 1. SYNTHETIC ORGANIC PESTICIDES: VOLUME AND VALUE OF SALES UNITED STATES, 1979-1982 MANUFACTURER'S LEVEL[1/]

YEAR	QUANTITY	CHANGES FROM PREVIOUS YEAR	VALUE	CHANGES FROM PREVIOUS YEAR
	1,000 Pounds	Percent.	1,000 Dollars	Percent
1979	1,429,408	0.9	3,685,268	20.3
1980	1,468,202	2.7	4,269,019	15.8
1981	1,498,309	2.0	4,794,588	12.3
1982	1,520,783	1.5	5,277,117	10.0

1/ Data are from The Pesticide Review 1978, Agricultural Stablilization and Conservation Service, USDA and personal communication for current data from D. L. Fowler

Table 2. SYNTHETIC ORGANIC PESTICIDES: VOLUME OF SALES BY CLASSES UNITED STATES, 1979-1981 MANUFACTURER'S LEVEL[1]

	1979		1980		1981	
CLASS	AMOUNT (1,000 POUNDS)	% OF TOTAL	AMOUNT (1,000 POUNDS)	% OF TOTAL	AMOUNT (1,000 POUNDS)	% OF TOTAL
FUNGICIDES	143,498	10.5	146,339	10.4	147,802	9.8
HERBICIDES	703,377	51.4	767,745	54.6	806,132	54.0
INSECTICIDES	522,194	38.1	492,237	35.0	541,460	36.2
TOTALS	1,369,069	100.0	1,406,321	100.0	1,495,394	100.0

1/Data are from The Pesticide Review 1978, Agricultural Stablilization and Conservation Service, USDA and personal communication for current data from D. L. Fowler

Table 3. SYNTHETIC ORGANIC PESTICIDES: VALUE OF SALES BY CLASSES UNITED STATES, 1979-1981 MANUFACTURER'S LEVEL[1/]

CLASS	1979		1980		1981	
	AMOUNT (MILLION DOLLARS)	% OF TOTAL	AMOUNT (MILLION DOLLARS)	% OF TOTAL	AMOUNT (MILLION DOLLARS)	% OF TOTAL
FUNGICIDES	253,483	7.0	290,165	7.1	322,208	7.1
HERBICIDES	2,165,085	59.6	2,588,287	62.7	2,716,665	60.0
INSECTICIDES	1,211,620	33.4	1,230,049	30.2	1,489,015	32.9
TOTALS	3,630,688	100.0	4,078,498	100.0	4,527,888	100.0

[1/] Data are from The Pesticide Review 1978, Agricultural Stablilization and Conservation Service, USDA and personal communication for current data from D. L. Fowler

Table 4. GROWTH IN DOMESTIC HERBICIDE PRODUCTION
1980-1985
MANUFACTURER'S LEVEL[1/]

YEAR	QUANTITY 1,000 POUNDS	VALUE 1,000 DOLLARS
1980	767,745	2,588,287
1981	806,132	2,716,665
1982	822,255	2,950,298
1983	838,700	3,204,023
1984	855,474	3,479,569
1985	872,583	3,788,812

[1/] Data are from The Pesticide Review 1978, Agricultural Stablilization and Conservation Service, USDA and personal communication for current data from D. L. Fowler

Table 5. THE U. S. HERBICIDE MARKET[1/]
USER'S LEVEL
1980

CROP	DOLLAR MILLIONS	% OF TOTAL	CROP	DOLLAR MILLIONS	% OF TOTAL
CORN	889	34.3	SORGHUM	70	2.7
SOYBEANS	884	34.0	FRUITS AND NUTS	66	2.5
COTTON	168	6.5	RICE	62	2.4
WHEAT	97	3.7	PEANUTS	37	1.4
POTATOES AND VEGETABLES	71	2.7	PASTURE AND RANGELAND	30	1.2
			TOTAL	2,396	91.4
			PERCENT OF TOTAL U.S. USE		92.5

1/Data are from Eichers, Theodore R. The Farm Pesticide Industry, Agricultural Economic Report No. 461, 24 pages, September 1980. Economics, Statistics, and Cooperatives Service, U.S. Department of Agriculture.

Benefits from Cooperative State, Federal, and Industrial Chemical Weed Research Programs

Our supply of wholesome food is among the best bargains the American people buy. Our efficiency permits each farm worker to produce enough for about 58 other persons. About 3 percent of the population of the United States is on farms. American families spend an average of only 16 percent of their income for food. This amount is less than that spent by families in any other nation. IWMS technology has contributed to this increased efficiency. In the Soviet Union 39 percent of the population is engaged in agriculture and they spend 56 percent of their income for food (8).

The use of IWMS technology has accounted for about 10 percent of the total increase in farm output since 1940. This is an enormous benefit when compared to the cost of developing this technology. Currently we have little excess production capacity. Any combination of factors that reduces our production by 6 percent would cause serious and untenable economic consequences. This knowledge alone explains why IWMS are so importnat to the production of food supplies (17, 36).

IWMS have greatly reduced the labor and equipment requirements in crop and livestock production. Production is also less dependent on manual labor. The yields and quality of crops have increased and losses caused by weeds have been reduced from 20 to about 10 percent. The chemical control of weeds that produce allergenic pollens greatly reduces human illness, and control of poisonous weeds prevents death of livestock and wildlife.

What are some of the direct benefits to crop production derived from the use of herbicides as a part of IWMS? In 1939, the average yield of wheat in the United States was 14 bushels per acre. This year, the average yield will be about 31 bushels per acre. Better varieties, improved cultural and soil improvement practices; weed control; protection against diseases, insects, and nematodes; and harvesting practices account for the increase. However, during the past 20 years the use of 2,4-D to control weeds on an aggregated 460 million acres of wheat increased the yield of wheat by about 2 billion bushels -- enough to supply each American family with over a 6-year supply of bread. The total increase in farm income during this period, from this single weed control practice was $3.25 billion. The bread is not only a bargain from the standpoint of cost, but it is also wholesome and nutritious (29).

The use of mechanical power has increased 30 percent and herbicides have increased seven-fold since 1950, while manual labor decreased 40 percent. Farming is becoming less physical and more mental (8). IWMS is at the forefront of these significant technological shifts. These trends are expected to continue with increased intensity in the 21st century.

In the past 30 years, wheat, rice, and potato yields in the United States have doubled and corn yields have tripled. IWMS in these crops have reduced labor requirements by 30 to 50 percent. In Japan, rice yields doubled between 1951 and 1961, while labor requirements for rice production were reduced 42 percent. Improvements in weed control accounted for 34 percent of the savings in labor.

The benefits of herbicides as a part of IWMS can also be illustrated by determining the economic impact of banning their use. Banning the use of 2,4,5-T would increase costs to domestic users about $47 million per year, even if other chemical herbicides were not restricted. However, if other phenoxy herbicides were not available, costs could increase an estimated $167 million per year. In the short run, these additional costs would be borne by farmers, governmental units, and the recreational, industrial, and timber industries. However, in the long run, consumers would pay the bill (13).

Herbicides when used in IWMS have many advantages: (a) a wide array of herbicides is available to control most weeds at practical costs; (b) herbicides act quickly and are effective against dense weed populations; (c) reliable equipment is widely available to apply herbicides; (d) herbicides permit the individual grower to protect his crops irrespective of any action taken by his neighbors; (e) most herbicides are used selectively, and (f) herbicides are dependable and essential to the effective use of IWMS (11).

Chemical weed control as a part of IWMS has contributed to economic stability in the United States through the creation of new occupations and a wide variety of employment opportunities at desirable pay levels. The use of herbicides is an effective and economical technique for the maintenance of airports, industrial sites, and rights-of-way. Effective and safe practices also contribute to aesthetic values of rural and urban living. Herbicides improve the maintenance of waterways, watersheds and impounded waters for commercial, agricultural, and recreational uses. They also improve the safety of our highways by removing vegetation hazards, thereby improving visibility and reducing the number of accidents and deaths of humans and wildlife.

Weed scientists, through multidisciplinary research team approaches, have contributed to the development of advances in IWMS technology that have had far-reaching impacts on all phases of crop production, including the selection of crops and varieties, seedbed preparation, methods of seeding, and seeding rates. They have made possible a wide choice of row spacings, plant spacings in the row, and plant populations. They also influence soil management and fertilizer practices, including time of application and placement (10).

Tillage and cultivation techniques have been revolutionized. For many crops, chemical weed control as a part of IWMS now makes conservation tillage, minimum tillage, and double cropping possible. Even zero tillage now seems feasible for a few crops on certain soil types. Rotational tillage is still important for control of perennial weeds in many crop production areas. Weed control has had a major impact on irrigation practices, harvesting, seed-cleaning operations, and erosion control.

New herbicides used in IWMS have markedly increased the efficiency of fallow practices for weed control. The use of IWMS has greatly reduced tillage in some of the fallow-farming areas. The adoption of conservation tillage, minimum tillage, and chemical fallow practices greatly reduces soil erosion; improves moisture conservation; reduces wind and sheet erosion; reduces energy requirements; improves fertilizer utilization; improves soil structure and drainage; and increases yield and quality of crops.

IWMS have also improved the effectiveness of various practices directed to the control of diseases, nematodes, and insects. IWMS have increased the effectiveness of pasture renovation techniques and the productivity of pastures, rangelands, and forests. The use of farm water resources for irrigation, recreation, and maintenance of reservoirs, drainage ditches, ditch banks, irrigation canals, and farm roadsides has been significantly improved by the use of herbicides as part of IWMS.

Crop production has been significantly improved because of major breakthroughs in improved weed control technology. New practices have established the necessity for a new research cycle in IWMS that can result in new plateaus of crop yields, crop quality, and production and harvesting efficiency. These are the kinds of benefits that are difficult to assess in terms of dollar values! Perhaps it is simply best to state that modern farming as we know it could not be practiced without herbicides.

Benefits of IWMS Research in Improving the Productivity of Agroecosystems

Weed science strategies in the 21st century must emphasize the development of improved technology for managing the agroecosystem for more effective weed control. Weed scientists recognize that weeds are a liability to the agroecosystem, the total farm, and region, and that all crops are subject to their competition. In the future we will give greater consideration to weed control problems on the total farm, area, or region as units rather than limiting control practices to weeds in a single crop in a single year. The development of IWMS as a directed agroecosystem approach offers new opportunities for improved farm management and environmental quality. Such approaches must emphasize the principles of applying selective stress to the weeds and weed populations without causing crop stress (21, 31, 34, 35).

In this approach, multidisciplinary team research is essential to success. The interrelationships among weeds, diseases, nematodes, and insects and the methods used to control them, must be understood. Crop production and soil management systems, as well as crop protection principles and practices, must be directed simultaneously toward the control of weeds and other pests (24).

A 14-year (1964-1978) IWMS research program conducted cooperatively by the Illinois Agricultural Experiment Station and the Agricultural Research Service, Science and Education, U.S. Department of Agriculture, at Urbana, Illinois, provides striking evidence of the impact of weed control technology on crop production. Chemical weed control significantly increased yields, reduced weed seeds in soil, reduced tillage, improved harvesting efficiency, reduced labor requirements, and dramatically increased net farm profits without damage to the biological, chemical, or physical properties of the soil; without reducing the productivity of the soil; and without causing undesirable shifts in weed populations. There is no evidence from this long and intensive research program that any weed species in the study has become more resistant to a specific herbicide (18, 36, 37).

Yields of corn and soybeans in the 14-year study were increased dramatically with the use of herbicides plus one cultivation compared with three cultivations without herbicides. Using a different herbicide treatment each year increased corn yields by 30 percent in a continuous corn system and by 25 percent when corn was rotated with other crops. Using a different herbicide treatment each year in soybeans increased yields by 17 percent, both in continuous soybeans and soybeans grown in rotation. Wheat yields were neither increased nor decreased as a result of herbicide treatment (36, 37).

The net profit per acre, after all costs of production were deducted, was substantially higher when the cropping sequence included herbicides as compared to cultural weed control. For example, in a 3-year rotation of corn, corn, soybeans, the net profit per acre per year during the period was $35.46 using cultural practices. The same rotation with herbicides returned $57.97 per acre per year, or an increase of 64 percent on the net return (36, 37).

This study and many others have shown that in order to obtain maximum benefits and reduce costs and risks, our total weed control technology must be used in a directed IWMS agroecosystem approach. In using herbicides as a part of IWMS, they must be rotated when a single crop is grown continuously and when double cropping is practiced. Greater effectiveness in most production areas has been achieved when crops and tillage systems are rotated and herbicides are rotated on all crops in the rotation and in double cropping systems. Combination herbicide treatments, sequential treatments, and mixtures of herbicides, when integrated with cultural, mechanical, and biological methods, especially rotational tillage, reduce the chance of undesirable ecological shifts to tolerant species, minimize the chance of an accumulation of herbicide residues in the soil, and facilitate a decrease in farm, area, and region-wide weed seed populations in soils. For the directed IWMS agroecosystem approach to be most effective, preventive weed control must precede and accompany standard weed control practices (30).

State, Federal, and Industrial Scientists Respond to Problems and Risks in IWMS

Perhaps the single greatest risk involved in chemical weed control is faulty application equipment and misuse. Application technology has not kept pace with herbicide development and use. Inadequate training of operators as to proper safety precautions is common. Volatility and drift of sprays are serious problems. Drift not only damages beneficial plants, but may also contaminate the environment. We do not know what effects, if any, airborne hebicide molecules have on the photosynthetic efficiency of crops in large herbicide-use areas (34, 35).

There is a serious need to develop a better fundamental understanding of the performance efficiency, crop safety, and fate of herbicides in plants, soils, surface runoff, and ground water in the changing agricultural production systems now and in the future. The recent finding of herbicide residues in ground water and the concern by some scientists that intensive herbicide use may be associated with crop yield decline in some production areas are problems that will require intensive basic rsearch for solutions. Many feel that inadequate application technology may contribute to these problems. These are the types of problems that must be resolved or progress in weed control in the 21st century will be impeded (35).

A common error is the transfer of herbicides to improper containers and the failure to provide for the safety of children and animals. Improper herbicide production practices that cause cross-contamination and handling, storage, transport, and disposal of unused herbicides, herbicide wastes, and herbicide containers rank high among the problems and risks.

Environmental contamination or side effects not anticipated or fully comprehended -- including unsuspected metabolites or contaminants in herbicide formulations that may be detrimental to humans, animals, or the environment -- must be monitored. Risks are also increased by the improper use of herbicides, a practice that may result in residues in food or feed (3, 9, 15).

We need a better understanding of the actual or potential long-range effects of continued and repeated use of herbicides. However, the evidence, after 20 years of rather intensive use, indicates that current practices have not caused serious problems in the past. This approach may not provide public assurance of safety in the 21st century. Our risk assessment and risk predictive capabilities are not adequate and must be improved (35).

Perhaps the greatest reassurance to the general public that herbicides, as currently used in IWMS, are being used safely and without significant effect on our environment is provided by the results of the national pesticide monitoring programs on food, water, soil, plants, domestic animals, and wildlife. These programs provide the best assessment of actual as well as potential risks from current use of herbicides. These results show that herbicides are rarely found in the food-monitoring studies conducted by the U.S. Department of Health and Human Resources. Trace amounts that are occasionally found are well below tolerances established for these chemicals in food (9, 15).

The results of our national monitoring studies also show that agricultural uses of herbicides do not cause an accumulation of residues in humans, domestic animals, wildlife, fish, birds, or other objects in the environment. Herbicides used at agricultural rates on croplands dissipate rapidly. There is little evidence from our monitoring programs of any accumulation of herbicidal residues in soils. Our ground water monitoring programs are not adequate and should be strengthened (35).

Although it is genetically possible, and there is growing concern that specific weeds may develop resistance to herbicides, some weed scientists believe that this is not a significant practical problem especially if farmers rotate herbicides and tillage systems and use IWMS. There are a few examples of biotypes of a weed species that are tolerant to some herbicides. This causes some concern. However, current evidence suggest that these biotypes, for example, that are tolerant to the triazine herbicides were always tolerant. That is, the tolerant biotypes were not previously controlled by a low rate of triazines but now require a higher rate. In other words, the tolerant biotypes were not developed as a result of using the triazine herbicides nor have the biotypes acquired increased tolerance. This situation will require expanded basic research and a continuing review and reevaluation.

There is probably greater concern, however, regarding ecological shifts to weed populations that are resistant to control by specific herbicides. Although such ecological shifts, and the potential for development of genetic resistance in weeds to herbicides, may involve some risks, they will not become serious if cultural, mechanical, ecological, biological, and chemical methods are combined and rotated in an IWMS approach.

There is also a general perception that the risk of using herbicides can be further reduced by the development of better knowledge of the their toxicological effects. Thus, more emphasis is being given to understanding the carcinogenic, mutagenic, and teratogenic effects of candidate herbicides during the research and development phase before they are registered for use.

At present, our knowledge of the behavior and fate of herbicides in soils is sufficiently complete to permit an approximation of their environmental impact. We have developed preliminary mathematical models for predicting the impact of pesticides on the environment. These models have proven helpful in identifying research, regulatory, and monitoring needs, and in avoiding unnecessary environmental risk in the use of pesticides. Current predictive models leave much to be desired. Nevertheless, we believe that such models represent a significant step in the quantitative assessment of the impact of pesticides on the environment (31).

Emphasis in Weed Research in the 21st Century

Multidisciplinary research that emphasizes the selective application of stress against weeds while reducing stress on crops and soils will characterize the new approaches to weed control as we approach the 21st century (34, 35). Basic economic research on the losses caused by weeds and the costs and benefits of their control must be given a high priority in state, federal, and industrial research programs (35). Multidisciplinary research teams will intensify basic research to develop a better understanding of the biology of weeds, including ecology, basis for competitiveness, genetic basis for resistance of weeds and crop tolerance to herbicides, allelopathic effects, phenology, physiology, biochemistry and threshold populations. We need to know more about the complete life cycle of weeds so that we can determine which physiological and biochemical systems during developmental growth are most vulnerable to control by naturally occurring and synthetic bioregulators (32, 33, 34, 35).

Weed scientists, in cooperation with chemists, will emphasize basic reserach to understand the allelopathic effects of weeds on crops, and vice versa, and the role of bioregulators and other secondary chemicals in crops and weeds on their competitiveness, including ecological shifts in weed populations. A better understanding of weed populations and threshold dynamics, as influenced by chemical and nonchemical treatments, would enable us to predict ecological shifts. This would facilitate an adjustment of treatments to prevent undesirable shifts that make control more difficult (34, 35).

Multidisciplinary research teams will emphasize IWMS research approaches to the control of weeds as a part of total farm and regional management of agroecosystems rather than to specialize too narrowly in research. In an IWMS agroecosystems stress induced approach to weed control, we need to multiple crop, rotate crops, rotate tillage systems, rotate herbicide treatments, sequential treatments, and mixtures of herbicides in a management system that includes mechanical, cultural, ecological, and biological methods. We need to develop a better understanding of weeds and their control in relation to other pests and their control. (34, 35).

ARS, state, and industrial scientists will emphasize the development of biological agents such as bacteria, viruses, plant pathogens, insects, and other organisms as control components for use in IWMS for crops, grazing lands, forests, and aquatic sites. The use of biological agents are species specific and are most useful for control of a single weed that dominates an ecosystem (35).

Improved IWMS for aquatic weeds are needed for the solution of this increasingly serious problem. Herbicides that do not have excessive residual action are needed for the control of perennial weeds such as nutsedges, Canadian thistle, and milkweeds on cropland. Some of the newer herbicides have properties that should help solve these problems. A much better understanding is needed of the acute and chronic toxicological effects of herbicides and their impact on the environment. Criteria and methods for measuring their environmental impact must be developed. A pool of fundamental information is gradually providing the data and knowledge necessary for risk assessment and models for predicting their environmental impact before they are widely used (31, 33, 34, 35).

We need to determine which herbicides and other pest control treatments, crop rotations, multiple cropping practices, and other agricultural practices are most effective in making conservation tillage, minimum tillage, and zero tillage possible in crop production. Reduced tillage practices conserve water, soil, and fossil fuel; reduce herbicide volatility; and reduce the losss of herbicides in sediment, sheet erosion, and runoff; and reduce soil erosion (35).

The effectiveness of most herbicides is reduced by their inadequate residual activity. There is also growing evidence that microbial populations can rapidly degrade structurallly related herbicides, fungicides, and insecticides used in corn production. This reduces the residual control effectiveness of pesticides. Currently, it is not known to what extent this phenomena may be associated with the occurrence of pest resistance to pesticides. To overcome these limitations, an excessive amount of herbicide is often applied initially (34, 35).

In our future strategies, we shall need to develop herbicides with controlled-release characteristics that are not biograded too rapidly. Intensive research is needed to exploit the potential controlled-release characteristics of polymerized herbicides, copolymers, encapsulation, crop seed coatings, and related formulation techniques. These would enhance the release of active moieties uniformly over predetermined periods of time. We critically need technology to prevent the movement of agricultural chemicals into ground water (34, 35).

Successful development of controlled-release technology could revolutionize chemical weed control. Herbicides that do not have adequate residual activity in conventional formulations could be used in controlled-release formulations to increase their residual weed control effectiveness and then disappear from the environment when they are released from the protection of the controlled release formulation. Losses from volatility, undesirable downward movement through the soil profile, sheet erosion, drift, and other environmental problems could be reduced (34, 35).

More research is needed on the effects of contaminants, analogs, isomers, and other ingredients in herbicides and formulations. Cross-contamination during the production of herbicides and other pesticides is a serious problem. Herbicide production technology to reduce cross-contamination is badly needed. Faulty disposal of unused pesticides, pesticide wastes, and pesticide containers constitutes a threat to a quality environment. A signifiant expansion of research for the development of better disposal technology will be essential to continued safe use of herbicides in the 21st century (34, 35).

The isolation, characterization, and synthesis of strigol was the first discovery of a naturally occurring weed seed germination stimulant. Strigol stimulates the germination of seed of witchweed (*Striga asiatica*) but does not stimulate the initiation of haustoria. Recently, a new class of chemicals known as Xenognosins have been identified, characterized, and synthesized which cause the initiation and growth of *Striga* haustoria (27).

The discovery of bioregulator weed seed germination stimulants and inhibitors for other weed seeds similar to those discovered for *Striga* could significantly improve weed management technology for the 21st century. If we could induce seeds of most species to germinate uniformly in a crop through the use of germination stimulants and use inhibitors to prevent seed production on weed escapes, weed control practices could be significantly improved. Many of the bioregulators that are known to stimulate weed seed germination are not effective because of their rapid degradation in the soil. Techniques, including controlled release, to increase their residual activity would greatly improve the chances of effective use (35).

Better herbicide application equipment of all types is critically needed even though steady progress is being made in achieving this objective. We need improved methods for minimization of herbicidal residues in plants, animals, soils, air, and water. Processes in need of more intensive research are adsorption, photo-decomposition, absorption by plants, degradation by microorganisms, volatilization, drift, aerial dissipation, chemical reactions, leaching, and surface runoff.

Conclusions

Weed scientists in cooperative multidisciplinary research programs have contributed to the development of agricultural technology that has assured an abundant and wholesome food supply produced on a continuously reduced cropland acreage. IWMS are an important part of this technology and their use needs to be increased in the future. The many advances have permitted us to save millions of acres of land for natural beauty, hunting, fishing, parks, wildlife preserves, and other forms of recreation. This contribution to an improved environment for all Americans must also be included in the cost/benefit/risk evaluations when agricultural practices are being judged (31).

The general public recognizes the growing need for food, feed, and fiber. We must, however, remain aware that population growth is combined with other social, cultural, and economic forces to raise the twin specters of famine and pollution. These are threats to the survival of civilization as we know it. The public view and expectation is that science will provide solutions. Solutions -- if they are to be effective -- must be developed quickly. Basic knowledge from weed science research is critically needed.

The greatest obstacle to increasing agricultural production is probably not technological, but psychological -- the traditional fear that if farmers grow everything they can, they will only produce a glut that will depress prices. In the light of tomorrow's domestic and worldwide needs, we must avoid such negative strategies. Moreover, some past criticism to the contrary, we can never over-produce knowledge from agricultural research. However, we do need to have a constant and continuing concern that our research programs are balanced and responsive to America's needs.

When we speak of basic and mission-oriented research as having the capabilities to solve problems, what do we mean? What could we expect from a 50 percent expansion, within the next 10 years, in public-supported weed research? Can we state these in terms that laymen understand and the public will view with confidence?

Some of the potential benefits from such an expansion of weed reserach would include:

1. A net annual savings of $4.0 billion, achieved by a reduction in crop losses caused by weeds from 10 percent to 7 percent.

2. A net annual savings of $700 million, achieved by a reduction of 10 percent in the current cost of weed control.
3. A savings of about $1 billion each year achieved by a reduction in the losses in livestock caused by poisonous weeds and an improvement in the quality of crops by one percent by preventing the occurrence of toxic and nontoxic weed seeds in food crops and weed debris in fiber crops.
4. An annual saving estimated to be $2 billion, achieved by an increase of four percent in crop production efficiency through improved IWMS that improves our environment and wildlife habitats, reduces hand-tillage costs, mechanical-tillage costs, fertilizer costs, irrigation costs, harvest costs, crop yield losses, grain and forage drying costs, transportation and storage costs, numbers of laborers needed, and acres required for crop production.
5. An annual saving of $4 billion, achieved by a reduction in fuel requirements from 8 billion to 4 billion gallons per year through reduced tillage and the use of improved IWMS technology.

Can we achieve an annual benefit of $11.7 billion through expanded weed research by the beginning of the 21st century? Weed scientists believe it can be done. When we consider that the annual losses caused by weeds and the cost of their control total more than $20 billion, such an objective seems within reach by the beginning of the 21st century and a goal that weed science should establish and attain. This would be an accomplishment that would contribute greatly to meeting the food requirements of the world's population in the 21st century (35).

Our progress in the 21st century in developing IWMS will be determined largely by the resources ARS, the states and industry allocate to support research to develop: (a) a better fundamental understanding of the biology, physiology, genetics, and biochemistry of weeds including allelopathic effects, ecological shifts, population thresholds, competitiveness, interactions, genetic basis for resistance of weeds and crops to herbicides, and their vulnerability to control; (b) new approaches that emphasize the selective application of stress to weeds and not to crops and new, more effective biological, genetic, physical, cultural, ecological, allelopathic, and chemical control components; (c) total farm agroecosystems approaches to weed management; (d) an understanding of the effects of herbicides on human health, plant and animal growth, soils, ground water, and the total environment of man, domestic animals, and wildlife; (e) knowledge of the economic losses caused by weeds and benefits, costs, limitations, and risks of current weed management practices; (f) formulations of economical, more selective, more efficient, and less toxic herbicides; (g) safety measures that are practical and easy to follow in the application of herbicides; (h) application systems technology to reduce drift and volatility and improve herbicide distribution and deposit; (i) technology for combining these techniques and practices into economic IWMS and productive agroecosystems that are compatible with a quality environment; and (j) regulations that minimize the importation of noxious weeds, restrict the intrastate and interstate flow of weeds, and provide Federal and state coordination and support for elimination of incipient infestations of newly introduced noxious weeds (33, 34, 35).

As agricultural scientists and administrators, we must be responsive to the problems and concerns of all citizens. The need for agricultural chemicals and other agricultural technology must be related to the needs of society as a whole. We cannot ignore agricultural principles and practices that impair the environment. We must continue to identify, define, and assess actual and potential environmental problems. We must devote more effort to advanced assessments of technology -- costs, benefits, and risks. Moreover, our criteria must evaluate social, aesthetic, and environmental parameters and be understood by, and credible to, the scientific community and the general public.

We must carefully examine the costs, benefits, and risks of all components in IWMS. When this has been done -- using acceptable scientific criteria -- if the risks remain questionable, such methods should be discontinued and replaced with safer alternatives. If such alternatives are not available, researchers must develop them.

We must in our basic, applied, and developmental research programs achieve and maintain a fine balance. On the one hand, we must protect our health and comfort and our capacity for producing food and fiber from the hazards of weeds. On the other hand, we must understand the ecological significance of weeds and the methods of control. We must protect all of the important components in our environment against the potential hazards. Costs, benefits, and risks must be carefully weighed before decisions can be made that are clearly in the public interest. I am confident that we will succeed.

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RESISTANCE TO HERBICIDES
"Always Present a Moving Target"

Boysie E. Day[1]

Strains of weeds resistant to the phenoxy, triazine, urea, and other classes of herbicides have appeared in various parts of the world from time to time and no doubt others will develop in due course to impair the usefulness of these and other herbicides. I refer to evolved resistance, that is, new biotypes with genetic adaptations, enabling them to withstand exposure to specific chemicals. This kind of response is not unique to chemicals, but applies to other control measures and to environmental changes generally. Weeds evolve tolerance to biological agents such as diseases and parasites, to control measures based on physical and mechanical action, and to managerial practices such as crop rotation. Such resistance is an expression of the universal capacity of organisms to make evolutionary adjustments to meet changing conditions.

Throughout history physical control methods have been the principal ones employed against weeds, and it is against these measures that the greatest evolution of resistance has occurred. The plowing of land has contributed over the centuries to the evolution of plants that not only

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[1]Plant Pathology Dept., University of California, Berkeley, CA.

survive such action, but prosper only when so abused. Our most serious agronomic weeds thrive only where the soil is frequently disturbed. They produce large quantities of seeds that survive long burial in the soil, and have evolved many other reproductive and vegetative characteristics adapted to agronomic conditions.

According to a current hypothesis, each evolutionary advance by one species in an ecosystem represents a net deterioration of the environment for the other species. I do not believe that this concept withstands close scrutiny in all cases, but its workings are clearly evident in the relationship of crops with their parasites, diseases, and competitors. For crops and pests to survive they must continuously evolve in response to one another, with each benefit to the one a detriment to the other. We control the evolution of our crops by selection and breeding. Pests must shift for themselves, at which task they appear to fare about as well on their own behalf as we can do for our crops. It is not so strange then that by selection and close nurture, our efforts have created crop plants so dependent that they can no longer survive in nature without our care, and other plants that can barely survive in the natural habitat without our maltreatments. Thus, in a large measure both crops and weeds are our creatures, the ones by design, and the others by inadvertence.

Contrary to popular notions, weeds also develop resistance to biological controls. Plant breeders go by the rule that for each gene for virulence or enhanced parasitism by an organism attacking a plant there is a corresponding gene for resistance in the host population. Thus, the genetic mechanisms to oppose biological agents are already present in weed populations. Our common weeds are as widely distributed as our crops and as a result have been exposed to the worldwide range of organisms that can attack them. This widespread association of weeds and their biological enemies and the corresponding widespread distribution of resistance to them greatly reduces the latitude for beneficial manipulation of biological agents. Introduced biotypes of natural enemies are all too readily neutralized by resistant biotypes and secondary biological factors. On the other hand, parasites and predators aid our efforts for biological control by evolving in turn to oppose weed resistance.

It is easy to understand that species would have within their gene pools the basis to cope with the kinds of physical and biological conditions that have affected them during past evolution. It is another matter to expect to find a genetic basis for resistance to conditions that have never existed before. Yet such is the case with new pesticides. We have every reason to believe that atrazine, 2,4-D, and other synthetic herbicides have never been components of the natural environment and that genes for protection against them would have no occasion to exist. Why then, does it appear that there lies ready-made in the gene pool of all organisms the genetic mechanism to cope with about any new chemical that comes along? It is not that we are dealing with genes arising anew as a result of exposure to the chemical, but with genes already present.

The answer is that the capacity to hydrolize, oxidize, and otherwise detoxify or oppose the action of chemicals is not specific to the entire molecule, but can operate on components of chemicals not previously encountered. The key is not the whole molecule, but its chemical bonds and sub-groups that fall within the metabolic repertory of cellular processes already present. The green plant is indeed the master chemical engineer, and in addition to decomposing or altering the offending molecule, latent metabolic pathways may come to the fore to bypass vital processes blocked by the chemical. There can be any number of mechanisms for resistance. Any heritable characteristic or combination of characteristics that counteract the pesticide can become the basis of resistance. The potential mechanisms are so diverse that we should recognize that all herbicides are subject to some degree of genetic opposition and must be looked upon as depreciable assets to be amortized to near worthlessness if used long enough.

Resistance develops by inheritance and the time module is the generation. Insects, with life cycles of weeks or months develop resistance in a few years. Intestinal bacteria, with a life cycle of less than an hour can develop a population resistant to medication in a day or two. Weeds, with their life cycles in temperate zones of at least a year, develop resistance more slowly. For perennial weeds, the effective breeding cycle may be many years. Even for annuals, the usual life cycle is greater than a year. The generations of annuals do not follow one another in orderly sequence, but are variously extended by means of the seed. Innate dormancy often delays the germintaion of seeds for one or more seasons and seeds that germinate only after long burial or other adversity can greatly lengthen individual life cycles. Thus, the typical generation for an annual weed is not one year but several, consisting of a season in the vegetative or fruiting phase and often one, or perhaps five, ten or even thirty years in the soil as a dormant seed. The situation for biennials is the same except that the minimum possible generation is two seasons. Perennials have longer and even more indefinite life cycles. Many reproduce vegetatively and are often poor or erratic seeders. Local populations may be primarily or entirely of the same clone, having spread by creeping or by the distribution of tubers and other vegetative parts by cultivation. In such cases, both the development and dispersal of resistant strains is greatly retarded. Resistance is further retarded by crop and herbicide rotations that leave generations of weeds untreated.

The evolution of resistance is not as rapid and as widespread in weeds as in insects and other organisms that breed rapidly and spread their germ plasm by running, swimming and flying. Biotypes of bindweed and Canada thistle resistant to 2,4-D have retained essentially local distribution since the earliest years of the use of that chemical. On the other hand, where dispersal is by contaminated crop seeds, feed grains, and other commodities, dissemination can be worldwide at the speed of the truck, ship, or jet plane.

The number of genes involved and numerous genetic and biochemical factors also enter the time equation for resistance, some to hasten and others to retard the process, however, the answer to the question of how quickly do plants develop resistance, the answer is, usually slowly, rarely rapidly, always inevitably.

We need enumerate only a few of the many biological, environmental, and managerial factors affecting the development of resistance. Rates of application that give only marginal control of weeds accelerate the development of resistance. Highly active herbicides, that is, ones effective in trace amounts and presumably attacking a single biochemical site, are more vulnerable to the development of resistance than ones requiring large doses but having less specific action, such as general narcosis, solubilization of membranes, or gross tissue breakdown. Organic pesticides are more vulnerable than inorganics or organometalics. Chemicals closely related to ones already in long use are more vulnerable than chemicals of new classes (cross resistance). Resistance based on dominant genes develop more rapidly than resistance based on recessives. Simple resistance involving a single gene (oligogenic), called "vertical" resistance, evolves more rapidly than complex resistance based on several genes (polygenic), or "hortizontal" resistance. Vertical resistance arises more rapidly, where possible, but is less stable, more erratic, and more subject to defeat by sinergists and chemical variations of the pesticide. Horizontal resistance involves a combination of genes no one of which is highly effective. If a highly effective gene is present it comes rapidly to the fore, and by reducing the selection pressure for the minor genes that make up horizontal resistance, counteracts their enhancement. Thus, vertical resistance is said to suppress horizontal resistance. An extreme example of horizontal resistance is the adaptation of weeds to tillage, a genetic adjustment involving deployment of a very large complex of genes over a long period of time.

As the effectiveness of an herbicide is depreciable, so likewise is resistance. When the use of a pesticide is discontinued, evolution reverses and resistance fades. The reason for this is that the genes for resistance impart lower biological fitness in the absence of the chemical. If this were not the case the resistant biotypes would already be the predominant ones. The fading of resistance may be rapid or slow, depending in part upon the rate factors that governed its development in the first place, and upon the severity of the biological burden imposed by the resistance factors. Resistance does not fade by the reverse of the curve by which it arose, but by a diffeent path, the diffeence between the two resembling the graphical representation of hysteresis loss. Long after organisms appear to have reverted to the susceptible type, renewed exposure to the toxicant results in a more rapid development of resistance than from the primary exposure. This "memory" factor is evident in curves plotting the increase and decrease of resistance with successive exposures to toxicants.

Successive or simultaneous exposure of organisms to two or more unrelated toxicants can lead to biotypes resistant to both or all of them. This could hardly be the work of a single gene, and being polygenic, such multiple resistance can arise only on the slow time scale of horizontal resistance. Thus combined or rotational use of several herbicides can be a major defense against the evolution of resistant biotypes. The combined loss of biological fitness resulting from multiple genetic changes may limit the number of toxicants that can be opposed by a biotype.

Although there is always the potential for evolved resistance, the loss of effectivess by herbicides has thus far been minor compared with the rapid obsolescence of organic biocides affecting arthropods and microorganisms. We can speculate that plants have less genetic potential than heterotrophic organisms for adaptive response to alien chemicals. There is nothing in plants comparable to the liver and kidneys to detoxify and excrete harmful compounds. It can be argued that plants have evolved in a nutritional environment of air, water and inorganic ions, and have had little exposure to complex organic molecules. Lacking this exposure, plants have not developed the genetic wherewithal to cope with organic toxicants. There is no evidence to support such a view, except that it is my impression that random screening programs in search of biocides do find a higher proportion of chemicals toxic to plants than to animals.

In any event, we need no such speculations to account for the observed low rate of development of resistance by plants. The long reproductive cycle alone can account for it. If five years and 50 generations of an insect produces widespread resistance to an insecticide, a comparable process requiring the same number of generations might take a century or more for an annual weed and a millenium or longer for a sparse-seeding perennial. Long life cycles and slow dispersal are the main delaying factors.

Even in pests with short, sequential life cycles development of resistance is not always immediate and dramatic. Despite widespread use, there has been little loss of effectiveness by the fungicide captan and the dithiocarbamate fungicides. Sulfur has been in use as a biocide since biblical times, and Bordeaux mixture has been heavily used for a century with only minor loss of potency. Copper, arsenic, mercury, and other heavy metals have a long history as practical biocides. It may be that such substances simultaneously affect so many functions that their toxicity can be overcome only by the coming together of a very large number of protective genes. Possibly in some cases the vital function disrupted may be so fundamental as to be beyond available genetic remedy. There are limits to the process of evolution. Although algae resistant to boiling temperatures have evolved in hot springs, we cannot imagine a genetic defense against incineration. Or can we? Some forest and range species are remarkably fire tolerant. There may indeed be weeds incapable of appreciable genetic adjustment to specific herbicides, but from what is known about organism generally, the odds are against it.

In conclusion, I turn to a different and more widespread kind of resistance, one based on ecological rather than genetic adjustments. In contrast to individual species, entire plant communities resistant to herbicides develop as quickly or more quickly than do resistant populations of individual insect or bacterial pests. This involves the selective survival not of resistant biotypes but of resistant species. From a practical viewpoint, the weed flora of a crop may be looked upon as a composite pest. The presence or absence of individual species in the weed flora is usually of less interest than the sheer volume of competing plant material. When a new herbicide capable of suppressing the weeds common to a crop habitat is introduced, weed species relatively resistant to the new treatment are often, if not typically, present. These quickly expand in numbers to occupy the vacated space. The removal of elements of the original weed flora permits rapid build-up of resistant species even though they were inconspicuous and seemingly unaggressive components of the original flora. When weed management is predominantly or entirely by chemicals with little or no tillage, as is becoming common practice nowadays, plants not formerly seen in cultivated fields often invade and become pests. The transition to a resistant weed flora may occur in a year or two or five or ten. The volume of new vegetation may be no less than was present prior to the use of the herbicide and the consequences in crop competition no less serious.

It is of no practical interest whether a resistant weed population arose from biotypes within species or by selection between species. The adjustments in competing flora, by whatever means, demonstrate again the rule that strict monocultures cannot be maintained. We cannot create an environment so specifically suited to a crop that no other plants can grow there. Thus croplands are always associations of crops and weeds. Measures taken against one group of weeds, by what ever methods, may give temporary relief, but create conditions for the development of a new flora suited to the new conditions. The process is in part genetic, but is predominantly écological. Let us suppose that an alfalfa grower, plagued by weeds, rotates to grain sorghum. He has a new crop, new cultural conditions, new herbicides and hopefully few weeds. In due course, however, a weed flora suited to the new conditions develop and another alteration of practices becomes necessary. No doubt some genetic adaptations to the herbicides used in the rotation took place, but the principle adaptations were foristic.

Resistance cannot be prevented if the herbicide is used at all, but its effects can be delayed and softened by proper management. Management should focus against vertical or single gene resistance. It is the only kind likely to amount to much within a time frame less than centuries. The way to delay single gene resistance is to use the herbicide where possible along with other lethal or stressful measures so that survival depends on the occurrence of genes opposing these measures as well. Resistance thus becomes effectively polygenic. The astute reader will recognize this as nothing more than the integrated management that has been touted so much recently. I will examine how its principles apply to the defense against resistance.

Neither an herbicide nor any other individual measure or set of conditions can provide a lasting solution in weed management. Good management programs combine a variety of methods so as to reinforce one another. Components of programs are changed when needed including rotation of the crop. Modern herbicides are the most powerful weapons in rotation schemes. They increase the dimensions, and intensify the impact of rotation systems, and may themselves be rotated to reduce the need for other rotations including the crop. Weed communities change to meet new conditions. The aim of management is to change conditions faster than weed communities can adjust to them. This requires floras to redeploy their species and species to mobilize their genes quickly and toward many tasks at the same time. Thus the best defense against changing germ plasm is the same as for changing floras.

In the defense against floristic artillery and genetic torpedos, maneuver is the proper tactic. Always present a moving target. It cannot win in the end, but it postpones defeat.

WEED THRESHOLDS

J. H. Dawson[1]

The total stress that weeds exert against crop plants results from interference. Interference consists of competition, allelopathy, and parasitism; these factors may be present alone or in combination. Interference reduces the growth and vigor of crop plants. Weed control is vital to crop production because it removes the stress of weed interference, and prevents the drastic yield reductions that uncontrolled weeds almost always cause.

A weed threshold represents a point along a rising continuum of stress from weed interference above which a permanent effect can be measured. A crop response threshold is the point in such a continuum above which a permanent effect can be measured on the yield of the current season's crop. A crop response can be measured in terms of weed numbers, weed biomass, duration of weed interference, or combinations of these. A crop response threshold is strictly a biological consideration. It does not consider the cost of control or the market value of the lost production. In contrast, an economic threshold is a practical consideration. The economic threshold is the point along a rising continuum of weed effect, above which the increased value of the harvested crop more than pays for the cost of weed control. The economic threshold can be measured in the same terms as a crop response threshold, but it must consider quality as well as quantity of the harvested crop. Certain low numerical populations of weeds may not compete enough to warrant their removal based on the yield of the current crop. But consider how quality and value of the harvested crops can be drastically reduced by things such as a few nightshade berries in green peas, the staining of the skin of dry beans by a few succulent lambsquarters passing through the combine during harvest, or a very few dodder seeds in a lot of alfalfa seed. Furthermore, if weeds cause the loss of part of the crop during harvest, such losses must be considered in determining an economic threshold.

In some cases, it is easy to determine that the threshold level for a weed must be zero. When a weed that is known to be especially troublesome appears in a field for the first time, it is usually worthwhile to invest whatever time and money are necessary to destroy it and prevent a serious and costly problem in future years. This would be a long-term economic threshold based on general knowledge of weeds rather than on specific local data.

A crop response threshold is normally considered for the current crop only, but could also be important for succeeding crops of perennial plants. An economic threshold may be considered for the current crop, or it may be considered over a longer period such as the crop rotation cycle, or the productive life of a perennial crop.

Weed thresholds should be of practical value in helping us predict the need for weed control practices. With adequate data to give us an

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[1]Research Agronomist, Agric. Res. Serv., U.S. Dept. of Agric., Irrigated Agric. Res. and Ext. Center, Prosser, WA.

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[1]Research Agronomist, Agric. Res. Serv., U.S. Dept. of Agric., Irrigated Agric. Res. and Ext. Center, Prosser, WA.

understanding of the effect of various levels of weed infestation, we should be able to construct meaningful and useful predictive models of the effects of weeds. Then with adequate field data, such models could help us plan integrated weed management systems wherein we would minimize the negative value of the combination of crop loss from weeds and the cost of weed control.

Selecting the parameter to measure in establishing weed thresholds is vitally important, and is not simple.

Weed number per unit area is a meaningful indicator of the intensity of a weed population, and is fairly easy to measure. The same environmental conditions that make crop seeds germinate also favor germination of weed seeds. Thus, a flush of weed seedlings usually emerges with the crop seedlings. These early-emerging weeds are much more harmful than weeds that may emerge later. Thus, it is meaningful to consider (for each weed species or group of similar species) the effect upon the crop of a range of numerical densities of those weeds that emerge with the crop plants and remain until harvest. Such data would allow us to establish thresholds that would tell us what numerical populations would reduce yields measurably (crop response threshold) and what numerical population would have to be exceeded before a control measure costing a known amount would be profitable (economic threshold).

Although such considerations are sound in theory, they would be of little help for deciding whether or not weed control measures would be required as part of the crop production practices for any given field in any given year. Weeds are so ubiquitous and so numerous that, on almost all fields, weeds will emerge with the crop plants every year at population densities great enough to reduce or eliminate crop production. Consequently, without any data at all on numerical thresholds, a farmer could predict that weed control measures would be needed, and he would probably be correct more than 99% of the time for most fields planted to annual crops in North America in the 20th century.

Although a numerical threshold appears to have little utility for predicting the initial need for weed control, such a threshold could be very helpful in predicting the need for and value of additional weed control measures after weed control measures had been applied that controlled most of the weeds. For example, 99.5% to 99.9% control of a population of 1,000,000 weeds per acre (a typical population in many areas), would leave 1000 to 5000 weeds per acre. Such populations would probably be within the range in which a numerical threshold might be established.

If the weeds that survived a weed control treatment were stunted, they would probably be less competitive than normal weeds. A number threshold based on data from uninjured weeds would be too strict, and adjustments would have to be made in considering the effect of surviving, injured weeds.

Starting with zero weeds, the crop-suppressing effect of a weed population for a given site increases as the number of weeds per unit area increases until a certain number (characteristic of each species) is reached. Beyond this point, an increase in weed numbers usually does not increase the crop suppression. Because of plasticity, an increase in number, even of many fold, within such a "saturating population" simply induces individual weeds to be smaller, while the biomass and the interfering effect of the population remains more or less constant. Although level of crop damage from such a "saturating population" will vary according to species composition, environmental conditions, and other factors, it will almost always be well above that from a numerical threshold. Such a weed population would almost always require weed control measures to protect the crop.

Although a "saturating population" may reduce crop yields by 30 to 100% the weeds can usually grow uncontrolled for some time before the irreversible yield-suppressing interference actually begins. Based on this relationship, a period threshold can be established, which can tell us how long (how many days after planting or emergence of the crop) the weeds can grow before they begin to interfere with growth of the crop. Such a threshold would be of special interest when weeds are to be controlled by herbicides applied postemergence.

It must be recognized that a herbicide applied postemergence does not make weeds disappear immediately. No doubt competition would continue for some time during the process of dying, and the time would vary with weed species and herbicides. If a period threshold had been determined based on time of hand removal, then postapplication competition would have to be determined so that the predicted time of treatment could be adjusted.

If a soil-applied herbicide had controlled most of the weeds, or if the natural population was less than a saturating population, than an interaction between time and number would be expected in defining a threshold for the surviving weeds. The lower the numerical density of the weeds, the longer the weeds could remain before their interference would injure the crop.

At a numerical threshold level, individual weeds would tend to be located far enough apart from each other that they do not interact with each other. In such cases, the total interfering effect of the population would equal the effect per weed times the number of weeds. It should be possible to measure the effect per weed with greater precision and with greater ease than it would be to measure the effect on the crop of a range of low densities of weeds growing with the crop. Having determined the average effect per individual weed for each important species, one could then estimate the potential loss per acre from low density of weeds by simply counting or estimating the number of weeds per acre and multiplying by the effect per weed. Such information would be extremely useful in establishing economic thresholds for the current season's crop. Thus, a very fruitful area of research is the determination of spheres of influence of individual weeds in each crop. Some weed scientists are already investigating this area, but much more needs to be done.

We must recognize that the effects of weeds that mature in a crop are not limited to the current season's crop. The seeds produced and deposited in the soil are the source of weed problems in succeeding years. Such seeds would not affect production of the current season's crop, and would not be considered in determining a crop response threshold for the current year. The current year's crop would have been affected by interference from the growing weed, but not by the mature weed seed deposited in the soil. Thus, such seeds do not enter into a calculation of an economic threshold based on the current crop only, but would have a very definite negative value based on future crops. Determing the long term effect of the current season's weeds, and thus a long term economic threshold is extremely complex and difficult.

It is recognized that weed thresholds are complex and a great deal more data are needed than we now have. With additional data, with the help of computers, and with the cooperation of economists and modelers, we should be able to construct predictive models that can help us make sound weed control decisions.

WEED THRESHOLDS IN RELATION TO LONG-TERM POPULATION DYNAMICS

Robert F. Norris [1]

General. The concept of the economic threshold has become central to much of the insect integrated pest management philosophy that has been developed in the last decade. There have been numerous definitions of an economic threshold, but that used by Glass (1) seems to be appropriate; it states that a threshold is 'that population density, or damage level, at which control measures should be taken to prevent an economic injury level from being attained.' This implies that control will cost less than the loss that would be expected to occur if nothing had been done.

Development of economic thresholds for weeds requires that accurate additive competition experiments be conducted. Such experiments can provide information concerning the losses to the current crop in relation to weed density, which then permits calculation of the economics of control measures. Work at the University of California at Davis (Norris, unpublished) indicates that such a threshold for barnyardgrass (*Echinochloa crusgalli* (L.) Beauv.) in sugarbeets (*Beta vulgaris* L.) is about one weed per 2 to 3 m of crop row on 75 cm centers. At one weed every 10 m of crop row the economic loss to the current crop does not justify removal of the weed. At densities of one weed per meter of crop row and above, the economic losses exceed control costs by a wide margin.

A major difficulty with attempting to assess the utility of such a threshold lies in the seed production by the weeds. Seeds from one year of production are the source for the next years' weed problem. Due to dormancy and longevity of seeds the 'inoculum' may last for many years, and thus one years' seeding may equal several years of weeding. Estimates of seed production for barnyardgrass growing in sugarbeets indicates that approximately 18,000 seeds/m^2 are returned to the soil from a density of only one weed/10 m of crop row. Similar estimates for barnyardgrass in grain sorghum show that one weed/m of crop row returns about 600 seeds/m^2 to the soil. Work with common purslane (*Portulaca oleracea* L.) has shown that as many as 18,000 seeds/m^2 are returned to the soil per day! The question then becomes how can an economic threshold be addressed for losses that will occur in future crops, and how can the impact of controlling the weed population in future crops be determined.

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[1]Botany Dept., University of California, Davis, CA.

Population dynamics concepts. It is apparent that some form of understanding of population dynamics of weeds is necessary. Creation of models can help in development of such understanding. Such models also have the potential to help in decision making for long-term weed management. Simple conceptual models have been developed by Harper (2) and are used in his book on 'Population Biology of Plants.' These consist of a seed bank (defined as the population of seeds in the soil at any given instant), a germination 'screen' which determines how many seeds germinate, plant growth, flowering, seed production, and seed rain (seeds that fall back to the soil surface at the end of the season) which is added to the seed bank. Sagar and Mortimer (9) have presented a slightly more complete model for both annual and perennial weeds. Price (6) has developed a rather more specific model for wild oats (Avena fatua L.).

All models require basic information in order that they can be constructed. The information for population dynamics models falls into two general categories: a) inputs (or gains) to the system, and b) losses from the system. Inputs can be listed as:

1. Seed production (annuals, biennials, perennials). All factors that contribute to production, such as competition (intra and interspecific), environment, etc.
2. Dissemination (all plants, most critical for wind-born seeds).
3. Vegetative propagule production (perennials only). Similar to seed production factors.
4. Parent plant carry-over (perennials only). Possibly not a true input but must be considered in the model.

No attempt will be made here to discuss population dynamics of perennial weeds. The reader is referred to Sager and Mortimer (9) for conceptual development of models for these weeds. Table 1 provides data for seed production for selected weed species. The reader is referred to the papers by Stevens (10), and Kempen and Graf (4) for data on additional weed species. The significance of these seed production data is that for the common annual weeds the seed production capacity is extremely high. This imparts on the annual weed the capability of an explosive population increase in a single generation. Inputs to the system due to dissemination are usually hard to ascertain, but there are examples in the literature of weed seeds in irrigation water (3). Windborn seed dissemination will be particularly difficult to model.

Table 1. Typical seed production for selected weed species.

Weed Species	Seeds (no./plant)	Ref. source
Wild oats	400-600	Price (6)
Redroot pigweed	100-250,000	Stevens (10)
Eastern blacknightshade (Solanum ptycanthum Dun.)	up to 800,000	Quackenbush & Andersen (7)
Barnyardgrass	up to 125,000	Norris (unpublished)

Losses from the system are more varied, and in many cases are difficult to quantify. Losses from the system can be considered under the following headings:

1. Death (prior to completion of lifecycle). This may be due to weed density; plants die because there are insufficient resources to support all individuals. This is competition, and is referred to as 'density dependent regulation.' Seeds may also die in the seedbank (8).
2. Parasitism. This is primarily by parasitic fungi, and is a major reason for the decline of the seed bank. This area is poorly understood. Only in limited cases are growing plants killed (see use of mycoherbicides (11)).
3. Predation. This is primarily soil-inhabiting insects, but can include other fauna, such as earthworms, birds, rodents, etc. Parasitism and predation probably account for the major loss in the seed bank. Without this loss the large numbers of seeds produced would mean that extremely high seed banks would be attained. It is apparent that this decline in the seed bank due to parasitism and predation is <u>the</u> most significant form of biological weed control; it goes <u>essentially</u> unrecognized, and unresearched. This author believes that most data available on the longevity of seed banks are considerable overestimates as the techniques employed either preclude predation (seeds placed in containers), and/or reduce the activity of pathogenic fungi (e.g. starting with sterilized soil).
4. Failure to emerge. Seed germinates too deep and cannot get to soil surface.
5. Germination at time when plants will fail to grow.
6. Cultivation. Plants killed by physical damage.
7. Herbicides. Plant killed by action of chemicals.
8. Biological control. Classic approach of releasing pathogen or predator. The previous three categories jointly comprise what would typically be called 'weed control', and have a profound impact on weed population dynamics.
9. Poor habitat. This comprises what is thought of as cultural crop management, such as competitive crop, locally adapted variety, planting date, fertility, irrigation, etc. so that the weed growth is reduced. Effects of environment on plant growth that may affect such factors as numbers of flowers and seeds also fit within this category.
10. Dissemination. This is the reverse of input dissemination; seeds or vegetative propagules are lost to the system.
11. Harvested. In many instances seeds may be removed with the crop; this is a special version of No. 10.

Most of the above noted types of losses cannot be quantified for weeds, and in fact only some are known for any plant species. This means that models have to be constructed based on assumptions derived from non-weed species, or from incomplete sets of data. Attempts to construct models are revealing the serious lack of data on weed population regulation.

<u>Weed population dynamics models</u>. Simple population dynamics calculations can be made using a pocket calculator. If the following assumptions are made then data of the type in Tables 2 and 3 can be generated. The assumptions used to generate Tables 2 and 3 are:

Initial weed density = 1 plant/10 m^2
Seed production = 5,000 seeds/plant
Survival of seed bank from fall to spring = 50%
Survival of seedlings to mature plants = 50%

Using these types of assumptions there is no density dependent regulation of the population and it will increase indefinitely. This is obviously incorrect but does provide insight into what will happen if certain levels of weed control are applied. Table 2 shows that at low levels of weed control the population would explode to very high levels within 2 or 3 years. Weed control at 99.9% would be required to maintain the population more or less static (rising very slowly in this example). It would not be until control approached 99.99% that the population would start to decline.

Table 2. Calculated weed populations over a period of several years using a hand calculator. Assumptions used presented in text.

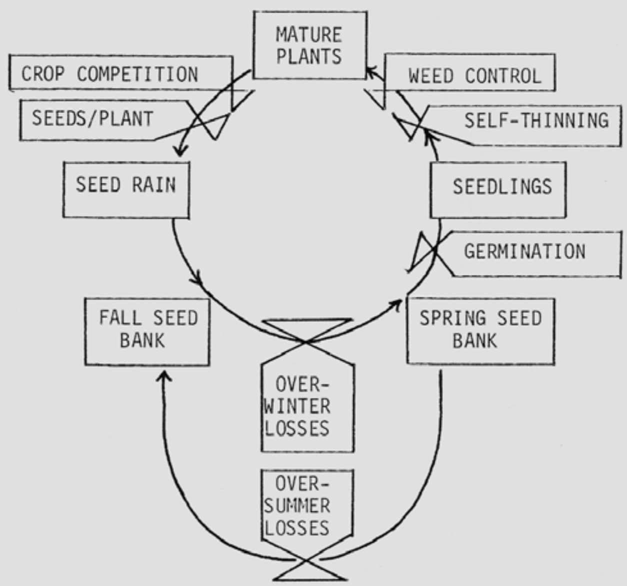
	Control level (%)				
Year	95	99	99.9	99.99	100
	(no seedlings after control measures completed)				
1	12.5	2.5	0.25	0.025	0.0
2	781	125	0.31	0.0031	0.0
3	48,828	1,562	0.39	0.0004	0.0
4	Infinite	Infinite	0.49	0.0000	0.0
8	Infinite	Infinite	1.19	0.0000	0.0

If the seed production is varied it is possible using the same type of calculation to determine how much weed control input would be necessary in order that the population remain static when different natural survival rates are assumed (Table 3). If seed production is relatively low (1000 seeds per plant here) then the weed control input is only high if the natural survival is high. This type of calculation clearly shows that if seed production is high, such as for pigweed or barnyardgrass, then very high levels of weed control are required even if most of the population dies due to 'natural' causes. These types of calculations demonstrate why most weed management programs do no more than 'hold their own'. Such calculations, as argued by Norris (5), suggest that the threshold for weeds with high seed production capacity should probably be zero.

Table 3. Calculated percent weed control required to maintain a weed population at a constant level.

Seed production	'Natural' combined survival rate (%)		
	25	10	1
(no./plant)	-------(required control, %)--------		
1,000	99.6	99.0	90
5,000	99.92	99.8	98
100,000	99.996	99.99	99.9

Figure 1. Word-model for basic population dynamics of an annual weed.



The advent of the computer, and more recently the micro-computer, have meant that the types of calculations done to develop the information in the preceding section can be done much more quickly, and many more variables can be included. An elementary model based on Figure 1 has been constructed. This type of simple model can be run conveniently on a micro-computer. The output from a simple model of this type is confirming the type of observations presented above for calculations made on a hand calculator. All variables, such as winter and summer losses, germination, weed control, crop competition, and seed production per plant, can be varied. The high speed of the computer then, allows many different possibilities to be explored rapidly. The self-thinning and crop competition variables are currently being developed and until such components of the model are adequate no attempt will be made to present actual examples of output. Results of varying number of seeds produced, and level of weed control are providing results which fit with those intuitively anticipated. An unexpected result was that as percentage germination is decreased, and all other varibles remain constant, the population level decreased.

It would seem feasible, if the necessary information can be generated, that computer calculation of weed population dynamics (modelling) can serve a useful role in the decision making for weed control programs, and could make long-term predictions possible that will permit economic thresholds for weeds to be projected over several growing seasons, or as long as required by the longevity of the weed and the anticipated cropping rotations.

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SOVIET UNION AGRICULTURE IN THE 1980's

D. M. Collins[1]

In Soviet agriculture, terms are used that hardly belong in a farming vocabulary such as desert farming or artic farming. About 60 percent of all grains are grown in what is called hazardous farming belts. Permafrost is underlying more than half of the territory of the USSR and severe droughts are a recurring calamity.

In one major natural resource - area of arable land - the Soviet Union enjoys a wide edge over the United States. The soviets currently plant over 500 million acres exceeding by nearly half the 350 million acres planted annually in the United States. Measured only by its cropland area, the Soviet Union is in a class by itself among world food producers.

The Soviet cropland advantage of 150 million acres, however, is partly offset by climatic differences favoring the United States. Whereas most U.S. cropland lies between 34 and 45 degrees north latitude, Soviet cropland lies farther north, mostly between 48 and 55 degrees north latitude.

In the Soviet Union, there are approximately 20,800 state farms with 13,000 acres of cropland and 26,000 collective farms with 9,000 acres of cropland each.

Depending upon the natural and economic conditions, state farms are specialized and have a corresponding scale of production. The know-how of state farms is used by the collective farms for increasing efficiency in their operation and for strengthening their economy.

The entire output produced by a state farm is the property of the state. Most of it is sold to procurement organizations in accordance with the state plan and part of it remains for the needs of the farm. Collective farms are cooperative organizations of farmers who voluntarily united for joining agricultural production. On an average, a collective farm unites 420 households.

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[1]Monsanto Company, St. Louis, MO.

In much of the Soviet Union, as in Canada, which is similarly situated, winter grain crops cannot survive the harsh winters. Over half of the wheat, the crop dominating Soviet agriculture, is spring wheat, wheat planted in May and harvested in September. This northerly location also means that the Soviet Union has much less potential than the United States for double cropping winter grains, such as wheat and barley, with summer crops such as soybeans.

The U.S.S.R. is carrying out an immense program aimed at stabilizing agricultural productions and to guarantee a steady output in defiance of natural conditions. The three main lines of the Long Range Comprehensive Agricultural Action Program are: to provide for new technical facilities to mechanize, electrify and automate production; chemicalization; and land reclamation.

The rapidly increasing use of chemicals is one of the major directions in the technological progress in Soviet agriculture. Recent years have shown a tremendous expansion in the output and use of mineral fertilizers. Measures are being taken to expand the production and improving the use of mineral fertilizers, herbicides, insecticides, fungicides, defoliates and other chemicals for use in agriculture.

The Soviet Union has a large nitrogenous fertilizer industry. Ammonium nitrate is the main type of nitrogenous fertilizer used in U.S.S.R. while superphosphate is the main phosphonic fertilizer. Potassium chloride is the most widespread potash fertilizer. In addition to fertilizer, U.S.S.R. plans to increase deliveries of herbicides, insecticides, fungicides and other plant protection chemicals by 100-150 percent in the next few years. Over 100 million hectares of land in the U.S.S.R. are chemically treated annually to protect crops and plantations from various insects, weeds and diseases.

Even though detailed data on fertilizer application by crop in the Soviet Union are not available, broad comparisons can be made between the two farm economies by relating fertilizer use to grain production, which dominates land use in both countries. Measured in terms of nutrient content, the Soviets used 26 million tons of fertilizer in 1981 and harvested 165 million tons of grain, while the United States used 21 million tons and harvested 331 million tons of grain. Thus, the Soviets are producing roughly six tons of grain per ton of fertilizer compared with 16 in the United States. A lack of specialized equipment to properly apply chemical fertilizer is reducing fertilizer efficiency.

Weeds in cereals and row crops are a major problem. The major perennial weed problems in cereals and row crops are *Cirsium* sp., *Sonchus* sp. and *Agropyron repens*. *Sorghum halepense* is found only in Moldavia. Perennial weeds are a particular problem in the northern part of the country except for *Sorghum halepense*. The annual weed problems in wheat and barley are *Avena fatua*, *Alopecurus* sp., *Apera spica-venti*, *Lolium* sp., *Polygonum* sp., *Galium aparine* and *Stellaria media*. In corn, sunflowers and soybeans, *Echinochloa crusgalli*, *Setaria* sp., *Panicum* sp., *Amaranthus* sp., *Matricaria* sp., and *Polyconus* sp. are the major annual weed problems. Broadleaved annual weeds are a problem in the northern part of the country while both annual grass and broadleaved weeds are a problem in the central and southern parts of the U.S.S.R.

The major herbicides used in corn are 2,4-D, atrazine, and EPTC. Trifluralin is used in sunflowers and soybeans. In wheat and barley, the phenoxies are the main herbicide used. Wild oats are controlled by mechanical cultivations and delayed seeding.

Rainfall differences also offset the Soviet advantage in arable land. The geographic distribution of rainfall in the United States is better than in the Soviet Union, where heavier rainfall is in the north while the cropland with a longer growing season is in the semiarid south. Indeed, the south central Soviet Union is largely semiarid, similar to the southwestern United States. The geographic mismatch between rainfall and land, a perpetual source of frustration for Soviet agricultural planners, has led to an intense effort to develop irrigation potential in the southern semi-arid regions.

Support for Soviet agriculture from the non-farm sector is generally inadequate. Despite the accelerated investment in farm equipment manufacture over the past three five-year plans, Soviet agriculture is still plagued by defective equipment and poor maintenance. This helps explain the frequent Soviet press reports of planting or harvesting delays caused by equipment breakdown. To compensate for equipment defects, Soviet farmers have become expert at cannibalizing one piece of equipment for the spare parts needed to keep a similar piece running, leading to the sprawling equipment 'boneyards' observed on state farms. Among the most revealing numbers published in Soviet statistical yearbooks are those showing that fewer tractors were in use at the end of 1981 than were manufactured between 1976 and 1981, indicating a short life expectancy.

The deterioration of Soviet agriculture is not confined to the production of grains alone. It permeates the entire agricultural sector affecting crop and livestock products alike. Underlying some of the Soviet crop production declines in recent years has been the cumulative soil erosion of the past several decades. The erosion problem in the U.S.S.R. is aggravated by large heavy equipment and vast fields that eliminate some of the natural boundary constraints on soil erosion by wind and water. But in the short term efforts to boost production responsible soil management practices are cast aside.

In their single-minded focus on expanding food production, the Soviets have neglected storage, packaging and transport. Some examples are grain harvested but no place to store but on the ground, fields red with ripe tomatoes but no crates to transport them to market, and potatoes left to rot in the fields because the farm-to-market roads are impassable.

In effect, the Soviet leadership faces two hurdles enroute to a productive agriculture: the decision to reform and the implementation of the reform. Launching reforms like those in Hungary will be far more difficult in the Soviet Union, with its longer bureaucratic tradition. Those now in power cannot remember working within a market economy, and farm workers accustomed only to taking orders cannot develop overnight the decision making skills essential to successful decentralized agriculture.

In constrast to poor harvest which can lead to starvation, poor Soviet harvests largely threaten the supply of livestock products. The Soviet food problem is a shortage of meat and not bread. The issue is not starvation, but worker morale and whether the system can provide the quality of diet that Soviet citizens have been promised and come to expect.

COTTON PRODUCTION LOSSES FROM WEED COMPETITION IN KERN COUNTY: A THREE YEAR EVALUATION

Harold M. Kempen[1]

Abstract

Several annual and perennial weeds were found to reduce cotton lint production by 0.5 B/A or more. At .75/lb, severe infestations of six competitive weeds cost an average of $237.00/A in lost lint alone. However, 58% of Kern County's fields were weed-free and only 4.5% were infested more than 10% at harvest time. Thus average losses were $5.30/A or 0.67% of the $787.50/A production value. Control costs in contrast are estimated to be $71.39/A.

The ten most common weeds at harvest were: clay loam soils: barnyardgrass (*Echinochloa crusgalli* (L.) Beauv.), groundcherry (*Psysalis lanceifolia* Nees), tumble pigweed (*Amaranthus albus* L.), sprangletop (*Leptochloa fascicularis* (Lam.) Gray), field bindweed (*Convolvulus arvensis* L.), green amaranth (*Amaranthus hybridus* L.), alkali mallow (*Sida hederacea* (Dougl.) Torr.), johnsongrass (*Sorghum halepense* (L.) Pers.), bermudagrass (*Cynodon dactylon* (L.) Pers.), and yellow nutsedge (*Cyperus esculentus* L.). Sandy loams: barnyardgrass, green amaranth, bermudagrass, black nightshade (*Solanum nigrum* L.), yellow nutsedge, cheeseweed (*Malva parviflora* L.), London rocket (*Sisymbrium irio* L.), sprangletop, tumble pigweed, and puncturevine (*Tribulus terrestris* L.).

Introduction

A three year study was undertaken to evaluate cotton lint losses from weeds in Kern county. Concurrently, the occurrence of weed species and their percent infestation of fields was measured. Funding from the Cotton Foundation and the California Planting Cottonseed Distributors permitted research assistance.

Materials and Methods

As part of a Beltwide study in cotton to determine losses from weeds, a boll count technique of assessing loss was used. From two 10-foot sections of rows in weed-infested and adjacent weed-free areas, mature bolls from two or more replicated samples were counted. Random fields were sampled in 1981, 1982, and 1983 just before harvest. Efforts were made to avoid sampling where other factors affected yields such as irrigation differences, soil type changes, stand variation, etc.

Estimates of percent weed infestations were taken in each field sampled in 1981. In 1982 and 1983 we randomly chose fields and made estimates of percent infestation (% weed cover in 1983) whether a boll count sample was taken or not. This was done to assess what percent of Kern county fields were infested and what percent infestation occurred. About 1% of all county acreage was sampled.

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[1]University of California Cooperative Extension, Bakersfield, CA.

Concurrently, the frequency of weed species was assessed in 1982 and 1983 by recording which weeds were present in and around each field. Sampling was separated between heavy (clay loam) soils and light (sandy loam) soils.

Results

The evaluation of 1981 showed surprising lint losses. The evaluation was verified by different technicians' evaluations in 1982 and 1983. The loss figures dramatically point out why growers rogue most weeds which are competitive.

Table 1. Lint losses due to weeds in Kern county[1]

Weed Species	Infestation[2]	Field Samples	Reduction (%)	Loss/A
Green amaranth	Severe	14 in 15	36	$195
Black nightshade	Severe	4 in 3	34	277
Ivyleaf morningglory	Severe	13 in 5	32	202
Barnyardgrass	Severe	5 in 2	45	266
Johnsongrass	Severe	19 in 7	56	319
Bermudagrass	Severe	5 in 3	29	165
Black nightshade	Moderate	5 in 3	6	41
Yellow nutsedge	Moderate	7 in 2	40	251
Ivyleaf morningglory	Moderate	6 in 3	22	138
Bermudagrass	Moderate	12 in 4	15	98
Barnyardgrass	Light	2 in 2	30	142
Lance-leaf ground-cherry	Light	3 in 2	5	26

[1]Study conducted during 1981, 1982 and 1983 with assistance from Joe Graf, Purdue, U.; Dean Harrell, Univ. of Calif., Davis; and Peter Belluomini, Calif. Polytechnic U., San Luis Obispo.

[2]Infestation at harvest.

Table 2. Lint Loss in 28 Fields [1]

	Weedy	Clean
1981	1.44	1.94
1982	1.21	1.64
1983	0.65	1.17
Avg.	1.10	1.58

Kern county avg. - 2.1 B/A

[1]Heavy, medium and light infestations.

In Table 2 a summary of lint losses in 28 field samples (heavy, medium and light infestations at harvest) to be over 0.48 bales/acre. Production in weed-free areas was only 1.58 B/A, considerably less than Kern county average, thus suggesting that other management practices or soils were poorer than average.

When evaluating losses due to severe infestations of six weeds, Table 3, the average loss (at .75/lb) was $237.01/A. However, only 4.5% of the Kern county fields had weed infestations greater than 10%.

Table 4 indicates that 58% of the fields were weed-free at harvest. Losses were only $5.30/A over an acreage of 390,000, or 0.67%. Previous loss estimates were 2%.

The major cost of weed control is in control efforts. Sample cost analysis to produce cotton is estimated to be $743.00/A (3). Of that, $71.39 is due to weed management. Herbicide and application costs are estimated at $20.85, hand weeding at $27.00 and cultivation at $23.54.

In comparison, insect and mite treatment cost was $27.75; nematode treatment (assuming 50% treated) cost $25.00 and defoliation $17.40. Weed management makes up half of the crop protection costs and 10% of the cash production costs. Surely it is a candidate for cost-reduction through research and extension.

Table 3. Dollar Loss/A Due to Severe Weeds in Kern County: 1981, 1982, 1983.

Green amaranth	$195
Black nightshade	277
Ivyleaf morningglory	202
Barnyardgrass	266
Johnsongrass	319
Bermudagrass	165
@ .75/lb Ave./A =	$237

Table 4. Percentage of Fields Infested & Loss Kern County: 1981, 1982, 1983.

No weeds	58%	
2.5% (1.5%)	31%	$ 716,330
7.5% (6-10%)	4.5%	311,950
25% (10%)	4.5%	1,039,840

Avg. lint loss @ $237/A = $5.30/A @ 1050 lb/A x .75 = $787.50; loss is 0.67%

The frequency of weed species in Kern county cotton was determined in 1982 and 1983.

Table 5. Weed Species Frequency in Kern Cotton[1]
1982-1983

	Sandy Loam & Loam	% Occurrence
1.	Barnyardgrass	69%
2.	Green amaranth	66
3.	Bermudagrass	60
4.	Black nightshade	59
5.	Yellow nutsedge	54
6.	Cheeseweed	50
7.	London rocket	49
8.	Sprangletop	47
9.	Tumble pigweed	39
10.	Puncture vine	37
	Clay Loams	% Occurrence
1.	Barnyardgrass	73
2.	Groundcherry	65
3.	Tumble pigweed	54
4.	Sprangle top	42
5.	Field bindweed	38
6.	Green amaranth	38
7.	Alkali mallow	38
8.	Johsongrass	30
9.	Bermudagrass	27
10.	Yellow nutsedge	27

[1]Over 1% of Kern county's 390,000 acres were sampled.

The sample of over 1% of the acreage showed that even after 20 years of usage of dinitroaniline herbicides on cotton that the susceptible weeds, barnyardgrass and pigweed species, are still commonly present. Not that they were common problems in sampled fields but they were in the 'wings' ready to be problems if no herbicide program was used.

Certain weeds were clearly associated with certain soil types. Groundcherry and field bindweed were clearly associated with heavy soils (clay loams).

Black nightshade and bermudagrass are associated with light soils. Nightshade is the most difficult weed species to consistently control in Kern county, unless sprinklers or timely rainfall activates the herbicide (2).

Cheeseweed and London rocket are much more common than in a previous survey (1, 4). Both can germinate in the fall if early rains occur before harvest and both are common on fallow beds. The increase in fall bedding before spring cotton planting, due in part to usage of cotton modules at harvest and persistent cotton residual herbicides, may be increasing their prevalence. New registrations of oxyfluorfen (2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene), cyanazine (2-((4-chloro-6-(ethylamino)-s-triazin-2-yl)amino)-2-methylpropionitrile), and prometryn (2,4-bis(isopropylamino)-6-(methylthio)-s-triazine) should reduce their incidence in the future.

Yellow nutsedge continues to become more prevalent as other weeds are controlled.

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ADVANCES IN LIVE MULCH CROP PRODUCTION IN THE TROPICS

I. Okezie Akobundu[1]

Abstract: Studies carried out at the International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria over the last four years show that two crops of maize can be grown each year on a sustained yield basis in an Alfisol by using a live mulch system. Maize yield declined in plots where conventional tillage was practiced while maize stover mulch was necessary to maintain good crop yield in the no-tillage system. The use of psopho (*Psophocarpus palustris* Desv.) as a live mulch cover eliminated the need to weed in these live mulch plots and also minimized the requirement for in-organic nitrogen fertilizer. On the other hand, two weedings were nec-essary to minimize the yield reduction caused by weeds in maize grown in a conventional tillage system. A two-year intensive crop production in the Alfisol resulted in 32% and 20% loss in organic matter (O.M.) content of

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[1]International Institute of Tropical Agriculture, P.M.B. 5320, Ibadan, Nigera.

soils that were under conventional and no-tillage maize, respectively, while identical cropping intensity in a live mulch system did not cause any net loss in soil O.M. between the precropping fallow and the end of the second year of cropping.

Introduction

Tropical soils are fragile and lose fertility rapidly when subjected to continuous cultivation. The traditional methods of dealing with declining yield in the tropics include shifting cultivation, bush fallow and rotational agriculture. All of these systems include a fallow period during which natural bush regrowth suppresses weeds, improves soil structure, returns organic matter to soil and restores fertility (5). Increasing population pressure on limited arable land has so reduced the length of the fallow period that the soil restoration advantages of the bush fallow system have virtually been lost. Weed pressure has increased in these frequently cultivated fields and crop yield has declined below levels ordinarily associated with poor crop husbandry.

The problem of increased crop production in the tropics is not only that of increased weed pressure but that of maintaining soil fertility. Herbacious legumes have been used for decades as cover crops in such plantation crops as oil palm (*Elaeis guineensis* Jacq.) and rubber (*Hevea brasiliensis* (Kunth) Mull Arg) and in pastures (7, 8). Although their beneficial effects in maintaining fertility have been demonstrated, the logistics of using herbaceous legumes in food crop production systems in the tropics had until recently proved difficult to implement. In order to maintain fertility in the fragile soils of the tropics, minimize erosion and suppress weeds without the need for transporting crop residue mulch, a legume cover management system for food crops needs to be developed. This paper discusses recent advances in herbacious legume cover management in the humid tropics and its contribution to weed management and maintenance of soil fertility.

Live Mulch Cropping System

Plant Screening for Live Mulches. Live mulch farming has been defined as a crop production technique in which a food crop is planted directly in the living cover of an established cover crop without tillage or destruction of the fallow (cover crop) vegetation (1). Earlier studies on this subject involved the screening of selected tropical grasses and legumes for possible use in live mulch crop production systems (3). Results of those studies showed that the grasses either failed to compete well with weeds or required to be killed in order to grow maize successfully in them. Several legumes such as *Desmodium triflorum* (L.) DC and *Arachis repens* Handro were not competitive against weeds. Others, e.g. *Indigofera spicata* Forsk, reduced maize yield when kept weedfree possibly as a result of allelopathic effects. Some other legumes such as centro (*Centrosema pubescens* Benth) and psopho (*Psophocarpus palustris* Desv) provided good ground cover and smothered weeds without interfering with maize yield. The characteristics of live mulch legumes have been outlined by Akobundu (2). These include ease of establishment, ability to smother weeds, drought and shade tolerance, non-climbing growth habit and ability to return nitrogen to the soil either through nodulation or litter fall. Current studies at the International Institute of Tropical Agriculture (IITA) are aimed at screening a wide range of tropical legumes to assess their suitability for live mulch cropping systems.

Effect of Live Mulch on Weed Competition. Weed pressure is generally low on newly cleared tropical forests. Such lands are usually abandoned by farmers after a few years of cropping partly because of declining fertility and partly because of increased weed pressure. Part of the objectives of the live mulch crop production system is to determine the effect of this type of land management on weed interference in crops. Weed interference due to uncontrolled weed growth has been reported to cause 25% and 42% yield reductions in conventional and no-tillage maize, respectively, but none in the live mulch plots (1). The long term effects of land management systems on weed biomass are shown in Table 1. After four years of continuous cropping, weed biomass increased in both the conventional and no-tillage plots but remained negligible in the live mulch plots. The long-term effect of the live mulches on weed seed population in the soil

Table 1. Effect of land management on weed biomass and weed seed population in soil in a continuously cultivated alfisol.

Land management	Change in weed biomass		Weed seed population in soil[a]
	1979	1982	
	----(kg/ha)----		(%)
Conventional tillage	1211	1760	54
No tillage	1680	2250	57
'Centro' live mulch	1003	153	13
'Psopho' live mulch	92	210	18

[a]Change after four years of continuous cropping.

was also monitored at the beginning and at 4 years later. Results show that weed seed population declined by over 80% in each of the live mulch systems but only 46% in the plots that were continuously cropped twice each year (Table 1).

Effect of Live Mulch on Soil Organic Matter and Earthworm Activity. The organic carbon content of newly cleared forest soils of West Africa is generally less than 2%. This organic carbon declines rapidly when the land is cropped, thus contributing to loss of soil structure, water holding capacity and decline in fertility. Results of one of the live mulch studies we have carried out show that this food crop production system has, so far, been more effective in reducing loss in organic matter content of intensively used Alfisols than any other land management system (Fig. 1). A two-year intensive maize production resulted in 32% and 23% loss in organic matter in conventional and no-tillage systems, respectively, while the organic matter loss in the psopho live mulch was less than 10% after the two years of continuous cropping.

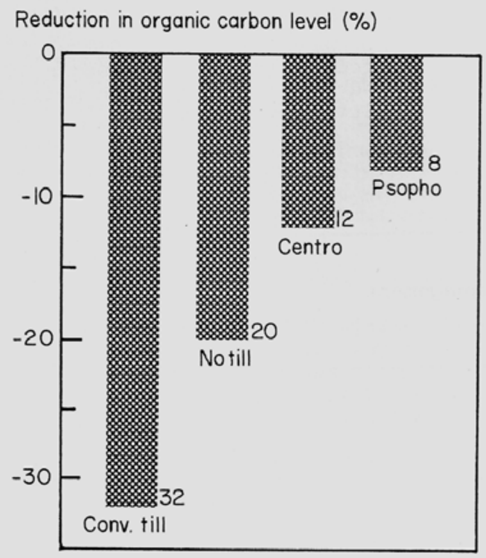

Fig. I Effect of ground cover management on organic matter changes in surface soil of continuously cropped alfisols (2-yrs. cropping).

Akobundu (1) had earlier reported that both the number and dry weight of earthworm casts were higher in live mulch plots than in the conventional tillage plots. The high earthworm activity is an indication of a highly favorable soil environment for the soil fauna.

Effect of Live Mulch on Crop Yield. Results of continuous maize production in an Alfisol using three distinct land management systems and varying levels of N-fertilizer are shown in Figure 2 (2). All plots received a blanket application of 60 kg/ha of K_2O and P_2O_5 fertilizer. Maize yield was high in all three cropping systems in the first cropping event after fallow because a blanket fertilizer application of compound fertilizer (15-15-15) at the rate of 400 kg/ha was applied uniformly to all plots. In the subsequent seasons, results show that without fertilizer, yield declined steadily in the conventional tillage plot. Although yield decline was prevented during the second cropping event in the conventional tillage plot by applying N-fertilizer at 60 and 120 kg N/ha, these high levels of N-fertilizer could not prevent yield decline in these plots when cultivation was extended to the fourth cropping event. This phenomenon was recognized long ago as characteristic of the humid tropical soils (6).

Crop yield in the no-till plot was expectedly low without N-fertilizer. Consistently high maize yield was, however, maintained under continuous cropping in the no-till plot by applying N-fertilizer. This confirms the results of other workers (5) that intensive cropping is possible in the tropics under a no-till system. This system, however, requires that weeds be controlled with herbicides at both preplant and postplant stages.

In the live mulch system in which psopho was used for ground cover, high maize yield was consistently obtained over the four cropping events without N-fertilizer. Only a slight yield increase was observed with N-fertilizer was added. Of the three land management systems, only the live mulch was capable of supporting high maize yield on sustained basis at low weed control and N-fertilizer input levels. Weeding has been shown to be unnecessary when maize is grown in a fully established live mulch (1).

Conclusion

It has been demonstrated in the studies reported here that tropical soils can be cropped intensively without that irreversible loss in soil fertility that in the past led to soil degradation and need for extended fallow periods. The live mulch crop production system appears to be more effective under intensive cropping, in maintaining fertility and restoring organic matter to tropical soils than traditional cropping systems. There is need for further study of this land management system in order to identify those parts of the tropics where this sytem will be most useful in food crop production.

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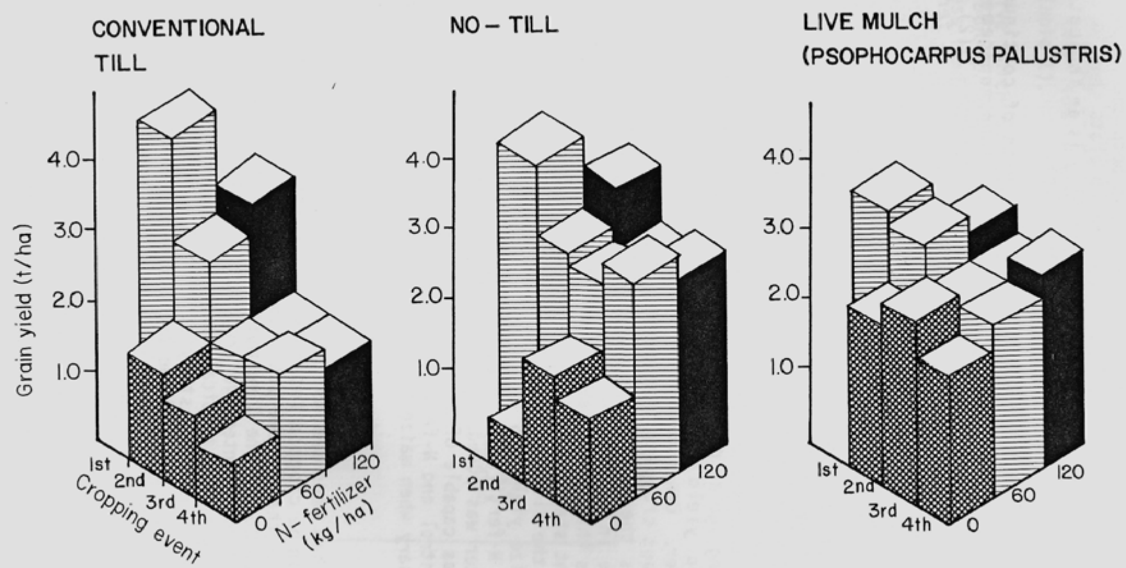

Fig.2: Effect of land management, N - fertilizer and cropping intensity on maize yield (Akobundu, 1982)

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POST-EMERGENCE WEED CONTROL IN CRUCIFERS WITH NITROGENOUS FERTILIZERS

H. Agamalian[1]

Crucifers are grown in the central coast area of California on approximately 80,000 acres. With the loss of nitrofen, a post-emergence herbicide, growers faced difficult to control weeds in the growing of these crops. The preplant or preemergence herbicides currently registered on crucifers are most limited in the weeds that they control. Some of the most serious weeds in this category include cheeseweed (*Malva parviflora* L.), shepherdspurse (*Capsella bursa-pastoris* (L.) Medic.), common groundsel (*Senecio vulgaris* L.), and pineappleweed (*Matricaria matricarioides* (Less.) Porter).

Methods and Materials

Earlier research indicated that certain contact-type fertilizers could be used as semi-selective herbicides. Field trials were conducted with ammonium nitrate (20-0-0) and ammonium thiosulfate (12-0-0-26). The performance of these directed spray applications have resulted in effective weed control of the above species.

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[1]University of California - Cooperative Extension, Salinas, CA.

For optimum selectivity, the application of nitrogen fertilizers is best made when the crucifer has at least 2-3 true leaves. It is felt at this time that the crop develops a good waxy cuticle which allows for its selectivity. The utilization of shields for this application will greatly enhance selectivity but is not essential. Applications of ammonium nitrate at 50-70 gallons per acre have been most effective when sprayed at this stage of crop growth. The utilization of low pressure nozzle tips such as 8002 or 8004 has been most effective. The benefits of the low pressure nozzle allow one to spray at 10-15 pounds pressure, thus reducing some of the fine particles from drifting to the growing point of the crop. The utilization of stainless steel tips results in less corrosive action.

Results and Discussion

It has been found that selectivity is best when the broccoli/cauliflower plants have no moisture on their leaves. In many cases, afternoon spraying will result in better selectivity than early morning applications. One advantage of nitrogenous fertilizers is that results may be seen within 4-6 hours after application. If the nitrogen fertilizers do not "bead-up" on the crucifer plant, then one should stop spraying.

Reduced selectivity is most apparent when previous insecticide/fungicide applications are made to the crucifer crop within 48 hours of the nitrogen fertilizer application. It is apparent that the surfactants in these sprays reduce the waxy cuticle so that the differential wetting principle is lost (Table 1).

There are several weeds that are resistant to this type of application. These are nettleleaf goosefoot (*Chenopodium murale* L.), lambsquarters (*Chenopodium album* L.), sowthistle (*Sonchus oleraceus* L.), and purslane (*Portulaca oleracea* L.). Most grasses seem to show little effect from the nitrogen treatment. Sensitive weeds are best controlled when they are less than 3-4 true leaf size, although some species may be killed at later maturity (Table 2). This post-emergence application is best utilized as a sequential treatment to preemergence herbicides. It is best to wait 2-3 days before using overhead irrigation. Sprinkler irrigation works best as it allows for the leaching of the nitrogen to the shallow rooted crucifer crop.

Certain hybrid varieties of broccoli may be more sensitive to nitrogenous fertilizers than others. Limited studies indicate that Futura and Green Valiant may be more sensitive than others (Table 3). Crop symptoms from nitrogen application are marginal leaf burn and necrotic spotting of leaves. Yield data that has been obtained with broccoli and cauliflower have resulted in no significant yield differences with nitrogenous fertilizer herbicide applications.

Conclusions

The utilization of nitrogenous fertilizers as a "surface banding" technique has resulted in effective broadleaf weed control while maintaining excellent crucifer tolerance. When using this technique, it is important to consider the following factors which influence selectivity: size/age of crop plant, dosage/concentration, crop/soil moisture stress, preceeding pesticide application, application technique, and variety interaction. The practice of using surface banding of fertilizers has greatly reduced weed control in crucifer crops.

TABLE 1
BROCCOLI RESPONSE TO AMMONIUM NITRATE

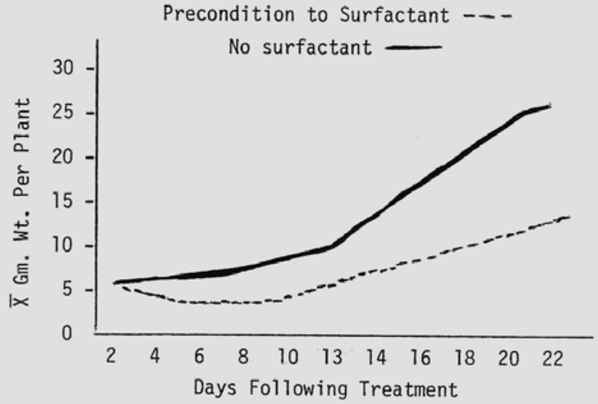

TABLE 2
WEEDS AND THEIR SENSITIVITY TO
AMMONIUM NITRATE APPLICATIONS*

Weed	Control	Weed	Control
cheeseweed	C	nettle	C
chickweed	C	nightshade	C
goosefoot	N	pigweed	C
lambsquarters	N	pineapple weed	C
groundsel	C	purselane	N
London rocket	C	shepherdspurse	C
mustard	C	sowthistle	N

*Applied when broccoli has 2-3 true leaves.

TABLE 3
BROCCOLI VARIETY-AMMONIUM NITRATE APPLICATION EVALUATION
MEAN STAND COUNT/30 FT. ROW

VARIETY	DIRECTED SPRAY	TOPICAL SPRAY	HAND WEEDED
GREEN VALIANT	115	121	110
EMPEROR	119	123	114
NK 1702	124	113	111
GREEN DUKE	117	109	112
EXCALIBUR	110	103	110
PREMIUM	120	111	113
FUTURA	101 b	96 b	119 a

1983 COMMERCIAL RESULTS USING SETHOXYDIM IN SUGARBEETS, ONIONS FOR SEED AND LADINO CLOVER FOR SEED UNDER A CRISIS LABEL IN CALIFORNIA

D. C. Wiley[1]

Abstract: With continuous heavy rains all winter and spring, a crisis situation developed in California. Growers could not carry on their normal cultural practices and grassy weeds became a major problem in most fields.

Onions

On April 6th, California Department of Food and Agriculture, (CDFA), issued an emergency exemption for the use of sethoxydim (2-(1-(ethoxyimino)butyl)-5-(2-(ethylthio)propyl-3-hydroxy-2-cyclohexen-1-one)), for the control of annual rye grass (*Lolium* spp) and wildoats (*Avena fatua* L.) on onions grown for seed.

Sethoxydim has federal registration in several crops and is sold under the trade name of POAST.

Of the commercial fields observed, application was made at 0.6 lbs AI/acre, 30 GPA of water and 40-60 PSI. One air application was located using sethoxydim at 0.6 lbs/acre and 10 GPA of water. All applications had included a crop oil concentrate at one quart per acre. 95 to 98% control of 2 to 3 foot tall annual rye grass, wildoats and canary grass (*Phalaris* spp) were observed. Many of these plants had seed heads formed at the time of application. No phytotoxicity was seen on the onions.

Ladino Clover

CDFA issued a second emergency exemption May 5th for sethoxydim to be used on ladino clover for seed. The target grasses this time were barnyardgrass (*Echinochloa crusgalli*) and annual rye grass.

Commercial treatments observed used 0.4 lbs/acre of sethoxydim, plus one quart of crop oil concentrate at 60 PSI in 20 GPA of water. This pressure allowed good penetration of a 5 inch canopy of clover and produced excellent control of 2 to 5 inch tall barnyardgrass. No phytotoxicity was noticed on any of the clover fields.

Sugar Beets

The third and last emergency exemption was issued June 6 by CDFA for the use of sethoxydim on sugar beets. All fields that were visited were band treated with sethoxydim in widths of 6 to 10 inches and applied directly over the tops of the sugar beets. Rates of 0.4 to 0.5 lbs/acre of sethoxydim in 15 to 25 GPA of water with one quart of crop oil concentrate was the standard treatment. These rates were on a broadcast basis and amounts reduced accordingly for the actual band applied. Barnyardgrass was the primary weed pest, but other grasses were present such as foxtails (*Setaria* spp), sudangrass (*Sorghum sudanense*), volunteer corn (*Zea mays*),

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[1]BASF Wyandotte Corp., Market Development, Parsippany, NJ.

volunteer wheat (Triticum aestivum). Excellent tolerance was observed on the sugar beets to sethoxydim. Grass control was good to excellent where thorough spray coverage of the grasses was obtained.

BASF plans a full registration for the use of sethoxydim on sugar beets in 1984.

CONSIDERATIONS FOR DESIGN OF A MICROCOMPUTER-BASED DATA MANAGEMENT SYSTEM FOR WEED SCIENCE

M. K. Edwards and P. W. Leino[1]

With the availability of microcomputers, data loggers and other peripherals, much interest has been shown in using this equipment to facilitate the rapid and less error-prone processing of large amounts of data generated in Weed Science.

In 1978 at the University of Idaho Reserach Center development of such a system began. An MSI/77 portable data terminal was used for field data collection. A Hewlett Packard microcomputer (9825A) was programmed to accept the data, process, store and write reports.

Presently, the data input program accepts the raw field data from the MSI and sorts variables according to the replication-treatment (and subtreatment if splitplot) identification. The program detects rep-treatment and variable errors, flags them, and allows them to be corrected. The sorted data can now be stored by variable on an eight inch floppy disk (Fig. 1).

Once the data are stored, they can then be manipulated. Randomized complete block or split plot statistical designs are supported and analysis of variance may be performed on individual variables. Other programs allow creation of new variables such as total yield or percent of total from the raw data without manually calculating or transcribing data. Using a terminal emulator program sorted data can be transferred to a mainframe IBM allowing access to a large memory and powerful statistics packages like SAS (Fig. 2).

Planning is the first and most critical step in designing a data management system. First determine raw data type and format, the value ranges of the variables, most common statistical analyses and the report format required. Then write these down and provide examples to the programmer (or software vendor). The better the programmer understands your needs the easier it is to get the program written that will fit your needs.

Once the program is written and in place in your computer, realize that it will take time to learn and debug (remove small errors) the program.

Some necessary ingredients of a good program are:

1. Error protection - detection and flagging of errors with correction ability.

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[1]University of Idaho Research & Extension Center, Aberdeen, ID.

2. User "friendliness" - good prompts and error recovery loops if something is entered wrong.
3. Documentation - easy to understand user instructions and internal documentation of the program with labeled modules and remarks.
4. Revisability - you must be able to update programs to your changing needs.

Developing a computerized data management system can involve a large investment in time and expense, but fewer transcription errors, immediate sorted data access and overall efficiency can be worth the investment.

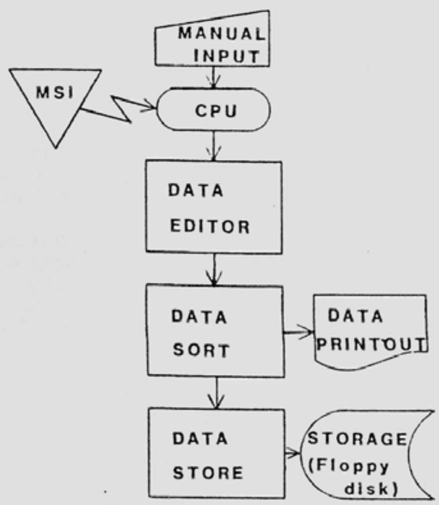

Fig. 1 INPUT PROGRAM STRUCTURE

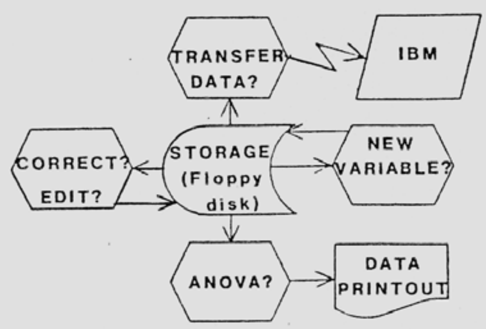

Fig. 2 ANALYSIS PROGRAM STRUCTURE

DEGRADATION OF CHLORSULFURON BY SOIL MICROBES

M. M. Joshi, H. M. Brown, and J. A. Romesser[1]

Abstract: Chlorsulfuron (2-chloro-*N*-((4-methoxy-6-methyl-1,3,5-triazin-2-yl)-aminocarbonyl)-benzenesulfonamide), degradation in acidic (pH 5.9, 5% OM and pH 6.5, 1.0% OM) and alkaline (pH 8.0, 5% OM) soils was assessed by plant bioassay and HPLC analyses using radiochemical detection. Breakdown was consistently faster in non-sterile soils than in soils sterilized with steam, ethylene oxide, or gamma irradiation. Reinoculation of sterilized soil with indigenous soil microorganisms restored rapid degradation of chlorsulfuron, confirming the role of microbes. Additionally, *Streptomyces griseolus*, a soil actinomycete, degraded ^{14}C-chlorsulfuron in *pure culture, forming* two metabolites which were also identified in non-sterilized soil treated with chlorsulfuron. In acidic soils, chemical hydrolysis plus microbial attack contributed to a relatively rapid rate of chlorsulfuron dissipation. In alkaline soils the rate of dissipation was less since the contribution of chemical hydrolysis became less significant. Both dissipation processes slowed markedly at low temperatures.

We conclude that chemical hydrolysis and soil microbes significantly affect chlorsulfuron dissipation, and that soil microbes are particularly important in alkaline soils where chemical hydrolysis is minimal.

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[1]E.I. Du Pont De Nemours & Co., Inc. Wilmington, DE.

INFLUENCE OF IRRIGATION TIMING ON THE PREEMERGENCE ACTIVITY OF OXYFLUORFEN

J. T. Schlesselman and A. H. Lange[1]

Introduction

Herbicides which are applied to the soil surface are subject to many degradative processes. The effectiveness of such materials is determined both by their inherent herbicidal properties and by their ability to resist degradation. Processes affecting the breakdown of herbicides may include photodegradation, volatility dissipation, microbial degradation and chemical degradation due to interaction with soil constituents. Factors such as soil moisture levels and soil temperature also affect herbicide performance, inasmuch as they affect both biological and physical processes in the soil.

Past research has shown that oxyfluorfen (2-chloro-1-(3-ethoxy-4-nitro-phenoxy)-4-(trifluoromethyl) benzene) applied in the fall can remain

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[1]Rohn and Haas Co., Reedley, CA and University of California, Parlier, CA.

on the soil surface for 3 to 4 weeks without activation by rainfall or sprinkler irrigation. The residual activity of oxyfluorfen is not severely affected by this time frame between application and irrigation.

Trials were established during the summers of 1982 and 1983 to evaluate the activity of oxyfluorfen (0.5 and 2 lb ai/acre) in treefruit and nut orchards. Residual activity from oxyfluorfen was substantially less than normally provided by fall applications. Indications were that certain environmental conditions may have reduced the activity of oxyfluorfen (i.e.: high air and soil temperatures, considerable time between application and rainfall).

Two irrigation timing studies were conducted during the summer and fall of 1983. These trials were established with primarily two objectives: 1) To determine the residual activity of oxyfluorfen when rainfall or sprinkler irrigation is delayed up to 28 days after application, and 2) To compare the residual activity of oxyfluorfen when applied under different temperature regimes, fall versus summer.

Materials and Methods

The summer trial was established during August 1983, when oxyfluorfen at 0.5 and 2.0 lb ai/acre was applied 28, 21, 14, 7, 3, 1 and 0 days prior to sprinkler irrigation (mean air temperature = 97F, mean soil temperature = 93F). The fall trial was established beginning October 14, 1983 with oxyfluorfen at 0.5 lb ai/acre being applied at 28, 21 and 0 days prior to sprinkler irrigation (mean air temperature = 79F, mean soil temperature = 67F). Within one hour after the '0' day applications the respective trial was sprinkler irrigated totalling 0.5 inches. Sprinkler irrigation continued as necessary to germinate the weeds as well as the seeded crops which are known to be sensitive to oxyfluorfen (lettuce, broccoli, sugar beets and wheat).

Results and Discussion

Summer Trial: Evaluations were made one month after initial irrigation. The weeds present at that time were tumbling pigweed (*Amaranthus albus*), junglerice grass (*Echinochloa colonum*), common crabgrass (*Digitaria sanguinalis*), and annual bluegrass (*Poa annua*). A poor stand of crops germinated and were not evaluated (crops were reseeded after one month). Figure 1 shows the 2.0 lb ai/acre rate of oxyfluorfen controlling 99-100% of the weeds regardless of irrigation timing. Although the 0.5 lb ai/acre rate of oxyfluorfen resulted in excellent overall weed control, there was a modest decrease in activity as time incrased between application and irrigation (99% down to 89%).

By the time 3 months had passed since the initial irrigation the overall activity of oxyfluorfen had decreased substantially (Figure 2). Both rates were also showing a slight reduction in activity as the interval for irrigation timing increased. However, this average weed control data can be misleading, since they are averages of lettuce, broccoli, wheat, annual bluegrass, redmaids (*Calandrinia caulenscans*) and southern brassbuttons (*Cotula australis*). For example, the activity of both rates of oxyfluorfen was 95-100% for redmaids and brassbuttons, regardless of irrigation timing. Species such as annual bluegrass (and wheat) proved to be more tolerant of oxyfluorfen especially at the 0.5 lb ai/acre rate (Figure 3).

FIGURE 1

PREEMERGENCE WEED CONTROL ACTIVITY OF OXYFLUORFEN
1 MONTH AFTER SPRINKLER IRRIGATION (SUMMER APPLICATION)

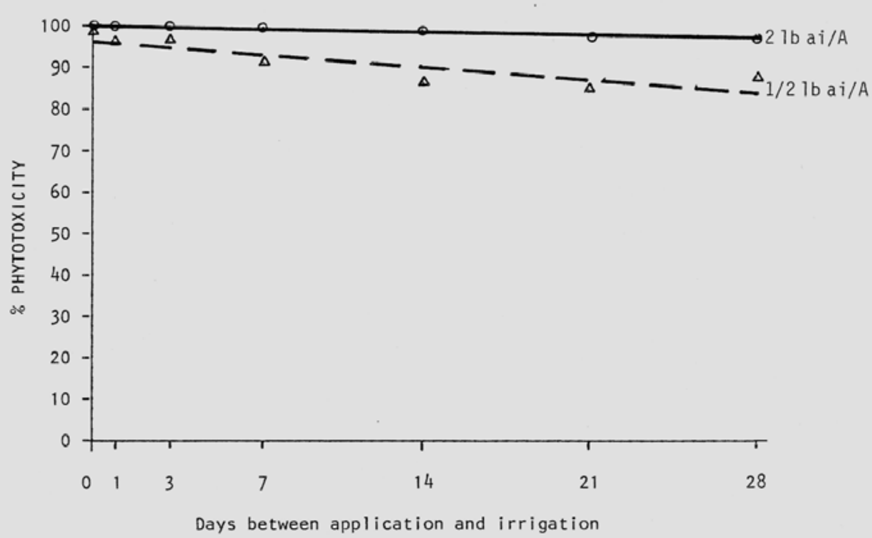
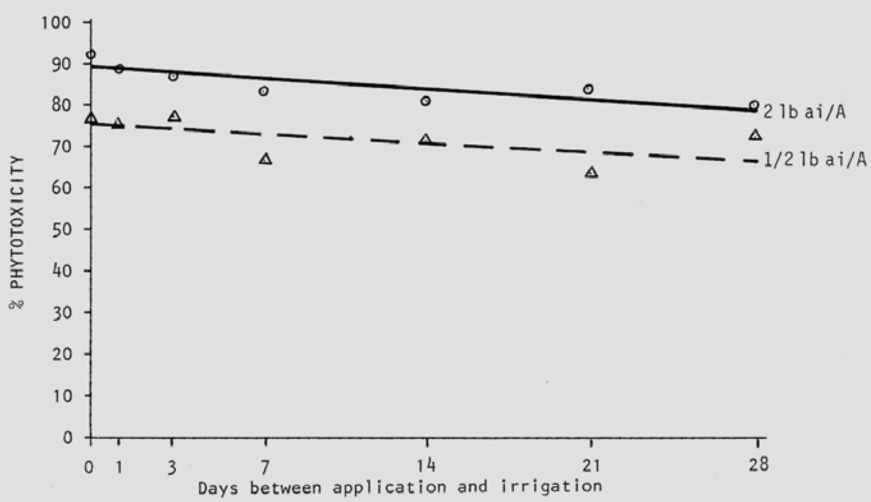


Figure 2

THREE MONTH EVALUATION OF PREEMERGENCE
WEED CONTROL ACTIVITY WITH OXYFLUORFEN (SUMMER APPLICATION)



Fresh weights of lettuce, broccoli and wheat were taken at 4 months. Results between these crops were similar and for that reason only the wheat fresh weights are shown in Figure 4. These weights show a dramatic decrase in the activity of oxyfluorfen at 2.0 lb ai/acre as the irrigation timing interval increases. The activity of oxyfluorfen at 0.5 lb ai/acre on wheat was only slightly affected by irrigation timing interval.

Fall Trial: Evaluations taken after 3 months resulted in oxyfluorfen at 0.5 lb ai/acre giving 89% overall weed control. There was only a 7% decrease in activity when the irrigation timing interval was increased from 0 to 28 days.

A significant difference in the activity of oxyfluorfen is shown in Figure 5 by comparing applications made under two temperature regimes. The residual activity of oxyfluorfen on lettuce and annual bluegrass averaged 96% when applications took place during the fall (temperature averaged 79F). The activity of oxyfluorfen on those same two species averaged only 66% when applications were made during the summer (temperature averaged 97F). Irrigation timing interval after oxyfluorfen application had only minimal effects on herbicide activity.

Conclusions

The greatest factor affecting the residual activity of oxyfluorfen appears to be the temperature regime at application. Applications made during the hot summer months significantly reduced the residual activity of oxyfluorfen compared to fall applications (when temperatures have moderated). Delaying irrigation beyond 3 days after a summer application can cause a decrease in the residual activity with oxyfluorfen. This is more apparent in the weed species which are less sensitive to oxyfluorfen.

FIGURE 3

RESIDUAL ACTIVITY OF OXYFLUORFEN ON ANNUAL BLUEGRASS 3 MONTHS AFTER INITIAL IRRIGATION (SUMMER APPLICATION)

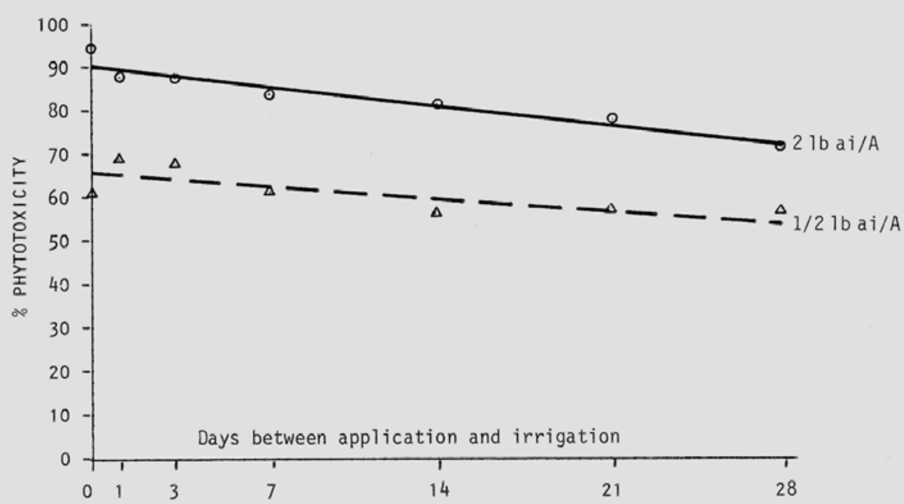


Figure 4

ACTIVITY OF OXYFLUORFEN AFTER 4 MONTHS
AS SHOWN BY WHEAT FRESH WEIGHTS (SUMMER APPLICATION)

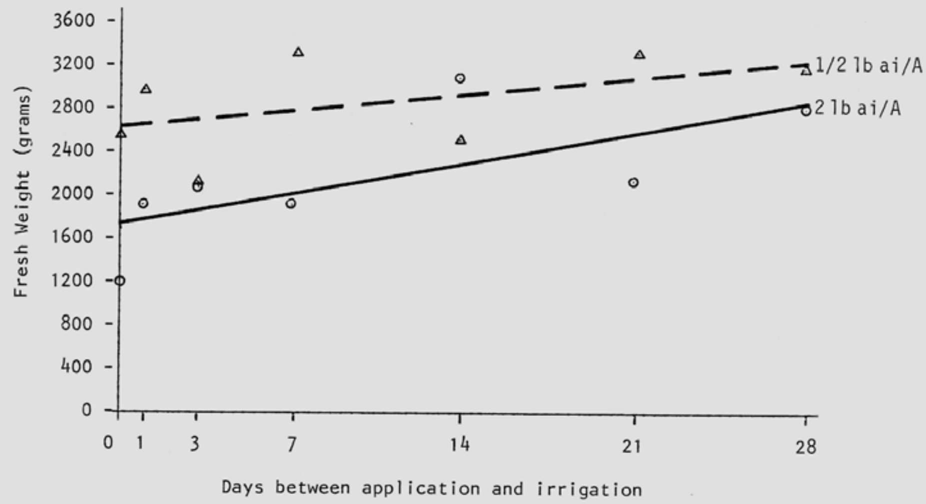
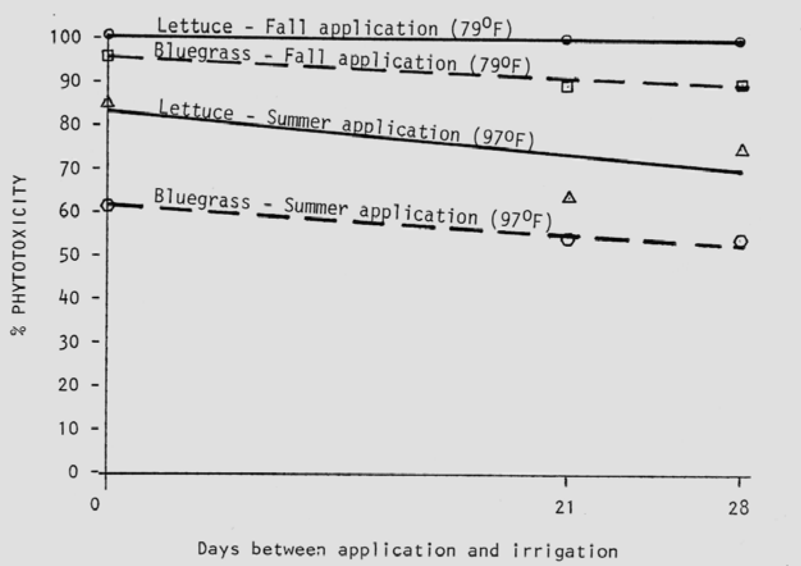


FIGURE 5

PREEMERGENCE ACTIVITY OF OXYFLUORFEN BASED ON SEASONAL DIFFERENCES AND IRRIGATION TIMING AFTER APPLICATION (OXYFLUORFEN AT ½ lb ai/A AT 3 MONTHS)



DIFFERENTIAL RESPONSE OF NIGHTSHADES TO HERBICIDES

Alex G. Ogg, Jr.[1]

Abstract: Field plots containing two accessions each of hairy nightshade (Washington and Nebraska) (*Solanum sarrachoides* Sendt.), black nightshade (Washington and England) (*S. nigrum* L.), American black nightshade (California and Florida) (*S. americanum* Mill.), and eastern black nightshade (Minnesota and Kentucky) (*S. ptycanthum* Dun.) were treated preplant incorporated, preemergence, and postemergence with herbicides commonly used on crops in the Western U.S. When applied preplant and preemergence, herbicides were applied at rates recommended for sandy loam. When applied postemergence, herbicides were applied at rates recommended for annual weeds 1 to 2 inches tall. Not only did species of nightshades respond differentially to herbicides, but sometimes accessions within a species responded differently.

Of the thiocarbamates evaluated, only cycloate (S-ethyl Nethylthiocyclohexanecarbamate) effectively controlled both accessions of all four species. EPTC (S-ethyl dipropylthiocarbamate), pebulate (S-propyl butylethylthiocarbamate), and vernolate (S-propyl dipropylthiocarbamate) controlled hairy nightshade, but were generally ineffective against the blackberried nightshades. The addition of an extender, R-33865 (O,O-diethyl-O-phenyl phosphorothioate) to EPTC improved the control of most of the nightshades.

Alachlor (2-chloro-2',6'-diethyl-N-(methoxymethyl)acetanilide), metolachlor (2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methyl-ethyl) acetamide), and ethalfluralin (N-ethyl-N-(2-methyl-2-propenyl)-2,6-dinitro-4-(trifluoromethyl)benzenamine) applied preplant and incorporated 1.5 inches deep controlled all accessions of all four species. Pendimethalin (N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinetrobenzenamine) reduced the number of nightshades only slightly, but severely suppressed the growth of all nightshades except black nightshade.

Preemergence applications of alachlor, chloramben (3-amino-2,6-dichlorobenzoic acid), metolachlor, PPG-884 (1'-(carboethoxy)ethyl-5-(2-chloro-4-(trifluoromethyl)phenoxy)-2-nitrobenzoate), and metribuzin (4-amino-6-tert-butyl-3-(methylthio)-as-triazine-5(4H)-one) + pendimethalin controlled both accessions of all four species. Metribuzin was only partially effective against the Washington accession of hairy nightshade but controlled the other nightshades. Propachlor (2-chloro-N-isopropylacetanilide) controlled all nightshades except the England accession of black nightshade. Pendimethalin applied preemergence controlled both accessions of American black nightshade and the Kentucky accession of eastern black nightshade, but was ineffective against the other nightshades.

When applied postemergence to nightshades less than 1 inch tall, PPG-844 + X-77 controlled both accessions of black nightshade, American black nightshade, and eastern black nightshade, but was only partially effective against hairy nightshade. Metribuzin controlled American black nightshade but was ineffective against the other nightshades. Acifluorfen (5-(2-chloro-4-(trifluoromethyl)phenoxy)-2-nitrobenzoic acid) controlled the Kentucky accession of eastern black nightshade and both accessions of Amercan black nightshade and suppressed the other nightshades. Bentazon

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[1]USDA-ARS, Irrigated Agriculture Research & Extension Center, Prosser, WA.

(3-isopropyl-1H-2,1,3-benzothiadiazin-4(3H)-one-2,2-dioxide) controlled all nightshades except black nightshade from England and hairy nightshade from Nebraska.

In summary, four species of weedy nightshades were controlled best by preplant application of cycloate, ethalfluralin, alachlor, and metolachlor and by preemergence applications of alachlor, chloramben, metolachlor, PPG-844, and metribuzin plus pendimethalin. None of the herbicides applied postemergence controlled all species.

HERBICIDES FOR BROADLEAF WEED CONTROL APPLIED AT DIFFERENT GROWTH STAGES OF WINTER WHEAT

R. E. Whitesides[1]

Abstract: Application of phenoxy herbicides to wheat is recommended when the crop is fully tillered but before it is in the boot stage of growth. The period of growth and development from fully tillered to the boot stage has been indexed (1983, Proc. WSWS, 36:123-124) based upon the number of nodes detectable (by feel) along the developing stem.

Soft white winter wheat (cv Stephens) was treated with bromoxynil (3,5-dibromo-4-hydroxybenzonitrile), 2,4-D amine ((2,4-dichlorophenoxy) acetic acid), 2,4-D ester, MCPA ester (((4-chloro-o-tolyl)oxy)acetic acid), dicamba (3,6-dichloro-o-anisic acid), bromoxynil plus MCPA ester, and chlorsulfuron (2-chloro-N-(((4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino) carbonyl)benzenesulfonamide) when the wheat was in the 1-, 2-, 3-, and 4-node stage of growth. Wheat yield from plants treated at each stage of growth was compared to the untreated control and wheat that was treated at the 3 to 5 tiller growth stage.

All herbicide treatments reduced wheat yield when compared to the untreated control. Wheat plants demonstrated maximum herbicide tolerance, however, when applications were made at the tillered or 1-node growth stage. When herbicide treatments were delayed until the 3- or 4-node stage of growth the greatest reductions in wheat yield were observed. When compared to wheat yield from applications at the tillered stage of growth, a slight reduction in yield was noted for most herbicides applied at the 2-node stage. As the wheat matured, there was a general tendency for yields to decline from all herbicide treatments after the 1-node stage of growth.

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[1]Department of Agronomy & Soils, Washington State University, Pullman, WA.

TOLERANCE OF SPRING WHEAT TO AC 222,293 AND OTHER HERBICIDES AND THEIR EFFECTIVENESS IN CONTROLLING WILD OAT

Larry W. Mitich and N. Lee Smith[1]

Abstract: Wild oat (*Avena fatua* L.) is a major weed in spring wheat grown in northern California, reducing yields and lowering quality. Some of the wheat varieties commonly grown in that area reportedly have been injured from application of the registered wild oat herbicides. Six spring wheat varieties were evaluated for the tolerance to AC 222,293 (methyl 6-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)-m-toluate) & (methyl 2-(4-isopropyl)-4-methyl--5-oxo-2-imidazolin-2-yl)-p-toluate) (a new wild oat herbicide), barban (4-chloro-2-butynylm-chlorocarbanilate), difenzoquat (1,2-dimethyl-3,5-diphenyl-1H-pyrazolium), and diclofop (2-(4-(2,4-dichlorophenoxy)phenoxy)propanoic acid) alone and in combination at reduced rates. The materials also were evaluated for their effectiveness in controlling wild oat.

Treatments were made when the wheat was in the 4-leaf stage with 2 to 3 tillers and the wild oat was in the 3- to 4-leaf stage and 1 to 3 tillers. Moderate phytotoxicity was observed only on wheat varieties Modoc and TL 75-409 from difenzoquat at 1 lb/A, however, the crop yield was not reduced.

Total control of wild oat was achieved with AC 222,293 at 0.75 lb/A and control was almost identical with a mixture of AC 222,293 and barban, each at 0.25 lb/A. Difenzoquat at 0.5 lb/A gave approximately 80% to 85% control of wild oat when combined with barban at 0.25 or 0.38 lb/A. About 80% control of wild oat was achieved with diclofop at 0.5 lb/A plus barban at 0.38 lb/A, but control dropped to 40% when 0.25 lb/A of diclofop was combined with 0.25 lb/A of barban. Yields reflected the reduction in wild oat from the herbicide applications and were significantly greater than the control in all wheat varieties with 6 of the 12 treatments.

In another trial 13 spring wheat varieties were evaluated for their tolerance to ACA 222,293 at 0.75 and 1.5 lb/A. Slight phytotoxicity was observed only on Modoc and TL 409 varieties at an early evaluation made in mid-June. However, the plants had outgrown the symptoms of stunting by the time a second evaluation was made in late July. Wheat yields were not significantly reduced from AC 222,293 at either rate of application.

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[1]University of California Cooperative Extension, Davis, CA.

CONTROL OF ANNUAL GRASSES IN ONIONS WITH FLUAZIFOP-BUTYL

S. D. Watkins & M. R. Hargrave[1]

Abstract: Annual grasses are often a severe problem in onions (*Allium cepa* L.) causing increased production expenses and reduced crop yields. Trials

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[1]ICI Americas Inc., Yuma, AZ and Visalia, CA.

were established in California and Arizona to determine the effectiveness of fluazifop-butyl, butyl (RS)-2(4-((5-(trifluoromethyl)-2-pyridinyl)oxy) phenoxy)propanoate, for control of volunteer wheat (*Triticum aestivum* L.), littleseed canarygrass (*Phalaris minor* Retz.), rabbitfootgrass (*Polypogon monspeliensis* (L.) Desf.), wild oat (*Avena fatua* L.), barnyardgrass (*Echinochloa crus-galli* (L.) Beauv.) and yellow foxtail (*Setaria lutescens* (Weigel) Hubb.) in onions. Postemergence applications of 0.28 kg/ha and 0.42 kg/ha consistently provided excellent seasonal control of all species excepting yellow foxtail which was well controlled with 0.56 kg/ha. Single applications of fluazifop-butyl were generally equivalent to two applications of the same total dose. No injury to onions was observed from any chemical treatment. Yields from plots trated with fluazifop-butyl were equal or superior to yields from untreated check plots.

Introduction

Annual grasses are often a severe problem in seedling onions due to the poor competitiveness of the crop and limited herbicide options. The cultural practice of planting several rows of onions on top of a flat bed, while improving crop competition also makes mechanical cultivation difficult and only marginally effective. In such cases, growers may spend a significant portion of their crop budget for hand weeding which may be required 1-3 times.

Field research conducted within ICI Americas Inc. and by university and extension researchers, have demonstrated the efficacy of fluazifop-butyl in controlling many annual grasses in onions while maintaining a wide margin of crop safety. The objectives of the studies reported herein were to determine the minimum effective use rate for six species of annual grass, evaluate the comparative effectiveness of single versus sequential applications and determine the effect on onion yield following broadcast foliar application of fluazifop-butyl.

Materials and Methods

Field epxeriments were conducted during 1982 and 1983 with grower-cooperators in Yuma County, Arizona and in the California counties of Imperial, Kern and Fresno. Cultural practices considered normal for the area preceeded the initiation of each study. Soil textures ranged from sandy loam to clay (pH 7.7 - 8.4) and contained 0.6 - 1.1 percent organic matter.

Fields were planted from September to December with the cultivars 'Southport White Globe', 'Basic White Dehydrator 613', 'White Creole', 'Collosal', 'Ringer Grano', and 'Granex 502'. Experiments were established 33 to 175 days after planting in onion fields moderately to severely infested with annual grass. Generally, initial treatments were administered to littleseed canarygrass and yellow foxtail 5-15 cm in height, rabbitfootgrass and wild oat 8-25 cm in height. Applications on grass in more advanced stages of growth occurred in selected studies.

Herbicide treatments were applied broadcast over-the-top at 220-355 l/ha with a tractor-mounted compressed air sprayer utilizing flat fan nozzles (Teejet 8003 - 8004) attached to a four-row boom. All herbicide treatments were conducted with 4 lb ai/gallon emulsifiable concentrate formulation and included a crop oil concentrate at 2.34 l/ha or 1% v/v. Plot size was 4m by 15m and all treatments were replicated four times in a randomized complete block design.

Single treatments of fluazifop-butyl were administered at 0.28 to 1.12 kg/ha and in certain studies, compared to split applications totaling 0.48 to 2.24 kg/ha. The second application of sequential treatments was applied to designated plots 2-6 weeks following the first application. Weed control was visually estimated once or twice after application. Ratings were based on a scale of 0 = no injury and 100 = complete kill. Dry bulb onion yields were determined in selected studies by hand harvesting a center portion of each plot. Analyses of variance were conducted on all efficacy and yield data. Duncans Multiple Range Test was used to determine significant differences among treatment means at the 0.05 level of probability.

Results and Discussion

Studies conducted at Brawley and Calipatria, California against littleseed canarygrass compared single and sequential applications of fluazifop-butyl, Table 1. Results from Brawley indicated that single applications of 0.42, 0.56 and 1.12 kg/ha provided excellent seasonal control 17 weeks after treatment with no advantage offered by split applications or by rates greater than 0.42 kg/ha. Yield data from all chemical treatments were statistically equivalent and were significantly greater than those from untreated plots. A similar trial at Calipatria compared single applications of 0.28, 0.42, 0.56 and 1.12 kg/ha with two applications of these same rates. Excellent grass control was achieved by all rates 12 weeks after treatment. No significant increase in grass control was observed with rates greater than 0.42 kg/ha nor with two applications of any rate. Yield data from this moderately infested trial site were not significantly increased by chemical treatment.

Table 1. Effectiveness of Single vs. Sequential Treatments of Fluazifop-butyl on Canarygrass Control and Onion Yield.

		Percent Control at Weeks After First Treatment and Yield for Location Shown					
		Brawley, CA			Calipatria, CA		
Treatment[a]	Rate[b] kg/ha	5-6	17	kg/plot[c]	3	12	kg/plot
Fluazifop-butyl	0.28				80	95	362
Fluazifop-butyl	0.42	96	100	249a	81	99	375
Fluazifop-butyl	0.56	98	100	270a	82	98	359
Fluazifop-butyl	1.12	98	100	246a	90	100	357
Fluazifop-butyl	0.28 + 0.28				89	100	345
Fluazifop-butyl	0.42 + 0.42	96	100	236a	89	100	392
Fluazifop-butyl	0.56 + 0.56	98	100	252a	89	100	340
Fluazifop-butyl	1.12 + 1.12	100	100	249a	94	100	364
Untreated		0	0	91b	0	0	367
LSD (0.05)		3.6		62.7	5.4	3.7	NS

[a]Sequential treatments applied 22 and 17 days apart at Brawley and Calipatria, respectively.

[b]Crop oil concentrate added to all fluazifop-butyl treatments at 2.34 l/ha.

[c]Means followed by the same letter are not significantly different at the 0.05 level of probability as determined by Duncan's Multiple Range Test.

A field study conducted against barnyardgrass in the San Joaquin Valley of California compared single applications of 0.28, 0.42, 0.56, 0.84 and 1.12 kg/ha with two applications each of 0.28, 0.42, and 0.56 kg/ha, Table 2. Initial treatments were applied when barnyardgrass was in the 3-5 leaf stage of growth with sequential treatments applied 14 days later. Barnyardgrass was well controlled 39 days after first treatment by single applications of 0.42 kg/ha and greater. Significantly less control was achieved with 0.28 kg/ha. Yield data were highly variable in this trial, hence, no significant differences were observed due to chemical treatment.

Table 2. Effectiveness of Single vs. Sequential Treatments of Fluazifop-butyl on Barnyardgrass Control and Onion Yield - Wasco, CA.

Treatment[a]	Rate[b] kg/ha	Percent[c] Control	Yield kg/plot
Fluazifop-butyl	0.28	74	228
Fluazifop-butyl	0.42	100	244
Fluazifop-butyl	0.56	99	289
Fluazifop-butyl	0.84	100	240
Fluazifop-butyl	1.12	100	248
Fluazifop-butyl	0.28 + 0.28	100	258
Fluazifop-butyl	0.42 + 0.42	100	271
Fluazifop-butyl	0.56 + 0.56	100	279
Untreated		0	186
LSD (0.05)		9.9	NS

[a]Sequential treatments applied 14 days apart.

[b]Crop oil concentrate added to all fluazifop-butyl treatments at 2.34 l/ha.

[c]Control evaluated 39 days after treatment 1, 25 days after treatment 2.

Table 3 indicates that yellow foxtail in the 3-5 leaf stage of growth proved more difficult to control, requiring an initial minimum of 0.56 kg/ha to achieve acceptable control. A single application of 0.84 kg/ha provided significantly better yellow foxtail control than did split applications of the same total dosage applied 14 days apart.

Two studies examined the effectiveness of fluazifop-butyl against rabbitfootgrass, Table 4. The Brawley, California study compared single applications of 0.42, 0.56 and 1.12 kg/ha with two applications each of 0.42 and 0.56 kg/ha applied to seedling grass 3-10 cm in height with a retreatment interval of 22 days. These data indicated that excellent control of small rabbitfootgrass could be obtained with single applications as low as 0.42 kg/ha. A similar study at Five Points, California compared

Table 3. Effectiveness of Single vs. Sequential Treatments of Fluazifop-butyl on Yellow Foxtail Control - Wasco, CA.

Treatment[a]	Rate[b] kg/ha	Percent[c] Control
Fluazifop-butyl	0.42	69
Fluazifop-butyl	0.56	86
Fluazifop-butyl	0.84	91
Fluazifop-butyl	1.12	97
Fluazifop-butyl	0.42 + 0.42	79
Fluazifop-butyl	0.56 + 0.56	99
Untreated		0
LSD (0.05)		12.4

[a]Sequential treatments applied 14 days apart.

[b]Crop oil concentrate added to all fluazifop-butyl treatments at 2.34 l/ha.

[c]Control evaluated 39 days after treatment 1, 25 days after treatment 2.

Table 4. Effectiveness of Single vs. Sequential Treatments of Fluazifop-butyl on Rabbitfootgrass Control in Onion.

		Percent Control at Weeks After First Treatment for Location Shown			
		Brawley, CA		Five Points, CA	
Treatment[a]	Rate[b] kg/ha	2	5-6	3-4	7-8
Fluazifop-butyl	0.42	84	100	70	88
Fluazifop-butyl	0.56	86	100	76	90
Fluazifop-butyl	0.84			83	93
Fluazifop-butyl	1.12	94	100	89	94
Fluazifop-butyl	0.42 + 0.42		100		98
Fluazifop-butyl	0.56 + 0.56		100		100
Untreated		0	0	0	0
LSD (0.05)		2.8		9.9	5.8

[a]Sequential treatments applied 22 and 24 days apart at Brawley and Five Points, respectively.

[b]Crop oil concentrate added to all fluazifop-butyl treatments at 2.34 l/ha.

single and sequential applications of fluazifop-butyl against larger rabbitfootgrass. At the time of the initial treatment, grass was 15-30 cm in height and flowering. Sequential treatments were applied 24 days after the first treatment. Adequate control was obtained 7-8 weeks after treatment from all treatments with higher rates providing greater control. Under the conditions of this study, split applications of 0.56 + 0.56 kg/ha provided significantly greater control than the same total dosage applied in a single application.

A field experiment near El Centro, California compared single applications of fluazifop-butyl at rates of 0.28, 0.42 and 0.56 kg/ha against wild oat ranging from seedling to boot stages of growth, Table 5. Excellent control was achieved 4 weeks after treatment from all rates with significantly greater control at 0.42 and 0.56 kg/ha. Seedling wheat near Yuma, Arizona was treated with single applications of fluazifop-butyl at rates of 0.28, 0.42, 0.56 and 1.12 kg/ha. All rates provided complete kill of the wheat 4 weeks after treatment.

Results suggest that a single postemergence application of fluazifop-butyl at 0.28 to 0.42 kg/ha will provide acceptable control of littleseed canarygrass, barnyardgrass, rabbitfootgrass, wild oat and wheat in onion. Seedling yellow foxtail may be well controlled with a single application of fluazifop-butyl at 0.56 kg/ha. These studies have demonstrated the excellent crop safety of fluazifop-butyl to onion. Onion yields in treated plots were equal or superior to untreated plots.

Table 5. Effectiveness of Fluazifop-butyl on Wild Oat and Volunteer Wheat Control in Onions - El Centro, CA; Yuma, AZ.

		Percent Control at Weeks After Treatment			
		Wild Oat		Wheat	
Treatment	Rate[a] kg/ha	2	4	2	4
Fluazifop-butyl	0.28	74	95	89	100
Fluazifop-butyl	0.42	84	99	95	100
Fluazifop-butyl	0.56	90	99	96	100
Fluazifop-butyl	1.12			100	100
Untreated		0	0	0	0
LSD (0.05)		8.8	3.0	3.3	

[a]Crop oil concentrate added to all fluazifop-butyl treatment at 1% v/v.

EDUCATION AND REGULATORY SECTION

Gus Foster, Moderator[1]

The Education and Regulatory Section of the Western Society of Weed Science considered two themes: Education of a Concerned Grower/Landowner and Education of a Concerned Public.

Under the Education of a Concerned Grower/Landowner three subjects were presented. "PIK and Weed Control: The Aftermath" was developed as a group discussion. Major questions raised from the discussion were: (1) should the WSWS and other ag related organizations put pressure on Congress to think practically and technically about the consequences of such programs as PIK; and (2) should the grower have the responsibility to use some money received from PIK government programs for weed control practices on set-aside acres. Robert Parsons, Supervisor - Park County Weed and Pest Control District, Powell, Wyoming discussed weed quarantine as a tool to promote weed control. An overview of Montana's noxious weed awareness program was presented by Celestine Lacy, a graduate student at Montana State University, Bozeman, Montana.

Two subjects were the focus of the Education of a Concerned Public. Herbicide Hullabaloo was the topic addressed by Dr. W. R. Mullison - consultant to Dow Chemical, Midland, Michigan. Pam Crocker-Davis of the National Audubon Society, Olympia, Washington, presented an overview of a citizen's perspective toward pesticide use in the environment.

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[1]Velsicol Chemical Corp., Fort Collins, CO.

WEED QUARANTINE ENFORCEMENT: ANOTHER TOOL TO PROMOTE WEED CONTROL

Robert R. Parsons[1]

On behalf of the Park County Weed and Pest Control District Board of Directors and myself, I want to thank you for the opportunity to be here today. I hope that by the conclusion of my talk that some of you who work in the enforcement end of weed control might consider adding a type of quarantine or inspection policy to your arsenal of weed controlling tools. We have used some type of enforcement program in Park County off and on for thirty years and are relatively satisified with the results.

To explain why the Wyoming State Legislature would be willing to give the power of a quarantine to Wyoming weed and pest control districts, a brief explanation of a weed quarantine is in order. "Quarantine", as used

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[1]Supervisor, Park County Weed and Pest Control District, Powell, WY.

in the Weed and Pest Act of 1973, is interchangeable with the words "enforcement or inspection". Although there are four types of quarantines defined in Wyoming statutes, they all basically allow for: inspection for contamination, control of movement of infested farm products, enforcement of the law, and penalties for violations. They do not authorize the weed and pest districts to destroy any crop or farm product, although that is an option the owner may take if found guilty of having infested farm products. I want to eliminate the concept of border guards or inspectors with guns on their hips. Basically, we're just a public relations agency with a little legal aid to help promote good weed control practices within our districts.

In order to best explain how we make the quarantine work in Park County, I need to give you a couple of history lessons. The first is a little background on Park County and why a quarantine works in that county as far as the topography, and also a short history on the Wyoming weed and pest districts and the Weed and Pest Act which gives us the authority to implement a quarantine. Park County is located in the northwestern part of Wyoming. It is bordered on the west by Yellowstone National Park, on the north by Montana and on the south and east by Big Horn, Hot Springs, and Washakie counties. Over fifty percent of Park County's 3,350,000 acres belongs to Shoshone National Forest. Along with the BLM and other federal lands, over seventy-two percent of Park County is owned by the federal government. Of the slightly more than one million acres of private land, only about 100,000 acres are irrigated and most of that by flood irrigation. The main cultivated crops are: malting barley, sugar beets, corn, dried beans, alfalfa and other forage crops.

It is in this farm ground that the majority of our noxious weed problems have developed. The infestation has increased over a period of time and is more noticeable in the earlier homesteaded areas than it is in areas which weren't settled until after World War II. Most of our farmers are either first or very young second generation farmers who are usually a little more progressive and more apt to utilize modern farming practices. This background provides Park County with the groundwork to pursue effective quarantine.

Weed and pest districts have existed in Wyoming since as early as 1936. In most cases these districts were not county-wide and were designed simply to serve the local need. In 1973, the state legislature passed a law requiring that all counties have a weed and pest district for the purpose of controlling certain designated noxious weeds and pests. These districts are county-wide and are governed by a five or seven man board appointed by the county commissioners. They may operate on a levy up to one mill of the accessed evaluation of the county, with an additional one mill available for leafy spurge control. The board is responsible for developing an effective weed and pest control program which can include treatment with chemicals or other types of control, the sale of pesticides, and the use of enforcement procedures when necessary. This law, with amendments made in 1979, is the basis for our present weed and pest program in Park County.

There are four types of quarantines authorized by Wyoming statutes. They are: the individual quarantine -- which brings actions against a single individual or farm unit that is spreading weeds or pests to the detriment of others; the section or state quarantine -- which is initiated to prevent the spread of infested farm products or equipment from a given area; the district-wide quarantine -- which prevents the movement of infested farm products into, within, or out of a county and the importation quarantine -- which is initiated by a county or counties to prevent the introduction of weeds, diseases, or pests which could become a problem within the state. The types of quarantines that Park County uses are the individual and district-wide.

Although the district-wide quarantine can be implemented in three different methods, we chose to hold a public meeting to insure that the direct input of the landowners affected by a quarantine could be discussed. Based on the input from the public attending the hearing (which was overwhelmingly in favor of a district-wide quarantine) we developed a law that basically makes it unlawful for any individual to move a farm product off of the farm on which it was grown without a prior inspection and release from the supervisor or his deputies. Exempt from the law are all livestock, livestock feed, and farm products that are grown and fed back on the same land. Although it has not been necessary to initiate legal action under this type of quarantine, it is an invaluable tool to our over-all weed program and aids in the success of the individual quarantine.

The individual quarantine has many advantages over the district-wide quarantine. Included are the facts that it can be used to require control on all crop land, range land, non-agricultural lands, subdivisions, interstate and intrastate transporters and even urban areas. Enforcement of the individual quarantine is also easier since violation can result in a fine of $50.00 per day to a maximum of $2,500.00, as compared to a maximum of $100.00 for violation of the district-wide quarantine. The individual quarantine is our most used tool and deserves a more detailed examination.

Wyoming statutes 11-5-109 states: "Whenever the district board has probable cause to believe that there exists land infested by weeds or pests which are liable to spread and contribute to the injury or detriment of others, it shall make . . . an investigation of the suspected premises through the use of lawful entry procedures." "If the suspected area is found to be infested, the district board, by resolution adopted by two-thirds of its members, shall confirm such fact." "The district board may set forth minimum remedial requirements for control of the infested area." "The district board shall deliver, . . . 1) a copy of the resolution, 2) a statement of the costs of fulfilling requirements and 3) a request that the requirements contained in the resolution be carried out at the owner's expense within a designated period of time or on a cooperative basis." "At the request of the landowner the district board shall hold a hearing in accordance with the Wyoming Administrative Procedures Act."

To anyone knowledgeable of the Wyoming Weed and Pest Act, this section of the law is lengthy and well spelled out compared to other parts of the act. It was designed to protect the rights of the individual at all times and to insure that the weed and pest board does not overstep their authority. Even the penalty and fine are described in detail stating: "A landowner who is responsible for an infestation and fails or refuses to perform the remedial requirements for the control of the weed or pest . . . may be fined no more than $50.00 per day for each day of violation and not more than $2,500.00 per year as determined by the court." "Any person under this act is entitled to a trial by jury."

With all this background, I'll try to tie it all together. In order to illustrate how we use our district-wide and our individual quarantines in conjunction with one another to promote better weed control in Park County, let's take a hypothetical situation of a farmer who is raising malting barley to be sold through one of the local elevators in town. Through visual observations during the spring, we see a weed problem developing. Someone from the district will visit the farmer in the early summer, discuss weed control, the Weed and Pest Act, the quarantines, and how they directly affect him. Most of the time this is the only action necessary to make the farmer aware of his weed problems and to convince him to take care of them before we have to take legal action. Should the farmer choose to ignore our suggestions or requests, we then consider our options. If we do not issue a release, the farmer cannot legally haul his crop to town as the elevators in Park County require that the individual have a weed release before they will accept this crop. If our hypothetical farmer should decide to use his barley for feed on his own place rather than control the weeds, we still have the option of using the individual quarantine if the district feels that these weeds will spread to other areas.

Based on past experience a typical individual quarantine action would take place as follows. First we would establish that the problem exists through a visual inspection taken from the county roads or other public access to insure that we do not violate the individual's rights by trespassing on his land. Then we would contact the landowner and/or renter to inform him that a problem exists. At this time we would issue what we call a "reminder-form", which is simply a written notice of the Weed and Pest Act, the Park County weed quarantine, and the fact that we believe the land is contaminated with weeds which could spread to the detriment of others. If no action is taken after a reasonable amount of time, we send a letter stating that the board is considering legal action. We also inform him of all of his rights and ask permission to go onto the land for the purpose of inspection. Unless the landowner specifically refuses us entry, this written notice is adequate to allow us to enter onto the land, otherwise, we have to try to obtain a search warrant. If the landowner still chooses to take no action, we then have a lawyer draw up a resolution for the board to approve or reject. Should the board approve the resolution, we send a copy of it to the operator along with a statement of estimated costs for treatment. To date, in the three years we have been operating under this procedure, we have never taken the quarantine past this step. In all the cases where the board has passed a resolution requiring that these problem areas be controlled, minimal action has been taken by the landowner in the time period allowed. However, should the individual still ignore our requests, we then would turn all of the materials over to our attorney to instigate legal action through the courts.

We feel that we need both types of quarantines in Park County to aid in an effective noxious weed control program. We use the district-wide quarantine as a public relations tool; and the inspection of every farm and ranch in Park County each year helps insure that we are on a first-name basis with the growers in Park County. This often eliminates us having to implement individual quarantines against many of the farmers and ranchers who are planning to harvest and sell a crop. If we do instigate an individual quarantine against someone, we can point out that we are attempting to control the noxious weeds on all facets of the county through the district-wide quarantine. It must be pointed out that whether we are considering an individual quarantine or enforcing the district-wide quarantine, that we use public relations and reason as much as possible, and fall back on legal action by the board or courts only as a last resort.

Believe it or not, the quarantine in Park County is relatively popular. Most farmers and ranchers feel that it not only requires that their neighbors control their weeds, but also it motivates everyone to do a better job of noxious weed control. Another reason for the popularity or acceptance of the quarantine, I feel, is because of the way that we enforce it by using it more as a tool or a motivator rather than an attempt to "strong arm" the individual. We remind the farmers and ranchers that they requested the quarantine and we are only trying to do what they asked. It is also a matter of public record that at the public hearing there were no negative comments against implementing a district-wide quarantine.

The advantages of a quarantine, whether it be district-wide or individual include: preventing or reducing the spread of noxious weeds, either from outside sources or from within the district; it reduces the chance of new infestations of non-designated weeds by restricting the movement of infested farm products; it cleans up weeds within the district by requiring that large infestations be controlled and eventually reduced to a non-problem size; it gives more purpose to the weed and pest district; and it forces a one-to-one contact between the weed and pest district and the landowner. This contact gives the district the opportunity to sell the weed and pest program and the advantages of weed control. Many times the discussions will be outside the realm of noxious weed and pest control, but this still helps to promote the program.

There are a few disadvantages to the quarantine, although I don't feel that these are in any way major ones nor do any outweigh the advantages. Some of the disadvantages are: it costs the district more money -- usually they have to hire additional people to do the inspections and the legal costs could also incrase, it is sometimes difficult to enforce a district-wide quarantine equally in different areas within the county -- in some areas the weed problem may have become so immense before the quarantine was implemented that requiring a 99 percent control of noxious weeds could break the landowner, the use of the district-wide and the individual quarantines require more time -- since the members of the district board are not paid it is important that the county commissioners appoint devoted individuals, and it must also be kept in mind that the quarantine is not popular with everyone -- especially individuals from outside the district who are trying to sell "infested" farm products into the country or individuals within the county who are not convinced that noxious weeds are hurting their overall crop yields.

To summarize, I want to insure you that I do not feel that a district-wide or even the intensive use of individual quarantines are going to be successful in all areas. One of the reasons why they have been successful in Park County is because we have a large amount of the private-owned land operated by farmers who are growing row crops for which there are pesticides and other farming practices that can help them control the noxious weeds. I do not feel that a district-wide quarantine would be of much benefit in an area that is used largely for livestock production. However, I would recommend that any counties that do have a large farming population and a serious noxious weed problem strongly consider the implementation of some type of an inspection and release system whether it be called a quarantine or any other name.

I hope that through this presentation I have answered a few questions, raised a few concerns, and promoted a lot of thinking. I hope that you will consider that I have tried to condense seven years of experience into a twenty minute talk, and that you realize that any oversight in the long and difficult enforcement process of quarantines was not intentional. Irregardless, the quarantine should only be considered as an additional "tool" in our neverending battle to control noxious weeds, much as a can of herbicide and a spray rig are considered "tools" of the trade.

MONTANA'S WEED AWARENESS PROGRAM

C. Lacey and P. K. Fay[1]

Introduction

There are over 63 million acres of rangeland in Montana. Although this land is a valuable resource, the economic return per acre is relatively low. Thus when weeds invade a range site, many landowners are reluctant to use control methods because the return on their investment may not be immediately apparent. As a result, several weed species have become a major threat to the productivity of range and pastureland in Montana.

Leafy spurge (*Euphorbia esula* L.) and spotted knapweed (*Centaurea maculosa*) are the two most serious range weed problems in Montana. Leafy spurge currently infests over 545,000 acres of rangeland in the state. This weed spreads both by seeds and vegetative buds, and once established, is very difficult and expensive to control. Herbicide costs to control leafy spurge can exceed $100.00 per acre and retreatments are usually necessary.

Spotted knapweed occupies over 2 million acres of rangeland in Montana. Although infestations are most severe in the western half of the state, spotted knapweed has been reported in every county. This weed can reduce forage production by as much as 95 percent and can spread rapidly because of an inhibitor effect on other plant species.

The key to controlling noxious range weeds is early detection and treatment. Therefore, in 1983 the Plant and Soil Science Department at Montana State University initiated a leafy spurge and spotted knapweed public awareness program.

The purpose of this paper is to review Montana's Extension effort on the two weeds in 1983. Hopefully, our experiences contain some ideas that will help you fight weeds in other states.

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[1]Plant and Soil Science Dept., Montana State University, Bozeman, MT.

Approach

The objectives of the program were to continue the leafy spurge effort started in 1980 and initiate an effort on spotted knapweed. Three specific goals were outlined for the program: 1) To increase public awareness of leafy spurge and spotted knapweed; 2) Disseminate current information on their biology and control; and 3) Evaluate the effectiveness of the program.

To meet these goals, several techniques were utilized:

Newsletter: A Leafy Spurge Newsletter, initiated in 1980, increased awareness, coordinated research, and provided information to people interested in leafy spurge control. Because of its success, we continued publishing it as a quarterly newsletter, and also initiated a newsletter on spotted knapweed in 1983. It is called "Knapweed Update" and includes information from researchers in California, Oregon, Washington, Idaho, Montana, British Columbia and Alberta. Current research programs and research results on both chemical and biological control of spotted and diffuse knapweed (Centaurea diffusa), will be reported. Over 2,000 people are currently on the mailing list for both newsletters which encompasses 17 states and 4 countries.

Bumper Stickers, Road Signs, and Posters: Bumper stickers with the slogans "Knockout Knapweed" and "Purge Spurge" were developed to distribute at tours, meetings, and county fairs. They were popular with the youth and adults, and were an effective tool to increase public awareness of these weeds.

Road Signs: Several years ago, the Canadian government designed a very attractive road sign to increase public awareness of spotted and diffuse knapweed. Eight of these signs were erected along Canadian highways at a cost of $8,000.00 each. Although this idea was considered as a possible awareness tool for Montana, it was rejected because of the high cost.

A more feasible approach in Montana would be to involve the Forest Service, Bureau of Land Management or other government agencies. Many of these agencies have sign making facilities and could construct road and trail signs to increase awareness of weeds on their land.

Posters: Posters on spotted knapweed have been effectively used in Canada as a weed education tool. These posters can be displayed in government offices, National Parks, and feed and chemical stores. This idea was recently used by the Lewis and Clark Conservation District in Montana in developing "wanted posters" for spotted knapweed.

Herbicide Demonstration Plots: We established leafy spurge and spotted knapweed herbicide plots in a total of 22 counties in June, 1983. Their purpose was to involve landowners in the evaluation of various kinds and rates of herbicides on control of these two weeds. All plots were easily accessible, large enough to show visible differences between treatments (minimum size should be 20 by 80 feet per treatment), and located near population centers when possible. The plots were established through a cooperative effort between Montana State University, Cooperative Extension Service, Soil Conservation Service, Chemical Companies, and Weed Districts. Some of the plots were used for educational tours in 1983, and others will be used for 1984 tours.

Field Tours: Over 745 people attended 14 field tours held during the summer of 1983. County agents, weed district supervisors, and Soil Conservation Service personnel helped organize and support the tours. The eudcational programs emphasized: an update and facts on biological control; leafy spurge control with sheep; the importance of treating small infestations (economics and eradication); and herbicide efficacy. Spray check demonstrations, where landowners were shown how to calibrate spray equipment; county weed equipment and the latest innovations in herbicide applicators for All Terrain Vehicles were also displayed at the tours. Dow Chemical Company sponsored picnic dinners and provided door prizes to people attending most of the tours.

Our experience indicates that several factors influence the attendance and successfulness of a weed tour:

*Attendance was greatest in areas where previous programs had been conducted.

*Attendance was greatest at tours that were well advertized. Radio tapes, news articles, and flyers should be sent to counties ten days in advance of the tours.

*Attendance was greatest at late afternoon and evening tours, and lowest at morning sessions. The date of the tour must not conflict with planting or harvesting seasons.

*Tour sites should be easily accessible and located near population centers.

Public Service Announcements: Three public service announcements (PSA's) were produced by the Cooperative Extension Service on spotted knapweed. Their purpose was to increase the awareness among the general public that the weed was a serious problem in Montana. One theme focused on the threat of knapweed to wildlife, the other two focused on the threat to recreation and livestock. Each of the major television stations in the state aired the videotapes. The PSA's were made by MSU's Film and Television Center for $2,000.00. They appeared to be very effective in increasing public awareness of spotted knapweed.

Weed Calendar: A weed calendar was designed for farmers and ranchers in Gallatin County. The purpose of the calendar was to help producers with selecting proper herbicides and timing herbicide applications on noxious weeds. Each month of the calendar features a specific weed with the recommended herbicides and time of application. The proper growth stage of the weed for herbicide treatments is featured within a bold square. The initial response to the calendar has been very favorable, and we hope to expand its use statewide.

Consulting Service: A free consulting service is being offered to landowners who have a serious spotted knapweed or leafy spurge problem. The purpose of the consultation service is to offer personal help in developing specific control programs with the landowners. Although the program has been successful with several ranchers, there are some problems. First, Montana is a large state and my travel to many areas is restricted because of time. Second, many of the landowners who have a problem are reluctant to request assistance. It seems that most of our requests to visit a ranch comes from the "good managers" who are proud of their program. I'm not sure how we can get our services to the managers who really need them.

Ranson Program: In this program, youth would be paid for locating and reporting new infestations of leafy spurge and spotted knapweed to their county extension agent or weed supervisor. By rewarding the youth with a small amount of money, the weed ransom program would increase awareness of weeds among youth groups and help map county weed infestations. Although the idea is excellent, most counties are reluctant to adopt it because of lack of finances.

Integrated Approach: Our extension program is utilizing an integrated approch to address the weed problem in Montana. This involves close cooperation between all the entities (including research scientists, chemical companies and county, state and federal agencies) that are involved with weed control or extension activities in the state. Through this cooperative planning, a statewide weed control effort is being established.

The Montana State Weed Fair is an example of this cooperative effort. Over 500 people attended the 1983 fair held in Columbus, Montana. The expertise, hard work, and funding for the event was provided by researchers and Extension personnel from Montana State University, USDA-SEA, the Montana Weed Association, DNRC, agricultural businesses, and chemical company representatives.

Much of the weed fair's success has to be attributed to the county agricultural agent. He did a tremendous job of advertising the fair and getting the local people involved. The fair included tours for youth, spouses, ranchers, farmers, weed supervisors, and legislators. Highlights of the tours included control methods for several noxious weeds; range improvement demonstration plots; sagebrush control with herbicides, fire, and mechanical treatments; and establishment of a grass nursery. A barbeque, dance and crowning of "King Thistle" and "Miss Morning Glory" followed the tours. Because of the positive response of the participants, I feel that the attendance would be much greater if the fair had been scheduled for the same county in 1984. However, in order to get more people involved, the state weed fair rotates to a new part of the state each year.

Conclusion

In conclusion, I would like to stress that the mission of any education program is to transfer technology developed by researchers to the producers. This involves utilizing mass media techniques such as radio and television; field tours and demonstration plots on a county level; newsletters to coordinate region-wide programs; and innovative ideas such as a ransom program and weed calendar. These activities must be integrated with researchers and county, state, and federal entities to enhance the overall effectivess of the program.

THE PESTICIDE CONTROVERSY - A CITIZEN'S PERSPECTIVE

Pam Crocker-Davis[1]

The pesticide controversy in this country has a long and, like some of the chemicals in question, volatile history. It is not going to go away. Sometimes it seems as if the only points of agreement in the discussions surrounding pesticide use come when all of the people involved agree that everyone else is a complete idiot or completely ignorant of the facts! That being the case, I hope you can appreciate that it was with some hesitation that I agreed to speak here today. I am here because there is an unfortunate 'them' and 'us' mentality growing in this country around the issue of pesticides. Because I find that mentality both dangerous and unnecessary, I feel it is imperitive that all of us take every opportunity we have to speak with each other.

There is no 'them'; there is no 'us'. The range of opinions about pesticide use - both for it and against it is massive. The background and values of the people holding those opinions is equally varied. If you put 20 people concerned about the use of pesticides (pro and con) in a room and honestly talked to them, you would hear 15 different explanations of why they are concerned. There are certain common themes in the pesticide reform movement; but you will never understand that movement or be able to deal with it effectively unless you understand not only the common concerns; but the individual concerns of the people within it.

The specific concerns, backgrounds, personalities and economic status of citizens involved with urban pesticide issues will vary tremendously from those of citizens involved in forestry, utility right of way, roadway, and agricultural issues. A mother who is angry because there was no sign posted to tell her that the park flower bed her child was playing in had just been sprayed has concerns very different from those of a bee keeper who has just lost all of his hives to pesticide poisoning. Both of their concerns are different from those of rural residents in commercial forest areas whose water and food supplies are being contaminated by fertilizer and pesticide operations that refuse to release their site evaluation data and will not even grant citizens the common courtesy of pre-notification before spraying begins.

Whether you ever accept the common concerns of people involved in pesticide issues (and many of you will not) if you take the time to hear the specific situations that occurred to involve individuals in this issue, I think you will find many of their complaints are valid.

The greatest disservice being done today to people concerned with maintaining their right to use pesticides is not being done by people who oppose pesticide use. It is being done by people within the user industries themselves who are spending a great deal of time and money to give you an instant description of who we are. We are not Ecofreaks. We are not Communist Dope Dealers. Those images of us are no more accurate than images which portray you as macho weed cops and mindless nozzleheads. I used to laugh about these stereotypes; but it appers there are many people out there who not only believe these images but actively promote them. It is a situation which can only lead to increased harassment and hostility for all sides of the issue.

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[1]National Audubon Society, Olympia, WA.

A logger in Washington State once stated at a public hearing that anyone who opposed the use of pesticides was a "communist, a pervert, and a dope dealer." Well, the thing I object to most about being called a "communist, a pervert, and a dope dealer" is that I am actually a Republican, a Texan, and a bourbon drinker! I don't mind if you accuse me of bad habits; I just hope in the future, you will accuse me of bad habits I actually have! If you, as users of pesticides, have money to invest in resolving the pesticide controversy, please don't invest or support the investment of money that perpetuates this kind of misrepresentation. Put your money into creating opportunities for both sides (or all sides) of the issue to meet, get to know each other, and share their concerns and knowledge.

I mentioned that common threads of concern run through the pesticide reform movement - no matter how diverse specific personalities, situations, and issues may be. I'd like to briefly discuss three of these common threads today.

1. Citizens concerned about pesticides believe the regulatory system created to protect them from unsafe pesticides has failed.
2. Citizens concerned about pesticides do not believe, in many cases, that adequate health and efficacy information exists or is accessible to support current declarations of safety on the part of pesticide users.
3. Given the highly political nature of both the regulatory and scientific process surrounding pesticide use, citizens concerned about the use of pesticides believe the only positive resolution to the controversy lies in looking at new pest management strategies that will satisfy the management needs of pesticide users while reducing chemical usage and the risk of involuntary exposure. (I might add that citizens feel the institutional research structure in this country is heavily weighted against research on and implementation of these new pest management strategies.)

Citizens are frequently told that pesticides are safe to use because they have been registered with the EPA. The implication is that pesticides registered with the EPA have passed stringent health tests. I frequently work with industry and agency people who bemoan the fact that the public's perception of pesticide risks seems to have developed without a knowledge of the extensive safety testing required of pesticides. Actually, most citizens are well aware of the extent of testing required by law to register a pesticide. They are also painfully aware that those testing requirements are seldom, if ever, met. The simple fact is that the legally required pesticide registration process in this country has been an abysmal failure.

In 1972, the EPA was directed by Congress to register pesticides for use only after extensive tests had been done to determine that the pesticide was unlikely to cause unreasonable and adverse environmental effects such as cancer, mutations, birth defects, sterility, neurotoxicity, and a variety of other injuries. The EPA was also directed to review and re-register the over 35,000 pesticides already in use.

Unfortunately, the EPA had too little time, money, or trained staff. They took shortcuts. Because of the massive number of chemicals in question, they chose not to test the 35,000 or so commercial formulations. Rather, they planned to eventually test the 1400 active ingredients. This means EPA has never yet and has no future plans to test the actual preparation that people are exposed to - despite the well known fact that many chemicals can react with each other to create adverse or beneficial affects that a single chemical might not have.

To date, only a handful of active ingredients have been reviewed. Even before the recent budget and staff cuts at the EPA, the agency estimated it would take 30 years to adequately evaluate data on the 605 active ingredients considered most important.

There was, and is, seldom time to check the adequacy of data on old or new pesticides. The EPA can only check, in many cases, to see if the data exists at all. Frequently the agency is provided only with abstracts or summaries of test results. They are unable to compare this with the raw data. This can be significant; because in re-evaluating data from labs suspected of poor test practices or deliberate falsification of data, the abstracts and the raw data do not match. In one test conducted by Industrial Biotest Laboratories, the summary indicated the test animals lacked eye pigmentation. When the summary was compared to the original data it was found that the rats did indeed lack eye pigmentation. They also lacked any eyes at all! The difference between lack of eye pigmentation and the lack of any eyes at all could be significant when evaluating the relative safety of a chemical.

That example is not an unusual one picked out for its shock value. The Industrial Biotest scandal is a well known one. We are told the problems with Industrial Biotest are not typical - that it is an isolated incident. Even if that was true (and it is not), the implications of IBT's 4000 or so flawed or falsified tests are massive. The tests by IBT were used to register 202 pesticides. The reality is that IBT is not an isolated incident. Audits conducted by the EPA/FDA from 1977 to 1980 show that 25 of 82 labs had serious deficiencies in the tests they ran for the registration of various pesticides. Twenty-two more labs could not be audited at all because they had not kept the original data. The reported deficiencies ranged from destruction of original data, to under-reporting of tumors and other adverse affects, improper record keeping, and substandard laboratory and testing procedures. Several of these labs are now faced with criminal prosecution. Irrigularities in studies done on methylene chloride have led the FDA to recommend that all FDA/EPA registration tests conducted by Gulf Southlabs be thoroughly audited.

Facts such as these do little to support the arguement that a pesticide is safe because it has been registered with the EPA. The EPA itself stated in 1980 that "the implication that adherence to label restrictions eliminates all threat to human health is not warranted." They also admit that the stark truth is fewer than 5% of the pesticides on the market today have been adequately tested or even had all of the legally required tests completed.

Public cynicism as to the safety or registered pesticides is further heightened by the refusal of industry to release pertinent health and environmental data on the grounds that information is a trade secret.

FIFRA mandated in 1978 that health and safety data be made public. Chemical companies have been in court ever since to block enactment of that requirement. Despite chemical company concern over the security of their actual product formulation, there is no valid economic reason for the suppression of health and safety data. If any of you here today are sincerely interested in finding points in the pesticide controversy where different factions can work together, consider working with us on the full disclosure of health and environmental data. Until that disclosure is achieved, the legacy of public distrust which has been created by improper past practices and regulatory failures cannot be undone. If that legacy is not broken - broken by access to facts and adequate regulations, rather than slick media campaigns and Madison Avenue half truths, we all run very high risks. Unsafe pesticides will remain in use. The controversy will continue. And pesticides which might be safe and useful management tools will die a slow death of guilt by association.

The regulatory debate over pesticides will continue for years. So will the technical and scientific debate. I prefaced this talk by saying if you took 20 people concerned about pesticides and locked them in a room that you would get 15 different reasons why they were concerned. Well, if you took 20 leading cancer researchers and locked them in a room you would probably get 25 different explanations of the mechanisms of carcinogenicity. Despite all the technical breakthroughs and advances in medicine in the last 15 years, our knowledge of biological systems, what makes them function and malfunction, is still very incomplete. Cancers and birth defects, while often enormously difficult to prove why they occur, are at least obvious to detect in lab animals. How does a researcher detect the more subtle; but in some ways equally disastrous effects of chemicals in terms of neurological, immunological, and behavioral disorders? How do you get a rat or a hamster to tell you he has headache, blurred vision, nervous dysfunctions or learning disabilities? Epidemiology, the study of human populations, is perhaps the most imprecise scientific field of all -- if only because humans are notoriously uncooperative about limiting and documenting the many factors than can daily affect their health.

The point is simply this. Beyond the obvious regulatory problems which exist, the scientific data we have to base our human health decisions on is not clear cut; engineering may contain absolutes; but toxicology, genetics and epidemiology do not. Huge gaps exist in our knowledge of many widely used pesticides and in our knowledge of how to set about testing them. How do we, and we must, find the time and money to test for the synergistic effects that often occur when several chemicals interact in a single commercial formulation? How do we assure, when we have not yet even made a dent in testing of primary chemicals, that their breakdown products will be tested and particularly when evidence suggests some of the breakdown products can be as great a problem to health and the environment as the primary chemical? Of the approximately 150 chemicals used as herbicides worldwide, complete metabolic pathways are known for only 3 or 4. Metabolic degradation of the remaining compounds is known only in part.

The debate on the adequacy of existing regulations and efficacy, environmental and health data is long standing, ongoing, and complex. The process of determining risks and degrees of risk is only further complicated by the intensely political arena in which the 'scientific' decisions must be made. We would be naive if we thought the debate would be resolved in our lifetimes. It is unfortunate that that debate is obscuring the fact that there is a growing number of people who are looking at and concerned about current chemical usage from a purely management standpoint. Even for chemicals that are considered safe, are they always the best way to go? I do not read about the problems applicators are having with outdated and ill-designed equipment in environmental journals. I read about that in Agrichemical and Agri-aviation journals. Concerns about drift, volatilization, soil deterioration, water contamination, and nontarget crop damage are not myths created by citizens; you document those problems yourself.

Despite a 10 fold increase in pesticide use over the last 30 years, annual crop losses to pests have remained constant. Any gain you made in controlling weeds is more than offset by a doubling of insect related losses. Even the gains made in chemical weed control may not be as permanent as we had hoped. Today, herbicide use represents 57% of America's pesticide market. As conservation tillage increases, so will that percent - even though our understanding of the long term implications of that use is incomplete. In the technical literature on weed control, there is growing documentation of herbicide resistance in some species and weed species displacement. Some herbicides produced changes in the crop plants that make the plants more susceptible to pathogens and pests. Both 2,4-D and picloram have been found to do this. Genetically manipulated plants often interact with pesticides, soils, and microflora in very different ways - and our ability to predict these new interactions is limited. All is not well in your chemically dependent industries.

The hullabaloo over health effects and the political and regulatory muddle surrounding pesticide use seem to be obscuring, for many of you, a very simple fact. If no citizen had ever raised their voice in protest over pesticides, if Rachel Carson had stuck to collecting seashells and never written Silent Spring, you would still, as users, researchers and applicators of pesticides, be facing a technological revolution in the places and the ways you apply chemicals. The day of the single action, quick-fix is over. It is the nature of technologies to change -- and the change should be positive. It would be a shame if the emotions of the pesticide controversy kept pest management (and I want to stress that it is pest management, not pesticides per se, that we should address) from evolving in a logical way.

If you accept that changes in the pest management industry are going to occur, perhaps you can accept the fact that they are not always bad and not always inflicted upon you by citified, bleeding heart bambi lovers! Many of the decisions modern pest managers are making today and will make in the future are being made because, quite simply, they work. These decisions are the same sort of decisions that pesticide reform activists have been pushing for years because of their concerns over health, jobs, and the environment. Why should we keep fighting on points where we come to the same conclusions simply because we came to that same conclusion for different reasons?

What are some of the aspects of pest management that we now or soon may agree upon? Well, in a nutshell (1) If it ain't broken, don't fix it. (2) If it is broken, prove it, and (3) If you plan to fix it, there is more than one way to go about it.

If it ain't broken, don't fix it simply means that spraying five times a year, whether you need it or not is out. We know that unnecessary chemical applications are being reduced - if only because the costs of pesticides are going up. But it is well documented that much unjustified (and I mean unjustified in the management sense) pesticide and fertilizer application is still going on in forest, agriculture, and urban pest control areas.

If it is broken, prove it means that site specific and documented evaluations of the need and success of spraying is going to be mandatory if citizens are ever going to accept chemical pest control. Those evaluations are going to be coupled with centralized record keeping and standardized notification systems. These points are not only logical because they keep pesticide reformers happy. From a management standpoint, they make good sense. You are in a much more defensible position if you can give proof that you have considered the need for pesticide applications at each site and that you are willing and able to inform citizens about your actions. Centralized record keeping on chemical use may seem like more bureaucracy; but you will never know if chemical use in a region is being conducted safely until you know what is being sprayed where and when.

If you plan to fix it, there is more than one way to go about it. Once you've determined there is a pest problem, don't assume going out and spraying it is the best solution. There is a broad and growing range of sophisticated control options which utilize new mechanical controls, biological control, and non-petrochemically based chemcical controls. You may say spray is the option of first choice, and I may say it is the option of last resort; but looking at a range of controls and a combination of several types of control still leaves a lot of room for positive discussion. Also, if spraying is not controlling a problem; don't keep on doing it. County weed boards that have been spraying the same stretch of road for years without reducing the weed problems are doing very little to aid public confidence in pesticides. If, after decades of chemical application you still have a problem, maybe you should look for a new control technique.

I'd like to repeat one of the statements I made earlier and I'd like to give you some tips on how you can deal with pesticide reformers. I hope the tips will enable you to work with us in a way that will be positive for everybody.

I cannot emphasize often enough that citizens concerned about the use of pesticides believe the federal regulatory system has failed. We believe there is ample evidence of past inadequancies and we believe the current reorganization of EPA has almost entirely negated its ability to regulate or evaluate pesticides. EPA employees have gone to Congress frequently over the last four years to declare that pesticide work at the EPA has all but been eliminated - that 'responsiveness to the needs of the Office of Pesticide Programs...is being...destroyed.' The loopholes in pesticide regulations that have always existed have grown larger under the Reagan Administration - and many new ones have appeared.

Recent investigations identified a 430% increase in emergency exemptions. Special Local Needs registrations for states have also increased dramatically. Both allow companies to market pesticides while avoiding rigorous health and environmental testing.

Congressional Reports say that a staggering 70-90% of pesticides have never been tested adequately to determine if they cause genetic mutations, sterility and reproductive effects, nerve damage or cancer. While no statutory weakening of FIFRA has occurred under Reagan, the EPA has made major administrative policy changes which severely weaken human and environmental protection. Congress found last year the EPA was 'ill prepared scientifically or otherwise to defend these policy decisions.' Statistical risk estimates given in recent decisions on benomyl, arsenic, and permethrin show that the agency is permitting cancer risks to the general population 100 times higher than in earlier decisions.

Data requirements for pesticide registrations can now be weakened through agency/industry negotiations - with no notice to the public and no public comment allowed. Much critical chronic and environmental testing is now virtually 'optional'.

I said I'd give you some tips on how to communicate with pesticide reformers. The first and obvious has to be - PLEASE do not base your arguments on pesticide safety on the fact it has been tested and registered with the EPA. It won't go down - and the conversation will end right there.

The second tip is - this turmoil at the federal level means you are going to be seeing a lot more of us at the state and local level. Individuals and organizations concerned about pesticides are going to be bringing their concerns to you - as state users, regulators, and researchers. This change can be positive or negative. It is up to you and to me to decide which. If we conduct the process by believing in nozzleheads and ecofreaks, it will not be useful to anyone. We must get beyond those stereotypes and get down to dealing with real people.

A third tip would be to realize that we are probably not going to change each other's minds about some parts of this controversy (at least soon). Why try? Let's concentrate our energies on those points where we may agree. Management issues. Where are you spraying and why? What's the economic and ecological justification? Are there alternatives that will meet your needs as pest managers and reduce the amount of chemicals used? Let's look at new ways of applying chemicals and be open to new techniques of managing without them.

Tip number four is that the issue of research is one of great concern to citizens. We believe our institutional structure is heavily weighted against research into low chemical or no chemical food and fiber production. Even when such research occurs we believe that there are few conduits to get that information out to the people who need it. USDA has a 430 million dollar annual research budget. Ten percent or less of that is devoted to alternate or transitional agriculture - and what little does exist is scattered throughout the agency in such a disjointed fashion that it is virtually useless. USDA bitterly opposed federal legislation this year that would have allocated a mere $2 million annually for a coordinated research effort on alternate agriculture.

Private research is largely done by the chemical producing industry, which has little profit motive for developing low or no chemical management systems. Even academic research is increasingly dependent on grants from the chemical industry. It seems as if research geared towards reducing chemical dependency is being thwarted at every turn, not because of lack of interest or concern; but simply from lack of funds and information delivery systems. In the future you can expect us to push for a re-alignment of research priorities in those public agencies and academic institutions that should be filling this critical research and education gap.

Tip number five is that if citizens wish to maintain areas themselves, respect it. It is not going to hurt you and it will increase the chances of positive communication in the future. Washington state has several examples of citizens choosing to be responsible for nonchemical pest control. Jefferson county residents contracted with the University of Washington to do a mile by mile analysis of their roadside vegetation problems. They then implemented a successful no-spray management program to control those problems. Several environmentalists have been active on their county weed boards and successfully promoted low-spray tansy ragwort control programs. Urban residents in King County pushed for and succeeded in getting a highly successful B.T. control program for gypsy moths. These situations, small though they may be, stand in sharp contrast to the situation that existed several years ago in Eugene, Oregon. Parents there were concerned about pesticide use in school yards where their children played. They asked that the spraying be replaced by manual control programs and they offered to weed the problem areas themselves. That simple request, to alter a pesticide program that had no economic benefit, that was being done for purely aesthetic reasons, created an enormous controversy. Pro-chemical groups spent thousands of dollars on a media campaign to try to prove that chemicals were safe enough to drink; parents filed law suits; maintenance personnel sent out decoy spray trucks to try to confuse parents about planned spray operations; parents then occupied school yards to stop spray operations. It no longer mattered what the school board finally decided to do about school yard pesticides. Everybody lost. Surely we can avoid that kind of situation in the future. You may think it is silly of someone to want to pull a weed when they could spray it, but if it is not going to hurt you and if it will reduce the potential for conflict, let them pull the weeds!

Tip number six - If you want to increase cooperation on the pesticide issue, make sure all sides have complete access to health and safety information. Be willing to keep and to share site specific evaluations on your need to spray. Be willing to work with us to develop efficient notification programs for residents living in spray areas.

The last tip I'd like to give you is - do not assume anti-spray is anti-technology. You may be more justified in accusing us of being future technologists. Nothing is more frustrating than to be proposing systems of pest management that depend upon extremely sophisticated knowledge of chemistry, engineering, and biology (and utilize techniques such as gene splicing and computer monitoring networks) only to be accused of being anti-tech freaks who want to go back to living in caves. Again, we don't mind if you don't like us (we don't like some of you either!) but we want you to know accurately <u>why</u> you don't like us.

I have to end by saying that I think any efforts that are made to resolve the pesticide controversy in a new way are faced with huge obstacles. There is a legacy of distrust on both sides. In many cases that distrust is well founded. There is a tendency on all sides to try to coopt other viewpoints rather than to cooperate with them and learn from them. There will be many failures before there are a few successes, and I mean success where all sides of the issue feel good about what happens. I still feel the effort, no matter how difficult, is worth making. I think the effort has to be based around people who are willing to frequently and honestly communicate with each other. People concerned about pesticides - pro and con - can no longer afford the luxery of isolation. That isolation will always exist if we allow agencies and industries that do not know us and our priorities to speak for us and about us. I hope that I (and the organizations I work with) can be part of the process of change. I hope you all will be too.

APPLICATION OF OXYFLUORFEN IN IRRIGATION WATER

L. D. West, R. C. Hildreth, M. F. Jehle and J. T. Schlesselman[1]

Abstract: Oxyfluorfen (2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoro methyl)benzene) has been used successfully in a number of crops over the past three years. We have found that oxyfluorfen can be effectively applied in irrigation water through a number of different systems. This technique not only allows for more efficient treatment but may also increase effectiveness and safety. Some possible uses of this technique are:

1. Preharvest treatment of nut crop row middles (sprinkler and flood).
2. Postemergence sprinkler application on onions.
3. Drip application in a number of crops.

The technique holds great potential for present and future uses of oxyfluorfen.

[1]Rohm and Haas Company, Fresno, CA.

SD 95481 - A NEW SOIL APPLIED HERBICIDE FOR USE IN BROADLEAVED CROPS

J. W. May, J. H. Long, Jr., and J. R. Goss[1]

Abstract: SD 95481 (7-oxabicyclo(2.2.1) heptane, 1-methyl-4 (1-methylethyl)-2-(2-methylphenylmethoxy)-,exo-) is a novel cineole herbicide invented by Shell Development Company. The compound's structure represents a unique class of herbicides, composed of oxygen, carbon and hydrogen

[1]Shell Chemical Company, Houston, TX and Modesto, CA.

atoms. SD 95481 has been evaluated as a preemergence or shallowly incorporated treatment for broad spectrum weed control in soybeans, cotton, peanuts, and most vegetable crops, including melons. SD 95481 is stable in solution and does not degrade under ordinary conditions of sunlight exposure, thus immediate soil incorporation is not necessary. Extensive testing since 1981, with a rate range of 0.56 - 1.12 kg/ha, has demonstrated that SD 95481 provides excellent grass control and good broadleaved weed suppression for 4-8 weeks. Good selectivity from preemergence applications has been observed with most broadleaved crops. Weed control performance is moderately affected by soil type. The formulation in development is a 840 g/l EC (equivalent to 7 lb/gal EC), but the technical material is also suited to a variety of other formulation types. Research has indicated SD 95481 to be compatible with other herbicides and a large effort has been devoted to evaluating mixtures for improved broadleaved weed control. Research suggests metribuzin to be an excellent combination candidate in tank mixture with SD 95481, without adverse effects on broadleaved crop selectivity.

The mode of action appears to be inhibition of meristematic tissues in roots and shoots of susceptible plants. SD 95481 has a water solubility of 63 ppm (w/w) and an analytically determined vapor pressure of 7.6×10^{-5} mm/hg at 20C. SD 95481 is rapidly metabolized by plants, soil microbes and animals, and does not persist in the environment for more than one season.

Cinmethylin is the proposed common name of SD 95481.

WEED CONTROL AND CROP TOLERANCE IN PULSE CROPS USING R-40244

T. W. Schultz, R. E. Whitesides, D. G. Swan, and T. L. Nagle[1]

The control of grass and broadleaf weeds in pulse crops usually requires the combination of several herbicides. Standard herbicide treatments include triallate (S-(2,3,3-trichloroallyl)diisopropylthiocarbamate), metribuzin (4-amino-6-*tert*-butyl-3-(methylthio)-*as*-triazin-5(4H)-one), and dinoseb amine (2-*sec*-butyl-4,6-dinitrophenol) alone or in combination.

Peas (*Pisum sativum* L.) and lentils (*Lens culinaris* Medic.) have shown good tolerance to R-40244, an herbicide developed by Stauffer, when used alone or in combination with triallate for grass and broadleaf weed control. Field studies were conducted from 1978-1983 to evaluate R-40244 treatments alone and in combination with triallate. Preemergence applications of R-40244 at .56 kg/ha following postplant incorporated treatments of triallate at 1.12 kg/ha provided weed control comparable to combinations of triallate at 1.12 kg/ha + metribuzin at .43 kg/ha, or triallate at 1.40 kg/ha + dinoseb amine at 3.36 kg/ha. R-40244 alone was moderately effective in controlling wild oat; however, control was enhanced when an application of triallate preceeded the R-40244, metribuzin, or dinoseb amine.

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[1]Agronomy & Soils Department, Washington State University, Pullman, WA.

Percent weed control was based on visual observations compared to a check rated at 0% weed control. R-40244 alone controlled wild oat 31%, common lambsquarters 66%, wild mustard 95%, and field pennycress was 96%. When triallate was used in combination with R-40244 wild oat control was increased to 92%, common lambsquarters 76%, wild mustard 100%, and field pennycress 98%. Triallate + metribuzin controlled wild oat similarly to triallate + R-40144 and common lambsquarters control was increased to 82%; however, wild mustard and field pennycress control decreased to 75% and 81%, respectively. The triallate + dinoseb amine treatment increased the wild oat control to 93%, but common lambsquarters control was reduced to 71%, while wild mustard and field pennycress control remained fairly high at 87% and 97%, respectively.

Percent crop tolerance was based on visual observations compared to an untreated check rated as 100% tolerant (no visible crop injury). Peas and lentils were rated at 90% or higher for all herbicide treatments indicating excellent crop tolerance. Yields for the three combination treatments of triallate + R-40244, triallate + metribuzin, and triallate + dinoseb amine were similar. Yields for the R-40244 alone were slightly lower, but higher than the unweeded checks.

There are a number of annual weeds and a few perennial weeds that show susceptibility to R-40244. The predominant weeds found in this study were wild oat (*Avena fatua* L.), common lambsquarters (*Chenopodium album* L.), field pennycress (*Thlaspi arvense* L.), and wild mustard (*Brassica campestris* L.). Some of the less populous weeds included henbit (*Lamium amplexicaule* L.), wild buckwheat (*Polygonum convolvulus* L.), coast fiddleneck (*Amsinckia intermedia* Fisch. & Mey.), and redroot pigweed (*Amaranthus retroflexus* L.).

SPRAYCHECK: A WAY TO SAVE MONEY

Bert L. Bohmont[1]

Abstract: It has long been known that many farmers do not check the condition of their equipment frequently enough or determine accurately the rate and deposition pattern of their ground spray equipment. Investigations by research and extension personnel in Nebraska several years ago indicated that one in three ground pesticide applicators was making significant errors in application. Calibration mistakes, equipment condition, and configuration were causing a great proportion of these losses. The Nebraska study showed that one in three applicators was making errors greater than 10 percent. The losses due to misapplication were estimated nationally based on the Nebraska results and were found to be approximately one billion dollars.

Since it is also believed that significant losses due to mistakes are also occurring in Colorado, and since it is obvious that traditional

[1]Colorado State University, Fort Collins, CO.

sprayer calibration efforts have not done an adequate job, our new approach is to bring greater awareness by introducing equipment that will demonstrate the misapplication patterns graphically and emphasize the economics of proper calibration through the use of rapid computer calculations and printouts.

The Colorado Operation SprayCheck requires the use of a checklist, pressure gauge, stop watch, measuring tape, collection containers and measuring bottles, and a sophisticated spray pan as well as a computer.

The SprayCheck involves checking a number of factors at five stations through which equipment is rotated to facilitate rapid analysis of each spray rig. The data is put into the computer and actual output is then printed and electronically compared to what the applicator thinks he is applying.

IDAHO WEEDS - A GROWING CONCERN (PUBLIC AWARENESS VIDEOTAPE)

Steven Dewey[1]

Abstract: It is estimated that weeds cost Idaho citizens between $400 and $500 million annually. Weeds reduce crop yields and increase production costs, and they reduce the productivity of grazing lands and cause livestock losses due to poisoning.

But, farmers and ranchers are not the only ones affected by weeds. Economic losses in our agricultural industry result in higher food prices, fewer tax revenues available for essential services, and fewer dollars circulating in our economy. Weeds are a menace and eye-sore to homeonwers and gardeners, who spend many hours and dollars in their control. Anyone who has suffered from hayfever or other allergies knows that weeds can make their life miserable, and cost them money. A significant portion of our tax dollar goes to control weeds. Without weed control along highways travel would become more hazardous, and roads would deteriorate.

There are also many less obvious ways that weeds impact our lives. One such area is quality of recreation. Campers, hikers, fishermen, hunters, and white water enthusiasts are all being threatened by weeds. Noxious weeds invading critical wildlife habitat have already seriously reduced available food and suitable cover in some areas. The beauty of many scenic rivers, canyons, hiking trails and campgrounds is being marred by the invasion of weeds. This could have a serious impact on tourism and recreation, two of Idaho's major industries.

Few people comprehend how serious the overall weed problem has become, and what could happen if the advance of this silent menace is not stopped. Let's look at just a few of the weeds.

> Leafy spurge (*Euphorbia esula* L.) is one of the most serious weed problems facing Idaho. It was first reported in 1933 near Coeur d'Alene and Dubois. It is now found in at least 33 Idaho counties.

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[1]Extension Weed Specialist, University of Idaho, Twin Falls, ID.

Leafy spurge seems to thrive under a wide variety of environmental conditions and soil types. It is found in gravelly high mountain soils as well as in fertile pastures and along stream banks. It is very difficult to control even under ideal conditions. However, it has now spread into remote and rugged areas of the state where control is incredibly difficult and costly.

Yellow starthistle (Centaurea solstitialis L.) was first reported in Idaho in 1952. Since that time it has spread to over 185,000 acres, and has the potential to spread over millions of acres in Idaho. Yellow starthistle is primarily a rangeland weed, but has been found in wheat fields and pastures. It is poisonous to horses and is of low nutritional value to cattle and wildlife. It is very thorny and poses an unsightly and painful obstacle to hikers and hunters.

Rush skeletonweed (Chondrilla juncea L.) was first discovered in the early 1960's in Idaho near Coeur d'Alene and Banks. It has now invaded over three and one-half million acres in Idaho, and is spreading throughout the Pacific northwest at an estimated rate of over 100,000 acres per year. It has infested rangelands, pastures, cropland, transportation rights-of-way, residential properties, and other disturbed sites. It can reduce crop yields by as much as 70%. In Australia this weed causes an annual loss to wheat producers in excess of $30 million dollars, and is an eminent threat to Idaho grain producers. The wiry, latex-exuding stems can obstruct harvest machinery and make crop harvest costly and difficult if not impossible. Rangeland infestations displace desirable forage plants.

Medusahead rye (Taeniatherum asperum Sim.) was first reported in Idaho in 1942. By 1952 it covered over 30,000 acres. In 1958 that number jumped to over 700,000 acres. Presently medusahead rye infests between 4 and 4-1/2 million acres of Idaho rangeland. It causes serious loss to the livestock industry, primarily due to reduction of desirable forage in infested areas. Medusahead has been shown to reduce the carrying capacity for domestic livestock on rangeland by as much as 40-75%. The long barbed awns of the seed also cause mechanical injury to the eyes, nose and mouths of grazing animals.

There are three species of knapweeds in Idaho that have become serious weed problems. All three are spreading rapidly and are having significant impacts on crops, livestock and wildlife. Spotted knapweed (Centaurea maculosa Lam.) was first reported near the Idaho border (in Montana) around the mid-1920's, and soon spread into Idaho. It is an extremely competitive weed that invades both forest and rangeland, as well as roadsides, pastures and disturbed sites. Spotted knapweed is well established in at least 23 counties. Diffuse knapweed (Centaurea diffusa Lam.) is a close relative of spotted knapweed. It first appeared about 1952, and has now spread into 15 counties. Like spotted knapweed, it continues to appear in new locations each year. It is very competitive for soil moisture and nutrients, crowding out native rangeland vegetation and even some crops. Russion knapweed (Centaurea repens L.) is a third species of knapweed in Idaho. It has a deep root system which allows it to survive in cultivated fields, pastures, roadsides, waste places, or on rangeland. It was first reported in our region in 1954. Presently it infests over half of Idaho's 44 counties.

Dyers woad (Isatis tinctoria L.) has become a serious problem. The first report of this weed in Idaho was in 1938. It is now found in 16 counties. It is a vigorous weed which infests range, pasture, orchards, roadsides and residential areas. It is also capable of invading grain and alfalfa. Another major concern is its ability to invade big game winter range and crowd out desirable native vegetation.

Musk thistle (Carduus nutans L.) is a biennial weed which was first reported in Idaho in the early 1950's. Since then it has invaded at least 23 Idaho counties and continues to spread. It is a prolific seed producer, and is capable of overtaking pasture, rangeland, and disturbed sites. Like many of our other noxious weeds it is invading some of our most scenic recreational and summer home areas.

Scotch thistle (Onopordum acanthium L.) was first noticed in Idaho along the Snake River near Lewiston in the late 1940's. It is particularly well adapted to sites along rivers and streams, but has also become a common occurrence in pastures, and waste areas where sufficient moisture is present. Once established, this plant can grow to a height of over 8 feet and presents a nearly impenetrable barrier to livestock and humans. Some of our worst Scotch thistle infestations occur in and around parks and campsites along our scenic white water rivers.

These weeds represent just a small portion of Idaho's weed problem. Others such as toadflax (Linaria sp.), Canada thistle (Cirsium arvense L.), poison hemlock (Conium maculatum L.), larkspur (Delphinium sp.), and field bindweed (Convolvulus arvensis L.), are also major concerns. Newcomers like wild proso millet (Panicum miliaceum L.), velvetleaf (Abutilon theophrasti Medic.), common crupina (Crupina vulgaris Cass.), hawkweed (Hieracium sp.), jointed goatgrass (Aegilops cylindrica Host) and many others have the potential to become just as serious and overrun large portions of the state.

The weed problem in Idaho is extremely serious. Insufficient public concern has been a major contributing factor in the ever increasing spread of the problem. Weeds affect all of us in one way or another, and it is only through a concerted effort between the agricultural community, recreationists, federal and state agencies, and the general public that this problem will be solved.

BOTANICAL CHANGES ASSOCIATED WITH APPLICATIONS OF TEBUTHIURON IN CREOSOTEBUSH (Larrea tridentata) COMMUNITIES

A. Melgoza, H. L. Morton, J. S. Sierra, and G. Melgoza[1]

Abstract: Creosotebush (Larrea tridentata (DC.) Cov.) has increased inthe desert rangeland and this extension has caused a decrease in forage production. Tebuthiuron (N-(5-1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl)-

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[1]Grad. Res. Asst., School of Renewable Nat. Res., Univ. of AZ, Tucson; ARS/USDA, Arid Land Ecosystems Improvement, Tucson, AZ; Ing. Agr. and Biol., Rancho Exp. La Campana, INIP, SARH, Chihuahua, Chih, Mexico, respectively.

N-N[1]-dimethyurea) has been shown to control creosotebush and some associated woody plants. This study was conducted to determine vegetation responses following application of different rates of tebuthiuron. Four areas were selected: three in the Chihuahuan desert and one in the Sonoran desert. Tebuthiuron was applied during the spring of 1981 and 1982 at rates of 0.5, 1.0, and 1.5 kg ai/ha. Shrub cover and herbaceous density were measured before and after treatment. Average shrub cover on the four areas decreased, average grass density tended to increase, and average forb density decreased on plots treated.

Creosotebush has no forage value but is invading grassland areas where livestock production is suitable. In the United States it covers about 262,680 km^2 (10) and in Mexico about 453,250 km^2 (11). At the present time, creosotebush is increasing its distribution (5), and this shrub and associated woody species reduce forage production of grasses and browse plants. It is well documented that control of woody species increases forage production (7, 9, 13, 14, 16). Tebuthiuron has been used to control many woody species in noncroplands (6, 14). In general, most of the studies not only report control of a specific woody species, but also an increase in herbage yield. Alley (1) using 2.2, 3.4, and 4.5 kg/ha almost completely controlled snakeweed (Gutierrezia sarothrae (Porsh.) Britt and Rusby) after two years; however, grass density decreased from 50 to 85%. Bjerregaard (2) controlled a wide range of woody species at 0.56 to 4.48 kg/ha rates. He found that rates up to 2.24 kg/ha were tolerated by herbaceous plants. Duncan and Scifres (4) report that 2 kg/ha was more effective than 1 kg/ha in controlling yaupon (Ilex vomitoria Ait.). Despite slow herbaceous response, grasses increased and forbs decreased. Johnsen (8) used 2.2 kg/ha to control juniper (Juniperus deppeana steud. and J. pinchottii Sudw.) and peak forage production was reached after 3 to 5 years. Meyer and Bovery (12) controlled Macartney rose (Rosa bracteata Wendl.) at 4.5 kg/ha. Sosebee et al. (15) report control of mesquite using 2.2, 4.5 and 9.0 kg/ha.

The objective of this study was to determine changes in the cover of shrubs and the density of grasses and forbs in four creosotebush communities following tebuthiuron treatments.

Materials and Methods

Four creosotebush areas were selected for the study. Three of them were located in Mexico: Rancho Los Pozos, Aldama; Rancho La Reforma, Allende; and Rancho El Toro, Villa Ahumada, in the state of Chihuahua; and one in the United States: Santa Rita Experimental Range (SRER), Tucson, AZ.

Los Pozos soils are of alluvial origin with gravel and some rocks in the profile. The topography of the area is mainly flat with undulating slopes which range between 0% and 4% (3). The elevation is 1400 m. The average annual precipitation is about 253 mm. The mean annual temperature is 17.9C. The main shrub species are creosotebush, whitethorn (Acacia constricta Benth.) and tarbush (Flourencia cernua DC.). The predominant grasses are fluffgrass (Tridens pulchellus (H.B.K.) Hitchc.), bushmuhly (Muhlenbergia porteri Scribn.), and spike pappus grass (Enneapogon desvauxii Beauv.).

La Reforma soils have an alluvial origin with a calcareus layer that occurs near the surface and as deep as 30 cm. The topography is undulating, slopes are from 2% to 16%, and the elevation is 1500 m (3). The average annual precipitation is 400 mm. The mean annual temperature is 17.5C. The most abundant woody species are creosotebush, whitethorn, shrubby senna (Cassia wislizeni Gray), tarbush, and mariola (Parthenium incanum H.B.K.). The most abundant grasses are grama grasses (Bouteloua spp.) and bushmuhly.

El Toro soils are alluvial with gravel and few rocks in the profile. The topography is mainly flat with slopes less than 5%, the elevation is 1380 m and average annual precipitation is about 270 mm (3). The mean annual temperature is 17.7C. The main shrubs are creosotebush, honey mesquite (Prosopis glandulosa (Toor) Cockll.) and tarbush. The main grasses are black grama (Bouteloua eriopoda Torr.) and fluffgrass.

SRER soils originated from alluvial material. The topography is relatively flat with slopes that vary from 1% to 5%. Elevation is 968 m. The average annual precipitation is 290 mm. The mean annual temperature is 17.5C. The dominant woody species are creosotebush, desert zinnia (Zinnia pumila Gray), and velvet mesquite (Prosopis juliflora var. velutina (Woot.) Sarg.). The most abundant grasses are fluffgrass, bushmuhly, and Santa Rita three awn (Aristida glabrata (Vasey) Hitchc.).

In 1981, 0.5 ha plots were established at the four areas and three tebuthiuron treatments were applied: 0.5, 1.0 and 1.5 kg ai/ha plus the control. Treatments were arranged in a complete randomized block design with three replications. The same number and size of plots with the same treatments were repeated in 1982 in all the areas. Since the beginning of the study in 1981, the whole area was fenced to exclude grazing.

Prior to the treatment applications, three permanent transects 30 m long were placed in each plot. Canopy cover was determined measuring the canopy of woody species that were intercepted by the transects. Associated with each transect a belt 30 cm wide was established where herbaceous plants were counted to determinate density. Measurements were made before and after the treatments were applied.

Cover and density were analyzed by using analysis of variance and, where appropriate, mean separation by Duncan's multiple range test.

Results and Discussion

El Toro Site. Table 1 summarizes the cover of creosotebush, mesquite, tarbush and other major woody species at El Toro before treatment and one and two years after. The minor species were whitethorn, condalia (Condalia spp.), snakeweed (Gutierrezia sarothrae (Porsh) Britt and Rusby), and wolfberry (Lycium spp.).

Cover of all shrubs was reduced by all the treatments. The only significant difference was between treatments and untreated control.

Response of herbaceous plants are presented in Table 2. The abundant perennial grasses were black grama, bushmuhly, and fluffgrass. There were no significant differences among rates of herbicide and control either before treatment or after one or two years. However, in plots treated in 1981 there was an increase of grasses between 1981 and 1983. There was a decrease between 1982 and 1983, with the greatest reductions occurring on the plots treated with the higher rates of tebuthiuron.

Table 1. Percent cover of creosotebush, mesquite, tarbush and other shrubs before treatment with 3 rates of tebuthiuron and 1 and 2 years after treatment at Rancho El Toro.[a]

Rate	Creosotebush		Mesquite		Tarbush		Other	
(kg/ha)	%[b]							
	Treated May, 1981							
	1981	1983	1981	1983	1981	1983	1981	1983
0.0	27a	31b	9a	8b	Ta	0a	1a	7b
0.5	39a	0a	9a	4a	2a	0a	5a	1a
1.0	37a	Ta	6a	2a	2a	0a	1a	0a
1.5	29a	1a	10a	Ta	6a	0a	2a	0a
	Treated May, 1982							
	1982	1983	1982	1983	1982	1983	1982	1983
0.0	26a	28b	6a	3a	6a	8b	22a	20b
0.5	27a	0a	17b	6a	Ta	0a	12a	2a
1.0	15a	0a	12b	4a	11b	1a	22a	1a
1.5	28a	1a	12b	4a	6a	0a	20a	1a

[a]Means within a column followed by the same letter are not significantly different (P<0.05) according to Duncan's multiple range test.

[b]T equals a value less than 1%.

Table 2. Density of herbaceous plants (plants/m^2) before treatment with 3 rates of tebuthiuron and 1 and 2 years after treatment at Rancho El Toro.[a]

Rate	Perennial Grasses		Annual Grasses		Perennial Forbs		Annual Forbs	
(kg/ha)	(plants/m^2)							
	Treated May, 1981							
	1981	1983	1981	1983	1981	1983	1981	1983
0.0	17a	40a	Ta	Ta	2a	1a	145a	2a
0.5	13a	28a	0a	0a	1a	0a	146a	3a
1.0	19a	14a	0a	0a	1a	0	150a	2a
1.5	15a	17a	2a	Ta	1a	0	208a	1a
	Treated May, 1982							
	1982	1983	1982	1983	1982	1983	1982	1983
0.0	41a	40a	2a	0a	0a	1a	12a	2a
0.5	50a	35a	0a	0a	0a	0a	9a	1a
1.0	48a	30a	Ta	Ta	0a	0a	8a	0a
1.5	46a	26a	1a	0a	0a	0a	4a	1a

[a]Means within a column followed by the same letter are not significantly different ($P<0.05$) according to Duncan's multiple range test.

[b]T equals a value less than 1.0 plant/m^2.

Annual grasses and perennial forbs were not present in significant amounts. Annual forbs such as spectacle-pod (Dithyrea wislizenii Engelm.) and Aphanostephus ramossisimus (Torr and Gray) were abundant before treatment in 1981, but not in 1983. The decrease could be due to herbicide treatments, but more probably was due to low rainfall in 1983, for the decrease also occurred on untreated plots.

SRER Site. Table 3 shows the percent cover of creosotebush, desert zinnia, and other shrubs which included whitethorn, velvet mesquite, and catclaw.

All treatments applied both in 1981 and 1982 reduced cover of all woody species. There were no significant differences among dosages of tebuthiuron for any species in the 1981 treatments. The 1982 treatments follow the same trend.

Table 4 shows the density of herbaceous plants. The main perennial grasses were fluffgrass, bushmuhly, and Santa Rita three awn. Perennial grasses increased in all plots treated with tebuthiuron in the 1981 and 1982 treatments.

Main perennial forbs were bahia, desert holly (Perezia nana Gray), and goldenweed (Haplopappus gracilis (Nutt.) Gray). Perennial forb response was not significantly different among treatments or between them and the control. However, they were reduced or completely eliminated on the plots treated with tebuthiuron, but the control plots had slight increases after both years of treatment.

Annual grasses were not present on any of the plots at the time of the sampling. Annual forbs present were Chorizanthe rigida (Torr.) Torr. & Gray, spurges (Euphorbia spp.) and Russian thistle (Salsola iberica L.). They were not abundant on the plots treated in 1981 or 1982.

Los Pozos Site. The dominant woody species were creosotebush, whitethorn, and tarbush. Other species present were catlaw, mariola, and whitebrush (Aloysia lycioides Cham.). Table 5 shows cover before and after treatment for applications in 1981 and 1982. All the rates of herbicide reduced shrub cover significantly for all the species in both years of application.

Table 6 presents the data for density of herbaceous plants. The perennial grasses of the area were primarily bushmuhly, fluffgrass and spike pappus grass. At all rates as well as in the control, their densities decreased after the 1981 applications. There were no significant differences between rates. They increased between 1982 and 1983, but without any significant difference between treatments.

Perennial forbs were bahia, croton (Croton corymbulosus Engim.), trailing four-o'clock (Allionia incarnata L.) and sida (Sida procumbense Sw.). On plots treated in 1981 they decreased, but there were no significant differences between treatments. On plots treated in 1982 there were low densities of perennial forbs which increased on the untreated plots by 1983 but not on the plots treated with tebuthiuron.

Annual grasses were not present in significant amounts. Annual forbs present in the area were Aphanostephus ramosissimus Torr. & Gray., spectacle-pod, and Cryptantha pusilla Torr. & Gray. They decreased on plots treated in 1981 and 1982, without significant differences between treatments.

Table 3. Percent cover of creosotebush, desert zinnia, and other shrubs before treatment with 3 rates of tebuthiuron and 1 and 2 years after treatment at SRER.[a]

Rate	Creosotebush		Zinnia		Other	
	(%)[b]					
(kg/ha)	Treated May, 1981					
	1981	1983	1981	1983	1981	1983
0.0	61a	65b	3a	6b	10a	5b
0.5	73a	10a	4a	0a	1a	0a
1.0	66a	Ta	5a	0a	8a	0a
1.5	68a	Ta	3a	0a	6a	0a
	Treated May, 1982					
	1982	1983	1982	1983	1982	1983
0.0	70a	63a	3a	7b	2a	6b
0.5	85a	31b	1a	0a	7a	2a
1.0	65a	5b	1a	0a	7a	2a
1.5	71a	2b	1a	0a	10a	0a

[a]Means within a column followed by the same letter are not significantly different (P<0.05) according to Duncan's multiple range test.

[b]T equals a value less than 1%.

Table 4. Density of herbaceous plants (plants/m^2) before treatment with 3 rates of tebuthiuron and 1 and 2 years after treatment at SRER.[a]

Rate	Perennial Grasses		Annual Grasses		Perennial Forbs		Annual Forbs	
	(Plants/m^2)[b]							
	Treated May 1981							
(kg/ha)	1981	1983	1981	1983	1981	1983	1981	1983
0.0	4a	11a	0a	0a	5a	7a	0a	1a
0.5	1a	16a	0a	0a	4a	1a	1a	1a
1.0	2a	58a	0a	0a	11a	1a	1a	0a
1.5	5a	23a	0a	0a	5a	0a	0a	1a
	Treated May 1982							
	1982	1983	1982	1983	1982	1983	1982	1983
0.0	2a	20a	0a	0a	Ta	2a	15a	1a
0.5	0a	21a	0a	0a	Ta	0a	10a	1a
1.0	2a	2a	0a	0a	0a	0a	1a	0a
1.5	2a	12a	0a	0a	0a	0a	6a	0a

[a]Means within a column followed by the same letter are not significantly different ($P < 0.05$) according to Duncan's multiple range test.

[b]T equals a value less than 1 plant/m^2.

Table 5. Percent cover of creosotebush, whitethorn, tarbush and other shrubs before treatment with 3 rates of tebuthiuron and 1 and 2 years after treatment at Rancho Los Pozos.[a]

Rate	Creosotebush		Whitethorn		Tarbush		Other	
(kg/ha)	(%)[b]							
	Treated May, 1981							
	1981	1983	1981	1983	1981	1983	1981	1983
0.0	51a	33b	1a	1a	3a	16b	3a	3a
0.5	46a	8a	1a	Ta	1a	2a	6a	5a
1.0	49a	7a	2a	0a	2a	1a	8a	1a
1.5	38a	2a	2a	0a	1a	0a	2a	0a
	Treated May, 1982							
	1982	1983	1982	1983	1982	1983	1982	1983
0.0	34a	28b	15a	18b	Ta	2a	6a	10b
0.5	48a	5a	7a	2a	4a	1a	12a	7a
1.0	39a	6a	15a	7a	3a	Ta	8a	0a
1.5	46a	7a	10a	0a	3a	0a	10a	2a

[a]Means within a column followed by the same letter are not significantly different ($P<0.05$) according to Duncan's multiple range test.

[b]T equals a value less than 1%.

Table 6. Density of herbaceous plants (plants/m^2) before treatment with three rates of tebuthiuron and 1 and 2 years after treatment at Rancho Los Pozos.[a]

Tebuthiuron	Perennial Grasses		Annual Grasses		Perennial Forbs		Annual Forbs	
(kg/ha)	(Plants/m^2)[b]							
	Treated May 1981							
	1981	1983	1981	1983	1981	1983	1981	1983
0.0	99a	32a	Ta	0a	80a	33a	80a	33a
0.5	77a	68a	Ta	0a	54a	11a	54a	11a
1.0	114a	38a	Ta	0a	46a	8a	46a	8a
1.5	28a	16a	Ta	0a	37a	3a	37a	3a
	Treated May 1982							
	1982	1983	1982	1983	1982	1983	1982	1983
0.0	21a	51a	0a	0a	4a	14b	97a	14a
0.5	26a	38a	0a	0a	2a	4a	92a	6a
1.0	23a	32a	0a	0a	2a	2a	100a	2a
1.5	33a	38a	0a	0a	2a	1a	91a	4a

[a]Means within a column followed by the same letter are not significantly different ($P < 0.05$) according to Duncan's multiple range test.

[b]T equals a value less than 1 plant/m^2.

La Reforma Site. The dominant shrubs were creosotebush, whitethorn, shrubby senna, and tarbush. Other shrubby species present were mariola, catclaw, and condalia. Table 7 shows their cover before and after treatments for 1981 and 1982. On the 1981 plots all tebuthiuron rates reduced the cover of creosotebush, tarbush, whitethorn, shrubby senna, and the minor shrubby species. There were no significant differences among dosages. In the plots treated in 1982, there were no significant differences in shrub cover in 1983 for all species, except whitethorn and shrubby senna.

Dominant perennial grasses were bushmuhly, sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.) and blue grama (*B. gracilis* (H.B.K. Log.). There was not a significant change from 1981 to 1983. Densities of perennial grasses decreased between 1982 and 1983.

Perennial forbs were sida, croton, and *Euphorbia* spp. On plots treated in 1981, perennial forb density decreased between 1981 and 1983. There were no significant differences between treatments. Plots treated in 1982 had some change, but they were not significantly different even though there was an increase on the untreated plots.

Annual grasses were not present in significant amounts at any of the sampling dates.

Main annual forb was *Aphanostephus ramosissimus*. On plots treated in 1981, only those receiving the 1.0 kg/ha rate showed a significant difference in density from other treatments. Plots treated in 1982 show a reduction of annual forbs from 1982 to 1983 with no significant difference between treatments.

Conclusions

Tebuthiuron reduced the cover of most woody species in the creosotebush communities one or two years after application. Perennial grass response varied among the areas since precipitation was also variable. At El Toro and SRER where annual precipitation was average or above average, perennial grasses increased. Los Pozos and La Reforma were the driest areas throughout the study and their grass densities decreased. Perennial forbs decreased regardless of precipitation on all the treated areas. Populations of annual plants were extremely variable and their abundance was due as much to precipitation as to herbicide treatments.

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Table 7. Percent cover of creosotebush, whitethorn, shrubby senna, tarbush and other shrubs before treatment with 3 rates of tebuthiuron and 1 and 2 years after treatment at Rancho La Reforma.[a]

Rate	Creosotebush		Whitethorn		Shrubby Senna		Tarbush		Others	
(kg/ha)	(%)[b]									
	Treated May, 1981									
	1981	1983	1981	1983	1981	1983	1981	1983	1981	1983
0.0	10a	10b	24a	22b	17a	18b	9a	18b	21a	22b
0.5	8a	3a	41a	9a	15a	3a	8a	1a	32a	7a
1.0	8a	5a	51a	7a	12a	Ta	10a	1a	42a	6a
1.5	7a	0a	34a	1a	30a	Ta	1a	0a	25a	Ta
	Treated May, 1982									
	1982	1983	1982	1983	1982	1983	1982	1983	1982	1983
0.0	9a	7a	62a	48b	14a	9b	5a	3a	23a	14a
0.5	5a	4a	47a	4a	12a	4a	1a	1a	35a	6a
1.0	5a	1a	30a	3a	9a	1a	5a	0a	47a	11a
1.5	8a	0a	48a	1a	3a	0a	8a	0a	32a	5a

[a]Means within column followed by the same letter are not significantly different ($P < 0.05$) according to Duncan's multiple range test.

[b]T equals a value less than 1%.

Table 8. Density of herbaceous plants (plants/m^2) before treatment with three rates of tebuthiuron and 1 and 2 years after treatment at Rancho La Reforma.[a]

Rate	Perennial Grasses		Annual Grasses		Perennial Forbs		Annual Forbs	
(kg/ha)	(Plants/m^2)[b]							
	Treated May, 1981							
	1981	1983	1981	1983	1981	1983	1981	1983
0.0	0a	1a	0a	0a	70a	24a	120a	20a
0.5	2a	2a	0a	0a	40a	20a	102a	30a
1.0	1a	1a	0a	0a	50a	7a	75a	201b
1.5	0a	0a	0a	0a	86a	6a	140a	25a
	Treated May, 1982							
	1982	1983	1982	1983	1982	1983	1982	1983
0.0	88a	7a	3a	0a	5a	14a	63a	30a
0.5	58a	10a	Ta	0a	8a	8a	46a	19a
1.0	60a	5a	0a	0a	10a	4a	40a	10a
1.5	72a	6a	Ta	0a	5a	1a	45a	4a

[a]Means within a column followed by the same letter are not significantly different ($P < 0.05$) according to Duncan's multiple range test.

[b]T equals a value less than 1 plant/m^2.

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TEBUTHIURON RESIDUES IN CHIHUAHUAN AND SONORAN DESERT SOILS

Fernando A. Ibarra and Howard L. Morton[1]

Abstract: Plots were treated with pellets containing 20% a.i. of tebuthiuron (N-(5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl)-N-N'-dimethylurea), during the spring of 1981 at three sites located in the Chihuahuan desert in the state of Chihuahua, Mexico and one site located in the Sonoran desert in the state of Arizona, United States of America. Three rates of tebuthiuron 0.5, 1.0, and 1.5 kg ai/ha were applied. Soils were sampled at 0-2, 2-10, and 10-20 cm at 6, 12, 18 and 24 months after application and analyzed for tebuthiuron residues using gas chromatography. Tebuthiuron concentrations were different between sites, years and soil depths. When all depths and sites were combined using weighted averages, tebuthiuron concentrations in the top 20 cm were 0.11, 0.10, and 0.04 ppm, after 12, 18 and 24 months, respectively, on plots treated at 0.5 kg ai/ha. Tebuthiuron concentrations on plots treated at 1.0 kg ai/ha were 0.31, 0.24, 0.16 and 0.11 ppm after 6, 12, 18 and 24 months, respectively. Tebuthiuron concentrations on plots treated at 1.5 kg ai/ha were 0.32, 0.26, and 0.16 ppm after 12, 18 and 24 months, respectively. Amount and distribution of precipitation, organic matter and clay content seem to infuence tebuthiuron persistence in the soils.

Introduction

Tebuthiuron is an effective substituted urea herbicide for total vegetation control (18) and for the control of certain brush species on rangeland of the Southwestern United States (12, 13, 14, 15, 16).

Since tebuthiuron was introduced for brush control on rangelands, many research studies have been done to determine the physiological effects of tebuthiuron in defferent species. Also parameters such as rates, formulations and time of application have been tested to improve brush control effectiveness. Several investigations have been conducted to determine the persistence of tebuthiuron residues in rangeland soils of the South and Southwest United States (3, 4, 6); however, only a few studies have been conducted on persistence of tebuthiuron residues in desert soil (7).

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[1]U.S. Dept. of Agric. Res. Serv., Arid Land Ecosystems Improvement, Tucson, AZ.

Since tebuthiuron is a soil applied herbicide which is absorbed by the roots of plants, its concentration, persistence and movement in the soil are very important for developing selective control measures for brush species in forage producing rangelands.

Bovey, et al (3) and Baur (2), indicate that the long, residual life of tebuthiuron makes it a useful product in brush control, but this persistence in soils may inhibit the growth of desirable vegetation and prevents the establishment of seedlings. Forb production and density have decreased when 1 kg/ha or more of tebuthiuron was applied; however, forb cover has recovered to original levels after 3 years (15).

Organic matter and clay content are two very important factors controlling the mobility of soil applied substituted urea herbicides in soils. The organic matter concentrated in the surface adsorbs the herbicide and prevents its leaching into lower levels. However, the herbicide seems to dissipate more rapidly in the surface layer primarily because the organic matter content and rates of microbial degradation are higher at the soil surface (5). Organic matter may be responsible for adsorption of herbicides in some soils and clay may be more important in others. The single most important variable regulating response of a susceptible species to tebuthiuron is the application rate (8, 10). Tebuthiuron is metabolized in the soil by microorganisms and absorbed by the roots of higher plants (1, 18). Change and Stritzke (6) showed that greater dissipation occured at 15% soil moisture and 30C than at lower temperatures or lower moisture levels. Vertical mobility of tebuthiuron decreases as organic matter, cation exchange capacity and clay content increase (5, 6, 9).

The objective of this study was to determine the level of soil residues of tebuthiuron at four rangeland sites over time.

Materials and Methods

Locations in the Chihuahuan Desert are all in the state of Chihuahua. They are Rancho La Reforma at Allende, Rancho Los Pozos at Aldama, and Rancho El Toro at Villa Ahumada. The location in the Sonoran Desert is on the Santa Rita Experimental Range near Tucson, AZ. Rancho La Reforma is at an elevation of 1500 m, with an average precipitation of 400 mm and a mean annual temperature of 17.5C. The major brush species are whitethorn (*Acacia constricta* Benth.), tarbush (*Floutensia cernua* DC.), creosotebush (*Larrea tridentata* (DC.) Coville) and shrubby senna (*Cassia wislizeni* Gray). The major grass species are spike pappusgrass (*Eneapogon desvauxii* Beauv.), fluffgrass (*Tridens pulchellus* (H.B.K.) Hitchc.) and blackgrama (*Bouteloua eriopoda* Torr). Rancho La Pozos is at an elevation of 1400 m, with an average precipitation of 253 mm and with a mean annual temperature of 17.9C. The major brush species are creosotebush, mariola (*Parthenium incanum* H.B.K.), whitethorn and tarbush. The major grass species are fluffgrass, threeawn (*Aristida* spp.) and spike pappusgrass. Rancho El Toro is at an elevation of 1380 m, with an average precipitation of 270 mm and with a mean annual temperature of 17.5C. The major brush species are creosotebush, whitethorn, and mesquite (*Prosopis juliflora* (Swartz) DC). The major grass species are black grama, fluffgrass and bushmuhly (*Muhlenbergia porteri* Scribn.). Santa Rita Experimental Range is at an elevation of 968 m, with an average precipitation of 290 mm and a mean annual temperature of 19C. The major brush species are creosotebush, desert zinnia (Zinnia pumila Gray), and velvet mesquite (P. julifora var. velutina (Swartz) DC). Major grass species are fluffgrass, bushmuhly and three awn.

Soils of the study site were characterized relative to textural components by the hydrometer method; organic matter content by acid digestion and titration; pH of 1:2, soil water slurries and electrial conductivity of saturated paste (Table 1).

Table 1. Physical and chemical properties of 3 Chihuahuan and 1 Sonoran Desert Soils.

Locations	% Soil Particles < 2 mm	% Soil Particles > 2 mm	Sand	% Silt	Clay	Texture Class	O.M.%	PH	EC Mmhos/cm
La Reforma	55	45	59	26	15	Sandy Loam	3.6	6.9	2.9
Los Pozos	71	29	60	29	11	Sandy Loam	1.5	7.2	1.3
El Toro	77	23	66	24	10	Sandy Loam	1.1	7.9	1.1
SRER	83	17	58	28	11	Sandy Loam	0.7	7.9	1.1

Plots were hand broadcast with tebuthiuron pellets (3.2 mm diameter by 4.8 mm long) containing 29% ai at rates of 0.5, 1.0 and 1.5 kg ai/ha during 1981. Soils were sampled 6, 12, 18 and 24 months after tebuthiuron application. Samples were collected from 10 holes dug by hand at 10 m intervals diagonally across each plot. Soils were removed from the sides of the holes at 0-2, 2-10 and 10-20 cm depths. Samples from each depth were combined into one sample, this made a total of one sample for each depth and a total of three samples on each plot. Prior to analysis soils were air dried and separated into fractions larger than 2 mm and smaller than 2 mm. The fraction smaller than 2 mm was thoroughly mixed and a 20 g subsample was taken for analysis of tebuthiuron.

Tebuthiuron soil residues were determined by following the method modified slightly from that developed by Loh et al. (11). Tebuthiuron was extracted from soil samples by refluxing in a mixture of methanol and hydrochloric acid, transferred from the extract into ethyl acetate by liquid-liquid partition, evaporated and reconstituted with a mixture of acetonitrile and isopropanol, and then passed through an alumina column in order to remove organic contaminant materials. Tebuthiuron residues were extracted from the column with acetronitrile and isopropanol, evaporated and reconstituted with pure acetonitrile, and quantified for tebuthiuron by gas chromatography with flame photometric detection.

Treatments at all locations were arranged in a randomized complete block design and replicated three times on 0.5 ha plots (100 x 50 m).

Concentration means for each location treated with the same rate of herbicide were graphed at each date of sampling. Then, location means were averaged at ech date of sampling obtaining a mean for all locations. Regression equations were developed in order to determine when the concentrations of tebuthiuron applied at each rate reach undetectable levels. Data was subjected to analysis of variance, and when significant ($P \leq 0.05$) differences were detected, residue means were compared using Duncan's Multiple Range Test (17).

Results and Discussion

Amount and distribution of precipitation was very variable between locations in 1981, 1982 and 1983. At Rancho La Reforma precipitation was below average during 1981, 1982 and 1983. At Rancho Los Pozos and Rancho El Toro precipitation was average in 1981 and below average in 1982 and 1983. At Santa Rita Experimental Range summer precipitation was below average in 1981 and above average in 1982 and 1983, but winter precipitation was above average in 1981, 1982 and 1983.

Results indicate a highly significant difference between treatment rates at all locations. Concentrations were usually greater in soils treated with 1.5 kg ai/ha than with 1.0 and 0.5 kg ai/ha rates. Tebuthiuron residues were significantly different between locations only at 6 months for the 1.0 kg ai/ha rate and at 12 months after application for all rates of tebuthiuron application. Tebuthiuron persisted on treated plots at all locations regardless of the amount of precipitation even 24 months after herbicide application. Tebuthiuron concentration means across locations for the top 20 cm of soil 24 months after application ranged from 0.021 to 0.059 ppm on the 0.5 kg ai/ha treated plots, from 0.071 to 0.171 ppm on the 1.0 kg ai/ha treated plots, and from 0.137 to 0.204 ppm on the 1.5 kg ai/ha treated plots (Table 2). Generally, tebuthiuron tended to move deeper into the soil over time. Tebuthiuron concentration on the top 2 cm was present in significant quantities only at La Reforma and El Toro 12 months after tebuthiuron application at a rate of 0.5 kg ai/ha, but disappeared almost completely after 18 months at all the locations (Figure 1). After 18 months most of the tebuthiuron was dissipated into the 2-10 and 10-20 cm depths. Tebuthiuron residues persisted longer in the 2-10 and 10-20 cm depths and significant levels were still present in the soil at La Reforma and El Toro 24 months after tebuthiuron application.

Tebuthiuron residues in the top 2 cm were greater 24 months after application on plots treated with 1.0 kg ai/ha than on plots treated with 0.5 kg ai/ha (Figure 2). Greatest tebuthiuron residues were found in the top 2 cm of soil on the sites with least precipitation. Significant levels of tebuthiuron were present in the top 2 cm 18 months after application in all locations; however, only at La Reforma were significant levels detected 24 months after application. Most of the tebuthiuron residues were moved to the 2-10 and 10-20 cm depths 18 months after tebuthiuron application.

Table 2. Tebuthiuron residues ppm. (Weighted) average) over time in the top 20 cm of soil after herbicide application at rates of 0.5, 1.0 and 1.5 Kg ai/ha in four desert soils.

Time after Treatment (Months)	La Reforma	Los Pozos	El Toro	SRER	Date mean
	(0.5 Kg ai/ha)				
6	-----	-----	-----	-----	-----
12	0.150	0.099	0.166	0.042	0.114
18	0.077	0.101	0.158	0.043	0.095
24	0.059	0.021	0.045	0.032	0.039
	(1.0 Kg ai/ha)				
6	0.502	0.308	0.124	-----	0.311
12	0.178	0.410	0.198	0.163	0.237
18	0.110	0.188	0.200	0.153	0.163
24	0.171	0.101	0.071	0.095	0.110
	(1.5 Kg ai/ha)				
6	-----	-----	-----	-----	-----
12	0.161	0.450	0.286	0.395	0.323
18	0.156	0.217	0.429	0.255	0.264
24	0.204	0.137	0.165	0.151	0.164

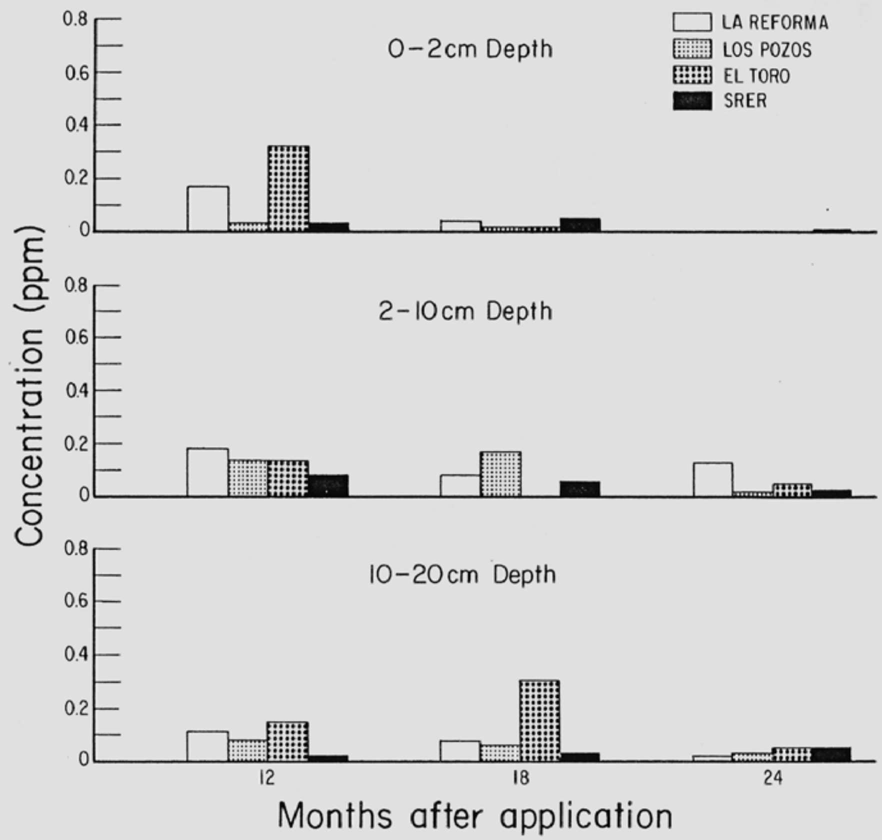

Figure 1. Tebuthiuron soil residues (ppm) over time at three soil depths after application of tebuthiuron at rates of 0.5 kg a. i./ha at four desert rangeland soils

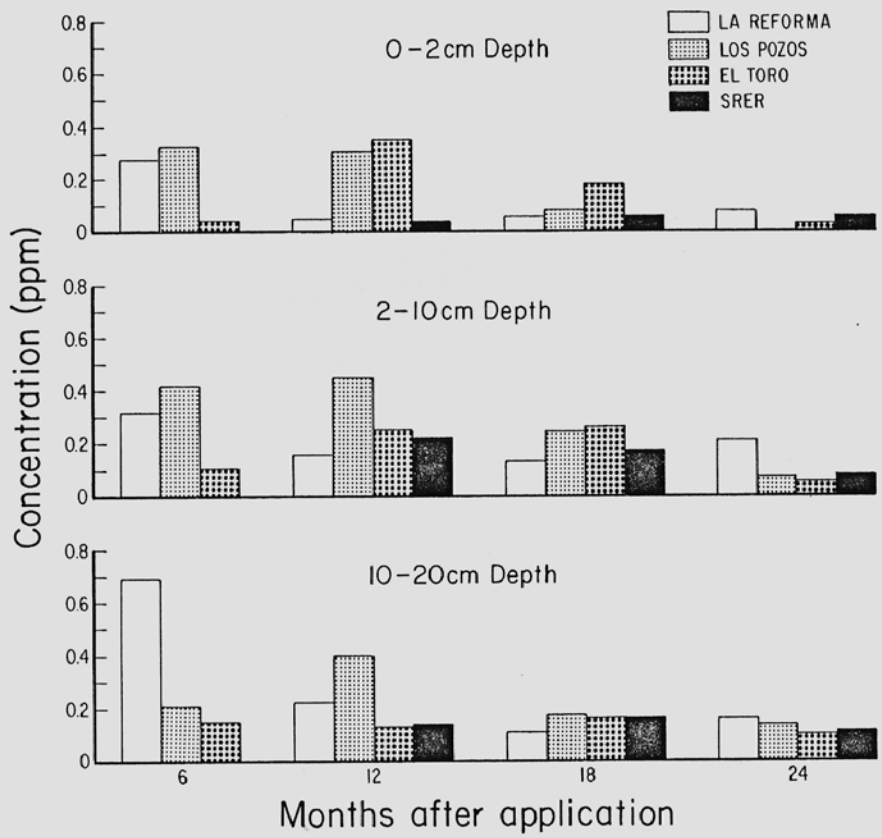

Figure 2. Tebuthiuron soil residues (ppm) over time at three soil depths after application of tebuthiuron at rates of 1.0 kg a. i./ha at four desert rangeland soils.

The greatest soil residues were found at La Reforma at all soil depths 24 months after tebuthiuron applications. Very similar tebuthiuron dissipation patterns were obtained on plots treated with 1.5 kg ai/ha rate, but higher concentrations were detected at all depths over time compared with the 0.5 and 1.0 kg ai/ha rates (Figure 3). Tebuthiuron residues were very well distributed across all soil depths during the first 12 months following herbicide application. However, 6 and 12 months later tebuthiuron residues dissipated from the top 2 cm of soil and soil residues were greater at 2-10 and 10-20 cm soil depths.

Data indicate that significant levels of tebuthiuron persist in the soil 24 months following herbicide application.

Greater levels of tebuthiuron were detected at La Reforma under all rates applied compared with the other locations. The higher organic matter content in soils at La Reforma may be reducing tebuthiuron dissipation to some degree. However, low precipitation occurred and the slightly higher clay content in the soil may also account for the slower tebuthiuron dissipation compared with the other locations.

Amount of precipitation following tebuthiuron application seems to directly influence herbicide dissipation in desert soils, and precipitation during the first 18 months following herbicide application seems to account for the greatest variations in tebuthiuron residues between locations. Tebuthiuron residues after the second rainy season were very similar between locations at plots treated at the same rate regardless of precipitation.

Significant ($P \leq 0.05$) regression equations were obtained with the application of both 0.5, 1.0 and 1.5 kg ai/ha when time (months) was regressed against tebuthiuron concentration (Figures 4, 5, and 6). Twenty-three, 32, and 32% of tebuthiuron was still present in the top 20 cm, 24 months after application of 0.5, 1.0 and 1.5 kg ai/ha, respectively. Using these equations it will take 31.5, 34, and 37 months for concentrations of tebuthiuron to reach undetectable levels after the application of 0.5, 1.0 and 1.5 kg/ha, respectively. These results are similar to those found by Emmerick et al. (7) in Tombstone, AZ after the application of 0.84 kg/ha of tebuthiuron in a watershed. They predict through a linear regression equation 2.9 years (34.8 months) for almost complete dissipation of tebuthiuron in the top 15 cm of soil.

A significant regression equation was also obtained when we graphed the rate of tebuthiuron applied versus the expected time of tebuthiuron disappearance (Figure 7). With this equation we can predict very closely the time of tebuthiuron disappearance from the top 20 cm of soil for given rates of tebuthiuron application.

Conclusions

When applied over a wide range of soil and vegetation types, tebuthiuron will dissipate from semiarid rangeland soils when applied for woody plant control. Based on linear regression equations, it is predicted that tebuthiuron will dissipate to undetectable levels in 3 years.

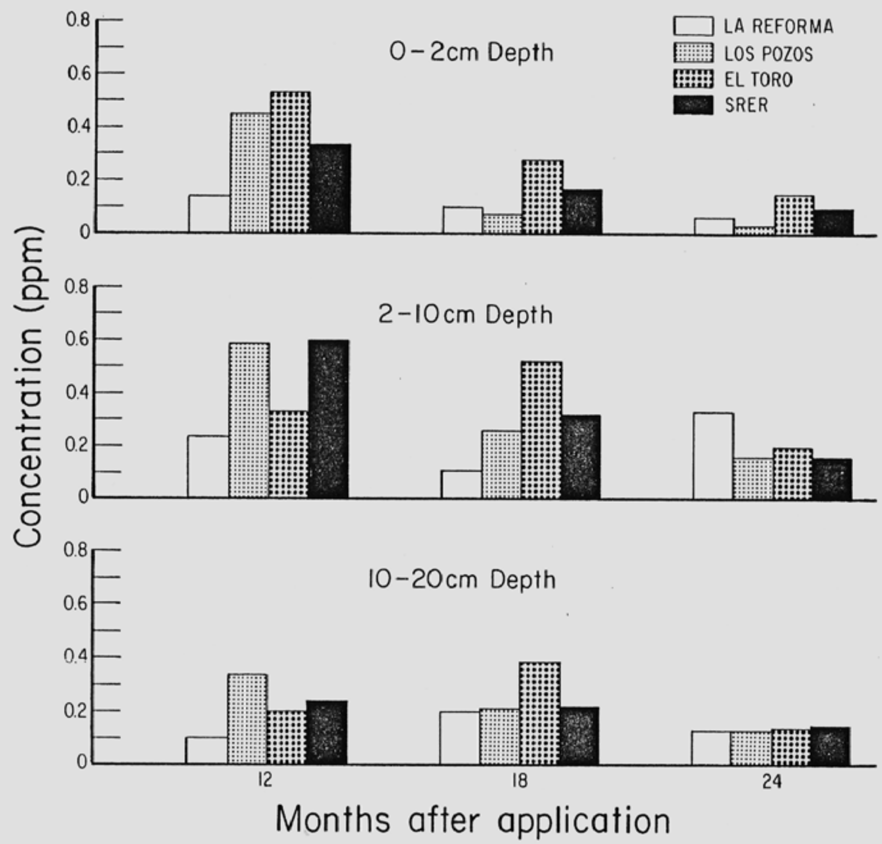

Figure 3. Tebuthiuron soil residues (ppm) over time at three soil depths after application of tebuthiuron at rates of 1.5 kg a. i./ha at four desert rangeland soils.

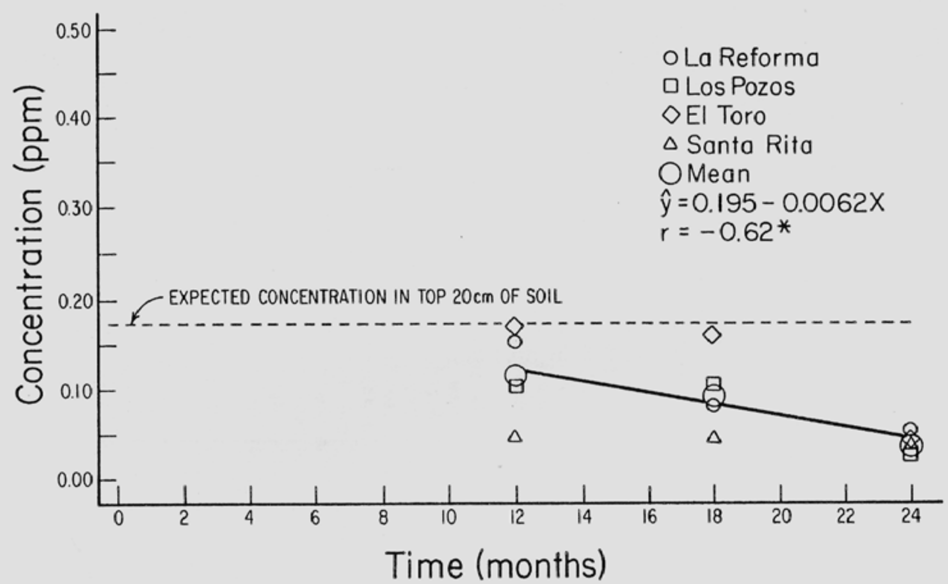

Figure 4. Tebuthiuron concentration in the top 20cm of soil after application at 0.5 kg a. i./ha at four locations.

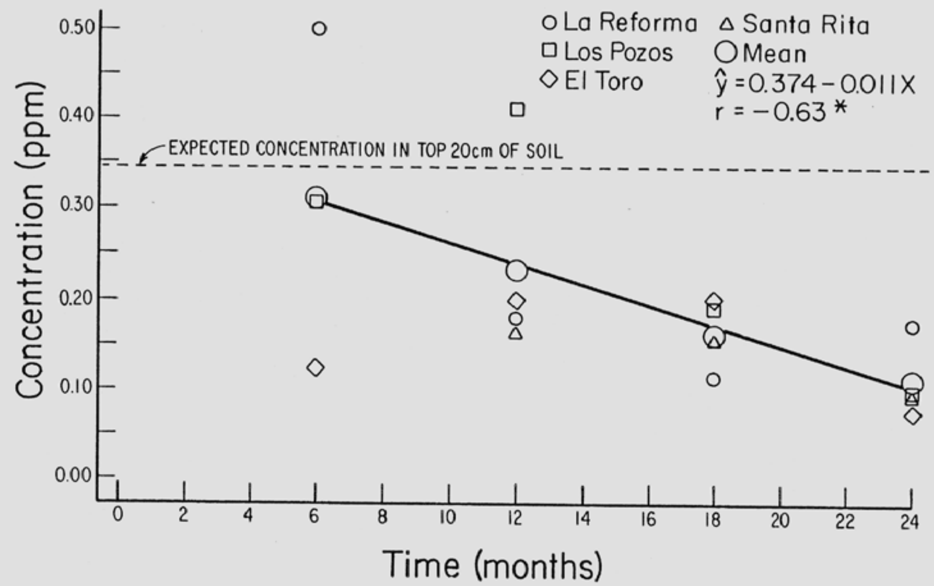

Figure 5. Tebuthiuron concentration in thr top 20cm of soil after application at 1.0 kg a. i./ha at four locations.

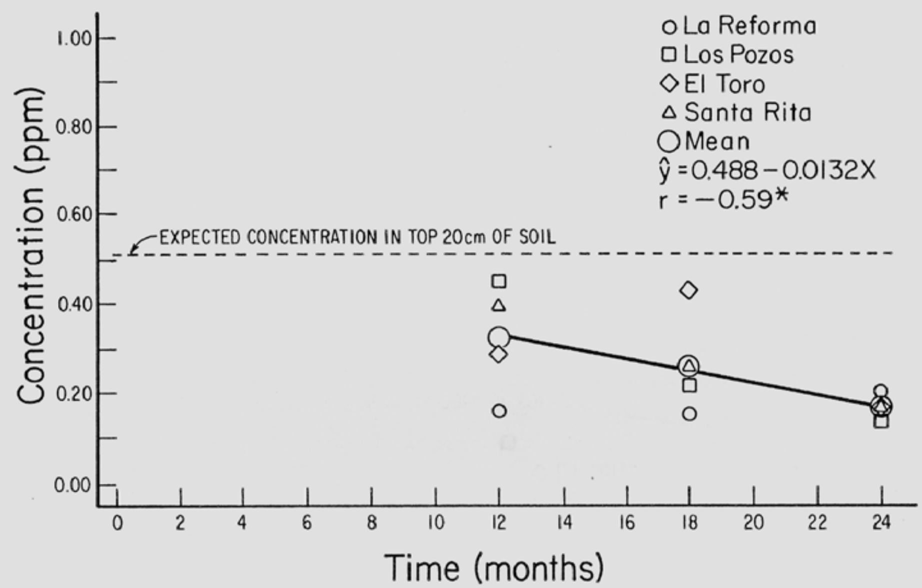

Figure 6 Tebuthiuron concentration in the top 20cm of soil after application at 1.5 kg a. i./ha at four locations.

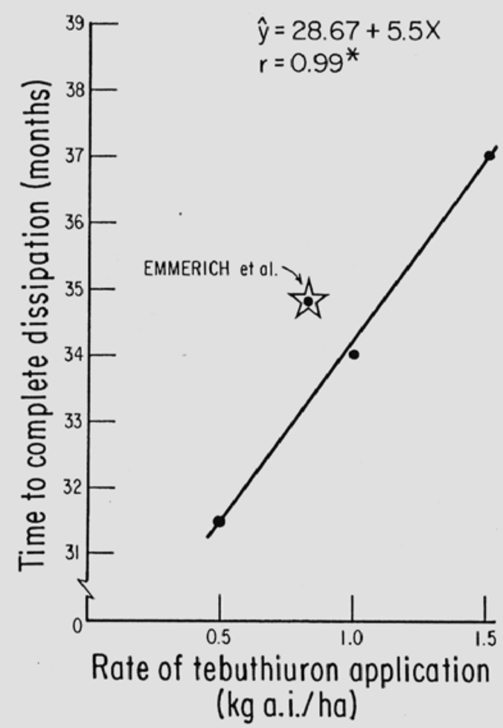

Figure 7. Expected time for complete dissipation of tebuthiuron from the top 20cm of semiarid rangeland soils.

Acknowledgements

We thank Consejo Nacional de Ciencia y Tecnologia, Martha Martin, Jerry Cox and Stephan Roth for assistance in the collection and analysis of data. We also thank Eloy Morales, Sergio Mendoza and Gilberto Valdez for permitting the field work on their ranches, and technical personnel of the ARS, USDA at Tucson, AZ and Rancho Experimental La Campana for superb assistance in making the treatments, collecting the data, and fellowship after the work was finished.

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BROOM SNAKEWEED CONTROL IN THE SOUTHWEST

Ronald W. Courtney and Ronald E. Sosebee[1]

Broom snakeweed (Gutierrezia sarothrae (Pursh) Britt. & Rusby) infests numerous acres throughout the western U.S., Canada and Mexico. It is more widespread and a serious range problem in the southwestern U.S. and Mexico. The literature suggests that infestations are cyclic and primarily dependent upon the climate. However, when infestations become severe, it is questionable whether the infestations are cyclic. When snakeweed dominates the plant community as it does on millions of acres in the Southwest, seemingly the only way that the community can be returned to productive rangeland is through chemical control.

Chemical control of snakeweed has been recommended for spring application when the plant is actively growing. Satisfactory control has often been erratic. Therefore, we initiated an intensive research program in October, 1980, to study timing, efficiency, and longevity of snakeweed control.

[1]Dept. of Range & Wildlife Management, Texas Tech University, Lubbock, TX.

Pilot research as well as research reported in the literature indicated that picloram (4-amino-3,5,6 trichloropicolinic acid) effectively control snakeweed. Therefore, we applied picloram at 0.25 and 0.5 lb ai/acre and picloram pellets (10% ai) at 0.5 lb ai/acre to 0.1 acre plots monthly from October, 1980, through September, 1981, and August, 1982, through December, 1983. The liquid herbicides were applied in aqueous solution with a boom sprayer mounted in the back of a pickup truck. The total volume/acre sprayed was 20 gal/acre. The pelleted herbicides were applied with an Ortho whirlybird seeder. All treatments were replicated three times at each location.

The study in 1980-81 included two locations in eastern New Mexico. Both locations included a Kimbrough soil (loamy, mixed, thermic, shallow family of Petrocalcic Calciustolls). The 1982-83 study involved six locations, including the same two from the 1980-81 study. Other locations involved three from eastern New Mexico and one from west Texas including a Patricia soil (fine-loamy, mixed, thermic family of Aridic Paleustalfs), a Brownfield soil (loamy, mixed, thermic Arenic Aridic Paleustalfs), and two Amarillo soils (fine-loamy, mixed, thermic Aridic Paleustalfs).

Phenolgocial stage of the snakeweed was recorded at the time of spraying. Ten plants per loctaion were collected on each herbicide application date for carbohydrate analysis. The plants were immediately identified and placed on dry ice until they could be returned to the lab for analysis. After drying at 60C in a forced-air oven for at least 4-5 days, the plants were dissected into small stems, large stems and roots, and ground to pass through a 40-mesh screen. Total non-structural carbohydrates were analyzed using spectrophotometry and anthrone as a reagent. Environmental parameters measured at the time of herbicide applications included air tempertaure, relative humidity, soil temperature at 6- and 12-inch depths and soil water content (0-6 and 6-12-inch depths). Soil temperature was measured with a glass, mercury-filled laboratory thermometer inserted at prescribed depths in a hole made with a 0.375 inch steel shaft. Soil water content was measured gravimetrically. Air temperature and relative humidity were measured with a standard weather bureau sling psychrometer.

Our research has revealed that the most consistent results can be obtained by spraying in the fall after the plants flower. The fall of 1980 and winter of 1981 had above average rainfall on our study areas, so the plants began to flower in late September - early October, 1980. They remained in flower through January and early February, 1981. We controlled 100% of the plants on the study areas when we sprayed with the liquid formulation of picloram at either .25 or .5 lb ai/acre in October and November, 1980, during anthesis and immediately after flowering. Less satisfactory control (50 to 75% reduction by weight, 0.24 and 0.5 lb ai/acre, respectively) was obtained in December, 1980.

Climatic conditions in 1982 and 1983 were less conducive for growth (below average precipitation during the summer and fall), but control followed a similar pattern to that obtained in 1980. Effective control (90% reduction by weight) was obtained when plants were sprayed during anthesis and immediately following flowering regardless of when it occurred.

Occasionally, effective control can be obtained during the winter or spring months if the plants are not actively growing vegetatively, but the results are less consistent than spraying in the fall. The risk of failure is greater when spraying is done in the spring. We have never obtained any satisfactory control when broom snakeweed was sprayed during the summer when the plants are vegetative.

No correlation was obtained between environmental variables and control as long as antecedent soil water was sufficient for the broom snakeweed plants to be physiologically active and for flowering to occur normally. Drought-stricken plants that were quiescent and did not flower were not susceptible to herbicidal control.

Our recommendations would be to spray broom snakeweed during anthesis or immediately after flowering.

INFLUENCE OF TEBUTHIURON FORMULATION ON CONTROL OF WOODY PLANTS AND FORAGE PRODUCTION[1,2]

Howard L. Morton

Abstract: Tebuthiuron (*N*-(5-(1,1-dimethylethyl)-1,3,4-thiadiazol)-*N,N'*-dimethylurea), formulated as cylindrical pellets 3.2 or 4.8 mm in diameter and containing from 10 to 60% active ingredient was applied at rates ranging from 0.6 to 4.5 kg ai/ha to determine the effects of formulation on control of woody plants and forage production. Tebuthiuron killed an increasing percentage of velvet mesquite (*Prosopis juliflora* var. *velutina* (Woot.) Sarg.) plants as the rate of application increased from 0.6 to 4.5 kg ai/ha. Rates of 2.2 kg ai/ha and above killed 46% or more of the velvet mesquite plants. Tebuthiuron killed an increasing percentage of catclaw acacia (*Acacia greggii* A. Grey) plants as the rates of application increased from 0.6 to 2.2 kg ai/ha with rates of 2.2 and 4.5 kg ai/ha killing all plants. Tebuthiuron killed over 90% of the wait-a-minutebush (*Mimosa biuncifera* Benth.) plants at all rates of application. Concentration and size of pellet generally did not significantly affect the percentage of woody plants killed but the formulation containing 10% ai was consistently less effective at the same rates than formulations containing higher concentrations. Forage production the first year after treatment was generally reduced on plots treated with pellets containing 10 or 20% ai when applied at rates of 2.2 kg ai/ha. However, by the third year after treatment forage production was usually higher on plots treated at rates of 2.2 kg ai/ha than on plots treated at lower rates. Forage production

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[1]ARS/USDA, Tucson, AZ.

[2]Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U.S. Dept. of Agric. and does not imply its approval to the exclusion of other products that may also be suitable.

increased with time after treatment on plots treated with tebuthiuron and usually peaked between three and five years after treatment.

Introduction

Tebuthiuron is a thiadiazole urea herbicide which has been shown to be effective for control of many herbaceous and woody plants in pastures and rangelands (1, 4, 5, 7, 8, 9, 10, 11). The formulated products used for weed and brush control on rangelands are cylindrical clay pellets 3.2 mm in diameter and approximately 4.8 mm in length. The pellets are formulated with tebuthiuron concentrations of 10, 20, or 40% active ingredient (ai). All the commercial formulations have a bulk density of about 1 kg/cubic decimeter (60 lb/ft^3) (6). There are about 17,500 particles per kg. When the 10, 20, and 40% pellets are broadcast, there are about 17.6, 8.8 and 4.4 $pellets/m^2/kg$ ai applied. While pelleted formulations reduce drift of aerially applied herbicides, they also increase selectivity. As the number of particles applied per unit area decreases, there is less likelihood that a pellet will be deposited upon a non-target plant. This study was conducted to determine the effects of concentration and size of tebuthiuron pellets on the control of woody plants, injury to herbaceous plants, and forage production.

Materials and Methods

The first study site was in the Alambre Valley of the Papago Indian Reservation, Pima County, AZ. The elevation is 1060 m and average annual precipitation is 325 mm. The soils are a moderately deep to deep gravelly sandy loam and are Typic Torrifluvents, coarse-loamy, mixed thermic. The site is classified as a semi-desert grassland (2) but has experienced a dramatic increase in density of wait-a-minutebush, velvet mesquite, and catclaw acacia which are now the dominant plants. The herbaceous vegetation was a thin stand of perennial grasses composed primarily of blackgrama (*Bouteloua eriopoda* Torr.), Arizona cottontop (*Digitaria californica* (Benth.) Henr.), and Rothrock grama (*B. rothrockii* Vassey). Annual grasses present were sixweeks threeawn (*Aristida adscensionis* L.) and feather finger grass (*Chloris virgata* Swartz). Tebuthiuron pellets 3.2 mm in diameter containing 10, 20 and 40% ai were each applied by hand at rates of 0.6, 1.1, 2.2, and 4.5 ai kg/ha to plots 15 by 30 m on February 22, 1974. Grazing was excluded from the treated plots after the second year.

The second study site was on the Santa Rita Experimental Range, Pima County, AZ. The elevation is 1200 m and average annual precipitation is 350 mm. The soils are a Whitehouse, gravelly fine sandy loam, (Ustollic Haplargids, fine, mixed, thermic). The dominant woody plant was velvet mesquite. The half-shrub, false mesquite (*Calliandra eriophylla* Benth.) was also uniformly present on the plots. The most abundant herbaceous plants were Lehmann lovegrass (*Eragrostis lehmanniana* Nees), Arizona cottontop, plains bristlegrass (*Setaria macrostachya* H.B.K.), slender grama (*B. filiformis* (Fourn.) Griffiths), sideoats grams (*B. curtipendula* (Michx.) Torr.), Rothrock grama, and poverty threeawn (*A. divericata* Hum. & Bonpl.). Tebuthiuron was applied in pellets which were 3.2 mm in diameter and contained 20% ai, and in pellets which were 4.8 mm in diameter and contained 20, 40, or 60% ai. Each formulation was applied at rates of 1.1, and 2.2 kg ai/ha to plots 15 by 60 m on August 27, 1976. This study site was grazed as prescribed by the 3-pasture 1-herd, Santa Rita Grazing System, which scheduled grazing during the summer growing season 1 year out of 3. At both study sites woody plant mortalities were estimated about 3 years after treatment by counting dead and living plants of each species and calculating percentage of plants killed. Forage production was estimated using the weight-estimate method 2 and 3 years after treatment at the Alambre site and 1, 3 and 5 years after treatment on the Santa Rita Experimental Range site. The experimental design was a randomized complete block with three replications. Data were subjected to analyses of variance and when appropriate, means were evaluated for significant differences by Duncan's multiple range test.

Results and Discussion

Alambre Study Site. The percentage of velvet mesquite plants killed increased with increasing rates of tebuthiuron application (Table 1). There were statistically non-significant, but consistently greater percentages of velvet mesquite plants killed by the 20% formulation than by the 10 or 40%.

Table 1. Percentage of velvet mesquite plants killed 42 months after treatment with three formulations of pelleted tebuthiuron applied at four rates[a]

Formulation		Rate of application kg a.i./ha				
conc.	dia.	0.0	0.6	1.1	2.2	4.5
(%)	(mm)	(%)				
10	3.2	-	12c	50ab	60ab	98a
20	3.2	-	65ab	78ab	88ab	100a
40	3.2	-	42b	68ab	95ab	98a
0	-	6c				

[a]Means in the same growing season followed by the same letter are not significantly different at the 5% level of probability.

Tebuthiuron did not consistently kill catclaw acacia plants at the 0.6 and 1.1 kg ai/ha rates (Table 2) but killed all plants at the 2.2 and 4.5 kg ai/ha rates.

All formulations of tebuthiuron killed more than 90% of the wait-a-minutebush plants at all rates (Table 3).

Table 2. Percentage of catclaw plant killed 42 months after treatment with three formulations of pelleted tebuthiuron applied at four rates[a]

Formulation		Rate of application kg a.i./ha				
conc.	dia.	0.0	0.6	1.1	2.2	4.5
(%)	(mm)	(%)				
10	3.2	-	20cd	85ab	100a	100a
20	3.2	-	60abc	40bcd	100a	100a
40	3.2	-	75ab	75ab	100a	100a
0	-	16d				

[a]Means in the same growing season followed by the same letter are not significantly different at the 5% level of probability.

Forage production generally increased with increasing rates of tebuthiuron (Table 4). However, forage production was variable in both the third and fourth growing seasons after treatment. Highest forage production was usually found on plots treated at the 1.1 kg ai/ha rates in the third growing season but more frequently were found on the plots treated at 2.2 and 4.5 kg ai/ha in the fourth growing season after treatment. This suggests that with time the forage plants were increasing in density and vigor on the plots treated at the higher rates. Forage production was about two to three times higher in the fourth year after treatment than in the third. Total precipitation in the thirfd and fourth years of the study were 434 and 307 mm, respectively. The higher forage production in the fourth year was probably due to increasing density of forage plants; and as Cable (3) pointed out, forage production is influenced by both current year and previous year precipitation.

Table 3. Percentage of wait-a-minutebush plants killed 42 months after treatment with three formulations of pelleted tebuthiuron applied at four rates[a]

Formulation conc. (%)	dia. (mm)	0.0	0.6	1.1	2.2	4.5
		Rate of application kg a.i./ha (%)				
10	3.2	-	98a	100a	95a	98a
20	3.2	-	92a	98a	100a	100a
40	3.2	-	100a	100a	100a	100a
0	-	14b				

[a]Means in the same growing season followed by the same letter are not significantly different at the 5% level of probability.

Correlation coefficients were calculated between percentage woody plants killed and forage production. They showed that production increased with increasing percentages of mesquite and catclaw acacia killed (Table 5). The relationship was not true for wait-a-minutebush because this plant proved to be very sensitive to tebuthiuron and even the lowest rate was very effective. Multiple correlation calculations were made involving forage production and the three shrub species but no significant correlations were found.

Santa Rita Study Site. Tebuthiuron killed more velvet mesquite plants at the 2.2 than at the 1.1 kg ai/ha (Table 6). The 20%, 3.2 mm tebuthiuron formulation killed more velvet mesquite plants than the other formulations.

Forage production during the year of treatment was lowest on the plots treated at the 2.2 kg ai/ha rate with 20%, 3.2 mm formulation and highest on the plots treated at 1.1 kg/ha rate with the 20% 4.8 mm pellets. As pellet size and concentration of tebuthiuron increased, forage production increased, suggesting that the lower number of pellets applied to each plot caused less injury to forage plants. This trend was also evident in the

Table 4. Forage production during the third and fourth growing seasons after treatment with three formulations of tebuthiuron at four rates[a]

Formulation		Rate of application kg a.i./ha				
conc.	dia.	0.0	0.6	1.1	2.2	4.5
(%)	(mm)	(Dry wt kg/ha)				
		Third Growing Season				
10	3.2	-	385bc	307c	376c	604abc
20	3.2	-	274c	865ab	590abc	398abc
40	3.2	-	142c	1056a	368c	424bc
-	-	278c				
		Fourth Growing Season				
10	3.2	-	627cd	1062bcd	1044bcd	1319abc
20	3.2	-	711cd	1004bcd	1720ab	1889a
40	3.2	-	431d	1444abc	981bcd	873cd
-	-	530d				

[a]Means in the same growing season followed by the same letter are not significantly different at the 5% level of probability.

Table 5. Correlation coefficients (r) and linear regression equations for the mortalities of three brush species versus forage production.

Relationship	r	Regression equation
% killed mesquite (X) vs. forage production (Y)	0.63*	Y = 454.8 + 8.0 X
% killed catclaw (X) vs. forage production (Y)	0.55*	Y = 455.3 + 7.0 X
% killed wait-a-minute (X) vs. forage production (Y)	0.45	Y + 393.2 + 6.4 X

Table 6. Percentage of velvet mesquite plants killed 38 months after treatment with four pelleted formulations of tebuthiuron applied at two rates[a]

Formulation		Rate kg a.i./ha		
Conc.	dia.	0.0	1.1	2.2
(%)	(mm)	--------------(%)-------------		
20	3.2		17c	66a
20	9.5		12c	47b
40	9.5		11c	59ba
60	9.5		7c	46b
-check-		0c		

[a]Means followed by the same letter are not significantly different at the 5% level of probability.

Table 7. Forage production during year of treatment with three pelleted formulations of tebuthiuron at two rates[a]

Formulation		Rate of application (Kg/ha)		
Conc.	dia.	0.0	1.1	2.2
(%)	(mm)	--------------(Kg/ha)--------------		
20	3.2	-	707abc	336c
20	4.8	-	1111a	763abc
40	4.8	-	725abc	958ab
60	4.8	-	585bc	935ab
0	-	694abc		

[a]Means followed by the same letter are not significantly different at the 5% level of probability.

third year after treatment (Table 8), but the differences in forage production were not evident during the fifth year after treatment (Table 9). This was due to the reestablishment of forage plants on the plots treated at the 2.2 kg ai/ha rate and the dominance of the area by Lehmann lovegrass.

From this study, I conclude that the effectiveness of tebuthiuron for brush control is not consistently affected by pellet size or tebuthiuron concentration, but these factors do influence injury to forage plants and can influence forage production for up to 3 years after treatment.

Table 8. Forage production three years after treatment with four pelleted formulations of tebuthiuron at two rates[a]

Formulation		Rate (Kg/ha)		
Conc.	dia.	0.0	1.1	2.2
(%)	(mm)	---------------(Kg/ha)-------------		
20	3.2	-	1364a	846b
20	4.8	-	1260ab	1098ab
40	4.8	-	890b	1170ab
60	4.8	-	1110ab	1500a
0	-	1245a		

[a]Means followed by the same letter are not significantly different at the 5% level of probability.

Table 9. Forage production five years after treatment with three pelleted formulations of tebuthiuron at two rates[a]

Formulation		Rate (Kg/ha)		
Conc.	dia.	0.0	1.1	2.2
(%)	(mm)	(Kg/ha)		
20	3.2	-	1172	920
20	4.8	-	924	1381
40	4.8	-	1214	1291
60	4.8	-	1058	1212
0	-	1048		

[a]Means not significantly different at the 5% level of probability.

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LONG-TERM EFFECTS ON VEGETATION OF HERBICIDE TREATMENTS IN CHAPARRAL

Jodie S. Holt, Steven R. Radosevich, and Walter L. Graves[1]

Abstract: Field studies were established in 1974 and 1975 at various locations in San Diego County, California, to evaluate several herbicides for the control of chamise (*Adenostoma fasciculatum* H. & A.) and redshank chamise (*Adenostoma sparsifolium* Torr.). These experiments were re-evaluated in 1982 for long-term herbicide effects on vegetation. Chamise-dominated plots originally treated with glyphosate (N-(phosphonomethyl) glycine) had virtually no regrowth 8 yr after treatment. Other herbicides used, including 2,4-D ((2,4-dichlorophenoxy)acetic acid), 2,4-D + 2,4,5-T ((2,4,5-trichlorophenoxy)acetic acid), fosamine ((ethyl hydrogen (amino-carbonyl)phosphonate), triclopyr (((3,5,6-trichloro-2-pyridinyl)oxy)acetic acid), 2,4-D + dichlorprop (2-(2,4-dichlorophenoxy) propionic acid), tebuthiuron (N-(5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl)-N,N'-dimethylurea), and picloram (4-amino-3,5,6-trichloropicolinic acid) had no long-term effects on chamise. Soil collected in 1982 from glyphoste-treated plots contained similar numbers of chamise seeds, but fewer seeds of other species as compared to non-herbicide treated plots. Redshank chamise regrew to complete canopy coverage after 8 yr, regardless of herbicide used. These results demonstrate the effectiveness of glyphosate in killing the underground root-crown of chamise which prevented sprouting, and thereby converted the vegetation to herbaceous cover.

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[1]University of California, Riverside, CA.

CHEMICAL AND MECHANICAL CONTROL OF WOODY PLANTS IN THE CREOSOTEBUSH TYPE OF THE CHIHUAHUAN AND SONORAN DESERTS

Fernando A. Ibarra and Howard L. Morton[1]

Abstract: Tebuthiuron (N-(5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl)-N-N'-dimethylurea) at rates of 0.5, 1.0, and 1.5 kg ai/ha, land imprinting, two-way railing, disk plowing, and disk plowing plus contour furrowing treatments were applied at three locations in the Chihuahuan desert in the state of Chihuahua, Mexico and one location in the Sonoran Desert in the State of Arizona, United States of America which were infested with creosotebush (*Larrea tridentata* (DC.) Coville). Treatments were applied during the spring and summer of 1981. Averge creosotebush mortalities at all four sites for the seven treatments in the order indicated above were 51, 71, 88, 12, 28, 81 and 81%, respectively, in fall of 1983. Whitethorn acacia (*Acacia consricta* Benth.) mortalities were 47, 78, 92, 11, 42, 84, and 81% respectively. Mariola (*Parthenium incanum* H.B.K.) mortalities were 51, 71, 89, 13, 38, 83 and 85%, respectively. Mesquite (*Prosopis glandulosa* (Swartz) DC) mortalities were 24, 45, 73, 8, 21, 74, and 74%, respectively. Wait-a-minutebush (*Mimosa biuncifera* Benth.) mortalities were 33, 82, 86, 0, 39, 76 and 84%, respectively. Whitebrush (*Aloysia lycioides* Cham.) mortalities were 76, 93, 98, 10, 61, 94 and 92%, respectively. Tarbush (*Flourencia cernua* DC.) mortalities were 66, 85, 94, 11, 33, 83 and 85%, respectively. All *Opuntia* species were not damaged by tebuthiuron but were significantly reduced by the mechanical treatments. Total aboveground standing crop of annual and perennial grasses increased over 100% in the Sonoran desert site following below average summer rainfall, 50 and 100% at two Chihuahuan desert sites following below average rainfall, and was reduced at one Chihuahuan desert site following below average rainfall in fall 1983.

Introduction

Creosotebush and associated species in the Chihuahuan and Sonoran desert ecosystems are of interest to Range Managers because of their wide distribution, adaptation to drought and lack of forage value. These species are important because of their invasion into large areas of the desert grassland types (4, 6, 9). Creosotebush is one of the most common and widely distributed shrubs in North American Deserts. This species either alone or in combination with other desert shrubs covers 26.3 million hectares in the United States and approximately 45.3 million hectares in Mexico. Recent studies indicate that creosotebush is expanding into new desert grasslands on an average of 1.6 km every year (2).

Once established, creosotebush and associated species cannot be reduced in density by proper grazing management alone and some mechanical and chemical treatments are required. Generally, foliage wetting sprays produce effective control of many shrubby species, but most have not worked on creosotebush. Of the wetting sprays, repeated applications of dicamba

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[1]Graduate Research Assistant, School of Renewable Natural Resources, University of Arizona and Plant Physiologist, USDA/ARS, Arid Land Ecosystems Improvement, Tucson, AZ.

(3,6-dichloro-*o*-anisic acid), and 2,4,5-T (2,4,5-trichlorophenoxy)acetic acid), plus picloram (4-amino-3,5,6-trichloropicolinic acid) have been among the most effective herbicides for creosotebush control (5, 13). Pelleted formulations of picloram, monuron (3-(*p*-chlorophenyl)-1,1-dimethylurea), fenuron (1,1-dimethyl-3-phenylurea mono)trichloroacetate), bromacil (5-bromo-3-*sec*-butyl-6-methyluracil) and tebuthiuron have been very effective for creosotebush control (5, 6, 7, 10). Of these herbicides, tebuthiuron has been shown to be the most effective herbicide for control of creosotebush and some associated brush species on rangelands in the Southwest United States (1, 10, 12).

Mechanical treatments such as root plowing and disking are among the oldest methods of controlling shrubby vegetation. However, because these operations generally destroy herbaceous vegetation this practice should be limited to areas where complete plant removal is needed followed by reseeding. In order to be effective any mechanical treatment should be able to cut off the plant base below the crown. Chaining, railing, rolling brush cutter and rotary mowing have not given long lasting plant control. However, these practices supress growth of shrubs for 2 to 5 years and temporarily release native grasses.

The objectives of this study were: To determine the effectiveness of the granular herbicide tebuthiuron for brush control of creosotebush and associated species. To determine the effectiveness of land imprinting, two-way railing, disking and disking plus contour furrowing for control of creosotebush, and to evaluate the response of native forage plants to tebuthiuron and these mechanical brush control methods.

Materials and Methods

Four locations, three in Chihuahua, Mexico and one in Arizona, United States of America, were selected to evaluate several brush control methods and the response of native grass species. The Chihuahuan locations are Rancho La Reforma at Allende, Rancho Los Pozos at Aldama, Rancho El Toro at Villa Ahumada, and the Arizona location is Santa Rita Experimental Range (SRER) at Tucson.

Rancho La Reforma is at an elevation at 1500 m, with an average precipitation of 400 mm. The major brush species are whitethorn acacia, tarbush, creosotebush and shrubby senna (*Cassia wislizeni* Gray.). The major grass species are: spike pappus grass (*Enneapogon desvauxii* Beauv.), fluffgrass (*Tridens pulchellus* (H.B.K.) Hitchc.) and black grama (*Bouteloua eriopoda* Torr.). Rancho Los Pozos is at an elevation of 1400 m, with an average precipitation of 253 mm. The major brush species are creosotebush, mariola, whitethorn, and tarbush. The major grass species are: fluffgrass, threeawn (*Aristida* spp.) and spike pappusgrass. Rancho El Toro is at an elevation of 1380 m, with an average precipitation of 170 mm. The major brush species are creosotebush, whitethorn and mesquite. The major grass species are black grama, fluffgrass and bushmuhly (*Muhlenbergia porterii* Scribn.). Santa Rita Experimental Range is at an elevation of 968 m, with an average precipitation of 290 mm. The major brush species are creosotebush, desert zinnia (*Zinnia pumila* Gray), and mesquite. Major grass species are fluffgrass, bushmuhly and threeawns. Soil physical and chemical characteristics of the study areas are shown in Table 1.

Table 1. Physical and chemical properties of soils at three Chihuahuan and one Sonoran desert site.

	% soil particles						OM		EC
Location	< 2 mm	> 2 mm	sand	silt	clay	Texture class	%	pH	Mmhos/cm
La Reforma	55	45	59	26	15	Sandy Loam	3.6	6.9	2.9
Los Pozos	71	29	60	29	11	Sandy Loam	1.5	7.2	1.3
El Toro	77	23	66	24	10	Sandy Loam	1.1	7.9	1.1
SRER	83	17	58	28	11	Sandy Loam	0.7	7.9	1.1

Treatments applied were broadcast applications of 20% pellets of tebuthiuron at 0.5, 1.0, and 1.5 kg ai/ha; land imprinting; two-way railing; disk plowing and disk plowing plus contour furrowing. Tebuthiuron was hand broadcast in May of 1981. Mechanical treatments were applied in June of 1981. Land imprinting was accomplished by pulling a land imprinter weighing 2050 kg with a track tractor. Because of equipment problems, land imprinting was performed only at Rancho Los Pozos and Santa Rita Experimental Range. Two-way railing was accomplished by dragging railroad rails weighing 770 kg which were fashioned in a triangular form, twice over the area with a track tractor. In addition, railroad spikes were welded on the back rail and extended 3 inches below the soil surface in order to improve brush mortality. Disk plowing was accomplished by using a disk plow with three 64 cm diameter disks. Furrowing was accomplished at 10 cm slope intervals on the contour.

Brush mortality was calculated after the growing season of 1983 on plots treated in 1981. Brush density by species was estimated by using a 44 m^2 circular quadrat. Ten randomly placed quadrats were used per plot. Brush mortality was calculated as a percentage of untreated check.

Forage production was estimated in fall of 1983 by using the weight estimate technique, where 5 samples were clipped and 20 estimated in each plot. Quadrat size was 1800 cm^2. Standing above-ground biomass was harvested separately by annual and perennial grasses. Forage was dried at 40C for 48h.

The study design was a randomized complete block with 8 treatments and 3 replications. Brush mortality was first compared by species across treatments at each location. Then, brush mortality of creosotebush was compared across treatments and locations. Total forage production and the annual and perennial components were compared across treatments within each location. Data were subjected to analyses of variance and when significant ($P \leq 0.05$) differences were detected, means were separated by Duncan Multiple Range Test (14).

Results and Discussion

Amount and distribution of precipitation was very variable across sites in 1981, 1982, and 1983. At Rancho La Reforma the precipitation was below average in all years. At Rancho Los Pozos precipitation was average in 1981 and below average in 1982 and 1983. At Rancho El Toro the precipitation was average in 1981 and below average in 1982 and 1983. At SRER summer rain was below average but winter rain was above average in 1981 and both summer and winter rain were above average in 1982 and 1983.

Brush mortality. Results obtained indicate a highly significant difference between treatments for brush control. Percentage mortality by species across treatments at each location are summarized in Tables 2, 3, 4 and 5. The greatest percent of plant mortality was obtained with either tebuthiuron at a rate of 1.5 kg ai/ha or disk plowing and disk plowing plus contour furrowing. All cactus species, walkingstick cholla (*Opuntia imbricata* (Haw.) DC.), tasajillo (*Opuntia leptocaulis* DC.), and priclypear (*Opuntia* spp.), showed high resistance to all rates of tebuthiuron. However, these species were very susceptible to disk plowing. Mesquite was the most resistant species to mechanical treatments.

Tarbush, shrubby senna, javelina brush (*Condalia ericoides* (A. Gray) M.C. Johnston), fern acacia (*Acacia angustissima* (Mill.) Kuntze), whitebrush, desert zinnia, broom snakeweed (*Xanthocephalum sarothrae* (Pursh) Britt. and Rusby) and coldenia (*Coldenia canescens* DC.) were very susceptible to tebuthiuron at a rate of 0.5 kg ai/ha at all sites. However, creosotebush, mesquite, whitethorn, mariola, wait-a-minutebush, catclaw acacia (*Acacia greggii* A. Gray), ratany (*Krameria* spp), little leaf desert sumac (*Rhus microphilla* Engelm.), burroweed (*Haplopappus tenuisectus* (Greene) Blake) and granjeno (*Celtis pallida* Torr.) were less susceptible to the low rate, but were controlled with tebuthiuron at 1.0 and 1.5 kg ai/ha.

Two-way railing and land imprinting resulted in the lowest percent of plant mortality. However, two-way railing was statistically superior to land imprinting for most of the species at all locations, but these treatments were not effective in controlling brush, because these practices only remove the shoots of the plants and suppress shrubby vegetation for a period of 2 to 5 years.

When mechanical creosotebush control was compared between locations, no significant differences were found, even though there were large differences in soils and precipitation between locations (Table 6). However, when chemical creosotebush control was compared between locations, two significant differences were detected between treatments. A greater percent of mortality was found at El Toro and SRER on chemically treated plots compared with La Reforma and Los Pozos. The inferior rate of mortality obtained at La Reforma and Los Pozos may be because the amount of precipitation was not enough to leach the herbicide and move it near the

Table 2. Brush Mortality (%) after three chemical and four mechanical treatments applied at Rancho La Reforma, Chihuahua, Mexico, in June 1981. Data collected in Oct. 1983.

Species	TREATMENTS Tebuthiuron kg a.i/ha. 0.5	1.0	1.5	Land Imprinting	Two-way Railing	Disk Plowing	Disk Plowing with Furrowing
	(% of Control)						
Creosotebush	27c	44b	74a	=	27c	82a	83a
Whitethorn acacia	48b	77a	84a	=	37b	82a	79a
Tarbush	75a	85a	90a	=	40b	81a	85a
Mariola	67bc	82ab	82ab	=	38c	83ab	86a
Mesquite	16b	33b	62a	=	16b	61a	65a
Shrubby senna	65b	93a	96a	=	46b	92a	86a
Wait-a-minute-bush	33b	82a	86a	=	39b	76a	84a
Javelina brush	69c	82b	96a	=	39d	89ab	86ab
Whitebrush	82ab	95a	98a	=	75b	94b	88ab
Fern acacia	90ab	96ab	99a	=	43c	83b	85ab
Range ratany	28c	68ab	86a	=	62b	85a	84a
Tasajillo	0c	0c	0c	=	47b	80a	73a
Walkingstick cholla	0c	0c	0c	=	32b	79a	82a
Pricklyp ar	0c	0c	0c	=	16b	83a	75a
Littleleaf sumac	16d	42bc	69a	=	25cd	67a	63ab
Granjeno	18b	52a	65a	=	16b	53a	67a
Catclaw acacia	23c	54b	76a	=	31c	73a	75a

a/ Means in the same row followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan's Multiple Range Test.

Table 3. Brush Mortality (%) after three chemical and four mechanical treatments applied at Rancho Los Pozos, Chihuahua, Mexico., in June 1981. Data collected in Oct. 1983[a].

	TREATMENTS						
	Tebuthiuron kg a.i./ha.			Land	Two-way	Disk	Disk Plowing
Species	0.5	1.0	1.5	Imprinting	Railing	Plowing	with Furrowing
	(% of Control)						
Creosotebush	46c	65b	85a	14d	34c	82a	83a
Whitethorn acacia	55c	80b	95a	10d	44c	89ab	85ab
Tarbush	53b	76a	92a	11c	36c	81a	85a
Mariola	34c	60b	88a	13d	37bc	82a	83a
Mesquite	18cd	39b	71a	9d	25bc	76a	79a
Whitebrush	69b	91a	98a	10d	46c	93a	95a
Tasajillo	0d	0d	0d	9c	43b	89a	94a
Pricklypear	0d	0d	0d	14c	35b	83a	85a
Catclaw acacia	38c	65b	97a	13d	33c	86a	90a

[a]Means in the same row followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan's Multiple Range Test.

Table 4. Brush Mortality (%) after three chemical and four mechanical treatments applied at Rancho El Toro; Chihuahua, Mexico, in June 1981. Data collected in Oct. 1983[a].

	TREATMENTS						
	Tebuthiuron kg a.i./ha.			Land	Two-way	Disk	Disk Plowing
Species	0.5	1.0	1.5	Imprinting	Railing	Plowing	with Furrowing
	---(% of Control)---						
Creosotebush	77b	94a	99a	=	26c	88ab	89ab
Tarbush	71c	95ab	100a	=	23d	86b	86b
Mesquite	40c	60b	76ab	=	18d	80a	78a
Javelina brush	92a	99a	100a	=	39b	86a	91a
Tasajillo	0c	0c	0c	=	56b	84a	84a
Pricklypear	0c	0c	0c	=	46b	82a	88a
Desert zinnia	77b	87ab	100a	=	76b	92ab	93ab
Broom snakeweed	53b	90a	98a	=	87a	95a	97a
Spiny allthorn	17c	32b	73a	=	20bc	77a	80a
Coldenia	89a	97a	100a	=	44b	87a	86a

[a]Means in the same row followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan's Multiple Range Test.

Table 5. Brush Mortality (%) after three chemical and four mechanical treatments applied at SRER, Arizona, USA, in June 1981. Data collected in Oct. 1983[a].

	TREATMENTS						
	Tebuthiuron kg a.i./ha			Land	Two-way	Disk	Disk Plowing
Species	0.5	1.0	1.5	Imprinting	Railing	Plowing	with Furrowing
	(% of Control)						
Creosotebush	54c	79ab	95a	9d	23d	70bc	69bc
Whitethorn acacia	37c	76b	97b	11d	46c	82b	80b
Mesquite	23c	49b	81a	7d	24c	78a	75a
Tasajillo	0c	0c	0c	9c	34b	83a	83a
Walkingstick cholla	0d	0d	0d	9c	27b	84a	80a
Pricklypear	0d	0d	0d	8c	39b	76a	82a
Burroweed	49b	83a	96a	21c	41b	85a	86a
Desert zinnia	81bc	96a	96a	15d	71c	92a	90a

[a]Means in the same row followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan's Multiple Range Test.

Table 6. Creosotebush control with three chemical and three mechanical treatments at four locations across the Chihuahuan and Sonoran deserts. Treatments applied June 1981. Data collected in fall 1983.

	TREATMENTS								
	Tebuthiuron Kg a.i./ha			Herbicide	Two-Way	Disk	Disk Plowing	Mechanical	Location
	0.5	1.0	1.5	Mean	Railing	Plowing	with Furrowing	Mean	Mean
La Reforma	27	44	74	48	27	82	83	64	56
Los Pozos	46	65	85	65	34	82	83	66	66
El Toro	77	94	99	90	26	89	88	68	79
SRER	54	79	95	76	23	70	69	54	65
Treatment mean	51	71	88		28	81	81		

root zone of the plants. The high organic matter content found in La Reforma soils may also account for the reduced percent of mortality. Change and Stritzke (3) indicate that tebuthiuron dissipation in soil decreases as organic matter, exchange capacity and silt content increase and amount of precipitation decreases.

Disk plowing, disk plowing plus contour furrowing and tebuthiuron application at a rate of 1.5 kg ai/ha gave the highest percent of creosotebush control. Percent of plant mortality increased as rates of herbicides applied increased. Two-way railing consistently gave the lowest percent of mortality across locations.

Forage production. Forage production estimates in the fall of 1983 showed highly significant differences between treatments. Forage production by annual grasses at La Reforma was consistently greater on mechanically treated plots than on chemically treated and untreated (Table 7). The greatest annual forage production was obtained with disk plowing and countour furrowing. Forage production of perennial grasses at La Reforma was significantly increased by all treatments except two-way railing. The highest production of perennial grasses was obtained on plots treated with tebuthiuron at a rate of 1.0 kg ai/ha. The highest total forage production at La Reforma was obtained with disk plowing plus contour furrowing followed by disk plowing alone, and tebuthiuron application at rates of 1.5, 1.0 and 0.5 kg ai/ha, respectively.

There were no significant differences in forage production by annual grasses at Los Pozos. Forage production of perennial grasses at Los Pozos was greatest on tebuthiuron treated plots and on the land imprinted plots. Total forage production at Los Pozos was almost the opposite of that at La Reforma, with the greatest production occuring on chemically treated and land imprinted plots.

There were no significant differences in production by annual grasses at El Toro; however, production by perennial grasses and total forage were greatest on untreated checks. Tebuthiuron applied at rates of 1.0 and 1.5 kg ai/ha and the mechanical treatments significantly reduced forage production compared with the check.

Forage production by annual grasses at Santa Rita Experimental Range was only significantly increased with two-way railing and land imprinting. The greatest forage production by perennial grasses was obtained with the application of tebuthiuron at a rate of 0.5 kg ai/ha and two-way railing, followed by tebuthiuron application at rates of 1.0 and 1.5 kg ai/ha and land imprinting. Disk plowing and disk plowing plus contour furrowing plots had the lowest perennial forage production, but production was greater than on the untreated plots. Total forage production was greatest on two-way railed and tebuthiuron treated plots which received 0.5 kg ai/ha followed by plots treated with tebuthiuron at rates of 1.0 and 1.5 kg ai/ha and land imprinted plots.

Forage production was greatest on plots where shrubs were removed on 3 out of 4 locations. Forage production increases may be expected on mechanically treated plots at those locations which suffered severe droughts. Future forage production increases may be expected on tebuthiuron treated plots on which grasses were injured during the year of treatment, because research has shown that grasses injured by tebuthiuron do recover after one to three rainy seasons (10, 11). Forage production estimates after three growing seasons show that in three of four locations

Table 7. Forage production by annual and perennial grasses in 1983, on plots treated with three tebuthiuron rates and four mechanical treatments at four locations in 1981[a]

	TREATMENTS							
	Tebuthiuron Kg a.i./ha			Land	Two-way		Disking and	
	0.5	1.0	1.5	Imprinting	Railing	Disking	Furrowing	Check
	(kg/ha)							
	Rancho La Reforma							
Annual	54c	68c	143b	---	128b	174b	271a	47c
Perennial	128b	180a	115b	---	34c	116b	138b	57c
Total	182cd	248bc	258b	---	162de	290b	409a	104e
	Rancho Los Pozos							
Annual	33a	22a	22a	33a	19a	23a	29a	35a
Perennial	61ab	79a	82a	58ab	43bc	42bc	39bc	22c
Total	94a	101a	104a	91a	62b	65b	68b	57b
	Rancho El Toro							
Annual	15a	20a	69a	---	33a	23a	33a	11a
Perennial	560ab	391bc	333c	---	280c	288c	355c	654a
Total	575ab	411bc	402bc	---	313c	311c	388bc	665a
	Santa Rita Experimental Range							
Annual	11c	4c	11c	22b	31a	5c	10c	6c
Perennial	382a	304b	259b	253b	373a	132c	161c	98d
Total	393a	308b	270b	280b	404a	137c	171c	104c

[a]Means in the same row followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan's Multiple Range Test.

total forage production increase as a result of brush control. At Rancho El Toro, which was the site with the highest potential, forage production was greater on untreated areas than on chemically and mechanically treated plots (Table 7). Mechanical treatments drastically reduced grass cover, especially the disk plowing treatments. Tebuthiuron applied at rates of 1.0 and 1.5 kg ai/ha significantly reduced forage production compared with tebuthiuron applied at 0.5 kg ai/ha. This indicates that brush control with tebuthiuron by individual plant treatments may be more suitable in areas with good grass cover, rather than general broadcast application of tebuthiuron. Response of grasses after tebuthiuron treatments would not be expected during a year with below average precipitation like the one experienced at La Reforma in 1982.

Conclusions

The mechanical treatments gave similar brush control at all locations regardless of the soil properties and precipitation differences between locations. However, a greater percent of brush mortality was obtained on chemically treated plots at the locations where precipitation was abundant than at locations with low precipitation.

Tebuthiuron effectively controlled a wide spectrum of brush species, but is not an effective herbicide for control of cactus species.

On the site with the lowest rainfall, total forage production increased as rates of tebuthiuron applied increased; however, on locations with the highest rainfall, forage production was greatest at the lowest rate of tebuthiuron applied. Disk plowing, disk plowing plus contour furrowing, and land imprinting gave the highest forage production only on the locations with the driest climate, which may indicate the effectiveness of these treatments for catching water under low rainfall conditions. However, two-way railing gave the highest forage production on the site with highest precipitation.

Mechanical treatments, with the exception of land imprinting, should not be considered as range improvement practices on creosotebush infested rangelands with good grass cover, since forage plants may be destroyed.

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SOME EFFECTS OF HEXAZINONE ON THE GERMINATION AND SURVIVAL OF NORTHERN ROCKY MOUNTAIN CONIFER SEEDLINGS

R. J. Boyd[1]

Abstract: Hexazinone (3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1H,3H)-dione) was applied over the top of planted ponderosa pine (*Pinus ponderosa* Laws.), lodgepole pine (*Pinus contorta* Dougl. var. *murroyana* (Grev & Balf) Engelm), western white pine (*Pinus monticola* Dougl. (Beissn) Franco), Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Beissn) Franco), Engelmann spruce (*Picea engelmanii* Parry), and western larch (*Larix occidentqalis* Nutt) on June 3, August 4, and September 23, 1980. Liquid hexazinone (as Velpar L) was applied at 1, 2, and 3# ai/acre in June and August and at 2# ai/acre in September. Granular hexazinone (as DPX 33674-206-A) was applied only at 2# ai/acre. Based on tree conditions in the spring of 1982, ponderosa pine was tolerant to all rates and formulations tested. White pine and western larch mortality was high at all rates, times, and formulations. Douglas-fir was tolerant of all summer and fall treatments. Lodgepole pine survived the 1# rate applied in June and the 2# treatments applied in summer or fall. Spruce was tolerant of the 1# rate in June and the 2# rate in August or September but suffered high mortality at 3#/acre.

In a second test, hexazinone liquid (Velpar L) was applied to field plots at 2# ai/acre in June 1983; soil samples to a 6-inch depth were removed from treated and untreated plots (1 and 2 weeks following treatment), placed in 6-inch pots, and sown to seven conifer species under greenhouse conditions. Germination of ponderosa pine and western white pine was two to three times greater in treated soil! Germination of lodgepole pine, Douglas-fir, western larch, Engelmann spruce and grand fir (*Abies grandis* (Dougl) Lindl.) was not affected by hexazinone treatment. Subsequent mortality of seedlings in the 6-week post-germination period was variable, depending on the species. Ponderosa pine survival was not influenced by treatment. Mortality of lodgepole pine and western larch was significantly higher (80% with larch and 65% with lodgepole pine) in treated than in untreated soil. Douglas-fir and white pine mortality was moderate (20%) but again significantly greater in treated than untreated soil. Survival of spruce and grand fir grown in treated soil was also less than that in untreated soil, but not significantly so.

Expressed as final plant percentage (i.e., number of living plants produced per unit of seed sown at 8 weeks after sowing, and when herbicide-induced mortality had ceased), hexazinone significantly increased percentages in treated soil for both ponderosa pine (2x) and western white pine (2.8x), had no significant effect on Douglas-fir, spruce, and grand fir, and decreased percentages for lodgepole pine (0.39x) and western larch (0.14x).

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[1]U.S. Dept. of Agric., Forest Service, Moscow, ID.

LACTOFEN, A PREEMERGENCE BROADLEAF HERBICIDE IN POTATOES

Thomas M. Cheney and Joseph Deli[1]

Abstract: Lactofen (Cobra, PPG 844) used preemergence in potatoes has demonstrated excellent crop selectivity and has provided good control of broadleaf weeds, especially lambsquarters (*Chenopodium album* L.) and nightshade species including black (*Solanum nigrum* L.), hairy (*S. sarachoides* sendt.), and cutleaf (*S. trifolium* Nutt.). In Euphrata, Washington, lactofen was evaluated preemergence in potatoes alone, and in combination with grass herbicides at commercial rates. Lactofen was applied alone at 0.224, 0.336 and 0.56 kg/ha, and at the same rates sequentially over EPTC (S-ethyl dipropylthiocarbamate) and tank mixed with metolachlor (2-chloro-N-(2-ethyl-6-methylpnenyl)-N-(2-methoxy--1-methylethyl)acetamide) and with alachlor (2-chloro-2',6'-diethyl-N-(methoxymethyl)acetanilide). A late application of the three rates of lactofen tank mixed with alachlor was applied at drag off. Plots were evaluated for weed control and crop phytotoxicity at two and four weeks after treatment and at harvest. Lactofen applied alone at all rates controlled pigweed, nightshades, and lambsquarter, however, grass control was only marginal. Lactofen applied sequentially over EPTC and tank mixed with metolachlor gave excellent control of grasses and broadleaves at all three rates. Lower rates of lactofen tank mixed with alachlor applied preemergence at drag off gave better control of grasses and broadleaves than the same preemergence treatment applied earlier. The commercial standard treatments of metolachlor and EPTC applied at drag off gave excellent control of grasses, but unacceptable control of many of the broadleaf weeds present. Lactofen showed excellent potential as a preemergence broadleaf herbicide in potatoes and demonstrated excellent control of a broad spectrum of grasses and broadleaves when applied in sequence or tank mixed with standard grass compounds.

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[1]PPG Industries, Inc., One PPG Place, Pittsburgh, PA.

PERENNIAL GRASS CONTROL IN PACIFIC NORTHWEST ORCHARDS WITH PRONAMIDE

T. J. Neidlinger[1]

Abstract: Perennial grasses left uncontrolled can cause serious problems in commercial orchards by: 1) competing for water and nutrients, particularly in new plantings, 2) providing cover for harmful rodents, 3) interfering with sprinkler and drip irrigation systems, and 4) hampering fruit picking operations at harvest time.

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[1]Rohm and Haas Co., Portland, OR.

Pronamide (3,5-dichloro(N-1,1-dimethyl-2-propynl)benzamide) was tested over a three-year period as a fall-applied herbicide in apple and pear orchards in Oregon and Washington.

Target weed species were: quackgrass (Agropyron repens), perennial ryegrass (Lolium perenne), orchardgrass (Dactylis glomerata), tall fescue (Festuca arundinacea), and Kentucky bluegrass (Poa pratensis). Rates of pronamide were 1.1, 1.7, 2.2, 3.4, 4.5, and 9.0 kg/h.

Results indicated no injury to apple or pear at rates as high as 9.0 kg/h when applied six months after transplanting.

Rates of 1.7 kg/h and higher provided good to excellent control of the above species when evaluated in April-May, approximately six months after application. By summer (July) the 1.7 kg/h rate was inadequate in most tests, with 2.2 kg/h providing 80% control. Twelve months after application 2.2 kg/h was giving 68% control of all species except Kentucky bluegrass, which was much more sensitive to pronamide. Good season-long control of this species was achieved with 1.7 kg/h.

Table 1. Control of quackgrass from 16 individual tests is summarized as follows[1]:

Rate (kg/h)	Time of Evaluation		
	April-May	June-July	Sept.-Oct.
1.7	88	64	50
2.2	91	80	68
3.4	93	87	85
4.5	95	93	91
9.0[2]	95	96	94

[1]Average ratings (percent control) from 16 tests, 8 apple, 8 pear, applied previous fall.
[2]Average from 8 tests, 4 apple, 4 pear.

Due to reinfestation of most species twelve months after application, tests were established over a two-year period to determine minimum double-application rates which would give acceptable control. Treatments were applied in early November one year apart.

Results of these tests indicated that 1.7 kg/h applied the first year was insufficient in a two-year spray program even when 3.4 kg/h was used the second year. However, when a minimum of 2.2 kg/h was applied the first year, even 1.7 kg/h applied the second year provided adequate control. Therefore, minimum acceptable rates were 2.2 + 1.7 and 2.2 + 2.2 kg/h.

MONO UREA SULFURIC, A CONTACT HERBICIDE

Donald H. Hall[1]

Abstract: Mono urea sulfuric, an adducted molecule, who's empirical formula is $H_6CSN_2O_5$ is being developed as a contact herbicide. This compound catalytically disrupts cell walls causing a contact kill of plant tissues not protected by a waxy cuticle.

This paper discusses the herbicidal information developed, the current California 24C registration for weed control in the onion family, and ongoing research and development field work.

Introduction

The addition of urea to concentrated sulfuric acid can greatly reduce the corrosive action on human tissue and equipment without neutralizing any of the acidity of the sulfuric acid. Both monourea sulfuric and diurea sulfuric adductions can be synthesized, but the monourea sulfuric is the one that is being most extensively evaluated as a contact herbicide.

The versatility of these two molecules include promise for use as soil and water amendments, anticrustants, efficient and soluble nutrient sources, a contact herbicide (California State Registration #02-10959 5001AA), straw and stubble digestion and vegetative management in orchards and vineyards (i.e. suckering or chemical pruning).

Brea Agricultural Service, Inc., a subsidiary of Union Oil of California, manufactures under patents pending, three eutectic formulations in Fresno, California. These formulations, trademarked as N-pHuric are respectively: 28% nitrogen with 27% sulfuric acid; 15% nitrogen with 49% sulfuric acid; and, 10% nitrogen with 55% sulfuric acid.

Commercial Weed Control

N-pHuric 15/49 has been registered under the trade name N-TAC for use as a post emergence broadleaf contact herbicide for onions, leeks and garlic (see label). Plant tissue is rapidly destroyed by dissolving cellulose and disrupting cell membrane structures in a catalytic non-acid-consumptive reaction. Because of its mode of action, maximum control is obtained within a few hours of application. Selectivity is based on the presence or absence of a waxy cuticle on leaf and stem surfaces. Onions and garlic are examples of waxy plants selectively protected from the spray. The addition of nonionic surfactants which dissolve surface waxes will extend effectiveness to include plants that normally resist wetting. The active ingredient is the sulfuric acid which produces no toxic intermediates or residual herbicide problems and can be applied as needed during the season. The rate and degree of weed kill is a function of the concentration of the active ingredient (sulfuric acid). Excessively dilute sprays (dilutions higher than 1 to 4) may cause too much runoff before evaporation concentrates the acid. This concentration must occur before adequate cell wall disruption is achieved. This is the main reason that

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[1]BREA Agricultural Service, Inc.

during wet drizzly non-drying weather periods field applications should be avoided. Field experience over a variety of climate and growing conditions has shown that high pressure, concentrated to moderately diluted sprays are most effective. Dilutions 1:1 or 1:2, are recommended if equipment will produce adequate pressure. Optimum is about 35 psi at the nozzle. Dual applications 3 to 5 days apart using 15 gal of N-TAC in 30 to 100 gals of total spray volume have been consistently successful. As with all herbicides, N-TAC applications should be made on healthy, unstressed crop plants. Physically damaged or severely stressed plants and seedlings smaller than one inch (first true leaf stage) may be damaged by untimely spraying; so, close attention to the crop during early growth stages is important.

Plants 3 to 8 inches tall are best treated with over the top sprays using hollow cone-type nozzles size D-6 or D-7 at 30-50 psi at the outlet. Remember, N-TAC is a true contact herbicide and as such has no systemic action, so coverage is essential. In crops taller than 8 inches, drop nozzles with directed spray patterns are most efficient. Spray should be directed toward the base of the crop plant and the shoulder of the furrow. Fan nozzles with 45 or 65 degree spray bands are recommended using label rates. Reports from field use indicate, as would be expected, N-TAC has an effect on nontarget species, such as mildews and small insects, that come in contact with the spray. No specific claims are included on the label for control of non-weed species.

Other considerations should include the fact that N-TAC is a concentrated nitrogen-sulfur fertilizer and the N and S should be considered in the overall fertility program. Because it is in a readily available form nutritional growth responses are usually seen shortly after herbicide application. The acid part of the active ingredient is not consumed in the destruction of plant tissue and can also benefit calcareous, sodic, and alkaline soils.

Experimental Weed Control

Cole Crops:

N-TAC has been successfully tested for weed control on cole crops in experimental sites in the coastal areas of California and the northwest. Broccoli, cauliflower, Brussels sprouts, red cabbage but not green cabbage, have shown resistance to damage while the spectrum of weeds controlled is the same as that listed for onions. Best results have been obtained when the crop has reached the two to four true leaf stage. Healthy plants show a minimum of phytotoxicity while those suffering from physical damage or severe stress cannot be safely treated. A trailing boom will shake beaded droplets from the crop and reduce leaf damage. Applications immediately following pesticide spraying (0-48 hours) should be avoided since most mixes contain solvents and surfactants that weaken the protective waxy cuticle.

The most successful application technique has been one of applying 10-15 gals of N-TAC per treated acre usually diluted up to 80 to 100 gals of applied spray. It is important to direct the spray with angled drop nozzles toward the base of the crop plant line while covering the target weeds as much as possible. Shielded sprayers are recommended where excessive tissue damage is expected. Across the top spraying is not recommended.

Fruits, Nuts, and Vineyards:

N-TAC has been used experimentally on both a broadcast and/or strip spray basis at rates of 25-75 gals per treated acre to provide efficient nitrogen fertilization and achieve contact weed control. Dilution rates range from 40 to 100 gals total spray per treated acre as necessary for thorough coverage. Additional experiments using combinations of N-TAC and systemic herbicides such as glyphosate (N-(phosphonomethyl)glycine), have been highly successful as combination fertilizer herbicide tank mixes. The N-TAC generally provides acidic protection from alkaline hydrolytic destruction of many herbicides and effective long-term control of a broad spectrum of weeds at reduced rates.

Timing of N-pHuric or N-TAC herbicide combinations should be based in accordance with accepted fertilization scheduling. Late winter and/or early spring applications for control of winter annuals has been quite successful. Caution should be used to avoid contact on new plantings until bark has formed and green coloration is no longer evident. N-TAC sprays will not harm woody tissue, bark, or cured wood structures. If residual or preemergence herbicide combination sprays are used, follow label instructions for the herbicide and avoid misdirected sprays.

Alfalfa:

N-TAC and N-pHuric-phosphoric acid combinations have been successfully tested as winter-spring fertilizer/weed control materials. Weed species controlled include those listed on the N-TAC label. Application rates are 15-30 gals per acre in a sufficient volume of water for complete coverage. Dilute only where necessary to get complete coverage (1:1, or 1:2 dilution should be adequate).

Addition of a quality nonionic wetting agent at the rate of 0.25% to 0.5% by volume will increase burn down, especially for grasses. It will also increase burn down of the crop. In many cases the addition of phosphorous is desirable and the combination of N-TAC and phosphoric acid has been highly successful for supplying soluble phosphorous and nitrogen. The combinations produce excellent weed burn down in addition to fertilizer benefits. In fields where there is a significant weed problem, mixes of N-pHuric 15/49 with phosphoric acid and winter herbicides, such as hexazinone (3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1H,3H)-dione) or diuron (3-(3,4-dichlorophenyl)1,1-dimethylurea), have produced excellent results at low herbicide label rates. Recommended mixture rates are similar to those for N-pHuric 15/49.

Both N-TAC and its combination with phosphoric acid are recommended for treating established alfalfa only. Do not use on alfalfa stands less than 1 year old, or on seedling alfalfa-grass mixtures, or other mixed stands. Apply during dormancy or winter period (December 1 through February 15) in the San Joaquin and Sacramento Valleys for best results. N-pHuric products may also be sprayed immediately after the hay has been picked up, but before significant regrowth has taken place. Applications during the growing season will retard growth and may delay harvest interval 4-5 days. Irrigating 24 hours after application will speed recovery of the crop.

General Research

A very interesting area of current field research is the evaluation of herbicide potentiation with the addition of N-pHuric 15/49 at about 3-5% by volume of the final spray. Weed control ratings are implying that equal efficacy can be obtained at herbicide rate reductions in the neighborhood of 20 to 30%.

It is expected that the urea sulfuric adducts will grow in usage as valubale agricultural chemical tools. What started out as simply a safe way to handle sulfuric acid has evolved into an intriguing area of new agricultural chemistry.

CONTROL OF OXALIS CORNICULATA CREEPING WOODSORREL IN COOL SEASON GRASS TURF

Clyde L. Elmore[1]

Abstract: *Oxalis corniculata* (creeping woodsorrel) has become the principal broadleaf weed problem in many turf areas. Before the banning of 2,4,5-T ((2,4,5-trichlorophenoxy)acetic acid) or silvex (2-(2,4,5-trichlorophenoxy)propionic acid), good control was obtained with either herbicide.

To evaluate methods of control preemergence herbicides, postemergence herbicides and combinations of herbicides with mowing height in two turf species were evaluated. Preemergence herbicides evaluated were DCPA (dimethyl tetrachloroterephthalate), oxadiazon (2-*tert*-butyl-4(2,4-dichloro-5-isopropoxyphenyl)-Δ^2-1,3,4-oxadiazolin-5-one), pendimethalin, (*N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine), and pyrazon (5-amino-4-chloro-2-phenyl-3(2*H*)-pyridazinone). One-half of each preemergence treatment was oversprayed with a combination of 2,4-D (2,4-dichlorophenoxy)acetic acid) plus dichlorprop (2-(2,4-dichlorophenoxy)propionic acid) the first year or triclopyr (((3,4,6-trichloro-2-pyridinyl)oxy)acetic acid) in the second year. Postemergence herbicides evaluated included 2,4-D + diclorprop, triclopyr amine salt, 2,4-D + mecoprop (2-((4-chloro-*o*-tolyl)oxy)propionic acid) + dicamba (3,6-dichloro-*o*-anisic acid) and ammonium thiosulfate. The growth retardant EL 500 (chemistry unavailable) was also evaluated. Each treatment was subdivided into a high (2 inch) and low (0.75) inch mowing regime at weekly intervals. Treatments were applied either to a *Festuca arundinacea* (tall fescue) or *Lolium perenne* (perennial ryegrass) turf for tolerance.

The preemergence herbicides applied alone or followed with 2,4-D plus dichlorprop did not give acceptable (70%) control. When triclopyr was applied postemergence at 0.75 lb/A over the preemergence materials excellent control was obtained.

Triclopyr applied twice at 0.5 lb/A or 1.0 lb/A gave excellent control of *O. corniculata*. The second year of treatment when the ester formulation of triclopyr was used improved results were obtained.

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[1]University of California Cooperative Extension, Davis, CA.

The growth retardant EL 500 was effective for shortening the internodes of O. corniculata and the grass overgrew the weeds. Both rates of 0.5 and 2 lb/A repeated twice during a season was effective. Growth suppression of the turf grass lasted for 12 weeks at the low rates and more than 20 weeks at the higher rates. When turf was mowed at 0.75 inch the early results from postemergence herbicides were better but long term control was equal. Both tall fescue and perennial ryegrass was tolerant of these herbicides.

In subsequent tests with triclopyr ester, a combination of 2,4-D and triclopyr ester, 2,4-D + dichlorprop or 2,4-D mecoprop + dicamba and MSMA (monosodium methanearsonate) it was found that the triclopyr ester formulation and mixture with 2,4-D gave excellent control. The four mixtures of 2,4-D, mecoprop, dicamba and MSMA gave good control. MSMA increased the three herbicide mixture activity. Bentazon (3-isopropyl-1H-2,1,3-benzothiadiazin-4(3H)-one 2,2-dioxide) plus a non-phytotoxic oil was not effective. EL 500 al 1 lb/A applied two times in a season also gave excellent control.

CHEMICAL DESICCATION OF POTATO VINES

L.C. Haderlie, P.W. Leino, J.L. Halderson, D.L. Corsini[1]

Abstract: Sulfuric acid, dinoseb (2-sec-butyl-4,6-dinitrophenol), diquat (6,7-dihydrodipyridol(1,2a:2',1'-c) pyrazinediium ion) and endothall (7-oxabicyclo (2.2.1)heptane-2,3-dicarboxylic acid) with various adjuvants were compared over 3 yr for potato (Solanum tuberosum L. cv 'Russet burbank') vine kill. Two potato maturity (4 to 6 wk difference) stages were tested. Vine rolling prior to chemical treatments was also evaluated during 2 yr. Adjuvants used with both diquat and dinoseb included Moract, Herbimax, and LI-700. Dinoseb was also tested with Wetsol and diquat with X-77. Herbicides were applied at 17.5 gpa at several locations in Southern Idaho. Herbicide rates were 80 lb/A sulfur equivalent for sulfuric acid, 2.2, 0.25 to 0.38, and 1.0 lb ai/A for dinoseb, diquat, and endothall, respectively. Rates of vine desiccation from most rapid to slowest were sulfuric acid, dinoseb, diquat, and endothall. All desiccants gave 90 to 100% vine kill 2 to 3 wk after treatment. Vine rolling aided vine desiccation rate in some instances up to 26% better kill while the average (over all rolling treatments) was 9% vine desiccation. Vines that were beginning to senesce were desiccated more rapidly than vigorously growing or less mature vines. Differences in vine kill were as much as 43% and commonly 20% between the two vine maturity stages tested within the first week after treatment. All adjuvants tested resulted in similar desiccation, but Moract tended to give better vine kill with dinoseb than did other adjuvants. Tuber stem-end discoloration was not increased with any chemical treatment or by rapid vine desiccation as previous literature suggested.

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[1]Assoc. Prof., Res. Assoc., and Assoc. Prof., respectively, and USDA Plant Pathologist, University of Idaho Research & Extension Center, Aberdeen, ID.

LOW RATE VOLUME INTERACTION STUDIES WITH GLYPHOSATE AND RESIDUAL HERBICIDES ON WINTER ANNUAL WEEDS IN TREES AND VINES

E. E. Sieckert[1]

Abstract: The requirement for light weight application equipment and lower carrier volumes in trees and vines has increased in the past several years due to extremely wet winters in California. The use of glyphosate (N-(phosphonomethyl)glycine) and residual herbicides in carrier volumes from 5 to 30 gpa will enable the grower to control weeds during the winter months when otherwise the application would not be feasible.

The activity of glyphosate is increased in lower volumes and when tank mixed with residual herbicides antagonism is not a concern. A study conducted and *Bromus rigidus* (ripgut brome) and *Raphanus sativus* (wild radish) (Table 1) has shown that glyphosate at 0.38 lbs ae/A in 10 gpa gave 85% control compared to 70% in 40 gpa. A 0.75 lbs ae/A in 10, 20, and 40 gpa was not decreased by carrier volume effect. Addition of simazine (2-chloro-4,6-bis(ethylamino)-s-triazine) at 3.0 lbs ae/A to glyphosate at 0.38 lbs ae/A has shown antagonism at all volumes. A 0.75 lbs ae/A rate of glyphosate provided 90% control of wild radish in 10 gpa. Lower volumes and a rate of 0.75 lbs ae/A are required for good weed control.

The use of flat fan nozzles and controlled droplet applicator nozzles (CDA) in orchards or vineyards with glyphosate plus residuals has been extensively researched over the past two years. Aplications of glyphosate + oryzalin (3,5-dinitro-N^4,N^4-dipropylsulfanilamide), glyphosate + simazine, and glyphosate + oxyfluorfen (2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene) in 5 to 30 gpa through both nozzle systems has given equal activity and can provide a major tool for orchard and vineyard managers in wet winter months.

Table 1. Low Rate Volume Interaction with Glyphosate + Residual Herbicides.

			PERCENT CONTROL 21 DAT	
Treatment	Lbs. a.i. or A.E./A	GPA	Raphanus sativus	Bromus rigidus
Glyphosate	0.38	10	85	99
Glyphosate	0.75	10	85	100
Glyphosate	0.38	20	75	100
Glyphosate	0.75	20	90	100
Glyphosate	0.38	40	70	100
Glyphosate	0.75	40	90	100
Glyphosate +	0.38	10	45	78
Simazine	3.0	20	55	80
		40	45	85
Glyphosate +	0.75	10	90	99
Simazine	3.0	20	80	95
		40	71	91

[1]Monsanto Agricultural Products Co.

THE RESPONSE OF SEEDLING ONIONS TO FLUAZIFOP-BUTYL AND BROMOXYNIL

Susan G. Colwell[1]

Fluazifop-butyl ((±)-butyl 2-(4-((5-(trifluoromethyl)-2-pyridinyl) oxy)phenoxy)propanoate) and bromoxynil (3,5,-dibromo-4-hydroxybenyoni-trile) were tested on onions (*Allium* sp.). The onions were grown under greenhouse conditions with a temperature range of 70F (night) to 85F (day) and ten hours of daylight. Both chemicals were studied separately at rates of 1, 2, 3, and 4 oz/A. Application dates included an early date (the first true leaf stage), a late date (10-14 days later) and a combination of the early and late application dates. A tank mix of fluazifop-butyl and bromoxynil at the 1, 2, 3, and 4 oz/A rates was studied. The crop oil, used as the carrier for fluazifop-butyl, was evaluated at the 2 oz/A rate for its role in the tank mix. Also, the effect of delaying the application (day 1, day 2 and day 3) of fluazifop-butyl after an application of bromoxynil rather than a tank mix of the two herbicides was examined. The onions were harvested 10-14 days after the last herbicide application. Statistical evaluations were based on the aggregate height of the onion plant at the time of harvest. In the tests with fluazifop-butyl, the treatment differences could not be distinguished from random fluctuation. There was a significant downward linear effect with the early application date of bromoxynil. However, the late and combination dates of bromoxynil showed no linear effect, but did show the controls to be significantly higher than the treatments. The same pattern occurred with the tank mix of fluazifop-butyl and bromoxynil. The early application date showed a significant downward linear effect, while the late and combination dates only showed significantly higher controls than treatments. Additionally, the tank mix appeared to be more phytotoxic to the onions than the bromoxynil alone. Using the Fischer's protected LSD to evaluate the effect of the crop oil in the tank mix, the bromoxynil, the fluazifop-butyl tank mix, and the bromoxynil and oil were found to be significantly different than the fluazifop-butyl and the control. However, the bromoxynil was not significantly different than the fluazifop-butyl and the bromoxynil was not significantly different than the bromoxynil and oil. Even though the test hinted that the oil does have an effect in the tank mix, further studies are needed to show possible statistical significance of the oil in the tank mix. Delaying the application of the fluazifop-butyl after application with bromoxynil did have a significant upward linear effect from the tank mix, when the onions were in the first true leaf stage. This test was repeated 14 days later and the tests only showed that the control was significantly higher than the treatments.

[1]Plant Science Department, University of Arizona, Tucson, AZ.

INFLUENCE OF IRRIGATION TIMING ON THE PREEMERGENCE ACTIVITY OF OXYFLUORFEN

J. T. Schlesselman[1]

Abstract: Past research has shown that oxyfluorfen (2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene) at relatively high rates of 2-4 lb ai/acre can remain on the soil surface for 3-4 weeks without incorporation by rainfall or sprinkler irrigation and still give excellent residual preemergence activity. Most of these trials were conducted during the fall when daily air and soil temperatures had begun to moderate following the peak summer heat. During the summer of 1982 and 1983 many trials were conducted with oxyfluorfen at rates as low as 0.5 lb ai/acre for contact weed control in treefruit and nut crops. Subsequent evaluations for residual activity resulted in a significant reduction in preemergence weed control 30-45 days after application.

An irrigation timing study was established in August 1983 to determine if this short residual activity was due to the lack of incorporation by rainfall or sprinkler irrigation. Oxyfluorfen at 0.5 and 2.0 lb ai/acre was applied 28, 21, 14, 7, 3, 1 and 0 days prior to irrigation with sprinklers. The average daily high temperature for this 28 day period was 97F. The evaluation taken 1 month after irrigation showed the 2 lb rate giving 99-100% weed control, regardless of time between application and irrigation. The 0.5 lb rate of oxyfluorfen showed a 10% decrease in weed control with the 28 day interval between application and irrigation compared to oxyfluorfen being applied and irrigated the same day (from 99% down to 89% control). However, this reduction in activity was not significant.

The 3 month evaluation resulted in an average 20% reduction in residual weed control with the 0.5 lb rate of oxyfluorfen compared to the 1 month rating. However, there was only a 5% reduction in activity from the 0 day treatment and the 28 day application prior to irrigation. From this work, it is apparent that the loss of herbicidal activity with oxyfluorfen was a result of the normal breakdown of the 0.5 lb rate and not loss due to lack of herbicide incorporation.

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[1]Rohm and Haas Company, Reedley, CA.

1983 COMMERCIAL RESULTS USING SETHOXYDIM IN SUGARBEETS, ONIONS FOR SEED AND LADINO CLOVER FOR SEED UNDER A CRISIS LABEL IN CALIFORNIA

D. C. Wiley[1]

Abstract: With continuous heavy rains all winter and spring, a crisis situation developed in California. Growers could not carry on their normal cultural practices and grassy weeds became a major problem in most fields.

Onions

On April 6th, California Department of Food and Agriculture, (CDFA), issued an emergency exemption for the use of sethoxydim (2-(1-(ethoxyimino)butyl)-5-(2-(ethylthio)propyl-3-hydroxy-2-cyclohexen-1-one)) for the control of annual rye grass (*Lolium* spp) and wildoats (*Avena fatua*) on onions grown for seed.

Of the commercial fields observed, application was made at 0.6 lbs ai/acre, 30 gpa of water and 40-60 psi. One air application was located using sethoxydim at 0.6 lbs/acre and 10 gpa of water. All applications had included a crop oil concentrate at one quart per acre. 95 to 98% control of 2 to 3 foot tall annual ryegrass, wildoats, and canary grass (*Phalaris* spp) were observed. Many of these plants had seed heads formed at the time of application. No phytotoxicity was seen on the onions.

Ladino Clover

C.D.F.A. issued a second emergency exemption May 5th for sethoxydim to be used on ladino clover for seed. The target grasses this time were barnyardgrass (*Echinochloa crusgalli*) and annual ryegrass.

Commercial treatments observed used 0.4 lbs/acre of sethoxydim, plus one quart of crop oil concentrate at 60 psi in 20 gpa of water. This pressure allowed good penetration of a 5 inch canopy of clover and produced excellent control of 2 to 5 inch tall barnyardgrass. No phytotoxicity was noticed on any of the clover fields.

Sugar Beets

The third and last emergency exemption was issued June 6 by CDFA for the use of sethoxydim on sugar beets. All fields that were visited were band treated with sethoxydim in widths of 6 to 10 inches and applied directly over the tops of the sugar beets. Rates of 0.4 to 0.5 lbs/acre of sethoxydim in 15 to 25 gpa of water with one quart of crop oil concentrate was the standard treatment. These rates were on a broadcast basis and amounts reduced accordingly for the actual band applied. Barnyardgrass was the primary weed pest, but other grasses were present such as foxtails (*Setaria* spp), sudangrass (*Sorghum sudanense*), volunteer corn (*Zea mays*), volunteer wheat (*Triticum aestivum*). Excellent tolerance was observed on the sugar beets to sethoxydim. Grass control was good to excellent where thorough spray coverage of the grasses was obtained.

BASF plans a full registration for the use of sethoxydim on sugar beets in 1984.

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[1]BASF Wyandotte Corp., Parsippany, NJ.

EFFECT OF FALLOW TILLAGE AND WEED CONTROL ON SOIL MOISTURE ACCUMULATION AND WINTER WHEAT YIELD

J. M. Lish and D. C Thill[1]

Abstract: Fallow is cropland left idle for one or more growing seasons while the soil is cultivated to control weeds and conserve moisture. Multiple tillage operations reduce water storage in the soil and weed growth during the fallow period. Combinations of six herbicide treatments and four tillage regimes were tested near Lewiston, Idaho for fallow year weed control, soil moisture and soil nitrate-nitrogen accumulation, and subsequent winter wheat (*Triticum aestivum* L.) injury and grain yield. Conventional fallow tillage controlled all weed species regardless of herbicide treatment. When summed over herbicide treatments, no-tillage was more weedy than other tillage regimes. No-tillage combined with atrazine (2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine) + cyanazine (2-((4-chloro-6-(ethylamino)-s-triazin-2-yl)amino)-2 methyl propionitrile) fall applied at 0.28 + 3.4 kg/ha or glyphosate (N-(phosphono-methyl)glycine) + dicamba (3,6-dichloro-o-anisic acid) sequentially applied in the spring at 0.42 + 0.57 kg/ha controlled all species except wild oat (*Avena fatua* L.). Total soil moisture tended to be lowest with propham (isopropyl carbanilate) + metribuzin (4-amino-6-tert-butyl)-3-(methylthio)-as-triazin-5(4H)-one) fall applied at 3.4 + 0.75 kg/ha and with the early chisel-late disk tillage regime. There was no crop injury from herbicide carryover. Crop establishment was variable in no-tillage when compared to other tillage treatments. Winter wheat planted in conventional fallow tillage yielded at least 1218 kg/ha more grain than the other tillage regimes. When summed over tillage, glyphosate + dicamba yielded 6106 kg/ha but was not significantly greater than atrazine + cyanazine or propham + metribuzin.

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[1]Dept. of Plant, Soil and Entomological Sci., University of Idaho, Moscow, ID.

EFFECT OF SMALL GRAINS AND CROP CANOPY REMOVAL ON RUSSIAN THISTLE GROWTH AND DEVELOPMENT

F. L. Young and L. A. Morrow[1]

Abstract: Russian thistle (*Salsola kali* L.) is an annual broadleaf weed prevalent in the low rainfall, nonirrigated wheat (*Triticum aestivium*) producing area of the Pacific Northwest. A 2-yr study was conducted to: (1) evaluate the effect of winter wheat and spring wheat on the growth and development of Russian thistle, and (2) measure the postharvest growth of Russian thistle after the crop canopy has been removed. Russian thistle plants were grown in crop-free, spring wheat, and winter wheat

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[1]USDA-ARS, Washington State University, Pullman, WA.

environments. Growth and development parameters measured included plant dry weight, height, width, and seed production.

Both spring wheat and winter wheat reduced all three growth parameters of Russian thistle as well as seed production, when compared to Russian thistle grown in a crop-free environment. Plant dry weight of Russian thistle was reduced similarly by spring and winter wheat, and this reduction continued during the postharvest growth period. Russian thistle plants grown in winter wheat were shorter than plants grown in spring wheat until crop harvest occurred. However, after harvest, Russian thistle previously grown in winter wheat grew as tall as plants that had grown in spring wheat. Winter wheat substantially reduced the width of plants and this reduction continued through the postharvest growth period. Seed production of Russian thistle grown in both spring and winter wheat was reduced, with the greatest reduction occurring in thistle grown in winter wheat.

Plant-emergence counts were recorded for native Russian thistle in each environment. Average total emergence of Russian thistle in winter wheat was approximately 50% less than in either the spring wheat or crop-free environment. Russian thistle emerging in winter wheat had the greatest seedling mortality.

PRE-PLANT INCORPORATED APPLICATIONS OF TRIALLATE FOR WILD OAT CONTROL IN SPRING WHEAT

Dennis Rasmusson and David G. Hanson[1]

Abstract: Triallate (S-(2,3,3-trichloroallyl)diisopropylthiocarbamate) emulsifiable concentrate has been used after planting by growers to provide preemergent wild oat (*Avena fatua* L.) control in wheat since 1963. Fall PPI applications of triallate EC have been used since 1965 and the granular formulation has been available since 1972. To allow fall application of the granule under reduced tillage, surface application was labeled in 1981. Due to weather conditions, fall application is not always possible on all of the targeted acreage. Therefore, in order to meet grower's needs in reduced tillage, a program was developed to identify methods for PPI application of triallate in the spring. Previous Monsanto studies indicated that spring PPI applications could be safe and efficacious. Factors evaluated in 1983 were formulation, rate, incorporation, time of application and depth of seeding. Evaluations were made at eleven Monsanto Product Development trials and fourteen Monsanto supervised grower comparisons in North Dakota, Minnesota and Montana.

The results showed that both the EC and granular formulations were safe and efficacious as PPI applications. Wild oat control increased as

[1]Monsanto Agricultural Products Co., Minot and West Fargo, ND.

the triallate rate increased from 1.0 to 1.5 lb ai/a, but control averaged over 90% at all rates. The effect of triallate rate on wheat yield as compared to the check was minimal; the average yield was only reduced 0.9 and 2.6 bu/a and 1.0 and 1.5 lb ai/a. One versus two pass incorporation had no effect on wheat safety and yield, but two pass incorporation increased wild oat control up to 6% over one pass incorporation. The effect of time application, the interval between application and seeding, had little effect on wild oat control, but there was a tendency for reduced wheat injury and a slight increase in yield by delaying seeding three to fourteen days after application. The differences between a seeding depth of 1.5 versus 3 inches were slight, but the shallower depth resulted in slightly higher yields. Overall, PPI applications of triallate were safe and efficacious under all conditions tested. PPI applications were similar to preemergent incorporated (PEI) applications in wheat safety and yield; wild oat control was increased by PPI applications compared to PEI.

ABSORPTION, TRANSLOCATION, AND METABOLISM OF METRIBUZIN BY DOWNY BROME AND WINTER WHEAT

D. L. Devlin, L. A. Morrow, and D. R. Gealy[1]

Abstract: The absorption, translocation, and metabolism of ^{14}C metribuzin by winter wheat (*Triticum aestivum* L.) and downy brome (*Bromus tectorum* L.) grown in nutrient solution was investigated. Downy brome roots absorbed a greater amount of metribuzin than did winter wheat. Metribuzin was rapidly translocated to the shoots of both species. On a fresh weight basis, metribuzin was translocated to a greater extent by winter wheat than by downy brome. Metabolism studies indicated that metribuzin was metabolized by both species. The major metabolite was deaminated metribuzin (DA) and was less than 10% of the metribuzin equivalent recovered in either species. The other identifiable metabolites, deaminated diketo metribuzin (DADK) and diketo metribuzin (DK), were found in trace amounts in both species. An unidentified metabolite was found in downy brome but not in winter wheat.

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[1]Agronomy Dept. and USDA-ARS, Washington State University, Pullman, WA.

ANTAGONISM BETWEEN SELECTED POSTEMERGENCE HERBICIDES FOR GRASS AND BROADLEAVED WEEDS

R. K. Zollinger and J. O. Evans[1]

Abstract: Field and greenhouse studies indicate possible antagonism between postemergence grasss herbicides and chlorsulfuron (2-chloro-N-(((4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino)carbonyl)benzensulfonamide), metsulfuron (methyl 2-(((methoxy-6-methyl-1,3,5-amino)carbonyl)sulfonyl)benzoate), and 2,4-D (2,4-dichlorophenoxy)acetic acid). Bromoxynil (3,5-dibromo-4-hydroxybenzonitrile), however, appears to be compatible with postemergence grass herbicides evaluated. Antagonism may result in greater injury to desirable plants and decreased effectiveness in controlling weed species. This antagonism is most pronounced when diclofop-methyl (2-(4-(2,4-dichlorophenoxy)-phenoxy)methyl-propanoate) is mixed with phenoxy or sulfonyl urea herbicides. Interactions of the herbicides produce significant decreases in the control of oat plants.

Results show that diclofop-methyl activity decreased when chlorsulfuron, metsulfuron, or 2,4-D were tank mixed with it. Diclofop-methyl activity was not effected adversely when it was combined with bromoxynil. When fluazifop-butyl (butyl 2-(4-((5-(trifloromethyl)-2-pyridinyl)oxy)phenoxy)propanoate) was tank mixed with broadleaved herbicides, antagonism was not as evident as expected. Chlorsulfuron reduced fluazifop-butyl activity towards grasses to a greater degree than some phenoxy herbicides. Sethoxydim (2-(1-(ethoxyimino)butyl)-5-((2-ethylthio)propyl)-3-hydroxy-2-cyclohexen-1-one) activity towards grasses was not reduced when it was combined with any of several herbicides commonly used against broadleaved weeds.

Introduction

Previous field and greenhouse studies have established probable antagonism when diclofop-methyl is combined with phenoxy and sulfonyl urea herbicides. This antagonism is postulated to result from combining certain herbicides containing phenyl or phenoxy ring structures. This study was initiated based on: 1) structural similarities between diclofop-methyl and other postemergence grass herbicides, 2) field and greenhouse research which indicate probable antagonism between diclofop-methyl and sulfonyl urea compounds, and 3) concern for crop safety when postemergence broadleaf and grass herbicides are tank mixed.

Tank mixes of diclofop-methyl and broadleaf herbicides are desirable for controlling both broadleaf and grassy weeds with a single spray application in small grains. Tank mixes of new postemergence grass herbicides combined with selected broadleaf herbicides designed for broadleaf crops are also desirable for controlling broadleaf and grassy weeds. Since some broadleaf compounds reduce the activity of diclofop-methyl on grassy weeds, it was suspected that similar antagonisms might occur when new postemergence grass herbicides were combined with certain

[1]Utah State University, Logan, UT.

broadleaf herbicides. Fababeans were used to screen this possible interaction. Interactions of postemergence broadleaf-grass herbicide tank mixes for several selected combinations were evaluated.

Objectives

The objectives of this study were:

1. To compare the activity of postemergence grass herbicides applied to wheat, oats, and fababeans.
2. To evaluate the crop injury potential of postemergence grass herbicides.
3. To compare the activity of postemergence grass herbicides when tank mixed with selected broadleaf herbicides.

Methods

In the fall 1983 a greenhouse study was established in which wheat, oats and fababean seeds were planted in 1 qt pots. Weston, Cayuse and Diana were chosen as the test varieties, respectively. Pots were placed in a randomized block design and maintained under uniform growth conditions until treatment time. Herbicide application was made with a precision greenhouse sprayer calibrated to deliver 187 l/ha (20 gpa).

At the time of application wheat and oat plants were in the early to full 3 leaf stage with 4 plants per pot. The average of the 4 plants measured 14 cm tall. Fababean plants were in the 4-6 leaf stage with 2 plants per pot. The average of the 2 plants measured 10 cm.

Diclofop-methyl, fluazifop-butyl, haloxyfop-methyl (methyl 2-(4-((3-chloro-5-(trifloromethyl)-2-pyridinyl)oxy)phenoxy)propanoate), and sethoxydim were applied alone and in selected tank mix combinations with bromoxynil, 2,4-D, chlorsulfuron, and metsulfuron. Diclofop-methyl was applied at the rate of 840 g/ha, while fluazifop-butyl, haloxyfop-methyl, and sethoxydim were applied at the rate of 280 g/ha. Bromoxynil and 2,4-D were applied at 426 g/ha, and chlorsulfuron and metsulfuron were applied at 18 g/ha.

Results

Table 1 shows the response of wheat, oats, and fababeans to several postemergence broadleaf-grass herbicides applied alone and in tank mix combinations. Diclofop-methyl applied alone showed an 81% vigor reduction as compared to the control. As suspected, the diclofop-methyl-bromoxynil tank mix was compatible and expressed no significant antagonism when they were tank mixed. The most antagonism shown occurred when diclofop-methyl was combined with 2,4-D. A 43% vigor reduction was expressed as compared to the diclofop-methyl treatment applied alone on oats. This finding is consistent with past field and greenhouse studies. When diclofop-methyl was applied with sulfonyl urea compounds a less dramatic effect was expressed, with metsulfuron showing more antagonism than chlorsulfuron.

Diclofop-methyl applied alone on wheat expressed excellent crop safety. However, when the compound was tank mixed with broadleaf herbicides used in this study, significant crop injury from highest to

Table 1.
Response of oats, fababeans and wheat to several post emergence broadleaf and grass herbicides applied alone and in selected combinations.

		Oat Response			Fababean Response			Wheat Response		
Treatment	Rate g/ha	Injury index	% Vigor reduction	Fresh wt. g/4 plants	Injury index	% Vigor reduction	Fresh wt. g/2 plants	Injury index	% Vigor reduction	Fresh wt. g/4 plants
diclofop-methyl	840	7.1	81	2.08	0	0	9.34	0	0	6.41
diclofop-methyl Atplus 411F	840 + 1%	7.5	70	3.18	0	0	10.86	0	0	6.91
diclofop-methyl bromoxynil	840 + 426	8.1	74	2.81	10	92	0.63	0	12	5.58
diclofop-methyl 2,4-D	840 + 426	7.6	38	6.60	10	94	0.48	0	24	4.85
diclofop-methyl chlorsulfuron	840 + 18	9.1	67	3.52	10	93	0.55	0	18	5.18
diclofop-methyl metsulfuron	840 + 18	6.5	55	10.87	10	92	0.69	0	35	4.12
fluazifop-butyl	280	10.0	94	0.62	0	13	7.19	10	94	0.40
fluazifop-butyl Atplus 411F	280 + 1%	10.0	96	0.40	0	13	9.32	10	95	0.30
fluazifop-butyl bromoxynil	280 + 426	10.0	96	0.39	10	92	0.69	10	96	0.23
fluazifop-butyl 2,4-D	280 + 426	10.0	96	0.47	10	94	0.49	10	94	0.36
fluazifop-butyl chlorsulfuron	280 + 18	10.0	96	0.40	10	92	0.67	10	94	0.39
fluazifop-butyl metsulfuron	280 + 18	10.0	96	0.40	10	91	0.73	10	94	0.37

cont.

Treatment	Rate g/ha	Oat Response			Fababean Response			Wheat Response		
		Injury index	% Vigor reduction	Fresh wt. g/4 plants	Injury index	% Vigor reduction	Fresh wt. g/2 plants	Injury index	% Vigor reduction	Fresh wt. g/4 plants
haloxyfop-methyl	280	10.0	97	0.37	0	32	5.61	10	96	0.27
haloxyfop-methyl Atplus 411F	280 + 1%	10.0	97	0.34	0	41	4.89	10	96	0.28
haloxyfop-methyl bromoxynil	280 + 426	10.0	97	0.34	10	95	0.45	10	95	0.30
haloxyfop-methyl 2,4-D	280 + 426	10.0	97	0.33	10	95	0.45	10	96	0.24
haloxyfop-methyl chlorsulfuron	280 + 18	10.0	96	0.41	10	92	0.64	10	96	0.27
haloxyfop-methyl metsulfuron	280 + 18	10.0	96	0.42	10	93	0.56	10	94	0.35
sethoxydim	280	10.0	96	0.48	0	0	11.49	10	97	0.34
sethoxydim Atplus 411F	280 + 1%	10.0	97	0.36	0	0	11.40	10	95	0.29
sethoxydim bromoxynil	280 + 426	10.0	96	0.47	10	92	0.64	10	94	0.36
sethoxydim 2,4-D	280 + 426	10.0	97	0.37	10	93	0.61	10	96	0.27
sethoxydim chlorsulfuron	280 + 18	10.0	95	0.52	10	94	0.50	9.5	91	0.54
sethoxydim metsulfuron	280 + 18	10.0	96	0.47	10	93	0.59	9.7	94	0.37
bromoxynil	426	0	17	8.87	10	93	0.55	0	3	6.15
2,4-D	426	0	0	11.43	10	94	0.47	0	0	6.36
chlorsulfuron	18	0	2	10.39	10	93	0.61	0	0	7.41
metsulfuron	18	0	27	8.28	10	94	0.52	0	1	6.27
control	--	0	0	10.71	0	0	8.22	0	0	6.34
LSD (0.01)		4.8	11	1.22	0	16	1.31	0.09	11	0.74

lowest is chlorsulfuron → 2,4-D → metsulfuron. These results are of practical importance because tank mixes of diclofop-methyl and broadleaf herbicides are desirable for controlling both broadleaf and grassy weeds in small grains. The tank mix of bromoxynil with diclofop-methyl gave acceptable crop injury ratings.

Thus far, the discussion has dealt with the response of different grass species to diclofop-methyl applied alone and in selected combinations. Perhaps a question could be posed, "Do postemergence grass compounds decrease the activity of broadleaf herbicides when applied to a broadleaf species?" Fababeans were used to screen this possible interaction. Two reasons for fababean screening are: 1) to detect possible grass herbicide antagonism of broadleaf compounds, and 2) to determine potential phytotoxicity of grass herbicides to fababeans. Diclofop-methyl applied alone and in selected combinations with bromoxynil, 2,4-D, chlorsulfuron, and metsulfuron resulted in no decrease of broadleaf activity by grass compounds. The same response occurred with the other broadleaf-grass herbicide tank mixes applied to fababeans.

When the postemergence grass herbicide treatments that were applied alone were evaluated, only the haloxyfop-methyl application gave any significant injury rating. Haloxyfop-methyl showed a 32% vigor reduction of fababeans.

The haloxyfop-methyl series on wheat is representative of the responses of wheat and oats to the new postemergence grass herbicides applied alone and in selected combinations. It is representative because fluazifop-butyl and sethoxydim gave similar results to haloxyfop-methyl. In conclusion, we can say that the other new postemergence grass herbicides gave similar results to haloxyfop-methyl and that oats gave the same response as wheat when treated with these same compounds.

Conclusions

Studies, as this one, have been going on at Utah State University for many years. The results obtained in this study regarding the interaction of diclofop-methyl with 2,4-D and chlorsulfuron are consistent with the results from previous years. In this study we not only wanted to test diclofop-methyl, but other structurally similar compounds applied alone and in combination with broadleaf compounds.

From research designed to test and evalute antagonism between selected postemergence herbicides for grass and broadleaved weeds, the following conclusions can be made:

1. Antagonism is expressed when diclofop-methyl is combined with 2,4-D, chlorsulfuron, and metsulfuron.
2. Bromoxynil is not antagonistic to diclofop-methyl when applied in tank mix combinations.
3. Under greenhouse conditions, wheat injury occurs when diclofop-methyl is combined with postemergence broadleaf herbicides.
4. Postemergence grass compounds used in this study caused no significant reduction in broadleaf herbicide activity when used in tank mix combinations.
5. Haloxyfop-methyl causes a significant vigor reduction in fababeans.
6. Antagonism did not result when fluazifop-butyl, haloxyfop-methyl, and sethoxydim were combined with the postemergence broadleaf herbicides used in this study and applied to wheat or oats.

THE DIFFERENTIAL SUSCEPTIBILITY OF SPRING WHEAT (TRITICUM AESTIVUM L.) TO TRIALLATE HERBICIDE

B. G. Schaat and D. C. Thill[1]

Abstract: In a preliminary greenhouse experiment, nine varieties of spring wheat (*Triticum aestivum* L.) showed a differential susceptibility to triallate (*S*-(2,3,3-trichloroally)diisopropylthiocarbamate) herbicide. Four of the nine varieties (Fieldwin, Owens, Dirkwin, and Waverly) were selected for further testing in a field experiment. Independent variables included the four varieties, two seeding depths, three seeding dates and three rates of herbicide application. The experiment was designed as a split-plot with a factorial arrangement of treatments. Dependent variables measured were shoot biomass at heading, visual crop injury, grain yield, and test weight. A variety by rate of herbicide by seeding depth interaction occurred for grain yield, while a variety by rate of herbicide interaction resulted for shoot biomass and visual crop injury.

[1]Plant, Soil and Entomological Sciences Dept., University of Idaho, Moscow, ID.

CHEMICAL FALLOW: A METHOD OF CONSERVATION TILLAGE USEFUL IN A WHEAT-FALLOW-WHEAT ROTATION

Glen P. Peel and John O. Evans[1]

Abstract: A major emphasis has been placed on conservation tillage in recent years. Chemical fallow is one method of conservation tillage that fits well into wheat-fallow rotations of the intermountain west. Fallowing is practiced to conserve soil moisture, however, a major problem associated with it is weed control. If conservation tillage is to be practiced in a wheat-fallow rotation, herbicides (chemcial fallow) must be used to control weeds during the fallow season.

In the fall of 1982, chemical fallow plots were established at three locations within Utah: Levan, Lehi, and Beaver Dam. These locations were used because they represented major wheat growing areas of the state with different annual precipitation. Spring treatments were superimposed on the fall treated plots to determine the weed control provided by the added herbicide treatment.

Atrazine (2-chloro-4-(ethylamino)-6-(isopropylamino)-*s*-triazine) at 0.56 kg ai/ha plus diuron (3-(3,4-dichlorophenyl)-1,1-dimethyl-urea) at 3.36 kg ai/ha demonstrated virtually 100 percent control of all weed species throughout the fallow year when applied as a fall treatment. Atrazine at 0.56 kg ai/ha plus terbutryn (2-(tert-butylamino)-4-(ethylamino)-6-(methylthio)-*s*-triazine) at 1.80 kg ai/ha, paraquat (1,1'-dimethyl-4,4'-bipyridinium ion) at 0.56 kg ai/ha, or glyphosate (*N*-

[1]Plant Science Dept., Utah State University, Logan, UT.

(phosphono-methyl)glycine) at 0.28 kg ai/ha also demonstrated good weed control during the fallow year.

Chlorsulfuron (2-chloro-N-((4-methoxy-6-methyl-1,3,5-triazin-2-yl) aminocarbonyl)-benzenesulfonamide) a new herbicide shows excellent control of broadleaved weeds but does not control volunteer wheat (Triticum aestivum). Chlorsulfuron at 9.35 kg ai/ha when tank mixed with glyphosate at 0.42 kg ai/ha demonstrated good control of volunteer wheat and broadleaved weeds.

A spring herbicide treatment is often helpful in controlling weeds that have escaped the fall treatment. Glyphosate or glyphosate plus chlorsulfuron are excellent spring treatments for use in a split application.

Improved management practices will be an important part of any type of conservation tillage system, primarily when herbicides are used. Timing herbicide applications is very important. The farm manager must be able to recognize changes in the weed spectrum and modify his herbicide program to compensate for them.

CHEMICAL CONTROL OF GRASSY AND BROADLEAF WEEDS IN NEW SEEDINGS OF ALFALFA

Vern R. Stewart and Todd K. Keener[1]

Abstract: Several grass and broadleaf herbicides were evaluated alone and in combination during 1982 and 1983 for weed control in new seedings of alfalfa (Medicago sativa L.). Applications were made preplant incorporate (PPI) and/or postemergence (PE) depending on instructions for each herbicide.

1982 Results. High yields were obtained from preplant incorporation and post plant applications, or a combination of both. Ethalfluralin (N-ethyl-N-(2-methyl-2-propenyl)-2,6-dinitro-4-(trifluoromethyl)benzenamine) 1.0 lb ai/a was the most effective PPI treatment. Sethoxydim (2(1-ethoxyimino)butyl)-5(2-(ethylthio)-propyl)-3-hydroxy-2-cyclohexen-1-one) 0.5 lb ai/a plus 2,4-DB (2,4-dichlorophenoxy)acetic acid) 0.75 lb ai/a gave the highest alfalfa yield of the PE application methods. Our standard treatment of EPTC (S-ethyl dipropylthiocarbamate) 3 lbs ai/a PPI plus 2,4-DB 1.0 lb ai/a PE, was also an effective application on alfalfa. All the above applications and techniques yielded greater than two tons per acre of forage with over 95% alfalfa composition and provided good control of field pennycress (Thlaspi arvense L.), lambsquarters (Chenopodium album L.), pigweed (Amaranthus retroflexus L.) and green foxtail (Setaria viridis (L.) Beauv.). Where bromoxynil (3,5-dibromo-4-hydroxybenzonitrile) or 2,4-DB were not used the percent alfalfa composition fell below 80% due to broadleaf weed pressure.

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[1]Northwestern Agricultural Research Center, Mont. Agric. Exp. Stn., Kalispell, MT.

1983 Results. Sethoxydim, DOWCO 453 (methyl 2-(4-((3-chloro-5-trifluoro-methyl)-2-pyridinyl)oxy)phenoxy)propanoate) and fluazifop-butyl (butyl 2-(4-(5-trifluoromethyl-2-pyridinyl oxy)phenoxy)propanotae) in combination with 2,4-DB or bromoxynil (PE) resulted in over 91% alfalfa in the harvested forage with excellent grass and broadleaf control. Grassy weeds included wild oats (*Avena fatua* L.), green foxtail and quackgrass (*Agropyron repens* (L.) Beauv.). Broadleaf weeds observed were pigweed, field pennycress and lambsquarters. The combination of EPTC (PPI) with fluazifop-butyl and sethoxydim (PE) also provided hay with better than 91% alfalfa composition yet were not as effective in controlling the broadleaf species. All the grass herbicides used in combination with EPTC were very effective in the control of quackgrass. Slight phytotoxicity resulted with the application of both 2,4-DB and bromoxynil, however, this was not noticeable at harvest except for minimal height reduction.

Comparing post application techniques to standard techniques it was discovered that sethoxydim, fluazifop-butyl, and DOWCO 453 plus either 2,4-DB or bromoxynil could provide comparable or better weed control and yields than EPTC in combination with a post application of 2,4-DB or bromoxynil.

DICLOFOP INTERACTION WITH MCPA AND DICAMBA[1] IN SUNFLOWER

Greg R. Gillespie and Stephen D. Miller[2]

Abstract. The interaction between commercial formulations of diclofop (2(-4(2,4-dichlorophenoxy)phenoxy)propanoic acid) and MCPA (((4-chloro-*o*-tolyl)oxy)acetic acid) or dicamba (3,6-dichloro-*o*-anisic acid) in sunflower (*Helianthus annuus* L.) was synergistic in greenhouse and controlled environmental chamber experiments. The synergism was greater when formulated diclofop was applied as a tank mix with MCPA or dicamba than when the herbicides were applied separately 24 h apart. Neither MCPA nor dicamba influenced the absorption or translocation of ^{14}C-diclofop by sunflower. However, diclofop increased the absorption of ^{14}C in treated leaves following application of ^{14}C-MCPA compared to when ^{14}C-MCPA was applied alone. Diclofop did not influence ^{14}C-MCPA translocation or the absorption and translocation of ^{14}C-dicamba by sunflower. The presence of MCPA or dicamba increased the amount of a diclofop metabolite in sunflower. The presence of diclofop decreased MCPA metabolism and had no effect on dicamba metabolism in sunflower.

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[2]Agronomy Dept., North Dakota State University, Fargo, ND.

Introduction

Seven million acres of hard red spring wheat and 3.5 million acres of sunflower were seeded in North Dakota during 1982 (5). Nalewaja et al. (4) reported that 86% of the North Dakota wheat acreage received an application of an auxin type herbicide to control broadleaf weeds in wheat during 1978. Diclofop may control grass weeds in sunflower. Previous experiments have indicated that postemergence application of diclofop may cause sunflower injury (2). The injury to sunflower was influenced by sunflower line, sunflower growth stage and temperature/humidity conditions following diclofop application.

Situations may arise where diclofop application to sunflower occurs through a sprayer contaminated with an auxin type herbicide or diclofop treated sunflower may be exposed to spray or vapor drift of an auxin type herbicide. Low levels of an auxin type herbicide combined with diclofop may effect the response of sunflower to diclofop.

The objective of this research was to (a) determine the sunflower response to diclofop in combination with low rates of either MCPA or dicamba and (b) examine the absorption, translocation and metabolism of diclofop, MCPA and dicamba in sunflower as influenced by each other.

Materials and Methods

Diclofop interactions with MCPA and dicamba. Four seeds of sunflower hybrid 894 were placed 3 cm deep in greenhouse potting soil (2:1:1 v/v/v Fargo clay:sand:peat compost) in 1-L plastic pots, and thinned to one sunflower plant per pot after emergence. This greenhouse experiment had a completely randomized design. Diclofop was applied at 1.7 and 3.4 kg/ha, MCPA at 0.007 and 0.014 kg/ha and dicamba at 0.0035 and 0.007 kg/ha. Treatments consisted of the herbicides applied alone, the MCPA and dicamba tank mixed with diclofop and the MCPA and dicamba applied 24 h prior to or after diclofop. There was also an untreated control. Each treatment was repeated five times, and the experiment was repeated once. The temperature was approximately 25C during the day and 20C during the night. The photoperiod was 16 h and consisted of natural light supplemented with fluorescent light at an intensity of 400 $uE.m^{-2}.s^{-1}$. Herbicide treatments were applied to sunflower in the 4-leaf stage with a moving nozzle pot sprayer that delivered 160 l/ha at 280 kPa pressure.

Plant height was determined two weeks after treatment and expressed as percent of the untreated control. Further, expected percent of control plant height values for plants treated with herbicide mixtures were calculated using an equation developed by Colby (1).

Absorption, translocation, and metabolism. Treatment of plants. Sunflower plants were established as previously described. Plants were grown in the controlled environmental chamber at 20C and 40 $\pm$ 10% relative humidity (RH) until 24 h prior to herbicide application when the conditions were changed to 30C and 90 $\pm$ 5% RH. Plants received a daily 16 h photoperiod of 250 uE $m^{-2}s^{-1}$ during the experiment.

Herbicides were applied to a 1.0 cm^2 area in the middle of the fourth leaf of sunflower and included ^{14}C-diclofop, ^{14}C-diclofop plus MCPA, ^{14}C-diclofop plus dicamba, ^{14}C-MCPA, ^{14}C-MCPA plus diclofop, ^{14}C-dicamba, and

^{14}C-dicamba plus diclofop. The treated leaf was not fully expanded when treated. Its average length was 5-6 cm at treatment. Stock solutions of formulated herbicides containing diclofop at 3.7 ug/ul, MCPA at 0.47 ug/ul, and dicamba at 0.047 ug/ul were prepared by diluting diclofop methyl ester, MCPA butoxyethanol ester, and dicamba dimethylamine salt with distilled water. The ^{14}C-diclofop stock solution was prepared by diluting formulated diclop and ^{14}C-diclofop (diclofop as the methyl ester, specific activty of 2.0 mCi/mM, uniformly labeled in the 2,4-dichlorophenoxy ring) with a 1% acetone solution to form an emulsion with diclofop at 3.4 ug/ul. The ^{14}C-MCPA and ^{14}C-dicamba stock solutions were prepared by diluting ^{14}C-MCPA (specific activity of 0.6 mCi/mM, uniformly ring labeled) and ^{14}C-dicamba (specific activity of 1.89 mCi/mM, uniformly ring labeled) with 50% ethanol (1:1 v/v ethanol:distilled water) to form solutions with MCPA at 0.14 ug/ul and dicamba at 0.07 ug/ul. Ten ul of the ^{14}C-diclofop, ^{14}C-MCPA, and ^{14}C-dicamba stock solutions with activities 0.045, 0.0049, and 0.0048 uCi, respectively, were applied to sunflower alone or with 9, 3, and 15 ul of the formulated diclofop, MCPA, and dicamba stock solutions, respectively. The ^{14}C present in all samples was quantified using liquid scintillation spectroscopy.

Absorption and translocation. The experiment was completely randomized with three repetitions and repeated once. Sunflower plants were harvested 96 h after treatment. The treated leaf was removed from each plant and dipped 10 times in 15 ml of scintillation fluid 'A' (1:1 v/v tuluene:ethanol plus 5.0 g PPO (2,5-diphenyloxazole)) and 0.5 g of dimethyl-POPOP (1,4-*bis*-(2-(4-methyl-5-phenyloxazolyl))-benzene/L) to remove unabsorbed ^{14}C. The ^{14}C in the treated leaf wash was quantified. The treated leaf and the remainder of each plant were dried in an oven at 70C for 24 h. The entire treated leaf was combusted in a biological material oxidizer. The remainder of each plant was finely ground, and 300 mg of the ground mixture combusted. Following combustion the evolved $^{14}CO_2$ was trapped in 15 ml of scintillation fluid 'B' (10:7:3 v/v/v toluene:2-methoxyethanol:ethanolamine plus 5.0 g PPO and 0.5 g dimethyl-POPOP/L) and the amount of ^{14}C quantified. Data collected included ^{14}C recovered, ^{14}C absorbed, and ^{14}C translocated out of the treated sunflower leaf each expressed as percent of applied ^{14}C. The recovery of ^{14}C averaged over all treatments was 81%.

Metabolism. The experiment was completely randomized with three plants per treatment and the experiment was conducted three times. Sunflower plants were harveted 96 h after treatment. The treated leaf of each plant was removed and the remainder of the plant discarded. Treated leaves were dipped 10 times in 15 ml of scintillation fluid 'A' to remove unabsorbed ^{14}C. The unabsorbed ^{14}C on the treated leaf was quantified.

The treated leaves were stored frozen until extraction. Treated leaves from three repetitions were combined for extraction. Leaves treated with ^{14}C-diclofop were extracted four times with 80% acetonitrile (8), and leaves with either ^{14}C-MCPA or ^{14}C-dicamba were extracted four times with 70% ethanol using a mortar and pestle. The extracts were centrifuged at 1500 g for 15 min. The supernatant was decanted and the volume adjusted to 8.0 ml. A 1.0 ml aliquot of the supernatant was added to 15 ml of scintillation fluid 'A' and the ^{14}C quantified. The remaining supernatant was evaporated to dryness under an air stream. The ^{14}C-diclofop samples were resuspended in 0.1 ml of 1:1 v/v 80% acetonitrile:95% ethanol. The ^{14}C-MCPA and ^{14}C-dicamba samples were resuspended in 0.1 ml of 80% ethanol (4:1 v/v ethanol:distilled water).

The ^{14}C-labeled compounds in the treated leaf extracts were separated using thin layer chromatography (TLC). A slurry (prepared by suspending 35 g of 7-GF silica gel in 70 ml of distilled water) was applied to acetone-washed glass TLC plates at a thickness of 0.25 mm. The TLC plates were dried at room temperature for 15 min and then activated by heating at 110 C for 30 min. The plates were used immediately after activation. Thirty ul of the concentrated treated leaf extracts containing ^{14}C-diclofop were applied to TLC plates. The chromatographs were developed to a height of 11 to 12 cm in 80:15:5 v/v/v chloroform:acetic acid:hexane. This solvent system failed to sufficiently separate two ^{14}C-labeled compounds near the solvent front. Therefore, this portion of the TLC plates was scraped into scintillation vials containing 5 ml of 80% acetonitrile. The silica gel was allowed to settle out, the supernatant decanted, and the solutions evaporated to dryness and resuspended in 0.1 ml of 1:1 v/v 80% acetonitrile:95% ethanol. The entire volume of these solutions was applied to TLC plates. The chromatographs were developed to a height of 11 to 12 cm in 2:1 v/v benzene:95% ethanol. Seventy ul of the concentrated treated leaf extracts containing either ^{14}C-MCPA or ^{14}C-dicamba were applied to TLC plates. The chromatographs were developed to a height of 10 to 11 cm in 8:1:1 v/v/v isopropanol:NH_4OH:H_2O. Radioactive bands on the TLC plates were located with a radiochromatogram scanner with a recording ratemeter. Radioactive bands on the TLC plates were scraped into scintillation vials containing 15 ml of scintillation fluid 'A' and the ^{14}C quantified.

The plant residue that remained following extraction was dried at 70C for 24 h. The residue was combusted in a biological material oxidizer, the evolved $^{14}CO_2$ trapped in 15 ml of scintillation fluid 'B', and the amoung of ^{14}C determined.

Data collected included the amount of ^{14}C present as unmetabolized and metabolized diclofop, MCPA, or dicama and the amount of ^{14}C in the plant residue each expressed as percent of the ^{14}C in the treated sunflower leaf.

Results and Discussion

Diclofop interactions with MCPA and dicamba. Applications of diclofop, MCPA and dicamba alone and in various combinations were not lethal to sunflower two weeks following treatment. Sunflower exhibited typical auxin injury symptoms following MCPA or dicamba treatment, but in no instance was the injury severe enough to cause plant death.

Diclofop applied with MCPA synergized injury to sunflower as determined by plant height (Table 1). The differences obtained by subtracting the observed from the expected percent of control plant height ranged from +12 to +48. The synergism of diclop with MCPA in sunflower was greater when applied as a tank mix compared to when diclofop was applied 24 h prior to or after MCPA application. For example, the synergism or difference values with diclofop at 1.7 kg/ha and MCPA at 0.007 kg/ha were +47, +37, and +29 when applied as a tank mix, or diclofop 24 h prior to or after MCPA application, respectively.

Table 1. Sunflower height as affected by diclofop and MCPA applied alone and in various combinations.

Herbicide treatment	Appli-cation	Rate (kg/ha)	Plant height		
			Observed	Expected	Difference
			-------- % of control ----------		
Diclofop	Alone	1.7	96		
Diclofop	Alone	3.4	95		
MCPA	Alone	0.007	112		
MCPA	Alone	0.014	90		
Diclofop + MCPA	Tank	1.7 + 0.007	61	108	+47
Diclofop + MCPA	Tank	1.7 + 0.014	47	86	+39
Diclofop + MCPA	Tank	3.4 + 0.007	58	106	+48
Diclofop + MCPA	Tank	3.4 + 0.014	42	86	+44
Diclofop + MCPA	Split	1.7 + 0.007	71	108	+37
MCPA + diclofop	Split	0.007 + 1.7	79	108	+29
Diclofop + MCPA	Split	1.7 + 0.014	50	86	+36
MCPA + diclofop	Split	0.014 + 1.7	74	86	+12
Diclofop + MCPA	Split	3.4 + 0.007	68	106	+38
MCPA + diclofop	Split	0.007 + 3.4	70	106	+36
Diclofop + MCPA	Split	3.4 + 0.014	58	86	+28
MCPA + diclofop	Split	0.014 + 3.4	72	86	+14
LSD (0.05)			12		

[a]Tank = tank mix; Split = first herbicide in series was applied 24 h prior to the other herbicide.

[b]Calcualted using an equation developed by Colby (1).

[c]A (+) value = synergistic interaction.

Diclofop applied with dicamba resulted in a similar synergism of injury to sunflower as observed with MCPA (Tables 1 and 2). The difference obtained by subtracting the observed from the expected percent of control plant height ranged from +3 to +29 (Table 2). The highest values of +25, +28, and +29 were obtained with diclofop at 3.4 kg/ha either tank mixed with dicamba at 0.0035 or 0.007 kg/ha, or applied 24 h prior to dicamba at 0.007 kg/ha, respectively.

Table 2. Sunflower height as affected by diclofop and dicamba applied alone and in various combinations.

Herbicide treatment	Application	Rate (kg/ha)	Plant height		
			Observed	Expected	Difference
			-------- % of control ----------		
Diclofop	Alone	1.7	96		
Diclofop	Alone	3.4	95		
Dicamba	Alone	0.0035	103		
Dicamba	Alone	0.007	96		
Diclofop + dicamba	Tank	1.7 + 0.0035	82	99	+17
Diclofop + dicamba	Tank	1.7 + 0.007	79	92	+13
Diclofop + dicamba	Tank	3.4 + 0.0035	73	98	+25
Diclofop + dicamba	Tank	3.4 + 0.007	63	91	+28
Diclofop + dicamba	Split	1.7 + 0.0035	88	99	+11
Dicamba + diclofop	Split	0.0035 + 1.7	96	99	+ 3
Diclofop + dicamba	Split	1.7 + 0.007	76	92	+16
Dicamba + diclofop	Split	0.007 + 1.7	73	92	+19
Diclofop + dicamba	Split	3.4 + 0.0035	86	98	+12
Dicamba + diclofop	Split	0.0035 + 3.4	83	98	+15
Diclofop + dicamba	Split	3.4 + 0.007	62	91	+29
Dicamba + diclofop	Split	0.007 + 3.4	73	91	+18
LSD (0.05)			9		

[a]Tank = tank mix; Split = first herbicide in series was applied 24 h prior to the other herbicide.

[b]Calculated using an equation developed by Colby (1).

[c]A (+) value = synergistic interaction.

These data indicated a synergism of injury to sunflower from diclofop with MCPA and dicamba. Further the synergism tended to be greatest when diclofop and the MCPA and dicamba were applied as a tank mix. Previous experiments (3, 6, 7, 8) have shown that these auxin type herbicides antagonize wild oat injury and control with diclofop. Olson and Nalewaja (6) reported that wild oat control with diclofop at 1 kg/ha was reduced from 96% to 48, 31 and 15% by 0.5 kg/ha of MCPA, 2,4-D, or dicamba, respectively. Qureshi and VandenBorn (7) indicated that the presence of MCPA amine or ester reduced the uptake of ^{14}C-diclofop by wild oat; in addition, MCPA reduced the rate of hydrolysis of diclofop to diclofop-acid and increased the rate of formation of diclofop conjugates in wild oat. Todd and Stobbe (8) suggested the antagonistic effect of 2,4-D on diclofop control of wild oat was due to reduced movement of diclofop-acid to the meristematic sites of action. Since absorption, translocation, and metabolism factors may account for the antagonism of wild oat control caused when auxin herbicides are mixed with diclofop, these factors were examined in an attempt to explain the observed synergism of diclofop plus MCPA and dicamba in sunflower.

Absorption and translocation. Foliar absorption of ^{14}C-diclofop by sunflower was not influenced by MCPA or dicamba (Table 3). Similar amounts of ^{14}C were present in the treated leaf and in the remaining plant parts when ^{14}C-diclofop was applied alone and with MCPA or dicamba. Todd and Stobbe (8) similarly reported no difference of absorption of ^{14}C-diclofop by wild oat when applied alone or with 2,4-D. In contrast, Qureshi and VandenBorn (7) reported that the presence of MCPA decreased the absorption of ^{14}C-diclofop by over 60%.

The percent of applied ^{14}C in the treated sunflower leaf was greater when ^{14}C-MCPA was applied with diclofop than alone (Table 3). The treated sunflower leaf contained 12 and 24% of applied ^{14}C following application of ^{14}C-MCPA and ^{14}C-MCPA plus diclofop, respectively. The additional surfactant and solvent in the diclofop formulation may have aided in the penetration of MCPA. Diclofop did not influence translocation of ^{14}C-MCPA out of the treated sunflower leaf or the total absorption of ^{14}C-MCPA by sunflower 96 h after treatment.

Absorption of ^{14}C-dicamba by sunflower was not influenced by diclofop (Table 3). In addition, similar amounts of ^{14}C were present in the treated sunflower leaf and the rest of the plant following application of ^{14}C-dicamba or ^{14}C-dicamba plus diclofop.

Metabolism. The total amount of metabolized diclofop in the treated sunflower leaf was not influenced by MCPA or dicamba (Table 4). However, the presence of MCPA or dicamba increased the formation of diclofop metabolite 1 in sunflower. The percent of the ^{14}C in the treated sunflower leaf present as diclofop metabolite 1 was 23, 37, and 34% following application of ^{14}C-diclofop, ^{14}C-diclofop plus MCPA, and ^{14}C-diclofop plus dicamba, respectively. The amounts of unmetabolized diclofop and diclofop metabolite 2 in the treated sunflower leaf were not influenced by MCPA or dicamba. Further, the amounts of ^{14}C in the plant residue were similar whether ^{14}C-diclofop was applied alone or with MCPA and dicamba.

Diclofop did not influence the amount of unmetabolized MCPA in the treated sunflower leaf (Table 4). However, the total amount of metabolized MCPA was reduced by 8% when ^{14}C-MCPA was applied with diclofop compared to when ^{14}C-MCPA was applied alone. The amounts of MCPA metabolites 1 and 2 were similar whether ^{14}C-MCPA was applied alone or with diclofop. The amounts of ^{14}C in the plant residue following ^{14}C-MCPA application were not influenced by diclofop.

Table 3. Absorption and translocation of ^{14}C-diclofop as influenced by MCPA and dicamba or absorption and translocation of ^{14}C-MCPA and ^{14}C-dicamba as influenced by diclofop.

Herbicide Treatment	^{14}C In treated leaf	^{14}C In rest of plant	Total absorbed	Leaf Wash	^{14}C recovered
	----------(% of applied ^{14}C)				
^{14}C-diclofop	51.8	1.4	53.2	29.4	82.6
^{14}C-diclofop+MCPA	55.9	4.2	60.1	20.1	80.2
^{14}C-diclofop+dicamba	55.3	3.4	58.7	24.7	83.4
LSD (0.05)	NS	NS	NS	NS	NS
	----------(% of applied ^{14}C)				
^{14}C-MCPA	12	49	61	19	80
^{14}C-MCPA+diclofop	24	50	74	7	81
^{14}C-dicamba	14	48	62	17	80
^{14}C-dicamba+diclofop	12	56	68	13	81
LSD (0.05)	5	NS	NS	NS	NS

The presence of diclofop applied with ^{14}C-dicamba did not influence the amount of unmetabolized or metabolized dicamba in sunflower compared to when ^{14}C-dicamba was applied alone (Table 4).

These data indicate that the presence of diclofop increased the amount of ^{14}C-MCPA label in the treated sunflower leaf following ^{14}C-MCPA application compared to when ^{14}C-MCPA was applied alone (Table 3). MCPA or dicamba increased diclofop metabolite 1 formation, but did not increase total diclofop metabolism by sunflower. Diclofop reduced the amount of MCPA metabolized by 8%, but did not influence dicamba metabolism in sunflower.

The basis of the synergism of diclofop plus MCPA and dicamba in sunflower was not due to a single effect of herbicide absorption, translocation, or breakdown of the parent herbicides. Absorption, translocation, and metabolism changes that occurred between herbicides applied alone and in combination were small when considered individually; however, their combined effects contributed to the synergism of diclofop with MCPA and dicamba in sunflower.

Table 4. Diclofop metabolism by sunflower as influenced by MCPA and dicamba or MCPA and dicamba metabolism as influenced by diclofop.

Herbicide Treatment	Unmetabolized	Metabolized ^{14}C			Unextracted ^{14}C
		Metabolite	Metabolite	Total	
	----------------(% of ^{14}C in treated leaf)-----------				
^{14}C-diclofop	27	23	11	34	39
^{14}C-diclofop+MCPA	11	37	9	46	43
^{14}C-diclofop+dicamba	25	34	10	44	31
LSD (0.05)	NS	11	NS	NS	NS
	----------------(% of ^{14}C in treated leaf)-----------				
^{14}C-MCPA	27	25	5	30	43
^{14}C-MCPA+diclofop	27	18	4	22	51
LSD (0.05)	NS	NS	NS	6	NS
	----------------(% of ^{14}C in treated leaf)-----------				
^{14}C-dicamba	20	47	--	47	33
^{14}C-dicamba+diclofop	19	48	--	48	33
LSD (0.05)	NS	NS		NS	NS

[a]Metabolite 1 R_f = 0.12 ± 0.02, 0.46 ± 0.10, and 0.47 ± 0.10 for diclofop, MCPA, and dicamba, respectively.

[b]Metabolite 2 R_f = 0.77 ± 0.06 and 0.76 ± 0.05 for diclofop and MCPA, respectively.

[c]^{14}C in the plant residue following extraction.

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POSTDIRECTED WEED CONTROL IN CALIFORNIA AND ARIZONA COTTON WITH OXYFLUORFEN

L.D. West, R.C. Hildreth, M.F. Jehle and J.T. Schlesselman[1]

Abstract. Oxyfluorfen (2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-trifluoromethyl)benzene) was registered for postdirected weed control in cotton in 1983. Since 1979 tests have been established to answer two major questions: 1) is oxyfluorfen safe on cotton and 2) how effective is oxyfluorfen in controlling summer annual broadleaf weeds.

Oxyfluorfen, at rates of 0.5 and 1.0 lb/A was as safe as prometryn on cotton (Table 1).

Annual morningglory (*Ipomoea hederacea* and *Ipomoea hirsutula*) was controlled equally well by oxyfluorfen and prometryn. Oxyfluorfen controlled both groundcherry (*Physalis wrightii* and *Physalis lanceifolia*) and black and hairy nightshade (*Solanum nigrum* and *solanum sarachoides*) somewhat better than prometryn (Table 2).

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[1]Rohm and Haas Company, Fresno, CA.

Early postemergence application was critical for effective control of the above weeds with oxyfluorfen. Early postemergence applications resulted in an increase in weed control ratings of 6-35% as compared to late postemergence applications (6-8 inch weeds).

Table 1. Initial Response of Cotton to Oxyfluorfen and Prometryn.

Treatment	Rate (lb/A)	Cotton Injury (%)[a]
Oxyfluorfen	0.5	10
Oxyfluorfen	1.0	11
Prometryn	0.5	11
Control	-	0

[a]0 = no injury, 100 = complete kill, 7 to 21 day evaluations.

Table 2. Control of Annual Morningglory, Groundcherry, and Nightshade by Oxyfluorfen

		Weed Control (%)[a]		
Treatment	Rate (lb/A)	Annual Morningglory	Groundcherry	Nightshade
Oxyfluorfen	0.5	84	97	96
Oxyfluorfen	1.0	83	98	--
Prometryn	0.5	83	94	92
Control	--	0	0	0

[a]0 = no control, 100 = complete kill.

Table 3. The Effect of Timing on Annual Broadleaf Weed Control from Postdirect Applications of Oxyfluorfen in Cotton.

		Weed control (%)[a]						
		Annual Morningglory			Groundcherry		Nightshade	
Treatment	Rate (lb/A)	Cotyledon[b]	2 in.	4-8 in.	2 in.	6 in.	2 in.	8 in.
Oxyfluorfen	0.25	-	-	-	100	65	-	-
Oxyfluorfen	0.5	100	96	94	100	80	95	73
Oxyfluorfen	1.0	100	99	94	-	-	100	78
Oxyfluorfen	2.0	100	100	100	-	-	-	-
Prometryn	1.6	89	85	68	-	-	-	-
Control	-	0	0	0	0	0	0	0

[a]0 = no control, 100 = complete kill.

[b]weed growth stage.

SETHOXYDIM FOR PERENNIAL GRASS CONTROL IN COTTON

G. C. Cramer and D. Wiley[1]

In 1983, sethoxydim (2-(1-(ethoxyimino)butyl)-5-(2-(ethylthio)propyl)-3-hydroxy-2-cyclohexen-1-one) was successfully tested against bermudagrass (*Cynodon dactylon*) and johnsongrass (*Sorghum halepense*) growing in cotton in Arizona and California. Broadcast treatments were applied to cotton at all stages of growth (cotyledon to boll opening) with no phytotoxicity problems.

The key to perennial grass control in cotton is an early application of sethoxydim prior to any competitive interaction by the grass on cotton. As regrowth occurs, subsequent applications should also be prior to any vigorous crop/weed interaction. In some cases, a later season (layby) application will be needed. At this time, drop nozzles may be needed to insure adequate herbicide coverage.

While reduced weed infestations have been seen two and even three years after a single season's application, no one should expect the outright eradication of the grasses treated. Light infestations may be eradicated, but old, well established weed stands will require persistence in both cultural (mechanical) and chemical controls.

Three tests were conducted against bermudagrass in Arizona and California this past season. These tests ranged in size from 2 to 4 acres. In all cases, 1 quart of nonphytotoxic oil concentrate per acre was used with the sethoxydim treatments. Rates of sethoxydim tested against

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[1]BASF Wyandotte, Corp., Tucson, AZ.

bermudagrass were 0.3, 0.4, 0.5, and 0.6 lb ai/acre. Subsequent applications of 0.3 lb ai/acre were applied to regrowth as needed (approx. 21 days). The sethoxydim broadcast treatments were applied in 15-20 gpa at 40 psi.

Excellent control was achieved by sethoxydim at all rates tested that had sequential applications. The bermudagrass infestations in these fields were well established. Regrowth began after approximately 30 days in test areas receiving only one application. Second applications of 0.3 lb ai/acre were applied approximately 25 days after initial treatments. At this time, regrowth had not yet begun and most of the stems and terminals of the bermudagrass were still brown.

Thirty six days after the initial sethoxydim treatments, the control ratings for single applications began dropping. Sequential treatments, however, were controlling 95-99% of the bermudagrass problem. This trend continued throughout the growing season. At the time of harvest, sequential applications were controlling 87-94% of the bermudagrass.

Sethoxydim was also tested against johnsongrass in cotton in 5 Arizona and 4 California trials. These trials ranged in size from 2-5 acres. Initial application rates of sethoxydim were at 0.4, 0.5 and 0.6 lb ai/acre. One quart per acre of a nonphytotoxic oil concentrate was added to all sethoxydim treatments. Total spray volumes of 10-20 gpa were applied at 40 psi.

Two weeks after initial treatment, johnsongrass control was excellent; 95-100%. This was true of all rates tested (0.4 - 0.6 lb ai/acre) on johnsongrass from 4-30 inches tall. Regrowth began in some of these tests approximately 30 days after the first application.

Midseason weed control ratings taken approximately 50-75 days after initial treatments and approximately 30-40 days after a second application of 0.3 lb ai/acre showed variable results. Control ranged from 70-90% for 0.4 + 0.3 lb ai/acre treatments. Control by treatments of 0.5 or 0.6 lb ai/acre followed by 0.3 lb ai/acre ranged from 80-100%.

Fields (3) evaluated at time of harvest showed continued control of the johnsongrass problems.

In order to maximize sethoxydim's potential, there are a few items that are essential. 1) A nonphytotoxic crop oil concentrate at a rate of 1 quart per acre must be added to the solution. Vegetable oil concentrates, when adequately refined and properly formulated, performed as well as currently recommended petroleum oil concentrates. 2) Follow the POAST label weed size recommendations. 3) Do not apply to stressed weeds as control may be reduced. 4) A timely cultivation is critical. In the irrigated areas of the west, the rhizome and stolon masses have excellent potential for regrowth. The initial sethoxydim treatment (0.5 lb ai/acre) will kill the above ground portion of the weeds. This treatment will also kill varying numbers of the potential growing points below ground. A cultivation not sooner than 7 days after an application will often eradicate the remaining growing points. Regrowth from treated plants usually has narrower leaves, is less thrifty overall, and is easily controlled by an application of 0.3 lb ai/acre. This application should also be followed by a timely cultivation.

Table 1. Bermudagrass (*C. dactylon*) control in cotton by sethoxydim.

	% Control		
Rate (#ai/A)[1]	23 DAT[2]	30-50 DAT[2]	Harvest
0.3[3]	75(3)[4]	30(2)	62(2)
0.3 + 0.3[5]	--	97(2)	94(2)
0.4[3]	83(3)	40(2)	50(1)
0.4 + 0.3[5]	--	97(2)	88(2)
0.5[3]	89(3)	50(3)	57(2)
0.5 + 0.3[5]	--	97(2)	87(2)
0.6[3]	93(3)	50(3)	57(2)
0.6 + 0.3[5]	--	97(2)	90(2)

[1]One quart nonphytotoxic crop oil/acre; 40 psi; 10-20 gpa.

[2]DAT = Days After first Treatment.

[3]First Treatment.

[4]Number of Trials (approximately 3 acres/trial)

[5]Second application (0.3 lb ai/acre) made approximately 20-30 days after first application.

Table 2. Johnsongrass (*S. halepense*) control by sethoxydim in cotton.

	% Control		
Rate (#ai/A)[1]	7-20 DAT[2]	50-75 DAT	Harvest
0.4[3]	99(7)[4]	--[5]	--[5]
0.4 + 0.3[6]	--	83(5)	99(2)
0.5	99(9)	--	--
0.5 + 0.3	--	91(6)	97(3)
0.6	99(7)	--	--
0.6 + 0.3	--	89(5)	99(2)

[1]One quart nonphytotoxic crop oil/acre; 40 psi; 10-20 gpa.

[2]DAT = Days After first Treatment.

[3]First Treatment.

[4]Number of treatments.

[5]See second application.

[6]Second application (0.3 lb ai/acre) made approximately 20-30 days after first application.

THE EFFECT OF CHLORSULFURON RESIDUES ON SEVEN CROPS IN MONTANA

D. C. Burkhart, W. E. Dyer, and P. K. Fay[1]

Introduction

Chlorsulfuron (2-chloro-N-(((4-methoxy-6-methyl-1,2,5-triazin-2-yl) amino)carbonyl)benzenesulfonamide) has the potential to be an important herbicide in Montana. Its unique properties make it the most important new herbicide since the discovery of 2,4-D ((2,4-dichlorophenoxy)acetic acid). Some of the properties that are important in Montana include: flexibility of application timing, broad spectrum of control, and crop safety on wheat.

There are ten million acres of cropland in Montana and about 70% of this acreage is planted to wheat or barley each year. In parts of Montana, safflower, sunflower, sugar beets, pinto beans, alfalfa, potatoes, and corn are important rotational crops. Since chlorsulfuron has a residue which damages many crops, we must determine how long the residue lasts. To answer this question, a chlorsulfuron plantback study was initiated in 1980.

Materials and Methods

In the fall of 1980 chlorsulfuron was applied to plots in Bozeman and Great Falls, Montana, at 35, 70 and 140 g/ha. The experiment at Great Falls was summer fallowed and spring wheat was planted on the plot in Bozeman in 1981. In the spring of 1982, sunflower, safflower, sugar beets, pinto beans, corn, wheat and barley were planted at both locations. The crops were harvested in August. In the spring, 1983, the same crops were planted at both locations. They were harvested in August.

Results and Discussion

Two years after application chlorsulfuron, at all rates, reduced the dry weight of all crops planted except wheat and barley at both locations.

At 35 g/ha the dry weight of pinto beans was 48% of plants grown in plots with no chlorsulfuron application. Dry weight percentages decreased with increasing rates of herbicide. Sugar beets were most sensitive to chlorsulfuron. At 35 g/ha the dry weight was only 18% of plants from the control (Table 1). Results from crops grown at Great Falls were similar.

In 1983 dry weights were again reduced by all rates of chlorsulfuron at both locations. Safflower dry weight, at 35 g/ha, was 53% of the dry weight of the control. At 35 g/ha the dry weight of sugar beets was only 21% of the dry weight from the control plot. At 140 g/ha sugar beets were 3% of the control (Table 2).

Wheat yields were not reduced in 1982 by any rate of chlorsulfuron at either location. Barley yields were reduced only at 140 g/ha at Bozeman (Table 3). Wheat and barley were not harvested in 1983 at either location due to hail damage. There was no visual damage from chlorsulfuron to either crop at either location.

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[1]Montana State University, Bozeman, MT.

Table 1. Results of 1982 chlorsulfuron plantback at Bozeman. Results are dry weight expressed as a percentage of the dry weight of control plots.

Rate g/ha	Pinto Bean	Safflower	Sunflower	Corn	Sugar Beet
	% of control				
35	48	30	25	18	18
70	33	26	2	15	1
140	21	11	1	12	1

Table 2. Results of 1983 chlorsulfuron plantback at Bozeman. Results are dry weight expressed as a percentage of the dry weight of the check plots.

Rate g/ha	Pinto Bean	Safflower	Sunflower	Corn	Sugar Beet
	% of control				
35	49	53	39	34	21
70	43	45	37	11	9
140	37	36	11	7	3

Table 3. 1982 wheat and barley yields (kg/ha) from chlorsulfuron plantbacks in Bozeman and Great Falls, Montana.

Rate	Wheat		Barley	
g/ha	Bozeman	Great Falls	Bozeman	Great Falls
35	1949	1727	1548	1236
70	1881	1882	1156	1290
140	1713	1929	956	1236
Control	1667	1613	1468	1360
LSD	571	641	435	532

Table 4. Montana Crops' Sensitivity To Chlorsulfuron

Wheat Oats	Barley	Safflower Dry beans Flax Faba beans	Garbanzo beans Potaotes	Corn Sunflower Lentils Alfalfa Sugar beets

LEAST ⟶ MOST

It should be pointed out that 35 g/ha is twice the recommended label rate of 18 g/ha chlorsulfuron in Montana.

In 1983 additional crops were planted in the plots and were rated according to their sensitivity to chlorsulfuron residues (Table 4). Wheat and oats are the most tolerant. Barley is more sensitive; however, barley yield has been reduced by chlorsulfuron residues. Safflower, dry beans, flax and faba bean are intermediate in tolerance. Corn, sunflower, lentils, alfalfa, and sugar beets are the most sensitive crops grown in Montana. Unfortunately, one of Montana's most important rotational crops, alfalfa, is among the most sensitive crops.

In order for farmers to use chlorsulfuron in Montana, precautionary methods will have to be adopted:

1. Accurate record keeping. Farmers will have to record when, where and how much chlorsulfuron is used on their farms. A farmer is likely to end up with a crop failure if he depends upon memory.
2. Accurate application. Chlorsulfuron is the first herbicide used widely in the state that is applied in fractions of an ounce per acre rather than pounds or quarts per acre. Mistakes in tank mixing or sprayer overlaps will magnify the intensity of chlorsulfuron's effect.
3. Loss of flexibility. If chlorsulfuron is going to be used, future rotations will be limited.

These are not unreasonable constraints for farmers. Herbicides are routinely used in other regions which have residual properties.

APPLICATION OF GLYPHOSATE TO DORMANT ALFALFA FOR POSTEMERGENCE WEED CONTROL

H. R. Mashhadi and J. O. Evans[1]

Introduction

Quackgrass (Agropyron repens (L.) Beau.) is a noxious perennial weed in most Utah alfalfa fields. Quackgrass not only reduces alfalfa yield substantially, but it also lowers the quality and protein content of hay. Glyphosate (N-phosphonomethyl glycine) is a non-selective systemic herbicide which has been shown to be very effective in controlling quackgrass.

Recently, Utah alfalfa growers have used glyphosate as a "salvage" herbicide on dormant established alfalfa to control quackgrass and other emerged weeds. Extension Specialists have reported up to 62 percent quackgrass control with .43 kg ai/ha when applied before alfalfa breaks dormancy. Ivani (2) found that fall applied glyphosate gave better control of quackgrass than spring application. Applying glyphosate at 1.12 kg ai/ha in late October gave good to excellent control of quackgrass. In

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[1]Utah State University, Logan, UT.

another study conducted by Mueller et al. (3) glyphosate gave excellent control of quackgrass when applied in both no till and conventional tillage prior to planting alfalfa. Wyse (4) reported 53 to 90% quackgrass control with 1.12 and 1.68 kg ai/ha of glyphosate before planting soybeans. Although preplant application of glyphosate reduced quackgrass in alfalfa, Wisconsin trials indicated that quackgrass reinfested the land after application (1).

The purpose of this study was to determine the efficiency of glyphosate on established dormant alfalfa to control quackgrass and dandelion (*Taraxacum officinale*) and to evaluate the potential for crop injury with glyphosate.

Materials and Methods

Two sites heavily infested with quackgrass were located within Utah; Logan and Heber City. Experimental plots were 3.4 X 9.1 meter and complete randomized design with four replications were used to conduct the experiment. Treatment included four rates of glyphosate i.e., 0.21, 0.43, 0.64 and 0.84 kg ai/ha alone and in combination with .50% v/v of R-11 surfactant. A bicycle sprayer was used to spray the plots at 65.5 l/ha. Herbicides were applied when alfalfa crowns were breaking dormancy with a few crowns which had less than one inch of growth on them. At this time quackgrass was on 3-4 leaf stage and dandelion was 2-5" rossette stage. No fertilizers were applied to the fields at Logan, but the fields at Heber City had been fertilized with 70 kg/ha nitrogen. Visual evaluations were made before, and at 20 days after first cutting. Plots were harvested with an experimental plot mower and fresh weights were recorded. Percent alfalfa was estimated visually and recorded for each treatment at harvest. Since the Logan field was severely and ununiformly winterkilled, no yield data were taken from this location.

Results and Discussion

Tables 1 and 2 indicate alfalfa injury due to glyphosate treatment at both locations. Injury level increased with increasing glyphosate rate. Surfactant increased the injury even more. Injury became progressively worse as crop matured but recovery occurred rapidly after 1st cutting. No alfalfa injury was recorded at either location by second cutting.

Low dosages of glyphosate suppressed growth of quackgrass and controlled dandelions. Increasing the rates of the herbicide increased control of the two weeds. R-11 intensified the action of glyphosate on quackgrass. Quackgrass reinfested the land after harvest at Heber City to the degree that there were no significant differences between the treatments after first harvest. Quackgrass control at Logan, however, was observed after harvest but the control was lower than that observed in the crop prior to first cutting. Dandelions reinfested the plots soon after the first evaluation. No control of dandelions were observed after the first cutting at either location.

Although satisfactory weed control was obtained by higher rates of glyphosate the injury to crop decreased alfalfa yield as shown in Table 2. Lower rates of glyphosate gave higher alfala yield but were laden with weeds.

Table 1. Effects of glyphosate applications on dormant alfalfa and early postemergence quackgrass and dandelion Logan, Ut. 1983.

		% Crop Injury[a]		% Quackgrass Control[a]			% Dandelion Control[a]	
Treatment	Rate	May 17, 1983[b]	June 16, 1983[c]	May 17, 1983	June 16, 1983	July 14, 1983	May 17,1983	June 18,1983[c]
	kg/ha							
glyphosate	.21	2 e	9 cd	48 c	68 d	31 c	84 b	84 b
glyphosate R-11	.21+ .5%	4 d	18 bc	76 ab	71 abc	30 cd	93 a	80 b
glyphosate	.43	6 abcd	20 bc	86 ab	83 abc	50 bc	96 a	86 ab
glyphosate R-11	.43+ .5%	6 abc	31 ab	89 a	84 ab	71 ab	96 a	88 ab
glyphosate	.64	5 bcd	20 bc	91 a	91 ab	64 ab	98 a	93 a
glyphosate R-11	.64+ .5%	7 a	45 a	94 a	93 a	83 a	97 a	91 a
glyphosate	.84	7 ab	44 a	93 a	91 a	80 ab	99 a	94 a
glyphosate R-11	.84+ .5%	8 a	45 a	95 a	94 a	76 ab	98 a	94 a
control	--	0 e	0 e	0 d	0 e	0 d	0 c	0 d

[a]alfalfa injury and quackgrass control were based on visual observations of biomass reduction; dandelion control was based on visual observations of stunting and stand reduction.

[b]Means within the same column followed by the same letter are not significantly different at the .05 level.

[c]There were no significant differences among treatments for the July 14, 1983 evaluation.

Conclusion

Glyphosate applications to dormant alfalfa failed to give full season weed control. At experimental dosages tested glyphosate appears to cause unacceptable alfalfa injury. Crop injury was greater early after application and at higher rates.

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HERBICIDE TOLERANCE OF WHITE LUPINES

M. G. Hagemann, F. L. Young and A. J. Ciha[1]

Lupines (Lupinus albus L.), a high protein grain legume, have the potential of being grown in the Palouse region of southeastern Washington. Greenhouse studies were conducted to evaluate the tolerance of the cultivar 'Astra' to several herbicides commonly used on legumes. Preplant incorporated, preemergence, and postemergence herbicides were applied at two rates. Lupine injury was evaluated visually on a scale of 0% (no injury) to 100% (death). At harvest, length of the hypocotyl, height of the plant, and dry weight were measured for all plants.

Atrazine (2-chloro-4-(ethylamino)-6-(isoproplyamino)-s-triazine), EPTC (S-ethyl dipropylthiocarbamate) + R-29148, alachlor (2-chloro-2',6'-diethyl-N-(methoxymethyl) acetanilide), and ethalfluralin (N-ethyl-N-(2-methyl-2-propenyl)-2,6-dinitro-4-(trifluoromethyl)benzenamine) applied pre-plant incorporated severely injured the lupines. Triallate (S-(2,3,3-trichloroallyl) diisopropylthiocarbamate) and trifluralin (o,o,o-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine) did not injure the lupines. The dry weights of lupines treated with preplant incorporated herbicides corresponded with crop injury. The majority of the herbicides corresponded

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[1]Grad. Res. Assist. and USDA/ARS, Washington State University, Pullman, WA.

with crop injury. The majority of the herbicides in the applied preemergence did not cause significant injury to the lupines; however, the lupines were severely injured by metribuzin (4-amino-6-tert-butyl-3-(methylthio)-as-triazin-5(4H)-one). There was a considerable reduction in the dry weight of the plants. There was greater injury to the lupines when the herbicides were applied postemergence to lupines in the 1-2 leaf stage than the 4-5 leaf stage, however, there was no difference in the dry weights or heights between the stages. Atrazine, bentazon ((3-isopropyl-1H-2,1,3-benzothiadiazin-4(3H)-one 2,2-dioxide), and MCPA Na salt (((4-chloropo-tolyl)oxy) butyric acid) caused death to the lupine. Fluazifop ((±)-butyl 2-(4-(5(5-(trifluoromethyl)-2-pyridinyl)oxy)phenoxy)propanoate) and diclofop (2-(4-(2,4-dichlorophenoxy) phenoxy) propanoic acid) were the only herbicides that did not injure lupines when applied postemergence.

BERMUDAGRASS RESPONSE TO MULTIPLE APPLICATIONS OF POSTEMERGENCE GRASS HERBICIDES AT VARIOUS TIMING

C. E. Bell and K. Little[1]

Abstract: The recently introduced postemergence grass herbicides have been shown to be effective chemicals for control of bermudagrass (*Cynodon dactylon* (L.) Pers.) when applied in 2 separate treatments. The timing of the second application is at present a poorly defined recommendation.

This trial was designed to evaluate several herbicides and timings for control of bermudagrass. The bermudagrass is being grown as a lawn and was irrigated regularly. Six herbicides: sethoxydim (2-(1-(ethoxyimino)butyl)-5-(2-(ethylthio)propyl)-3-hydroxy-2-cyclohexen-1-one), fluazifop butyl (butyl 2-(4-(5-tri-fluoromethyl-2-pyridyloxy)phenoxy)propianate), HOE-33171, CGA-82725, DPX-Y6202 (2-(4-((6-chloro-2-quinoxalinyl)oxy)-phenoxy)-propionic acid, ethyl ester), and SC-1084 were tested in a split plot design. Each herbicide was applied to plots 2 feet by 100 feet long, with 4 replications, on June 24, 1983. Separate 20 foot sections of each plot were retreated at different time intervals of 2 weeks, 5 weeks and 8 weeks after the first treatment. Untreated strips 1 foot wide were left between each plot as a control. All treatments were made with .5 pounds of active ingredient per acre.

A single treatment of any of these herbicides was able to achieve 40 to 70% control 38 days after first treatment (DFT) at this rate. By 95 DFT the control had dropped to 18% or less and at 159 DFT control had reached 0% for all treatments. With a second treatment 2 weeks after the first, control ranged from 47.5 to 72.5% control at 38 DFT. By 95 DFT control was 5 to 18% and less than 15% at 159 DFT.

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[1]University of California Cooperative Extension, El Centro, CA and University of Arizona, Tucson, AZ.

When the second treatment was applied 5 weeks after the first, control was the same at 38 DFT. At 65 DFT, or 30 days after the second treatment, control was variable, ranging from 35% for CGA 82725 to 90% for sethoxydim. At 95 DFT, control ranged from 12.5 to 72.5%, with fluazifop-butyl showing the best activity. At 159 DFT control varied from 0 to 32.5%.

Application of the second treatment 8 weeks after first treatment occurred when most plots had achieved considerable regrowth. Control at 65 DFT was from 20 to 30%. At 95 DFT, or 32 days after second treatment, control ranged from 40% for CGA 82725 to 90% for DPX - Y6202. At 123 DFT, or 60 days after the second treatment control for 5 herbicides varied from 22.5 to 47.5% and 20 to 30% at 159 DFT. At 123 DFT, control for DPX - Y6202 was still 90% and 62.5% at 159 DFT.

Introduction

The recently introduced postemergence grass herbicides all seem to have several features in common. They share the ability to control annual and perennial grasses without having any significant effect on broadleaf plants. However, these herbicides do differ in their ability to control particular species of grasses. Numerous papers have dealt with with aspect of these chemicals. In addition, some grasses are more difficult in general for these materials to control. Bermudagrass (*Cynodon dactylon* (L.) Pers.) is one such grass. Previous work by one author (1) and others has demonstrated the tolerance of bermudagrass to these herbicides.

For maximum benefit, these herbicides need to be applied in two sequential applications to perennial grasses such as bermudagrass. The exact timing of the second application is not precisely understood and is the subject of this paper.

Materials and Methods

Six herbicides, sethoxydim, fluazifop-butyl, HOE-33171, CGA-82725, DPX-Y6202, and SC-1084 were tested for their ability to control bermudagrass using a split plot design. The bermudagrass was being grown as a lawn and was irrigated regularly. Each herbicide was applied to a main plot strip 2 feet wide by 100 feet long, with 4 replications, on June 24, 1983. The herbicides were applied with a CO_2 pressured sprayer at 40 psi, using a 8004E flat fan nozzle at a spray volume of 30 gallons per acre. All treatments were made with .5 pounds of active ingredient per acre with 1 quart per acre of oil surfactant. A one foot strip was left untreated between each main plot as a control.

Subplots consisted of 20 foot random sections of each main plot. Retreatment was made at three timings following the first application. These timings were at 2, 5 and 8 weeks. Visual evaluations were made six times (12, 38, 65, 95, 123 & 159 days after the first treatment (DFT)) and is presented in Table 1 as percent control.

Results and Discussion

It is apparent from the data in Table 1 that differences exist between these herbicides in their ability to control bermudagrass. Two methods present themselves for interpretation of these data. One is to compare a

Table 1. Bermudagrass control for six herbicides.

Treatment	Timing	12	38	65	95	123	159
		Days after first treatment					
		Percent control					
sethoxydim	1	47.5c	47.5d	20.0f	5.0e	0.0f	0.0h
	2	--	62.5c	20.0f	10.0e	0.0f	0.0h
	3	--	--	90.0a	45.0cd	25.0d	14.0ef
	4	--	--	--	62.5bc	32.5cd	30.0c
fluazifop-butyl	1	40.0d	50.0d	20.0f	0.0e	0.0f	0.0h
	2	--	62.5c	30.0e	17.5e	5.0f	5.0gh
	3	--	--	87.5a	72.5b	27.5d	22.5cd
	4	--	--	--	50.0cd	45.0bc	27.5bc
HOE-33171	1	55.0b	50.0d	20.0f	0.0e	0.0f	0.0h
	2	--	57.5c	20.0f	5.0e	0.0f	0.0h
	3	--	--	45.0d	12.5e	5.0f	5.0gh
	4	--	--	--	52.5cd	22.5de	20.0de
CGA-82725	1	42.5d	40.0e	20.0f	0.0e	0.0f	0.0h
	2	--	47.5d	20.0f	0.0e	0.0f	0.0h
	3	--	--	35.0e	12.5e	0.0f	0.0h
	4	--	--	--	40.0d	27.5d	27.5bc
DPX-Y6202	1	60.0a	70.0b	35.0e	17.5e	10.0ef	0.0h
	2	--	72.5a	35.0e	17.5e	10.0ef	10.0efg
	3	--	--	70.0c	55.0cd	32.5cd	32.5b
	4	--	--	--	90.0a	90.0a	62.5a
SC-1084	1	40.0d	50.0d	20.0f	0.0e	0.0f	0.0h
	2	--	62.5c	22.5f	10.0e	5.0f	0.0g
	3	--	--	77.5b	50.0cd	25.0d	22.5cd
	4	--	--	--	50.0cd	47.5b	30.0c
Untreated Control		0.0e	0.0f	0.0g	0.0e	0.0f	0.0g

Numbers in each column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Timing: 1 = single application on 6/24, 2 = second treatment at 2 weeks, 3 = second treatment at 5 weeks, 4 = second treatment at 8 weeks.

Table 2. Bermudagrass control compared at separate timings.

Treatment	Timing	12	38	65	95	123	159
		Days after first treatment					
		Percent control					
sethoxydim	1	47.5c	47.5d	20.0f	5.0e	0.0f	0.0h
fluazifop	1	40.0d	50.0d	20.0f	0.0e	0.0f	0.0h
HOE-33171	1	55.0b	50.0d	20.0f	0.0e	0.0f	0.0h
CGA-82725	1	42.5d	40.0e	20.0f	0.0e	0.0f	0.0h
DPX-Y6202	1	60.0a	70.0b	35.0e	17.5e	10.0e	0.0h
SC-1084	1	40.0d	50.0d	20.0f	0.0e	0.0f	0.0h
Control	1	0.0e	0.0f	0.0g	0.0e	0.0f	0.0h
sethoxydim	2	--	62.5c	20.0f	10.0e	0.0f	0.0h
fluazifop	2	--	62.5c	30.0e	17.5e	5.0f	5.0gh
HOE-33171	2	--	57.5c	20.0f	5.0e	0.0f	0.0h
CGA-82725	2	--	47.5d	20.0f	0.0e	0.0f	0.0h
DPX-Y6202	2	--	72.5a	30.0e	17.5e	10.0ef	10.0fg
SC-1084	2	--	62.5c	22.5f	10.0e	5.0f	0.0h
Control	2	--	0.0f	0.0g	0.0e	0.0f	0.0h
sethoxydim	3	--	--	90.0a	45.0cd	25.0d	15.0ef
fluazifop	3	--	--	87.5a	72.5b	27.5d	22.5cd
HOE-33171	3	--	--	45.0d	12.5e	5.0f	5.0gh
CGA-82725	3	--	--	35.0e	12.5e	0.0f	0.0h
DPX-Y6202	3	--	--	70.0c	55.0cd	32.5cd	32.5b
SC-1084	3	--	--	77.5b	50.0cd	25.0d	22.5cd
Control	3	--	--	0.0g	0.0e	0.0f	0.0h
sethoxydim	4	--	--	--	62.5bc	32.5cd	30.0bc
fluazifop	4	--	--	--	50.0cd	45.0bc	27.5bc
HOE-33171	4	--	--	--	52.5cd	22.5de	20.0de
CGA-82725	4	--	--	--	40.0d	27.5d	27.5bc
DPX-Y6202	4	--	--	--	90.0a	90.0a	62.5a
SC-1084	4	--	--	--	50.0cd	47.5b	30.0bc
Control	4	--	--	--	0.0e	0.0f	0.0h

Numbers in each column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Timing: 1 = single treatment on 6/24, 2 = second treatment at 2 weeks, 3 = second treatment at 5 weeks, 4 = second treatment at 8 weeks.

particular herbicide against itself over time for efficacy. The other is to compare all the herbicides at a single time.

When you compare a particular herbicide against itself, several conclusions can be drawn. Data from Table 1 indicate that a single application of any one of these herbicides was unable to provide significant long-term control of bermudagrass. Control at 65 DFT (approx. 9 weeks) for all these herbicides had diminished greatly (to 20-35%). By 123 DFT (approx. 4 mos.) control was down to 0% for all treatments, except for DPX-Y6202, which was very slight (10%).

In the case of sethoxydim, fluazifop-butyl and SC-1084 the highest total control is achieved when the second treatment is applied 5 weeks after the first. This 5 week application coincided with some regrowth of the grass but not total recovery. With HOE-33171 and CGA-82725 a second application did not markedly improve the activity of the herbicide regardless of the timing.

DPX-Y6202 acted differently than the other herbicides. The first treatment had a significantly better effect than any of the other herbicides and recovery of the grass was slower. The best treatment overall was when the second application was 8 weeks after the first. Because of the greater initial effect, the grass was just beginning to recover at 8 weeks.

Comparing one herbicide against another in the context of this trial leads to certain observations and is shown in Table 2. Clearly, DPX-Y6202 is more effective at this rate. The only time this herbicide didn't outperform the others was when the second treatment was at 5 weeks. In this case, sethoxydim, fluazifop-butyl and SC-1084 were all significantly better than DPX-Y6202 at 95 DFT. AT 123 DFT, fluazifop-butyl was still significantly better than DPX-Y6202, although the differences were diminishing. HOE-33171 and CGA-82725 would not appear to be very effective on bermudagrass.

For most of these herbicides, retreatment at 2 weeks had a slight increase in activity over the single treatment, but the effect was not long lasting. At 65 DFT, or just 30 days after the second treatment there was little significant difference between the single application and the plots retreated at 2 weeks.

In a similar fashion, retreatment at 8 weeks was approximately as effective as the first treatment. Since recovery of the grass was essentially complete by this time, this treatment was the same as starting over. The only significant exception was DPX-Y6202, which exhibited very good control at this timing, as discussed earlier.

The abilities of these herbicides have been shown to be improved by cultivation and crop competition. Neither of these factors were included in this experiment. Cultivation and/or crop competition would probably change the results of this trial by lengthening the time for the bermudagrass to recover from the first treatment and thereby delaying the most efficacious time for the second treatment. The underlying principle seems to be that the second treatment is most effective when applied after the bermudagrass begins to regrow but before recovery is complete.

Summary

The recently introduced postemergence grass herbicides all have an effect on bermudagrass, but the degree of control relates to the relative

tolerance of the weed to the particular chemical and to the timing of the required second treatment. In this experiment, no treatment provided long lasting control with one treatment. Two materials (HOE-33171 and CGA-82725) were unable to exhibit good control regardless of timing. Sethoxydim, fluazifop-butyl and SC-1084 were relatively effective when the second application was applied 5 weeks after the first, but not at 2 or 8 weeks. DPX-Y6202 was the most effective chemical overall and the most beneficial timing for the second application was at 8 weeks.

Literature Cited

1. Bell, C. E. and J. Castro. 1982. Evaluation of grass herbicides for bermudagrass control on established alfalfa. pp 112-113. Proc. West. Soc. of Weed Sci. Vol. 35.

SETHOXYDIM FOR GRASS CONTROL IN ALFALFA

D. C. Wiley, G. C. Cramer, and L. C. Darlington[1]

Abstract: In 1983 BASF established several large alfalfa trials in Arizona, California and Washington to study timing, rates and application techniques of sethoxydim (2-(1-(ethoxyimino)butyl)-5-(2-(ethylthio(propyl)-3-hydroxy-2-cyclohexene-1-one) for post emergence grass control. Sethoxydim has federal registration on several crops and is sold under the trade name POAST.

Field trials were established near Sacramento, CA., Brawley, CA., Yuma, AZ., and Quincy and Pasco, WA. These trials were all approximately one acre and either commercial or BASF self-propelled sprayers were used for application.

Annual grasses encountered were barnyardgrass (*Echinochloa crusgalli*), yellow foxtail (*Setaria lutescens*), southwestern cupgrass (*Eriochloa gracilis*), green foxtail (*Setaria virdis*), junglerice (*Echinochloa colonum*), Mexican sprangletop (*Leptochloa uninervia*) and Italian rye grass (*Lolium multiforum*).

Bermuda grass was the only perennial found in our test sites, however, it has been reported that Italian rye grass acts as a perennial in the Pacific Northwest.

Sethoxydim was applied after the first cutting using water at 15-20 gpa with flat fan or cone nozzles at 35-40 psi. Rates compared were 0.1, 0.2, 0.3, and 0.4 lbs ai/acre. All applications included an oil concentrate at one quart per acre. Results: Crop tolerance was excellent on all established stands of alfalfa. Excellent tolerance was also observed on seedling alfalfa trials established by BASF and various state university personnel.

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[1]BASF Wyandotte Corp., Parsippany, NJ.

Grass species encountered varied by geographic locations. In Arizona and California, 0.3 lb/acre of sethoxydim resulted in better than 95% control of yellow foxtail, barnyardgrass, green foxtail, and southwestern cupgrass. In Washington, 95% control was obtained using 0.2 lb/acre on barnyardgrass, green foxtail, and Italian rye grass. Single applications will stop growth and give control for a limited time, however, multiple applications should prove more satisfactory.

Bermuda grass was mainly located in Southern California and Arizona. The best results were obtained with a split application of 0.5 lbs/acre followed by 0.3 lbs/acre 29 days later. The grass was 3-8 inches tall, at first application, and was still showing 90-95% control after two months.

Marginal control (60-70%) was obtained on junglerice, and poor control was observed on Mexican sprangletop.

BASF plans to have a full registration for alfalfa in 1984. Air applications have been submitted to federal EPA, and some tank mixes will be labeled for most states.

DPX-Y6202 - A NEW POSTEMERGENCE GRASS HERBICIDE FOR SOYBEANS, COTTON AND OTHER BROADLEAF CROPS

A. J. Parsells, M. M. Fawzi, J. S. Claus, and J. C. Summers[1]

Abstract: Weed killer (NCI-96683 and DPX-Y6202) is a selective postemergence grass herbicide under development by E.I. du Pont de Nemours & Co., Inc. DPX-Y6202 effectively controls both annual and perennial grasses and has demonstrated excellent safety on soybeans, cotton and other broadleaf crops. DPX-Y6202 does not control sedges or broadleaf weeds. The chemical name of DPX-Y6202 is 2-(4-((6-chloro-2-quinoxaylinyl)oxy)-phenoxy)propionic acid ethyl ester. It is formulated as an emulsifiable concentrate containing 95.8 g ai/liter. DPX-Y6202 is a systemic herbicide which is rapidly absorbed and readily translocates, basipedally and acropetally, throughout the plant. Plants stop growing soon after treatment. Chlorosis/necrosis of the younger leaves is followed by a progressive collapse of the remaining foliage. The 'speed' of activity is influenced by one or more factors, including weed growth stage, application rate, the addition of spray adjuvants, and environmental conditions. Postemergence rates of 35-140 g ai/ha provide effective control of annual species, and rates of 70-280 g ai/ha provide effective control of rhizome johnsongrass (Sorghum halepense). Perennial species, such as bermudagrass (Cynodon dactylon) and quackgrass (Agropyron repens) are effectively controlled with applications of 140-560 g ai/ha. The addition of a nonionic surfactant or a crop oil concentrate can result in a 2-4X performance improvement over applications of DPX-Y6202 alone. Under field conditions, DPX-Y6202 appears to be rainfast one hour after application.

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[1]E.I. du Pont de Nemours and Co., Inc., Wilmington, DE.

While most effective when applied to foliage, DPX-Y6202 has also demonstrated some preemergence activity. Preemergence grass control is dependent on several factors, including use rate, soil type, organic matter, and soil moisture. In acute and subacute studies, DPX-Y6202 is relatively low in toxicity to mammals and wildlife. Interim results from long-term toxicology tests have been favorable. An EUP has been filed to allow field-scale testing on soybeans and cotton. Full registration on soybeans and cotton is anticipated in the mid-1980's with subsequent registration on other broadleaf crops.

CHANGES IN A LEAFY SPURGE (*EUPHORBIA ESULA* L.) INFESTED PLANT COMMUNITY AFTER AN APPLICATION OF PICLORAM

B. D. Maxwell and P. K. Fay[1]

Introduction

Leafy spurge (*Euphorbia esula* L.) is a perennial weed on pasture and rangeland. It is a noxious weed, not only because it competes with forage species but also because the plant contains an irritant that causes cattle to avoid dense stands.

The most effective tool for controlling leafy spurge is the herbicide picloram (4 amino-3,5,6-trichloropicolinic acid), but relatively high rates of application are required for prolonged control. Few of the broadleaf plants found on Montana range and pasture lands are resistant to picloram. There are areas where picloram has been repeatedly used over several years. The appearance of those plant communities has been drastically altered. With the increased use of this herbicide on rangeland, we feel the long-term effects on the plant communities should be studied.

We had the opportunity, on a ranch in central Montana, to study leafy spurge infested land that was aerially sprayed with 1.1 kg/ha picloram. The objectives of this study were to measure changes in the plant community after application by recording loss of species, reinfestation of species, and species composition changes.

Methods

Biomass, canopy cover composition, frequency, and number of plant species were measured on grazed and ungrazed areas which were subdivided into sprayed and unsprayed areas.

Two sites were studied: one on native rangeland and one on pasture land. There were three replicated treatment blocks on each site, with four treatments in each block. On both sites, plastic tarps were used to create

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[1]Plant & Soil Sci. Dept., Montana State University, Bozeman, MT.

an unsprayed portion on each block. On site one, exclosures were built around half the block to create an ungrazed portion. On site one, there were four treatments per block: ungrazed-unsprayed, ungrazed-sprayed, grazed-unsprayed, and grazed-sprayed. There were two treatments per block on site two: grazed-unsprayed and grazed-sprayed, since no exclosures were built.

Percent canopy cover was estimated for each species by using a 20 by 50 cm frame with 30 replications per treatment on a site. Frequency, percent composition, and number of species were all determined from canopy cover data. Dry weight biomass was measured by species group by clipping one half meter frames and oven drying the plant material. Fifteen biomass frames were clipped per treatment on each site. Data has been collected annually at estimated maximum plant production starting in 1982 one month after herbicide treatment.

Results

Annual precipitation was an important factor that had a confounding effect on making comparisons between years. Grazing is a factor that is highly variable in this study, because of increased use by the cows in the areas immediately surrounding the exclosures.

Leafy spurge significantly decreased in all respects from unsprayed to sprayed treatments at one month and 13 months after application of picloram. The other perennial and biennial forbs not only decreased from unsprayed to sprayed treatments but also from 1982 to 1983. This is primarily due to a dense stnad of the biennial, sweet clover (*Melilotus officinale*) occurring during 1982, a moist year. Sweet clover was not present in 1983 because conditions were dry early in the growing season.

Perennial grasses, the important forage species, were examined in detail. Under both grazed and ungrazed conditions there was an increase in biomass from unsprayed to sprayed treatments but the increase was not significant (Table 1). There was a significant increase from grazed-unsprayed to ungrazed-sprayed. The competition from the forbs and some utilization of the grass on the grazed-unsprayed treatment could account for the difference. There were no differences between number of perennial grass species with any of the treatments. There was a significant increase in perennial grass canopy cover 13 months after spraying (Table 1). The percent composition of total plant cover for perennial grasses had increased from unsprayed to sprayed treatments the second year.

Table 1. Perennial grass measurements one and thirteen months after treatment with Picloram on a pasture site.

	Biomass (Kg/ha)		Number of Species	Canopy Cover (%)	Composition (%)	
Treatment	1982	1983	1983	1983	1982	1983
Ungrazed:						
Unsprayed	1125 a	1337 ab	4 a	90 a	45 ab	74 a
Sprayed	1535 a	1545 b	5 a	96 b	58 bc	97 b
Grazed:						
Unsprayed	1027 b	1262 a	5 a	83 c	38 a	63 a
Sprayed	1462 b	1395 ab	6 a	92 a	66 c	98 b

Numbers with the same latter are not significantly different at 0.05 level (LSD).

Perennial grass frequency was measured by species as percent occurrence and percent dominance. Poa pratensis occurred on 100% of the frames in all treatments and was dominant 67% of the time on ungrazed-unsprayed and dominant 57% of the time on the ungrazed-sprayed treatment. Agropyron cristatum occurred 67% and 77% of the time on unsprayed and sprayed treatments respectively. It also increased in dominance from unsprayed to sprayed treatments. Agropyron smithii, the most well represented decreaser grass species, was never dominant and decreased from 83% to 57% occurrence on unsprayed and sprayed treatments respectively.

Total vegetation biomass decreased from unsprayed to sprayed treatments within the exclosures. This indicates that the increased grass production, as a result of the open niches in the community, does not make up for the losses in forb biomass.

There has been a drastic decrease in the number of total species over the two year period since picloram was applied. All the species lost have been forbs.

Summary

With the decrease in forb species there is a decrease in the diversity of the plant community. It is unknown how this may affect the ecosystem, but it could have consequences on future management plans. Future analysis of these sites will help quantify the long-term effects of picloram on plant communities. The trends following herbicide application will be fully realized after the residue has diminished to sublethal levels.

THE LONGEVITY OF VIABILITY OF SPOTTED KNAPWEED SEEDS IN MONTANA SOILS

T. K. Chicoine and P. K. Fay[1]

Introduction

Spotted knapweed (Centaurea maculosa L.) is an introduced perennial weed that has become a major problem in Montana. Spotted knapweed reproduces and is disseminated primarily by seed. The average plant in Montana produces over 1,000 seeds, and 30,000 to 43,000 seeds per 0.5 m^2 are produced annually in a mature stand. However, seedling densities rarely exceed 500 to 1,000 seedlings per 0.5 m^2 which leaves over 98% of the annual seed production unaccounted for. The longevity of the soil seed reserves of the plant must be known before a long-term control program for spotted knapweed can be implemented. The objective of this study was to determine the time necessary to exhaust soil reserves of spotted knapweed seed.

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[1]Plant & Soil Sci. Dept., Montana State University, Bozeman, MT.

Methods and Materials

Burial Study. PVC pipe 15 cm in diameter was cut into sections 2.5 cm wide, filled with soil from the prospective burial site and 100 fresh spotted knapweed seeds. The rings were covered with nylon window screen, and buried to a depth of 2.5 cm. The rings were retrieved at several time intervals and the number of seeds that had germinated in each section were counted. The viability and vigor of ungerminated seeds was measured by floating recovered seeds on water in Petri dishes.

Cultural Practice Study. Several cultural practices were used to try to increase seed germination by improving the seed-to-soil contact to hasten the exhaustion of seed reserves. The entire study area (except for the control plots) received an application of 2.24 kg/ha of 2,4-D amine in June, 1982. Cultural practices including harrowing, burning, mowing, and rolling were applied in October, 1982. The effect of the cultural practices on the seed reserve was then compared to treatment with 2,4-D alone and an untreated control plot. Six soil cores were taken with a standard tulip bulb planter to a depth of 7.6 cm in June, 1982, prior to herbicide treatment, in April and October, 1983 (10 and 15 months after seed production was stopped, respectively). Spotted knapweed seeds separated from the soil through a series of screenings, washings, and air separations. Germination tests were performed on the recovered seeds.

Results and Discussion

After 2.5 months of burial less than 1% of the buried seeds had germinated. Ungerminated seeds were fully viable. There was 15% germination of seeds in rings recovered between 2.5 and 9 months of burial (December, 1982 and June, 1983). Twelve and one-half months after burial germination remained at approximately 15%, and viability of those seeds which had not germinated was 90%. Elongation of seedlings buried for 12.5 months indicated that seedling vigor was reduced when compared to seedling elongation of seed from the original seed lot that had been stored under ideal laboratory conditions. The greatest differences in elongation were noticed after one and two days of growth, with the unburied seeds reaching a total length of 79 mm, while the buried seeds grew only 55 mm. After two days, the rate of growth of the unburied seeds declined, with 20 mm of elongation per day. Seedlings from buried seed did not reach their maximum rate of elongation until the third day when growth slowed markedly.

When the study was initiated in June, 1982, there were approximately 550 viable seeds present in a 0.5 m^2 by 7.6 cm area. Between June and April, 1983, the level of the seed reserve in the untreated plots rose slightly due to annual seed production in the fall of 1982. Where seed production was blocked with an application of 2,4-D, the reserves fell from 550 to 180 viable seeds per 0.5 m^2 by 7.5 cm area. In June, 1983, seed production on the treated plots was again blocked with an application of 2.24 kg/ha of 2,4-D. Where seed production was not stopped, the number of viable seeds per 0.5 m^2 doubled, rising from slightly over 600 to 1214 by October, 1983. There was no significant change in the seed reserves from April to October, 10 to 15 months when seed production was blocked in the treated plots. The cultural practices used did not increase the rate of decline in the soil seed reserves.

Stand counts were taken to determine the number of seedlings germinating in June, 1983, prior to the second application of 2,4-D amine. Density counts were then compared to the seed reserves found in April of that year. Where seed production was permitted, June seedling densities accounted for 75% of the April seed reserves. This is undoubtedly due to the germination of seed produced in the fall, 1982. Where seed production was blocked in June, the seed reserves were only one-third of the control plots. Less than 20% of the April reserves were accounted for in the June, 1983 stand counts with approximately 20 seedlings per 0.5 m^2. The lack of seedling establishment may be a result of the declines in vigor associated with seed burial in conjunction with grass competition which resulted when spotted knapweed was removed. The soil reserve was comprised of seeds that were at least 18 months old.

In 15 months without seed production, the number of viable seeds present in the soil seed reserves at Harlowton and Ovando, the two test locations, fell 72% and 81%, respectively. The central question is: "What will happen to the seed reserve in the next 30 to 60 months?" If seed viability declines occur at the rate of 72% and 81% at Harlowton and Ovando, respectively, every 15 months, it will take 60 to 75 months to totally exhaust the soil reserves of spotted knapweed seed if seed production is prevented. However, this prediction does not take into account the decline in vigor that occurs with natural aging of the seed, nor does it address the effect of increased grass competition these weakened seedlings will have to contend with when the allelopathic affect of mature plants is removed. Perhaps viability will decline at a faster rate than predicted. (See Table 1.)

Table 1. Changes in the soil reserve of spotted knapweed seeds 10 and 15 months after seed production was stopped on 6-20-82, and various cultural practices were applied to increase seed germination at Harlowton and Ovando, Montana.

Cultural Practice Treatment	Viable Spotted Knapweed Seeds per 0.5 m² — Months After Seed Production Was Stopped					
	Harlowton			Ovando		
	0	10	15	0	10	15
Harrowing	420 a	140 b	107 b	549 a	41 b	86 b
Rolling	670 a	195 b	238 b	463 a	53 b	64 b
Burning	594 a	203 b	201 b	439 a	96 b	109 b
Mowing	648 a	301 a	246 b	447 a	22 b	164 b
Sprayed check	248 a	92 b	115 b	502 a	96 b	53 b
Control	523 a	564 a	1214 a	603 a	607 a	635 a
C.V.	30.3%	16.3%	15.9%	16.5%	14.5%	13.8%

[1]Numbers followed by the same letter in the same column do not differ significantly at the 0.05 level.

Summary

Seventy-seven percent of buried spotted knapweed seeds remained viable after 12.5 months of burial. There was a decline in vigor associated with the length of burial. Over 100 viable spotted knapweed seeds per 0.5 m^2 to a depth of 7.6 cm remained after 15 months without seed production. The cultural practices employed in the study did not increase the rate of decline in the seed reserves.

THE ACTIVITY OF SELECTED MIXTURES OF PLANT GROWTH REGULATORS AND HERBICIDES ON LEAFY SPURGE

Mark A. Ferrell and Harold P. Alley[1]

Regeneration of leafy spurge (Euphorbia esula L.) from viable root buds is a major problem encountered in its control. While certain herbicides have been shown to be effective in controlling shoot growth they appear to not be as effective in destroying the root systems from which new shoots can develop.

The purpose of this study was to evaluate various growth regulators in order to assess their potential value for increased herbicide activity, stimulation of dormant buds and effects upon vegetative growth. It is hoped that such research will lead to the discovery of a growth regulator that will effectively control leafy spurge by itself or have a synergistic effect when used in combination with an herbicide, thus providing more effective and inexpensive control.

An initial growth regulator screening study was conducted at the University of Wyoming Plant Science Greenhouse in order to select growth regulators that showed activity on leafy spurge.

The growth regulators used in the initial screening study were 2,4-D amine ((2,4-dichlorophenoxy)acetic acid), appied at rates of 1/16, 1/8 and 1/4 lb ai/A; NAA (1-naphthaleneacetic acid) applied at rates of 3, 6 and 12 g ai/A; ABG-3034 a cytokinin (6-benzylaminopurine) applied at rates of 3, 6, and 12 g ai/A; glyphosate (N-(phosphonomethyl)glycine) applied at rates of 1/32, 1/16 and 1/8 lb ai/A; PP333, an antigibberellin (2RS, 3RS)-1-(4-chlorophenyl)-4,4-methyl-2,2,4-triazol-1-yl-pentan-3-ol), applied at rates of 3, 6, and 12 g ai/A; mixed cytokinins, mostly zeatin-like, extracted from marine algae tissue, applied at rates of 1, 2, and 4 gal product/A; and gibberellic acid (2,4a,7-trihydroxy-1-methyl-8-methylenegibb-3-ene-1,10-carboxylic acid-1,4-lactone), applied at rates of 3, 6 and 12 g ai/A.

The herbicides used in the initial screening study were dicamba (3,6-dichloro-o-anisic acid) applied at a rate of 1.0 lb ai/A and piloram (4-amino-3,5,6-trichloropicolinic acid) applied at a rate of 0.25 lb ai/A.

Leafy spurge plants were established from cuttings of stock plants, which included 20 mm of shoot and 30 mm of root, with individual cuttings

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[1]Division of Plant Science, University of Wyoming, Laramie, WY.

planted in containers 6 inches in diameter by 7 inches in height. The plants were grown in a greenhouse at a temperature of 22C and were watered as needed. Growth to 8 inches took approximately 4 months at which time treatments were applied.

The experiment was a completely randomized design with two replications. Treatments were applied with a hand operated spray atomizer. A fine mist spray with premeasured solutions of growth regulators and herbicides was applied singularly and in combination at the desired rates on June 12, 1982. The treatments were first evaluated on August 11, 1982, 60 days after treatment, with the evaluations based on visual damage and fresh weight of the shoots. The visual evaluation showed a highly significant difference between treatments, with the gibberellic acid + picloram treatment showing the greatest activity. There were no significant differences between treatments based on the fresh weight of the shoots. However, the treatment with the lowest shoot weight was picloram applied by itself at 0.25 lb ai/A.

After the first evaluation the spurge plants were allowed to regrow for 58 days and were evaluated on October 8, 1982, 118 days after the start of the experiment. The final evaluation was based on shoot regrowth, number of shoots per container, visual evaluation, shoot weight, and root weight. A statistical analysis showed no significant differences between treatments for any of the evaluations. However, treatments containing gibberellic acid and mixed cytokinins resulted in the greatest activity on leafy spurge growth and were selected for further study.

The growth regulators selected for additional study were gibberellic acid applied at rates of 3, 6 and 12 g ai/A and the mixed cytokinins applied at rates of 1, 2, and 4 gal product/A.

The herbicides used were picloram at a rate of 1/8 lb ai/A and dicamba applied at a rate of 0.5 lb ai/A. As in the previous screening study herbicides were applied at less than normal rates to observe any increased activity caused by the growth regulators.

Leafy spurge plants were established as in the earlier screening study. However, after approximately 5 months of growth in the greenhouse they were transferred to growth chambers with conditions set at 14 hours of daylight at 27C and 10 hours of dark at 10C, with an average relative humidity of approximately 40%. Plants were moved from the greenhouse to the growth chambers in order to stimulate growth and stabilize growth conditions.

The experiment involving growth regulators selected from the previous screening study was a randomized complete block design with five replications. Treatments were applied on January 15, 1983 with a hand operated spray atomizer in the same fashion as for the previous screening study. Immediately prior to treatment the length of the main shoot and number of shoots per container were recorded, for comparision at the conclusion of the experiment.

The experiment was concluded on March 4, 1983, 49 days following treatment, and evaluated with respect to the following parameters:

1. The number of buds on the crown;
2. a visual evaluation with 1 indicating no damage and 5 indicating a dead shoot;
3. difference in shoot length from time of treatment to time of evaluation;

4. weight of shoots dried at 60C;
5. the number of buds per cm of root, which was determined by taking counts on the primary roots and dividing by the root length;
6. length of the longest primary root;
7. weight of the roots dried at 60C;
8. and the difference in the number of shoots per container from time of treatment to time of evaluation.

Evaluation of the data indicate the mixed cytokinins at 2 gal/A significantly increased the number of crown buds when compared to the check. Whereas, gibberellin at 3 and 6 grams/A, gibberellin at 6 and 12 grams/A + picloram at 0.125 lb/A and the mixed cytokinins at 1 and 2 gal/A + picloram at 0.125 lb/A significantly decreased the number of crown buds when compared to the check. However, when the treatments containing growth regulators + picloram were compared to picloram applied alone the decrease was not significantly better.

With the exception of treatments where gibberellin and the mixed cytokinins were applied alone all treatments exhibited significant visual damage such as yellowing and twisting of stems and leaves, with the mixed cytokinins at 4 gal/A + picloram showing the greatest visual damage. However, it did not show greater significant damage than picloram applied alone at 0.123 lb ai/A. At the time of the evaluation no shoots were completely dead.

Treatments showing a significant increase in shoot length were gibberellin at 6 and 12 g/A and the mixed cytokinins at 1 gal/A. Cytokinin at 4 gal/A + picloram was the only treatment that significantly reduced shoot length when compared to the check. However, the reduction was not significantly better than the picloram applied alone.

Treatments resulting in a significant decrease in shoot weight were gibberellin at 3, 6, and 12 g/A + picloram with the mixed cytokinins at 1, 2 and 4 gal/A + picloram showing the greatest significant difference when compared to the check. However, the reductions in shoot weight were not significantly better than picloram applied alone. None of the treatments significantly increased shoot weight.

There were no significant differences between treatments for the number of buds per centimeter of root, root length, root weight, and the number of shoots per container.

Although there was a wide difference in the number of shoots between treatments these differences were not significant due to the wide variation of shoot numbers within treatments.

Although the mixed cytokinins and gibberellic acid did increase the activity of the herbicides, especially picloram, in reducing shoot weight and vegetative growth, they did not aid in reducing root growth and had no significant effect on the number of root buds. Even in the treatments where the growth regulators did increase the activity of the herbicides the increase was not significantly better than where the herbicides were applied alone.

Results of this study would indicate the mixed cytokinins and gibberellic acid are ineffective in aiding picloram and dicamba in controlling the regeneration of leafy spurge from viable root buds when used at the rates evaluated.

A field study was also conducted during the summer of 1982 using the same growth regulators and herbicides utilized in the initial greenhouse screening study. Results from this study also indicate that the growth regulators were ineffective in aiding the herbicides in controlling leafy spurge.

THE RESPONSE OF SELECTED RANGE GRASS SPECIES TO CHLORSULFURON

J. C. Davison, J. M. Krall, and W. S. Johnson[1]

Abstract. 'Nordan' crested wheatgrass (*Agropyron desertorum* Fisch.), Russian wildrye (*Elymus junceus* Fisch.), alkaligrass (*Puccinellia distans* L.), 'Alta' tall fescue (*Festuca arundinacea* Schreb.), bermudagrass (*Cynodon dactylon* L.), and alkali sacaton (*Sporobolus airoides* Torr.) were tested for response to chlorsulfuron (2-chloro-N-((4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino)carbonyl)benzenesulfonamide). Plants were treated with chlorsulfuron at rates of 26.3, 52.5, 105.3, and 157.5 g/ha both pre- and post-emergence and cultured in the greenhouse. Plant response was measured as percent mortality and dry weight of surviving plants determined at the four to five leaf stage.

Results indicate that 'Nordan' crested wheatgrass, Russian wildrye, and bermudagrass are tolerant to chlorsulfuron when applied at these rates either pre- or postemergence. Survival of 'Alta' tall fescue and alkaligrass was significantly reduced by both pre- and postemergence applications. Response of alkali sacaton to the herbicide was variable and dependent on the rate and time of application.

[1]University of Nevada, Reno, NV.

LATE SEASON PHOTOSYNTHESIS IN CANADA THISTLE

P. W. Leino, L. C. Haderlie and R. B. Dwelle[1]

Abstract. Canada thistle (*Cirsium arvense* (L.) Scop.) can produce aerial shoots from roots in late summer and fall. Research was done to characterize late fall photosynthesis and to compare it with summer measurements.

Diurnal measurements of gross photosynthesis (P_G) were made on three ecotypes of Canada thistle at three locations in southern Idaho after a period of heavy frost to compare late fall and summer P_G. Every 3 hrs from dawn to dusk 10 plants of Canada thistle were sampled using a dual isotope porometer. Substantial rates of photosynthesis were measured in October and November with peak rates (22 mg CO_2 dm^{-2} hr^{-1}) approaching summertime peak rates (25 mg CO_2 dm^{-2} hr^{-1}) (Fig. 1). A diurnal plot of fall photosynthetic rate reveals a nearly linear rise of P_G soon after sunrise at a temperature just above freezing, to the peak rate of photosynthesis at about 10:00 am MST. The P_G rate plateaued in October after the maximum was obtained and then gradually declined from 4:00 pm MST as the light level declined in late afternoon. P_G generally followed light intensity. There was no mid-afternoon depression of P_G which was typical of the summertime

[1]University of Idaho Research & Extension Center, Aberdeen, ID.

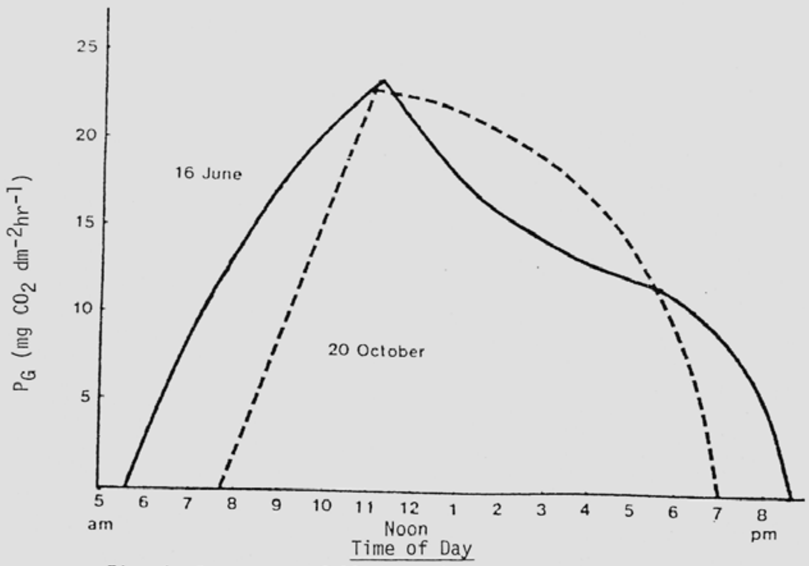

Fig. 1 Summer and fall diurnal patterns of photosynthesis in Canada thistle - 1983

diurnal P_G rates and thus the rate at midafternoon in the fall was actually higher than rates at midafternoon in the summer (Figure 1).

Fall regrowth of Canada thistle produced less above-ground biomass than at flowering stage but proportionately more of this biomass was invested into leaves (80 to 99%) compared to about 32% at full flowering.

Canada thistle was able to take advantage of the cold fall season to fix appreciable amounts of carbon when other ceompetitors for light and water were absent. Fall photosynthetic activity of Canada thistle supports recommendations for fall applications of herbicides to control this weed.

PICLORAM AND 2,4-D COMBINATION TREATMENTS FOR LEAFY SPURGE CONTROL

Rodney C. Lym and Calvin G. Messersmith[1]

Picloram (4-amino-3,5,6-trichloropicolinic acid) is an effective herbicide for leafy spurge (*Euphorbia esula* L.) control, especially when applied at rates from 1 to 2 lb/A. However, the high cost of picloram at 2 lb/A makes it uneconomical to treat large acreages in pasture and rangeland weed control programs. Research by North Dakota State University has suggested that picloram at 0.25 to 0.55 lb/A applied annually will give satisfactory leafy spurge control after 3 to 5 years. The purpose of this experiment is to establish the number of annual applications of picloram needed to provide 90 to 100% control of leafy spurge at three locations in the state, to investigate possible synergism between picloram and 2,4-D ((2,4-dichlorophenoxy)acetic acid) and to evaluate picloram residue in three soil types.

The experiment was established on 25 August 1981 at Dickinson, 1 September 1981 at Sheldon and on 11 June 1982 at Valley City. All treatments were applied annually except 2,4-D alone which was applied biannually (both spring and fall). Picloram treatments were applied in late August 1981 and in June of 1982 and 1983. Thus the Dickinson and Sheldon sites have received three picloram and picloram plus 2,4-D treatments and five 2,4-D treatments, while the Valley City site has received two and four treatments, respectively. The plots were 10 by 30 ft and each treatment was replicated four times in a randomized complete block design at all sites. Evaluations were based on percent stand reduction as compared to the control.

A soil bioassay was conducted to determine the herbicide residue from annual broadcast applications of picloram at 0.25, 0.375, and 0.5 lb/A. Three soil samples per plot to a 4 inch depth were taken to form a composite sample in June and August of each year. Sunflower height, fresh weight and dry weight in a greenhouse bioassay were used to determine picloram residues. The soil at Dickinson was a loamy fine sand with pH 7.2 and 0.6% organic matter, at Sheldon was a silty clay loam with pH 5.8 and 3.4% organic matter, and at Valley City was loam with pH 6.0 and 3.3% organic matter.

Picloram at 0.25, 0.375 and 0.5 lb/A provided 42, 61 and 75% leafy spurge control, respectively, after three treatments when averaged across the Dickinson and Sheldon locations (Table 1). Control in August 1983 was not increased when compared to the August 1982 evaluations. 2,4-D alone provided between 19 and 30% control of leafy spurge after biannual applications for three years.

Leafy spurge control was increased when 2,4-D was applied with picloram at 0.25 lb/A and when 2,4-D at 1.5 lb/A was applied with picloram at 0.375 lb/A at Dickinson and Sheldon (Table 1). Leafy spurge control increased 29 and 20% when 2,4-D at 1.5 lb/A was applied with picloram at 0.25 or 0.375 lb/A, respectively. Picloram at 0.5 lb/A plus 2,4-D provided 78 to 85% leafy spurge control and was similar to picloram at 0.5 lb/A alone at 75%. The greatest synergism of 2,4-D and picloram seems to be

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[1]Dept. of Agron. and ARS-USDA, North Dakota State Univ., Fargo, ND.

Table 1. Leafy spurge control from annual picloram or picloram plus 2,4-D treatments and biannual 2,4-D treatments at three locations in North Dakota.

		Site/Evaluation date												
		Sheldon				Dickinson				Valley City			Mean	
		1982		1983		1982		1983		1982	1983		1982[a]	1983
Herbicide	Rate	June	Aug	June	Aug	June	Aug	June	Aug	Aug	June	Aug	Aug	Aug
	(lb/A)	(% Control)												
Picloram	0.25	33	49	12	48	24	48	35	37	68	21	25	49	42
Picloram	0.375	46	79	38	77	37	56	34	49	78	57	63	66	61
Picloram	0.5	72	75	45	80	30	74	31	70	81	49	48	74	75
2,4-D bian	1.0	23	22	23	35	11	30	16	27	5	22	14	27	30
2,4-D bian	1.5	9	15	23	33	10	20	6	9	14	38	29	18	19
2,4-D bian	2.0	14	20	31	54	8	9	6	11	37	38	28	14	30
Pic+2,4-D	0.25+1.0	26	54	29	76	53	69	34	62	41	11	33	63	68
Pic+2,4-D	0.25+1.5	35	58	39	91	46	61	31	56	50	23	54	60	71
Pic+2,4-D	0.25+2.0	52	78	40	83	53	49	33	45	49	43	49	61	61
Pic+2,4-D	0.375+1.0	70	78	38	87	49	64	40	65	67	50	68	70	74
Pic+2,4-D	0.375+1.5	68	74	29	84	63	67	29	78	61	55	65	70	81
Pic+2,4-D	0.375+2.0	43	81	46	87	65	69	44	39	64	57	56	74	60
Pic+2,4-D	0.5+1.0	76	77	44	89	66	79	39	83	61	57	59	78	85
Pic+2,4-D	0.5+1.5	79	58	47	78	66	65	30	84	82	87	68	62	84
Pic+2,4-D	0.5+2.0	66	75	40	76	66	80	41	81	87	71	71	78	78
LSD(0.05)		27	26	31	22	23	19	21	24	30	34	28	18	18

[a]Experiment at Valley City began in June 1982 and is not included in August 1983 mean.

with 2,4-D rates of 1.5 lb/A or less and picloram at 0.375 or less. In general, leafy spurge control was lower at Valley City than at Dickinson or Sheldon after two years. Also at Valley City, the addition of 2,4-D to picloram tended to increase leafy spurge control compared to picloram alone and control in August 1983 was similar to or slightly higher than control in August 1982.

Picloram soil residue did not accumulate from annual applications regardless of location (Table 2). Picloram residue ranged from 0 to 0.18 ppm in August following June application but generally was undetectable the following spring. Thus the general increase in leafy spurge control was due to a gradual stand reduction and not to an increased picloram level that would prevent reestablishment.

Table 2. Picloram soil residue following annual applications in 1981, 1982 and 1983 at Dickinson and Sheldon, and in 1982 and 1983 at Valley City, North Dakota.

		Location/Evaluation date									
		Dickinson			Sheldon				Valley City		
	Rate	1982	1983		1982		1983		1982	1983	
Treatment	(lb/A)	Aug	June[a]	Aug	June[a]	Aug	June[a]	Aug	Aug	June[a]	Aug
		(ppm)									
Picloram	0.25	0	0	0	0	0.10	0	0	0	0	0.10
Picloram	0.375	0	0	0.01	0	0.12	0	0	0	0	0.08
Picloram	0.5	0	0.01	0.08	0	0.18	0	0.03	0	0	0.09

[a]Soil samples were obtained immediately before the annual picloram treatment was applied.

Three years after the experiment was begun picloram at 0.5 lb/A provided the best leafy spurge control and with the addition of 2,4-D is approaching the 90% control range. Picloram at 0.25 and 0.375 lb/A plus 2,4-D at 1.5 lb/A or less is synergistic for leafy spurge control and picloram residues have not accumulated after three annual applications.

THE EFFECT OF MACHINE-PULLING ON THE CONTROL OF LEAFY SPURGE (*EUPHORBIA ESULA* L.) REGROWTH

D. L. Coble, B. D. Maxwell and P. K. Fay[1]

Abstract. Leafy spurge (*Euphorbia esula*) pulls easily from the ground and a significant amount of root damage is incurred. Measurements were taken on stem diameter, root diameter, length of root material pulled, and foot-pounds required to pull leafy spurge plants from soil. With a pulling force of 4 to 6 ft. lbs., 2.4 to 4.8 cm of root material was removed from the ground.

A timing experiment was established to determine the optimum time of year to pull leafy spurge. Plants were hand pulled every two weeks throughout the growing season in 1982. The percent control of leafy spurge was measured by counting the stems per square foot. The most effective long term control was produced when plants were pulled on June 17, 1982.

A third experiment was initiated in June, 1983 to compare the effect of machine pulling of leafy spurge with mowing, herbicide applications, and applications of herbicide to regrowth after pulling and mowing. Two different designs of pulling machines and two herbicides, 2,4-D amine ((2,4-dichlorophenoxy)acetic acid) (2 lb/A), and picloram (4-amino-3,5,6-trichloropicolinic acid) (0.5 lb/A) were tested.

Preliminary data indicated that 2,4-D amine alone, machine pulling, and mowing with an application of 2,4-D amine to regrowth provided the best control of leafy spurge.

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[1]Plant & Soil Science Dept., Montana State University, Bozeman, MT.

CONTROL OF COCKLEBUR AT LAKE SUCCESS, CALIFORNIA

S. D. Wright and V. H. Schweers[1]

The reservoir of Success Lake, located near the Sierra foothills in Tulare County, California, is under the control of the U.S. Army Corps of Engineers. The reservoir is used for flood control and water storage for recreational purposes and irrigation.

When water is released for irrigation, submerged land becomes exposed. As the soil begins to dry, cocklebur (Xanthium stumarium L. canadense) germinates and eventually forms a carpet beginning at the high water mark and porgresses down the slopes with older weeds at the top and younger weeds at the lower edge. Populations of 25 to 30 plants per square foot are common in the area.

Cocklebur seed burs present a serious problem to wild animals, dogs, horses, other livestock and humans that use the lake. Gradual buildup of the weed is also of concern to the irrigation district officials and farmers.

A study was initiated in 1980 to evaluate herbicides for the control of cocklebur. MSMA (monosodium methanearsonate) at 2.0 lbs ai/A and 2,4-D amine ((2,4-dichlorophenoxy)acetic acid) at 1.0 lb ai/A gave good control. Dicamba (3,6-dichloro-o-anisic acid) at .25 lb and Amitrole (3-amino-s-triazole) at 1.0 lb ai/A controlled only the smallest plants.

The Army Corps of Engineers chose not to use 2,4-D as part of their weed control program; therefore, a second trial was established in 1982 to evaluate other herbicides. Treatments were applied to a solid stand of cocklebur in two stages of growth: 1. Seedling to early flower bud stage (2-8 inches tall), and 2. flower bud stage to seed formation (8-16 inches tall).

Treatments were applied using a backpack CO_2 sprayer at 30 gpa. Air temperature was 80F. Plots were 6 by 25 ft arranged in a randomized complete block with four replications.

Herbicide treatments were most effective when cocklebur was treated prior to flower bud stage. Dicamba at 0.5 and 1.0 lb ai/A, 2,4-D at 1.0 lb, glyphosate (N-(phosphonomethyl)glycine) + dicamba treatment combinations, and glyphosate alone at 0.5 and 1.0 lb ai/A rates were most effective in controlling cocklebur at this stage.

When herbicides were applied from the flower bud stage to the seed formation stage, dicamba at 0.5 and 1.0 lb ai/A rates and 2,4-D at 1.0 lb ai/A gave good control. Seed still formed on some plants, however, seed production was reduced significantly. Glyphosate at 0.5 and 1.0 lb ai/A rates, and glyphosate plus dicamba mixes were the most effective in killing cocklebur and stopping seed production at this late stage of development.

Because of the steep and rough terrain of the lake rim, an application by air is necessary for effective control. The application of glyphosate in this manner could not be approved. In September 1983, dicamba was approved for use at Lake Success. On October 20, 1983 over 400 acres of the lake rim were treated effectively by an aerial application with dicamba at 0.5 lb ai/A. A surfactant and drift control agent were also added to the spray solution.

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[1]University of California Cooperative Extension Service, Visalia, CA.

Table I. Herbicide treatment results for cocklebur control, 1980

Treatment	Rate (lb/A)	Weed Control 1/ 10/17/80	11/20/80
2,4-D	1.0	7.0	8.8
MSMA	2.0	7.5	8.5
Amitrol	1.0	4.3	4.5
Dicamba	0.25	5.5	5.8
Check	0.0	0.0	0.0

1/ Rating: 0 = no control 10 = all plants dead

Table II. Cocklebur control when treated at the seedling to early flower bud stage, 1982

Herbicide	Rate lb ai/A	Weed Control 10/28/82	11/29/82	Plant/ft²	Seeds/ft²
dicamba II	0.125	6.5	6.6	3.1	0.8
dicamba II	0.25	6.4	8.4	0.09	0.3
dicamba	0.25	7.8	9.3	0.19	0.09
dicamba	0.50	8.9	9.9	0.0	0.01
dicamba	1.00	9.9	9.9	0.0	0.01
dicamba + glyphosate	0.25 + .25	9.4	9.9	0.0	0.01
dicamba + glyphosate	0.25 + .50	9.9	10.0	0.0	0.0
glyphosate	0.50	9.8	9.9	0.0	0.01
glyphosate	1.0	10.0	9.9	0.0	0.01
2,4-D	1.0	9.9	9.6	0.02	0.07
check	--	0.0	0.0	4.2	24.3

1/ Average of 4 replications where: 0 = no control 10 = all plants dead

Table III. Cocklebur control when treated at the flower bud to seed formation stage, 1982

Herbicide	Rate lb ai/A	Weed Control 1/ 10/28/82	11/29/82	Plant/ft²	Seeds/ft²
dicamba II	0.125	3.8	5.1	2.3	9.3
dicamba II	0.25	5.9	6.6	0.3	1.2
dicamba	0.25	6.2	7.8	0.2	0.5
dicamba	0.50	8.3	9.0	0.1	0.3
dicamba	1.0	9.1	8.7	0.1	0.4
dicamba + glyphosate	0.25 + .25	8.4	9.2	0.1	0.3
dicamba + glyphosate	0.25 + .50	9.9	9.8	0.2	0.5
glyphosate	0.50	9.5	9.3	0.07	0.02
glyphosate	1.0	9.6	9.6	0.07	0.01
2,4-D	1.0	8.4	8.4	0.1	0.3
check	--	0.0	0.0	4.9	25.5

1/ Average of 4 replications where: 0 = no control 10 = all plants dead

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THE USE OF PRONAMIDE TO CONTROL FOXTAIL BARLEY (*HORDEUM JUBATUM*) IN PASTURES AND HAY MEADOWS

J. C. Klauzer[1]

Abstract. Foxtail barley (*Hordeum jubatum*) is a pasture, meadow and hay field grassy weed found throughout the Western United States and Canada. It is found principally in boggy, water-soaked fields but can also be found in dryland hillsides, expecially near saline-seep areas. Grass infested with foxtail barley is avoided by cattle as graze and as hay, because the long awns cause injury to the mucous membranes of the face. Foxtail barley is known to cause lumpy jaw in cattle and has been blamed as a source of infection for pink eye.

In the fall of 1982 a total of 25 trials were established throughout Montana, South Dakota, Wyoming, Colorado, Nevada and Oregon. Pronamide (3,5-dichloro(*N*-1,1-dimethyl-2-propynyl)benzamide) was investigated at

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[1]Rohm and Haas Co., Boise, ID.

rates of .28, .43, .56 and .84 kg ai/ha in the 13 replicated trials. Only the .43 kg ai/ha rate of pronamide was applied in 12 demonstration tests. It was found that the higher rates of pronamide at .56 and .84 kg ai/ha gave 100% control of the foxtail barley, but severely injured the desirable grasses in most tests. The two lower rates of pronamide provided adequate foxtail barley control when adequate winter moisture was received. Pronamide, at rates of .28 and .43 kg ai/ha, showed good tolerance to the following genus of grasses with only slight suppression noted: Dactylis, Elymus, Agropyron, Alopecurus and Agrostis. Some suppression has been observed with pronamide when applied to grasses in the Phleum and Festuca genus. Both Bromus and Poa genus have shown poor or inconsistent tolerance to pronamide, at all rates tested.

FIELD METHOD FOR STUDYING SEASONAL TRANSLOCATION PATTERNS IN SNOWBRUSH CEANOTHUS (*CEANOTHUS VELUTINUS* DOUGL.)

R. F. Stovicek, R. H. Callihan, and D. C. Thill[1]

Abstract. Leaves of two-year-old (15 to 61 cm) snowbrush ceanothus (*Ceanothus velutinus*) seedlings were exposed to short pulses of air containing $^{14}CO_2$, under light saturated conditions, to observe seasonal variations in assimilate translocation. The method enables researchers to study 15 to 25 ceanothus seedlings (approximately 100 leaves) over a 3 hr period. Studies can be conducted in remote or rough areas with natural plant communities.

Plants were tested on 7 dates between May 20 and October 12, 1983. Immediate removal of subsamples from the exposed leaves enabled the measurement of gross photosynthetic rates and recovery rates. Early season retention and accumulation of ^{14}C in leaves, and late season accumulation of ^{14}C in roots and stems allows prediction of seasonal shifts in source sink relationships. Relative significance of translocation measurements were validated by gross photosynthetic and recovery rates.

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[1]Plant, Soil & Entomological Sciences Dept., University of Idaho, Moscow, ID.

EFFECTS OF DAYLENGTH AND CLIPPING TREATMENTS ON BASIPETAL TRANSLOCATION OF GLYPHOSATE IN FIELD BINDWEED

T. C. Lauridson, E. E. Schweizer, and G. L. Orr[1]

Abstract. Field bindweed (Convolvulus arvensis L.) was grown from seed in two growth chambers, one providing a 12 hour photoperiod, the other providing a 12 hour primary photoperiod and a 15 minute white light treatment beginning 6 hours into the dark period. Plants were either left intact, clipped below the apical meristems, or clipped two to three leaves above soil level 7 weeks following emergence. Two 5 ul droplets of ^{14}C-glyphosate (N-(phosphono^{14}C-methyl)glycine) each containing 0.05 uCi were applied to one healthy leaf within one to two leaves above soil level on each plant either on the day that the plants were clipped, or 5 days following clipping. Plants were harvested 66 hours following ^{14}C application. The plants were then sectioned and oxidized, roots being sectioned into three portions, proximal, middle, and distal. For each segment of the plant, DPM/mg dry weight was determined. Interrupting the dark period had no significant effect on the translocation of ^{14}C. Intact plants had overall means of 5.5, 5.1, and 5.1 DPM/mg dry weight from proximal to distal portions of roots, respectively. Roots of apically clipped plants had 8.2, 5.1, and 5.2 DPM/mg dry weight, proximal to distal, immediately after clipping and 3.3, 2.9, and 3.1 DPM/mg dry weight 5 days after clipping. Roots of basally clipped plants had 7.7, 4.3, and 2.0 DPM/mg dry weight, proximal to distal, immediately after clipping and 13.2, 3.8, and 2.0 DPM/mg dry weight 5 days after clipping. Differences in ^{14}C between the proximal and middle portions of basally clipped plants were significant. The loss of the stem apex increased translocation to proximal portions of basally clipped plants. Enhanced control of dormant root buds may be achieved by removing the apex prior to glyphosate application.

[1]USDA-ARS and Colorado State University, Ft. Collins, CO.

THE INFLUENCE OF ETHEPHON ON SPRING BARLEY GRAIN YIELD AND QUALITY

D. R. Gaiser and D. C. Thill[1]

Abstract. The ethylene-releasing plant growth regulator ethephon (2-chloroethyl phosphonic acid) was applied at 0 and 0.42 kg/ha to 15 varieties of spring barley (Hordeum vulgare L.) between growth stages 9 and 10.1 (Feekes-Large scale) at Moscow (dryland) and Kimberly (irrigated), Idaho to determine its effect on grain yield and qualtiy. The variables measured were plant height, lodging, kernel plumpness, thin kernels, test weight, and grain yield. At Kimberly, there were no variety by treatment

[1]Plant, Soil and Entomological Sciences Dept., University of Idaho, Moscow, ID.

interactions for any of the variables. A differential varietal response was observed for all variables when summed across ethephon treatments. Plant height and lodging were reduced by 13% and 25%, respectively, and yield was increased by 3% in response to the ethylene treatment when summed across all varieties. At Moscow, there were variety by treatment interactions for all variables but percentage lodged. A differential varietal response was observed for percentage lodged when summed across ethephon treatments. Lodging was reduced by 12% in response to the ethephon treatment when summed across varieties.

INFLUENCE OF DROUGHT ON WILD OAT SEED DORMANCY

B. L. Heimbigner, A. J. Ciha, and D. R. Gealy[1]

Abstract. The effects of drought stress on seed dormancy in wild oat (*Avena fatua* L., WSU ecotype #68) were investigated. In a greenhouse study, stress was induced in half the plants by partial withholding of water and elevated temperatures. Seeds with or without hulls were germinated at regular intervals after flowering in distilled water at 15C (control) or in 1.4 mM GA_3 and 4 mM KNO_3 at alternating 12C/18C (germination stimulant). Physiological maturity occurred 32 days after flowering (DAF). In the control, seeds with hulls had less than 10% germination, whereas hulless stressed seeds reached a maximum germination of 51% at 8 DAF and hulless nonstressed seeds peaked at 43% at 20 DAF. Regardless of stress treatment, hulless control germination was 0% at 36 DAF, whereas dry afterripening (100 d) increased germination to 5% for unstressed and 15% for stressed seeds. The germination stimulant resulted in nearly 100% germination subsequent to 12 DAF regardless of the stress or hull treatment.

[1]Washington State University and USDA/ARS, Pullman, WA.

A PHOTODECOMPOSITION STUDY OF NAPROPAMIDE

C. E. Stanger and T. C. Vargas[1]

Abstract. The suggestion has been made for the possible existence of a photosensitizer in either the soil or the wettable powder formulation of napropamide (2-(A-naphthoxy)-N,N-diethyl propionamide). These substances are capable of absorbing and transferring light energy to adjacent chemical molecules causing degradation.

A study was initiated to determine if a photosensitizer was present in the desert soils around Ontario, Oregon, or in the commercial wettable powder formulation of napropamide. Three formulations of napropamide were applied to the surface of glass plates and air dried soil. Treated glass plates and soil were in turn exposed to 0, 300 and 600 W/m^2 of cumulative ultraviolet light energy. Half of the samples were protected from UV exposure by a polycarbonate plastic screen.

The data failed to prove the existence of a photosensitizer for napropamide in either the soil or wettable powder formulation of the herbicide. Some loss of napropamide from the glass plates was due to photolysis as the polycarbonate screen slowed the rate of loss. There remained considerable loss of napropamide under the polycarbonate screen suggesting significant degradation resulted from other than photolytic means. In addition, the polycarbonate screen had little affect on slowing the rate of napropamide loss from the soil surface.

Introduction

In a recent study Apley (1) found napropamide to absorb light at wavelengths from 218 to 324 nm. The shortest wavelength of sunlight reaching the earth's surface is 290 nm, thus the absorbtion spectrum of napropamide was determined to be 290 to 324 nm. Additional tests indicated napropamide was not subject to loss by volatilization. She concluded napropamide was lost by photolysis and yet one aspect of her work remained puzzling. Soil samples placed under a polycarbonate plastic screen that absorbs ultraviolet light below 385 nm showed the same rate of napropamide degradation as samples exposed to direct sunlight (Fig. 1 & 2). She felt the presence of a photosensitizer in either the wettable powder formulation of napropamide or the soil might possibly absorb light energy above 385 nm and transfer this energy to the herbicide molecule resulting in photodecomposition.

In September, 1982, a study was initiated to determine if a photosensitizer was present in the desert soils around Ontario, Oregon, or in the wettable powder formulation of napropamide. Should evidence support the presence of a photosensitizer in the herbicide formulation then altering the formulation offered promise to increase the soil surface life of napropamide.

Materials and Methods

Ten inch square glass plates and two inch square soil cups containing 50 grams of air dried soil were treated with technical grade, 2E and 50-WP formulations of napropamide at 4 lb/A. Treatments were replicated three

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[1]Oregon State University, Ontario, Oregon & Stauffer Chemical Company, Jerome, ID.

Figure 1. Napropamide recovered from soil after direct exposure to various amounts of ultraviolet radiation. (K.L.Apley 1983)

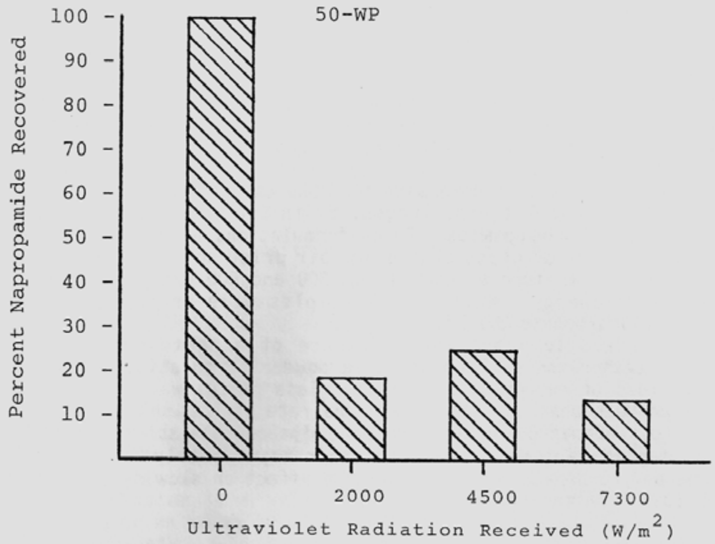
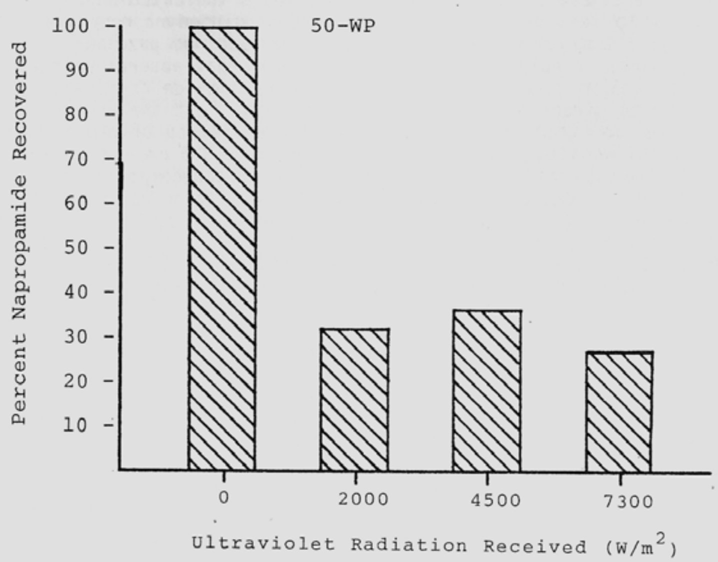


Figure 2. Napropamide recovered from soil covered with polycarbonate plastic after exposure to various amounts of ultraviolet radiation (K.L. Apley 1983)



times and applied with a CO_2 backpack sprayer in an enclosed room under incandescent light. Acetone was used as the solvent and carrier for technical napropamide and water as the carrier for 2E and 50-WP formulations. Ultraviolet exposure intervals of 0, 300 and 600 W/m^2 (watt hours per square meter) were studied. Samples with a zero exposure interval were packaged immediately after the treatments were applied. The remaining glass plates and soil cups were placed in one of two 1 by 4 by 8 foot boxes constructed to prevent exposure to light until the lids were opened to begin the exposure process. One box was fitted with a polycarbonate plastic screen to protect the samples from exposure to ultraviolet radiation. The lids of both boxes were opened at 10:30 am and closed at 3:00 pm daily, thereby allowing the samples to be exposed to sunlight during its greatest intensity each day. A photometer was placed between the boxes to measure the accumulated watt hours per square meter of ultraviolet radiation received. As each desired exposure interval was obtained the lids of both boxes were closed and the samples removed during darkness. All of the samples were carefully packed in light tight containers and shipped to Stauffer Chemical Company's de Guigne Technical Center for residue analysis.

Results and Discussion

Technical and 2E napropamide disappeared rapidly from the glass plates (Fig. 3). Some loss can be attributed to photolysis as the polycarbonate screen slowed the rate of loss, however, there remained considerable loss under the polycarbonate screen (Fig. 4). The wettable powder formulation did not break down nearly as fast as the other formulations on glass and the polycarbonate screen failed to slow the loss. An immediate loss of all formulations was recorded from the soil surface after which little loss occurred for the technical and emulsifiable concentrate formulations (Fig. 5) and the polycarbonate screen failed to slow the loss of either (Fig. 6). Surprisingly, the wettable powder formulation degraded more rapidly on the soil surface than on the glass plates.

Conclusion

The results fail to establish the presence of a photosensitizer in either the soil or the wettable powder formulation of napropamide. Had a photosensitizer been present in the wettable powder formulation, the rate of loss from the glass plates should have been greater than the other formulations rather than less as the data show. Likewise, if the soil contained a photosensitizer, all three formulations should have exhibited similar rates of loss from the soil surface and they did not.

The general failure of the polycarbonate screen to consistently and substantially reduce the rate of loss suggests significant degradation may have resulted from other than photolytic means. Additional studies are needed to explain the rate of loss of napropamide under the polycarbonate screen and accelerated rate of loss of the wettable powder formulation from the soil surface.

Literature Cited

1. Apley, K. L. 1983. Studies of napropamide decomposition on the soil surface. Master's thesis. Corvallis, Oregon State University. 85 numb. leaves.

Figure 3. Napropamide recovered from glass plates with direct exposure to various amounts of ultraviolet radiation.

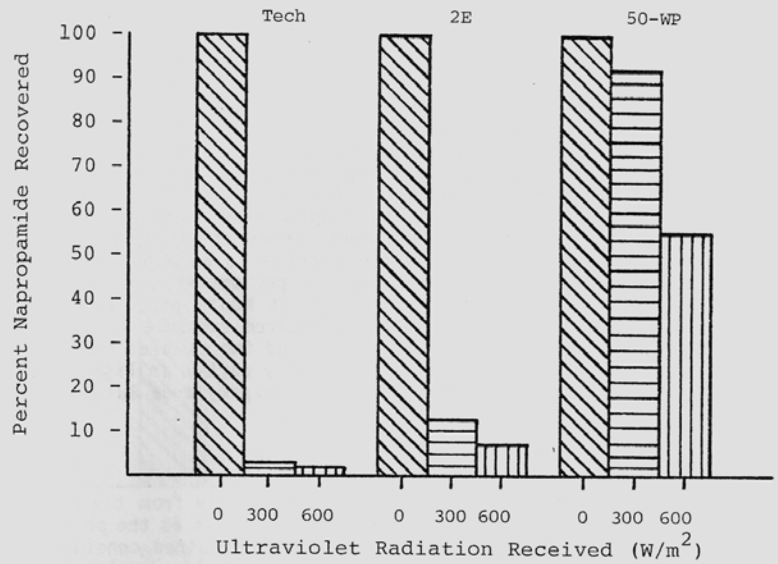


Figure 4. Napropamide recovered from glass plates shielded by polycarbonate plastic after exposure to various amounts of ultraviolet radiation.

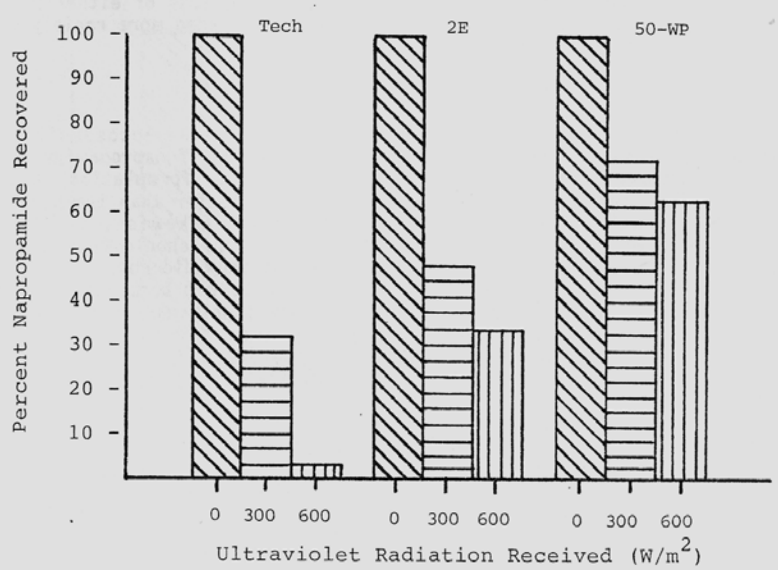


Figure 5. Napropamide recovered from soil with direct exposure to various amounts of ultraviolet radiation.

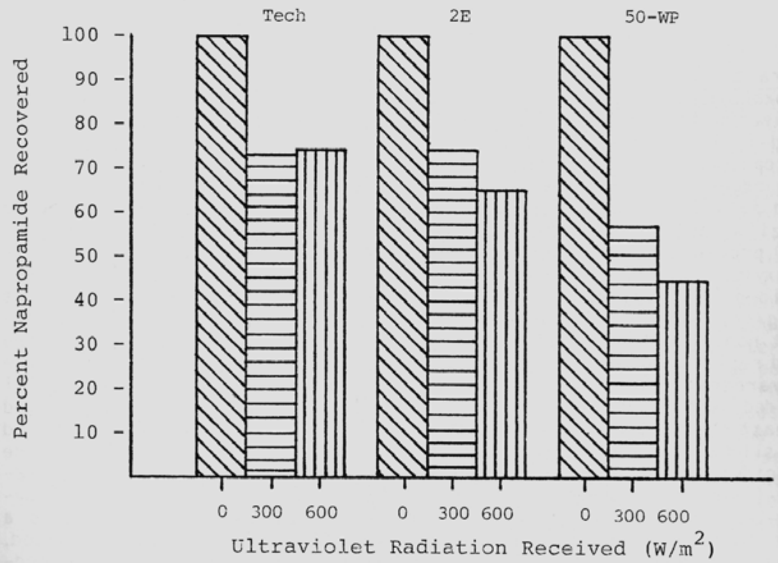
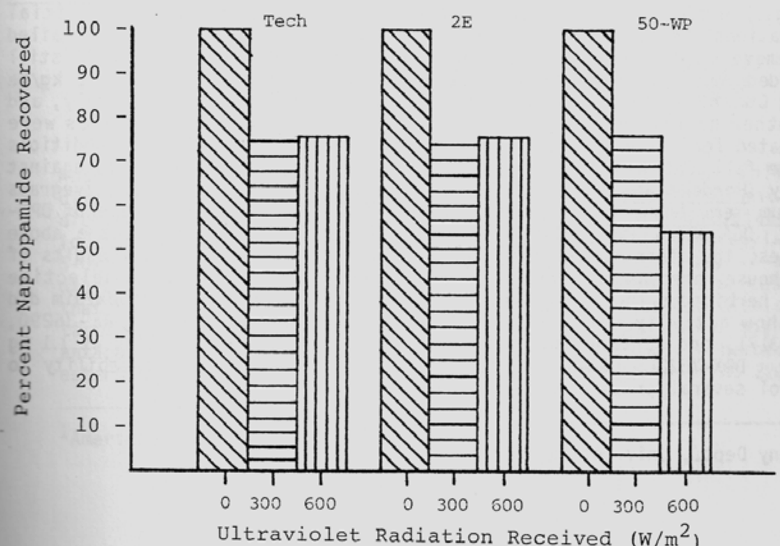


Figure 6. Napropamide recovered from soil shielded by polycarbonate plastic after exposure to various amounts of ultraviolet radiation.



ACTIVITY OF POSTEMERGENCE GRASS HERBICIDES APPLIED TO THE SOIL

Robert F. Norris and Renzo A. Lardelli[1]

Abstract. Greenhouse testing showed that DPX-Y6202 (2-(4-((6-chloro-2-quinoxaliny)oxy)phenoxy)-propanoic acid, ethyl ester), CGA-82725 (chemistry not available), DOWCO-453 (methyl-2-(4-((3-chloro-5-(trifluoromethyl)-pyrid-inyl)oxy)phenoxy)propanoate), and diclofop methyl (2-(4-(2,4-dichlorophenoxy)-phenoxy)propanoate) at either 0.3 or 1.1 kg ai/ha controlled barnyardgrass (*Echinochloa crusgalli* (L.) Beauv.) when the herbicides were mixed into fine sandy loam soil. HOE-00581 (chemistry not available) and fluazifop-butyl (butyl 2-(4-(5-trifluoromethyl-2-pyridoxy)phenoxy)propionate) provided only partial control at the lower rate; sethoxydim (2-(1-(ethoxyiminoL)butyl)-5-(2-(ethylthio)propyl)-3-hydroxy-2-cyclohexen-1-one) provided only partial control at 1.1 kg/ha and essentially no control at 0.3 kg/ha. The soil was dried following harvest, remixed (including old plant roots) and returned to the pots, and reseeded. At harvest of the third replanting the 0.3 kg/ha rate of all herbicides did not control the barnyardgrass, but the 1.1 kg/ha rate of CGA-82725 and DPX-Y6202 still provided over 80% control, and diclofop-methyl and DOWCO-453 still provided at least 60% control. Sethoxydim, fluazifop-butyl and HOE-00581 showed only slight to essentially no activity at this third replanting. The same herbicides, plus SC-1084 (chemistry not available) and RE-36920 ((E,E)-2-(1-(1-((3-chloro-2-propenyl)oxy)imino)butyl)-5-(2-(ethyl-thio)propyl)-3-hydroxy-2-cyclohexen-1-one), were applied preplanting and incorporated to a depth of 6.5 cm to a field experiment that was furrow irrigated. Sugarbeets showed to affect of any herbicide. The control of barnyardgrass for 0.3 and 1.1 kg/ha respectively, for sethoxydim was 0 and 0%, for HOE-33171 (ethyl-2-(4-((6-chloro-2-penzoxazolyl)oxy)phenoxy)propanoate) was 10 and 50%, for fluazifop-butyl and SC-1084 was 0 and 80%, for RE-36290 was 10 and 80%, for DOWCO-453 was 80 and 100%, and for DPX-Y6202 and CGA-82725 was 90 and 100%. Activity against yellow foxtail (*Setaria lutescens* (Weigl.) Hubb.) was similar to that outlined above. After initial evaluations the field was allowed to dry, the tops of the beds were flailed to remove weed growth and retilled, and then replanted. DPX-Y6202 still provided nearly 100% control of barnyardgrass from the original 1.1 kg/ha rate; CGA-82725 or DOWCO-453 gave 50% and 30% control, respectively, and all other herbicides were inactive. The same series of herbicides were evaluated for activity when applied preemergence under rainfall conditions in the fall and winter. The 0.3 kg/ha rate showed little activity against barley (*Hordeum vulgare* L.), wild oats (*Avena fatua* L.) or annual ryegrass (*Lolium temulentum* L.) under these conditions. The 1.1 kg/ha rate of DPX-Y6202, DGA-82725 and DOWCO-453 provided from 40-80% control of the above species; the other herbicides listed above showed no activity. Results of greenhouse, preplant incorporated, and preemergence testing of selective grass herbicides indicated that for practical considerations sethoxydim did not show activity when applied to the soil. Fluazifop-butyl, RE-36290, HOE-33171, and SC-1084 showed limited soil activity when applied at 1.1 kg ai/ha. DPX-Y6202, CGA-82725 and DOWCO-453 all demonstrated capability to control several grass species when applied to the soil.

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[1]Botany Dept., Univ. of California, Davis, CA.

STUDIES ON THE BIOLOGY AND PHYSIOLOGY OF SEVERAL JOINTED GOATGRASS ACCESSIONS

D. R. Gealy and L. A. Morrow[1]

Abstract. Rachis segmets (RS) of jointed goatgrass (*Aegilops cylindrica* Host.), each containing 1 to 3 seed, were obtained from winter wheat producing regions in Washington, Montana, Wyoming, Colorado, Nebraska, Kansas, and Oklahoma. Greenhouse and field experiments were conducted on these accessions at Pullman, Washington. Plants were grown in the greenhouse (14 h photoperiod and 15C) except during a 2 week vernalization period at the 2 to 4 leaf stage when plants were placed outdoors (12 hr photoperiod and 0 to 10C). There were marked differences in days to flowering, leaf and stem dry weight, RS yield, RS per head, RS per plant, weight per RS, head length, awn length, and RS germination among some of the accessions whereas leaf photosynthesis rate, tillers produced, flag leaf length, plant height, heads per plants, and RS diameter did not differ. The ratio of RS yield:leaf and stem dry weight was positively correlated with RS germination among all accessions. In the field only, plant height, awn length, and RS germination differed among accessions but trends were not consistent with greenhouse results. In both the field and greenhouse, RS produced by the Oklahoma accession were strigose whereas those of all other accessions were glabrous. The differing results for plants grown in the greenhouse compared to those grown in the field may be partly due to differing vernalization requirements among accessions.

[1]USDA-ARS, Washington State University, Pullman, WA.

EFFECTS OF MECOPROP AND DICHLORPROP ON ^{14}C-AC 222,293 UPTAKE, TRANSLOCATION, AND METABOLISM IN *AVENA FATUA*

D. L. Shaner, P. A. Robson, and K. Umeda[1]

Abstract. Experiments were conducted to determine the influence of different forms of mecoprop (2-((4-chloro-*o*-tolyl)oxy)propionic acid) and dichlorprop (2-(2,4-dichlorophenoxy)propionic acid) on the uptake, translocation and metabolism of ^{14}C-AC 222,293 (methyl 6-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)-*m*-toluate and methyl 6-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)-*p*-toluate) in *Avena fatua*. Greenhouse tests showed that the dimethylamine and potassium salts of mecoprop and dichlorprop antagonized the activity of AC 222,293 on *A. fatua* while there was no antagonism with the butylglycol ester of either broadleaf herbicide. The esters of mecoprop and dichlorprop increased absorption of AC 222,293 into

[1]American Cyanamid Company, Princeton, NJ.

A. fatua leaves approximately 2-fold and, as a result, increased the total amount of radiolabeled material translocated from the treated leaf. The dimethylamine and potassium salts of mecoprop and dichlorprop decreased uptake of AC 222,293 5-fold and also decreased the total amount of radiolabeled material translocated from the treated leaf. None of the forms of either mecoprop or dichlorprop affected absorption and translocation of AC 222,293 applied to the roots of *A. fatua*. Metabolism of AC 222,293 to the active acid form was not affected on a qualitative basis by either mecoprop or dichlorprop. Antagonisms of the salt forms of both mecoprop and dichlorprop with AC 222,293 is primarily due to effects on uptake of AC 222,293 into *A. fatua* leaves.

GREENHOUSE SCREENING TECHNIQUE FOR TRIAZINE TOLERANT SPRING WHEAT

S. K. Parrish, L. A. Morrow, and D. R. Gealy[1]

Abstract. In 1979 a number of spring wheat lines were obtained from the world collection. These lines were planted in the field and treated with metribuzin (4-amino-6-tert-butyl-3-(methylthio)-as-triazin-5(4H)-one) at 3.36 kg/ha at the three leaf stage. Lines were rated for metribuzin tolerance. Tolerant lines were selected and retested in 1980.

In order to determine differences in metribuzin tolerance among these lines and between established spring wheat varieties, a screening technique was developed which would allow for a large number of cultivars to be screened. The technique consisted of floating a 1.28 cm thick 30.1 X 60.2 cm piece of styrofoam on half strength Hoagland solution. The solution was contained in a 7.7 cm deep 31 X 61 cm tray. Oxygen was provided to the seedlings by percolating compressed air through pinholes in rubber tubing placed lengthwise at the bottom of each tray. Three-day-old germinating wheat seeds were placed in 6 mm diameter holes in the floating styrofoam in such a way that the exposed radicals would make contact with the nutrient solution. The nutrient solution contained starting metribuzin concentrations of 0, 50, 100, and 150 ppb.

A metribuzin concentration of 50 ppb reduced the dry matter accumulation of the most tolerant wheat line 51%. The most sensitive line was Wampum spring wheat which had a dry matter accumulation reduction of 86% at a 50 ppb concentration of metribuzin. Injury ratings and dry matter accumulations corresponded to the field evaluations.

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[1]Washington State University, Pullman, WA.

STUDIES ON THE BIOLOGY OF DOWNY BROME

J. M. Richardson, L. A. Morrow, and D. R. Gealy[1]

Abstract. In a greenhouse study, 10 downy brome (*Bromus tectorum* L.) caryopses per pot were planted at 1 cm intervals from 0 to 9 cm deep in 3 L pots of Ritzville silt loam soil (coarse-silty, mixed, mesic Calciorthidic Haploxerolls). Pots were subirrigated as needed throughout the study to maintain a moist soil environment. Coleoptile emergence was recorded daily. After 15 days, no coleoptiles had emerged from depths greater than 6 cm. Greatest establishment was achieved from caryopses germinating on the soil surface. After 15 days, the soil was removed from the pots and fractured, showing that caryopses in the treatments with no coleoptile emergence had germinated and elongated.

A similar experiment was conducted, using soil compacted to a bulk density of 1.7 g/cm^3. After 21 days, coleoptiles had emerged from no deeper than 2 cm, indicating that the depth from which downy brome caryopses will emerge is greatly reduced by soil compaction.

The effect of plant density on tillering and heading was studied by planting downy brome seedlings at densities of 5, 14, 27, and 55 plants/m^2 in 3 L pots of Ritzville silt loam. No tillers were produced for 21 days after planting. Tiller numbers in the four densities were similar during early tillering, but by 45 days after planting, tillering rates in the 55 and 27 plants/m^2 treatments were significantly slower than for the lower plant densities. The production of panicles was observed until 116 days after planting. These results indicated that the number of heads/m^2 increased as plant density increased, even though there were fewer tillers per plant. No heads were produced by plants in the lowest density treatment.

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[1]Agronomy Dept. and USDA-ARS, Washington State University, Pullman, WA.

INTERACTION OF CHLORSULFURON WITH OTHER HERBICIDES

S. W. Howard and R. E. Whitesides[1]

Abstract. Greenhouse and field studies were conducted to determine the efficacy of chlorsulfuron (2-chloro-N-(((4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino)carbonyl)benzenesulfonamide) when combined with dicamba (3,6-dichloro-O-anisic acid), 2,4-D ((2,4-dichlorophenoxy)acetic acid), MCPA (((4-chloro-O-tolyl)oxy)acetic acid), and bromoxynil (3,5-dibromo-4-hydroxybenzonitrile). Mayweed (*Anthemis cotula* L.) was used as an assay plant because it is only moderately susceptible to the herbicides being tested.

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[1]Agronomy & Soils Dept., Washington State University, Pullman, WA.

The field study, established in early summer 1983, showed an apparent antagonism between mixtures of dicamba or MCPA with chlorsulfuron. Combinations of chlorsulfuron with bromoxynil may be additive or synergistic.

In the greenhouse the methodology for growing the mayweed and the determination of dosage-response levels has been completed for use in comparing three interaction models.

SOIL STERILANT INJURY TO LANDSCAPE PLANTS: AN EDUCATIONAL ATTEMPT TO STOP THE SLAUGHTER

Richard D. Gibson[1]

Unnecessary destruction of landscape plants has led the Arizona Cooperative Extension Service to implement a public education program to attack the indiscriminant use of soil sterilant herbicides.

In situations where complete vegetation control is important, the potency and persistence of soil sterilant herbicides make them a valuable weed control asset. There are conditions, however, where these materials can severely injure or destroy non-target plant species. In the low-rainfall, desert areas of Southern Arizona, misapplied soil sterilants can and do cause severe injury to urban landscapes.

The incidence of herbicide poisoning in urban and residential landscapes is dependent upon weed pressure, a desire on the part of the public to control weeds for long periods of time, and a misunderstanding, again on the part of the public, of the persistence of soil sterilants in an arid environment.

Injury diagnosis is usually a simple task. Symptoms caused by prometon, bromacil, simazine, and dicamba are unique and easy to recognize. Dealing with public reaction, especially of those who have made the application themselves, is not so easy. At best, their response is a sick frustration as they realize the true impact of soil sterilants in desert soils. Others react with disbelief, others with open hostility. Under these conditions, even one incident is too many.

Most incidents, fortunately, result from sub-lethal dosages of sterilant. Occasionally, incidents involving lethal dosages do occur and shrubs and trees fall victim to man's inability to correctly use science. Landscape trees and shrubs, especially those that have been in place for a number of years, are extremely valuable. Lethal applications, even when they are relatively infrequent, can cause significant losses. Sub-lethal applications can destroy the beauty of landscape plants and lower property values.

Pinal County, Arizona derives income from agriculture, mining, and light industry. The largest city, Casa Grande, has a population of less than 20,000 people. Although the county is not highly urbanized, landscaping in the area does constitute an important part of the urban environment. Shade and dust control are important.

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[1]Arizona Cooperative Extension Service, Casa Grande, AZ.

Different types of landscaping are found within the area. At an elevation of about 1200 feet, the county is situated within the boundaries of the Sonoran Desert. Standard lawn and shade tree landscapes are common, but increasing amounts of low water use desert landscaping is appearing.

Within these types of landscaping regimes various types of weed problems occur. Newly planted lawns will often be overcome by a summer weed complex, the major weed being common purslane (Portulaca oleracea L.). Although summer weeds usually are not a problem in healthy turf, significant problems can occur in weakened or diseased lawn areas. Russian thistle (Salsola kali var. tenuifolia Tausch), and bermudagrass (Cynodon dactylon (L.) Pers.) are common problems in alleys and disturbed ground areas.

During the winter dormant season, the winter annuals can cause significant problems for the lawn owner. Bur clover (Medicago hispida Baertn.), spiny sowthistle (Sonchus asper (L.) Hill), and prickly lettuce (Lactuca serriola L.) can be common problems. Creeping woodsorrel (Oxalis corniculata L.) can be a perennial weed problem. Little mallow or cheeseweed (Malva parviflora L.) with several species of annual grasses can also be winter problems.

The common interest of residential owners is to find a simple but effective means of controlling these weed pests. While effective and safe chemicals do exist, most home owners, when given the choice, tend to opt for the more long lasting soil active materials. Unfortunately, they usually get into trouble.

There seems to be two possible solutions to the endemic destruction of landscape plants. Restriction or elimination would effectively remove these materials from homeowner use. It would also deprive the public of highly effective and valuable weed control tools and unfairly penalize the many people who use them correctly. Regulatory action does not seem to be an appropriate action. The other solution is public education.

The Arizona Cooperative Extension Service has initiated an educational program to air the dangers of soil sterilants in the home and business landscape, to demonstrate the correct uses of these materials, and to minimize the property damage from their applications. The program is aimed at nursrymen, sales people, and the general public. Programs have included presentations at plant diagnostic clinics, local garden clubs, the Boyce Thompson Southwestern Arboretum, and other public meeetings. Extension Agents, Specialists, and Master Gardener Volunteers have participated in these programs and have further involved newspaper colümns, radio talk shows, direct mail, and one-on-one interviews in the effort.

The public seems to be responding to the emphasis. Many people have been contacted through the media and personal contacts. Where incidents have been identified, public opinion has usually been changed. Persistence has been paying off. Nurserymen have been trained in the proper use of long term weed materials and have been teaching these principles to their customers. While complete eradication of the problem may not be possible, minimization may, indeed, be an obtainable goal.

IN-FIELD SPRAYER EVALUATION WITH PORTABLE COMPUTERS AND USER-FRIENDLY, INTERPRETIVE SOFTWARE

Mike Harrell[1]

Abstract. Inaccurate sprayer calibration and poor spray distribution have been cited as causes of many cases of herbicide nonperformance. While much effort has been put into educating and training growers and custom applicators, little measurable progress has been made. New tools have recently become available which allow applicators to more fully understand precise herbicide application. A portable spray patternator, developed by Accu Tech Associates, evaluates sprayer boom patterns and clearly demonstrates the concept of pattern uniformity. A highly user-friendly and interpretive computer program developed by CENEX and the DuPont Company train applicators on the components of application and allow them to understand how those components relate to each other and contribute to overall application precision. Additionally, this software runs on portable personal computers which are easily transported to the field. It is expected this new approach to increasing applicators' awareness of spraying technology will make significant gains in improving herbicide performance and customer satisfaction.

[1]CENEX, St. Paul, MN.

COMPUTERIZED "SWINGLOCK" SPRAY SYSTEMS

Johnny Kubacak[1]

Abstract. There have been numerous problems associated with the application of herbicides on right-of-ways such as streets, roads, drainage ditches, and utility lines. Some of these problems are: Different kinds of weeds often require different herbicides to keep them under control. Hence separate applications need to be made; Rough terrain or obstacles in the right-of-way prevent the spray operator from always driving a constant speed with the spray vehicle thus resulting in varied rates applied; The spray operator could never accurately vary the application rate using less chemical on small weeds and more on larger weeds; Chemicals in the past have always had to be tank mixed with water.

The computerized "SWINGLOCK" Sprayer by Cibolo Mfg. incorporates the most recent technology to eliminate these problems.

A. An automated computerized chemical injection system allows for use of multiple chemicals in the same operation either independently or in combination.

[1]Cibolo Manufacturing, Jourdanton, TX.

B. The operator can easily change the rates of chemical applied per acre with a push button rate per acre button that reads in quarts per acre.
C. Both liquids and wettable powders can be used in the system.
D. The rate applied per acre is correct irregardless of whether the operator drives 2 miles per hour or 20 miles per hour.
E. The system eliminates the need for calibration.
F. No tank mixing is required.
G. The system provides constant pressure irregardless of the numbers or combinations of nozzles used. Thus, particle size remains constant reducing the possibility of off target drift.
H. This spray system allows the operator to spray selective treatments in the right-of-way in four nine foot sections for a total of a 36 foot swath. Swaths can be used individually or in any combination.
I. The system has no long booms that can be bent or broken.
J. The system also has capabilities of applying foliage herbicides on brush. It will also apply bareground treatments to curb and gutter, under guardrails, on shoulders, and around signs or delineators.

Major advantages of the "SWINGLOK" System are: 1) It saves labor, 2) It accurately applies chemicals, and 3) It achieves high production per day.

MONTANA'S LEAFY SPURGE AND SPOTTED KNAPWEED AWARENESS PROGRAM

C. Lacey and P. K. Fay[1]

Introduction

Montana is an important livestock-producing region with over 63 million acres of rangeland. Although this land is a valuable resource, the economic return per acre is relatively low. Thus, when weeds invade a range site, many landowners are reluctant to use control methods because the return on their investment may not be immediately apparent. As a result, two weeds, leafy spurge (*Euphorbia esula* L.) and spotted knapweed (*Centaurea maculosa*) become a major threat to the productivity of range and pasture land in Montana.

The key to controlling both weeds is early detection and treatment. Therefore, in 1983 the Plant and Soil Science Department at Montana State University initiated a leafy spurge and spotted knapweed public awareness program.

The purpose of this paper is to review Montana's extension effort on the two weeds in 1983. Hopefully, our experiences contain ideas that could be useful in other states.

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[1]Plant & Soil Science Dept., Montana State University, Bozeman, MT.

Program

The objectives of the program were to continue the leafy spurge effort started in 1980, and initiate an effort on spotted knapweed. Three specific goals were outlined for the program: 1) To increase public awareness of leafy spurge and spotted knapweed, 2) disseminate current information on their biology and control, and 3) evaluate the effectivess of the program.

To meet these goals, several techniques were utilized:

Newsletter: The purpose of the Leafy Spurge Newsletter, initiated in 1980, was to increase awareness, coordinate research, and provide information to people interested in leafy spurge control. It has proven to be an excellent form of communication between researchers, extension personnel and landowners. Therefore, the Leafy Spurge Newsletter was continued, and because of its success, a newsletter on spotted knapweed was started in 1983. The "Knapweed Update" has contained information from researchers in California, Oregon, Washington, Idaho, Montana, British Columbia, and Alberta. Current research programs and research results on both chemical and biological control of spotted and diffuse knapweed will be reported. Over 2,000 people are currently on the mailing list which encompasses 17 states and 4 countries.

Bumper Stickers, Road Signs, and Posters: Bumper stickers with the slogans "Knockout Knapweed" and "Purge Spurge" were developed to distribute at tours, meetings, and county fairs. They were popular with the youth and have been an efficient tool to increase public awareness of these weeds.

Herbicide Demonstration Plots: The purpose of herbicide demonstration plots is to show landowners the efficacy of various chemicals. Twenty-two plots were established on leafy spurge and spotted knapweed in June of 1983. The plots were located and treated through a cooperative effort between Montana State University, Cooperative Extension Service, Soil Conservation Service, Chemical Companies and Weed Districts. Some of the plots were used for educational tours in 1983, and others will be used for 1984 tours. The sites of the demonstration plots are accessible and the plots are large enough to clearly show differences between treatments (minimum plot size is 20 by 80 feet). The demonstration sites were located near population centers when possible.

Field Tours: Over 745 people attended 14 field tours held during the summer of 1983. County agents, weed district supervisors, and Soil Conservation Service personnel helped organize and support the tours. The educational programs emphasized: An update and facts on biological control; leafy spurge control with sheep; the importance of treating small infestations (economics and eradication); and herbicide efficacy. Spray check demonstrations where landowners were shown how to calibrate spray equipment; county weed equipment and the latest innovations in herbicide applicators for All Terrain Vehicles were also displayed at the tours. Dow Chemical Company sponsored picnic dinners and provided door prizes to people attending most of the tours.

Our experience indicates that several factors influence the attendance and success of a weed tour:

*Attendance was greatest at followup tours (where previous programs had been conducted).

*Attendance was greatest at tours that were well advertised. Radio tapes, news articles, and flyers should be sent to counties ten days in advance of the tours.

*Attendance was greatest at late afternoon and evening tours, and lowest at morning sessions. The date of the tour must not conflict with planting or harvesting seasons.

*Tour sites should be easily accessible and located near population centers.

Weed Calendar: A weed calendar was designed for farmers and ranchers in Gallatin County. The purpose of the calendar was to help producers with selecting proper herbicides and timing herbicide applications on noxious weeds. Each month of the calendar features a specific weed with the recommended herbicides and time of application. The proper growth stage of the weed for herbicide treatments is featured within a bold square. The initial response to the calendar has been very favorable, and we hope to expand its use statewide.

Ransom Program: In this program, youth would be paid for locating and reporting infestations of leafy spurge and spotted knapweed to their county extension agent or weed supervisor. If the infestation had not been located on the county weed map, then the 'finder' is paid a certain amount of money. The objectives of a weed ransom program would be to increase awareness of weeds among youth groups and to help map county weed infestations. Although the idea is attractive, most counties are reluctant to adopt it because of lack of finances.

Integrated Approach: Our extension program is utilizing an integrated approach to address the weed problem in Montana. This involves close cooperation between research scientists, chemical companies, and county, state, and federal agencies that are involved with weed control or extension activities in the state. Through this cooperative planning, a statewide weed control effort is being established.

The Montana State Weed Fair is an example of this cooperative effort. Over 500 people attended the 1983 fair held in Columbus, Montana. The expertise, hard work, and funding for the event was provided by researchers and extension personnel from Montana State University and USDA-SEA, the Montana Weed Association, and chemical company representatives.

The fair included tours for youth, spouses, ranchers, farmers, weed supervisors, and legislators. Highlights of the tours included control methods for several noxious weeds; range improvement demonstration plots; sagebrush control with herbicides, fire, and mechanical treatments; and establishment of a grass nursery. A barbecue, dance, and crowning of "King Thistle" and "Miss Morning Glory" followed the tours. The location of the state weed fair rotates to a new part of the state each year.

Another example of our integrated approach is the Knapweed Symposium scheduled for April 1984. The purpose of the symposium is to coordinate research activities and generate ideas on a region-wide basis. The symposium is made possible through a coordinated effort between Montana State University, Cooperative Extension Service, Western Montana Weed Council and Soil Conservation Districts.

Program Evaluation

Our weed education program through the Plant & Soil Science Department is like many others in that funds must be allocated wisely. Therefore, it is important to evaluate the program to determine its overall effectiveness.

A questionnaire, developed in October 1983, was used to evaluate the program. The questionnaire was mailed to producers in four counties that held 1983 weed tours. Leafy spurge tours were held in two counties while spotted knapweed tours were held in the other two counties. Although our programs centered upon one of the weeds, information was provided on both leafy spurge and spotted knapweed at all four tours.

Landowners attending the weed tours were mailed a questionnaire. The county agents in the four counties then selected an equal number of landowners that had not attended the tours and a questionnaire was mailed to this group.

The purpose of the questionnaire was to determine if the differences in weed awareness and control existed between landowners that did and did not attend the weed tours. The questionnaire also provided information on: 1) Reasons for lack of weed control in the state, 2) The major source of weed information, and 3) Educational programs that landowners felt were needed to improve weed control practices in Montana.

Survey Results

Sixty eight percent of the surveys were completed and returned. There was no difference in returns between landowners that did and did not attend the weed tours which indicates the two groups were equally concerned about weeds.

The results for the survey showed a significantly higher degree of weed awareness in tour participants than in non-tour participants (Table 1). This suggests the tours increased public awareness of leafy spurge and spotted knapweed among those who attended.

In order to measure weed control practices of the two groups, survey participants were asked to indicate whether they used herbicides for spotted knapweed and/or leafy spurge control. There was no difference between the two groups in the use of herbicides for control of spotted knapweed. However, a significantly greater number of tour participants used herbicides for leafy spurge control that did non-tour participants (Table 2). These results may be a reflection of the length of time our weed awareness program has been in effect. The intensive leafy spurge effort was initiated in 1980 compared to 1983 for spotted knapweed. It may take several years before landowners are willing to adopt sound weed management practices.

The survey also provided us with information on: 1) Why landowners are not controlling weeds in Montana (Table 3), 2) The major source of weed control information (Table 4), and 3) Programs that the Cooperative Extension Service should utilize to promote weed control in Montana (Table 5).

Conclusions

Based on the response from landowners in these four counties, we believe that our weed education effort has been successful in Montana. Our program has utilized three approaches for transferring technology to the landowners: 1) Tours and seminars have proved to be an excellent method for increasing weed awareness and control, 2) These traditional approaches have been enhanced by innovative ideas such as the ransom program & weed calendar, 3) The overall effectiveness of the educational program has been improved through cooperation with research scientists, chemical companies, and county, state, and federal organizations.

Table 1. Percent of landowners able to recognize whether leafy spurge and/or spotted knapweed were serious problems on their propery.1/

Plant Species	Landowners Attending Tour	Landowners Not Attending Tour
	%	%
Leafy Spurge 2/	100 a	55 b
Spotted Knapweed	94 a	65 b

1/ Data based on information collected from 210 questionnaires returned by Montana landowners during January, 1984. About one-half of the respondents did attend a weed tour in 1983, while the remainder did not attend a weed tour in 1983.

2/ Percentages in the same row followed by the same letter are not significantly different at the .005 level.

Table 2. Percent of landowners using herbicides for control of leafy spurge and spotted knapweed.1/

Plant Species	Landowners Attending Tour	Landowners Not Attending Tour
	%	%
Leafy Spurge 2/	95 a	66 b
Spotted Knapweed	57 a	54 a

1/ Data based on information collected from 210 questionnaires returned by Montana landowners during January, 1984. About one-half of the respondents did attend a weed tour in 1983, while the remainder did not attend a tour in 1983.

2/ Percentages in the same row followed by the same letter are not significantly different at the .005 level.

Table 3. The relative importance of four reasons for not controlling weeds, as rated by landowners in four Montana counties.1/

Reasons	% of Total Responses Indicating that the reason was most important2/
Lack of Information	41
Value of Land too Low	27
Lack of Application Equipment	19
Fear of Herbicides	15

1/ Data based on information collected from 210 questionnaires returned by landowners during January, 1984. About one-half of the respondents attended a weed tour in 1983, while the remainder did not attend a tour in 1983.

2/ Total percentage does not equal 100 because several respondents listed two reasons as being the most important.

Table 4. The major source of weed information for landowners in four Montana counties.1/

Source of Information	% of Landowners2/
Cooperative Extension Service	52a
Montana State University	25b
Neighbor	11c
Agricultural Business	10c
Periodicals	9c
Newsletters	5c
Radio or Television	4c

1/ Data based on information collected from 210 questionnaires returned by Montana landowners during January, 1984. About one-half of the respondents did attend a weed tour in 1983, while the remainder did not attend a tour in 1983.

2/ Percentages followed by the same lower case letter are not significantly different at the .005 level. Total percentage does not equal 100 because several respondents listed two sources of information as being the most important.

Table 5. The most important stratagies the extension service should utilize to improve weed control practices, as perceived by landowners in four counties.1/

Extension Stratagies	% of Landowners 2/
Conduct Tours and Seminars	69
Publicize Weed Problems	15
Publish Newsletter	10
Provide Consultation	9
Focus on Small Landowner	5

1/ Data based on information collected from 210 questionnaires returned by landowners during January, 1984. Afout one-half of the respondents attended a weed tour in 1983, while the remainder did not attend a tour in 1983.

2/ Total percentage does not equal 100 because several respondents listed two stratagies as being the most important.

AN ON-FARM HERBICIDE DISPOSAL SYSTEM

M. A. Batchelor, B. D. Maxwell, and P. K. Fay[1]

Abstract. There is a need for safe, on-farm disposal of unused herbicide solutions. A prototype disposal system was fabricated using materials which are readily available on most farms.

The system utilized a 55 gallon drum with one end removed which was placed in the ground to a point level with the soil surface. A 50% soil, 50% organic matter (dried cow manure) mixture was placed in the drum to provide an active herbicide degradation medium. A heat tape was wound throughout the medium to permit elevated soil temperatures to encourage maximum microbial activity. An activated charcoal filter was placed in the system betwen an initial reservoir which receives the herbicide from a sprayer tank and the drum containing the degradation medium. The charcoal filtering system was designed to permit retrieval of the herbicides. Alternatively, the activated charcoal filtering system could be returned to a central location where the trapped chemicals could be combusted safely as CO_2 into the atmosphere.

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[1]Plant & Soil Science Department, Montana State University, Bozeman, MT.

WSWS BUSINESS MEETING MINUTES
March 15, 1984

The meeting was called to order by President Garry Massey at 7:30 a.m.

Business Manager LaMar Anderson presented the following WSWS Financial Report for 1983-84.

Financial Statement
March 1, 1983 - March 6, 1984

<u>Income</u>

Registration, Las Vegas Meeting		
140 x $30.00	4,200.00	
preregistration - 158 x $25.00	3,950.00	
graduate students - 38		$ 8,150.00
Dues, members not attending annual meeting (95)		475.00
Extra luncheon tickets		238.50
1983 Research Progress Report sales		3,489.94
1983 Proceedings sales		4,319.84
Sale of back issues of publications		251.00
Payment of outstanding invoices from 1982		40.50
Advance order payments		376.50
Coffee Break donations		750.00
Total 1983-84 fiscal year income		$18,091.28

<u>Expenditures</u>

1983 Annual Meeting incidental expenses	$ 1,195.53
1984 Annual Meeting incidental expenses	358.37
Luncheon, 1983 Annual Meeting	3,958.69
Guest Speaker expenses	212.00
Graduate Student room subsidy	910.00
Graduate Student paper awards	150.00
Business Manager honorarium	500.00
CAST dues	534.00
1983 Research Progress Report publication costs	2,646.54
1983 Proceedings publication costs	3,698.51
Postage	834.67
Newsletters, publication costs	198.98
Office supplies	286.05
Refunds	68.00
1984 Program printing costs	537.60
Total 1983-84 fiscal year expenditures	$16,088.94

1983-84 operational profits	$ 2,002.34
Interest on checking account	303.39
Interest on savings	2,768.39
Actual total increase during 1983-84	$ 5,074.12

Assets

Savings certificates	$21,000.00
Checking	9,771.39
Cash on hand	50.00
	$30,821.39

Vern Stewart, Chairman of the Finance Committee, reported that an audit of the financial records showed everything to be in order and that the Society was in a sound financial standing. He moved acceptance of the financial report, motion carried.

CAST REPORT
by
Lowell S. Jordan, CAST Representative

CAST is mounting an aggressive campaign to increase individual and sustaining membership under the leadership of Gary Mulhall, Assistant Vice President. Dr. Cecil Howes, CAST Washington Representative, is devoting all of his working time to keeping decision makers aware of CAST's activities. The Science of Food and Agriculture magazine is well accepted by science teachers throughout the country.

Task force reports are to be produced in a more timely fashion. A recent report, "The Emerging Economics of Agriculture: Review and Policy Options," was cited by Senator Jepsen at the annual CAST-Congressional Breakfast meeting as the cornerstone for future United States agricultural policy. Other recent reports include those concerned with pest resistance to control measures, agricultural mechanization, and water use in agriculture.

The weed science societies have been well repaid for their investment in CAST. They have contributed a total of about $39,000 to CAST while participating in publications related to weed science with a publication cost of over $800,000. There is no way other than through CAST that weed science's interests can be placed before so many important people.

WSSA Report 1984

WSWS Representative - Clyde Elmore
Weed Science Society of America Met - February 8-10, 1984
at the Hyatt Regency, Miami, Florida

Officers - 1984: C. G. McWhorder, Pres.; J. D. Nalewaja, Pres. Elect.;
J. D. Rigglemen, Vice Pres.; Dean Linscott, Sec.;
G. R. Miller, Treas.

Officers - 1985: J. D. Nalewaja, Pres.; J. D. Rigglemen, Pres. Elect.; Orvin Burnside, Vice Pres.; G. R. Miller, Treas. J. Doll was selected as member-at-large.

News

- Composite list of weeds and code names are ready to print (Fall, 1984).
- Crop losses publication is in printing.
- Reviews of Weed Science to be started. 1984 and 1985 issues have reviews assigned and should be published.
- Registration changes:

	Old	New
Membership	$15.00	$25.00
Preregistration	20.00	30.00
Registration at Meeting	30.00	40.00

- Weed Science has increased page charges to $50/page as of July 1, 1984.
- $2,500 has been allocated for a very successful CAST High School bulletin.
- A WSSA delegation will visit and lecture in China - Alex Ogg is USDA representative.
- Future meeting sites:

  1985 - Seattle, Washington
  1986 - Houston, Texas
  1987 - Canada or North-Northeastern U.S.

  There will be an agency selected for travel arrangements.

- Weeds Today has 1104 subscribers. WSSA supports $12,000/yr.

Monographs - Leafy Spurge monograph complete and in print.
Reduced Tillage - final copy at February meeting.
Weed Control in Wheat - 1985-86.
Biological Control of Weeds - in preparation.

1984 Awards - WSSA Fellow's:

Gale Buchanan
Walter Gentner
Marvin Schreiber
Robert Zimdahl

Honorary Member - Abed Saghir, Lebanon
Teacher Award - Dr. Doug Worsham, North Carolina
Research Award - Dr. Floyd Ashton, California
Extension Award - Dr. Ford Baldwin, Arkansas
Young Weed Scientist - Dr. Stephen Duke, Mississippi

Outstanding Weed Science Paper - J. D. Banting "Growth and Control of Wild Oat"

WSSA is a joint sponsor of "Conservation Tillage Conference" Oct. 3,4,5, 1984 at Opryland, Nashville, Tennessee.

WSSA sent a detailed analysis of the ARS 6-Year Implementation Plan to the Intersociety Consortium for Plant Protection (ISCPP) which was then summarized by Dr. Sheets and sent to Agriculture Secretary Block.

Site Selection Committee

Dale Christensen, Chairman

Dale Christensen presented the pros and cons for Hawaii as a future meeting site. Christensen and Massey gave strong support for Hawaii as a future meeting site. The loss of student participation in the student paper contest, lack of funding for USDA scientists, decrease in mainland attendance, and financial problems which occurred in the past were given consideration.

PROS

- Include and involve weed scientists and graduate students from Hawaii.
- Broaden horizons and knowledge regarding tropical agriculture.
- All good, hard-working scientists deserve some R & R.
- Include vacation time along with business.
- Opportunity to treat spouses to a luxurious vacation.
- Extra cost is reasonable, and worth it.
- Air fare and room rates are not that much different than some of our present meeting sites.
- Give graduate students a rest for one year.
- The 1974 meeting in Hawaii was held during the oil embargo and may have influenced attendance negatively.

CONS

- It will be more expensive.
- Graduate students may not be able to attend.
- University and USDA funds may not be available.
- Some workaholics will refuse to take time to broaden their knowledge regarding tropical agriculture nor take time to enjoy some rest and relaxation.

A hand vote by members attending business meeting was 95 for Hawaii for a future meeting site and 43 against.

Student Paper Contest

Bob Zimdahl reported that 21 students participated in the student paper contest. Winners were:

Third Place: E. A. Lacey, Montana State University, "Montana's Leafy Spurge and Spotted Knapweed Awareness Program."

Second Place: T. K. Chicoine, Montana State University, "The Longevity and Viability of Spotted Knapweed Seeds in Montana Soils."

First Place: D. L. Devlin, Washington State University, "Adsorption, Translocation and Metabolism of Metribuzin by Downy Brome and Winter Wheat."

Nominations and Elections

Del Harper reported the election results for 1984-85 officers as follows:

President Elect	Harvey Tripple
Secretary	Lloyd Haderlie
Chairman Elect Research Section	Ralph Whitesides
Chairman Elect Education & Regulatory Section	Phil Olsen

Resolution Committee

Warren Bendixen, Chairman, presented the following resolution:

Resolution No. 1: Local Arrangements and Program

WHEREAS, the facilities and arrangements for the 1984 annual meeting of the Western Society of Weed Science are of excellent quality and well organized; and

WHEREAS, the organization and content of the program are excellent and vital to the society;

THEREFORE, BE IT RESOLVED that the membership of the Western Society of Weed Science in conference assembled expresses its appreciation to Chairman Dean Swan and members of the 1984 Local Arrangements Committee, to Stanley Heathman and members of the 1984 Program Committee, and to the 1984 Project Chairman.

The resolution was passed unanimously.

Research Section Report

Darlene M. Frye

The 1984 progress report was about 20 pages shorter than the preceeding year partially due to the lack of papers submitted for the Aquatics, Ditchbank, and Non-crop Weeds project 6 section. The membership needs to be reminded to follow the editorial rules, especially those dealing with margin allowances, clarity of type and the use of trade names as several papers violated these rules this year. Timely submission of reports is also urged.

The Research Chairman for 1984-85 is Charles Stanger, Oregon State University, Route 1, Box 620, Ontario, Oregon 97914 (503-889-2174). The Chairman-elect is Ralph Whitesides, Department of Agronomy and Soils, Washington State University, Pullman, Washington 99164-6420 (509-335-3630).

The new project chairmen and chairmen-elect for 1984-85 are as follow:

Project 1: Perennial Herbaceous Weeds

Chairman: Lloyd C. Haderlie, Univ. of Idaho, P.O. Box AA, Aberdeen, ID 83310 (208-397-4181)
Chairman-elect: Galen Schroeder, Velsicol Chemical Corp., 1233 4th St. No., Fargo, ND 58102

Project 2: Herbaceous Weeds of Range and Forest

Chairman: Terry Peterson, Champion Intl. Corp., P.O. Box 8, Milltown, MT 59851
Chairman-elect: Mark Ferrel, Univ. of Wyoming, Laramie, WY 82071

Project 3: Undesirable Woody Plants

Chairman: Mike Newton, School of Forestry, Oregon State University, Corvallis, OR 97331 (503-753-9166)
Chairman-elect: Bruce Kelpasas, Sylvan Reforestation Consultants, Corvallis, OR (503-745-7357)

Project 4: Weeds in Horticultural Crops

Chairman: Robert Parker, Washington State University, I.A.R.E.C., P.O. Box 30, Prosser, WA (509-786-2226)
Chairman-elect: Ron Brenchly, Mobay Chemical Co., Ashton, ID

Project 5: Weeds in Agronomic Crops

Chairman: Sam Steadman, County Extension Offices, 820 East Cottonwood Lane, Casa Grande, AZ 85222 (602-836-5221)
Chairman-elect: Steve Miller, Plant Science Division, Univ. of Wyoming, Laramie, WY 82071

Project 6: Aquatic, Ditchbank and Non-crop Weeds

Chairman: Carl Tennis, U.S. Bureau of Reclamation, 2800 Cottage Way, Sacramento, CA 95825
Chairman-elect: David Spencer, USDA-ARS, Botany Department, University of California, Davis, CA 95616

Project 7: Chemical and Physiological Studies

Chairman: Dave Gealy, USDA-ARS, 215 Johnson Hall, Washington State University, Pullman, WA 99164
Chairman-elect: Louis Marquis, USDA-ARS, I.A.R.E.C., P.O. Box 30, Prosser, WA 99350 (509-786-3454)

The reports from individual project sections are as follow:

Project 1: Perennial Herbaceous Weeds

Chairman - Rodney Lym, Chairman-elect - Lloyd Haderlie

Eleven papers were published in the Research Report and over 75 people attended the discussion section. Dr. Galen Schroeder was elected to serve as chairman-elect in 1985.

The first subject discussed was whether university extension personnel are doing an adequate job informing the public of perennial weed control problems and programs. Most western states do not have a full-time perennial weed extension specialist. The effort devoted to perennial weed problems is often secondary despite the fact all present agreed perennial weed infestations are steadily increasing. Problem weeds of the arly 1900's such as field bindweed and Canada thistle are still present with relatively new perennial weeds such as leafy spurge and knapweed continually expanding. Perennial weeds often infest economically low value land, thus most herbicide treatments are not cost effective and must be considred as an insurance against further loss of productive land.

The second discussion was a lively debate of whether a university weed control program should emphasize basic or applied research. The group was decisively split. Some people felt the researcher should work for the people of the state and thus emphasize applied research. Other researchers present stated a weed scientist is qualified to do much more basic work than is presently conducted and would if funding were easier to obtain. It was pointed out that recent funding for basic work is available on a national level and few weed scientists have even applied for it. It was agreed that more information concerning these funds should be made available to weed scientists as few present knew the funding programs existed. Several graduate students present expressed concerns over their education, since many are trained in basic research and most employers require experience in applied research. If weed science is to advance as a discipline it must expand and upgrade the current effort on basic research.

Project 2: Herbaceous Weeds of Range and Forest

Chairman - Tom Whitson

Topic 1. How do you evaluate species composition before and after herbicide applications?

Methods in use included:

- Daubenmire's method for estimating either for canopy cover or species frequency.
- Point transects and point frame - live canopy and species frequency are evaluated before and after treatment.

Evaluations taken over various time periods were dependent on herbicides used, weed species present and the objectives of the experiment. Most equilibrium shifts in species composition taken from three to five years, therefore, evaluations should be taken until this point has been reached.

Are early changes (2-3 years) more than just of academic interest? Yes, to predict early shifts and to find early seccessional changes, such as downy brome.

SCS Rangeland Guidelines might be used effectively to determine both utilization and climax vegetation for rangeland sites for specific soil and precipitation zones.

How do we determine forage amounts produced as a result of herbicide treatments? Quadrats are used randomly in treatment areas after grasses have matured, which determine grass areas to be clipped. This quadrat can be either tossed randomly or located permanently. The permanent location can be clipped annually without grass damage; therefore, paired comparisons can be made with the previous years.

Clipping studies sometimes fail to accurately prdict actual livestock utilization. A common failure with our current approach is that we can tell landowners how much of an increase to expect, but fail to explain how the increase will take place.

A common concern was that clipping should be done at the same time of actual grazing. Phenology studies were suggested as a method to predict changes.

The rule-of-thumb for range management of taking half of the grass and leaving half is difficult to predict. A better approach might be to use short-term high intensity grazing systems to better utilize all plants to the same level rather than the palatable species.

Forage production is difficult to evaluate visually because plant weight is not evenly distributed in the plant. SCS has charts that help in making a weight estimate for various grazing levels for individual species.

Topic 2. Rangeland and Forest Management after a Herbicide Application.

With herbicide applications we create many niches that will be filled in as secessional changes take place. How do we determine if proper management is being applied after the control of an unwanted species? Recommendations must be made for specific locations, educational programs and demonstrations should be used to help producers make management decisions for carrying capacity.

The message is not getting across to ranchers because they are more animal orientated than vegetation management orientated. They do not understand how grazing management will affect the herbicide response. Wildlife such as burros and antelope must be considered when figuring range carrying capacity.

Other factors are also involved in proper range management such as: early changes in range species have occurred during the late 1800's and during the depression, public education is needed to make them aware of these man-made changes and the effects these changes have on present species composition. Specialists from all fields outside of weed science should be involved in order to make proper recommendations for rangeland managers. An integrated agricultural research approach should be used.

A recommendation was made to the WSWS directors and received unanimous support from those attending the meeting that WSWS sponsor a sympsoium for a part of next year's program that would include: various agency people, environmentalists, and other involved people in range management to allow a program of this nature to take place. Most public rangeland is located in the western states; therefore, this problem should be addressed at this level. An important part of proper herbicide recommendations should be to involve many people and communicate well.

Jack Warren was asked to chair a committee to explain this need to the board and to suggest other members to make up a committee to plan the symposium. Tom Whitson will work with Jack Warren on the symposium plans.

Topic 3. Our Involvement in Litigation that Defends Uses of Rangeland and Forest Herbicides.

Who and how should we in the Weed Science Society be involved in a herbicide defense case? Two important decisions involving herbicides have recently been ruled on in the courts, that of 2,4,5-T and the use suspension of all herbicides on public lands. Only two people attending the meeting were involved with either of these cases.

A concern was expressed that we do not have toxicology expertise or a knowledge of upcoming court cases or support from administration to become involved in this legal process.

An appeal expressed for WSSA membership to be involved in the legislative process and write letters of concern to our legislators about the need to revise the environmental impact statement requirements, as well as the National Environmental Quality Act which gives federal judges the authority to suspend uses of pesticides on Federal lands even though they have been found environmentally safe by the Environmental Protection Agency. A request was also made that WSSA write a letter in support of this change.

Chairman-elect - 1986 for Project 2: Herbaceous Weeds of Range and Forest will be Mark Ferrell - University of Wyoming.

Project 3: Undesireable Woody Plants

A total of 29 people attended this section (see attached list). A wide variety of topics were covered.

A major part of the discussion was concerned with the interaction of environmental and physiological factors in treating brush species. Often the physiologically most sensitive stage is environmentally inappropriate for applications (i.e. late summer drought stress).

Application methods were also mentioned. In particular, the utility of granular febuthiuron treatments and basal treatments of triclopyr were discussed. Depending on the time of application, type of application, and environmental concerns, a variety of methods can be used.

Soil persistence of residual or soil applied materials was also mentioned, with the majority opinion being that in most cases extensive persistence is not a major problem. However, under extremely dry environmental conditions or very high use rates (i.e. stump treatments), residual activity of some materials can be quite extensive.

A final area discussed was how the industry/academic community should be involved in public attitudes towards chemical usage as brush control. Most people felt the best approach would be a more pro-active (rather than reactive) stance at earlier points in the debate of public issues.

Bruce Kelpsas (Sylvan Reforestation Consultants, Corvallis, OR, 745-7357) was nominated by Mike Newton (through Ed Sieckert) to chair the Section in 1986. Motion carried.

Project 4: Weeds in Horticultural Crops

Robert Parker chaired the session for Linda Willits who was unable to attend. The topics developed and the discussion lead by Bob Parker were:

Subject 1: What do we know about the selective postemergence herbicides - phytotoxicity, yield reduction, oils, combinations with broadleaf herbicides?

Subject 2: Management of yellow nutsedge in horticultural crops.

About 80 people participated in the active discussion. Ron Brenchly with Mobay was voted chairman-elect for project 4.

Project 5: Weeds in Agronomic Crops

Russell P. Schneider, Chairman. Sam Stedman, County Extension Director, Casa Grande, AZ will be the 84-85 Chairman. Steve Miller, University of Wyoming, Laramie, WY is the Chairman-elect.

Low volume applications and the future of herbicides and plant growth regulators were discussed extensively from the floor. Few points of agreement were reached, but new research direction ideas were established.

Subject 1: Low volume application methods have been attempted in many areas. In general, low volume application does not fit all herbicides and certainly not all methods of application. The biggest concern revolves around application variability and the concept that low volumes through special equipment automatically means reduced rates. In some cases, participants indicated a 20 fold difference in herbicide deposition when comparing CDA to flat fan. The flat fan was superior. Final conclusion was of tremendous importance: 1) Science is behind in the knowledge and use of low volume application. 2) Need exists for joint research between weed scientists and engineers, and 3) The responsibility of the work lies with Industry, USDA and the University system.

Subject 2: Plant growth regulators or turf grass retardants have a fit in the market place. If the producer should see or measure an economic difference from a PGR, he would buy and use such a product. From a turf standpoint, reduced mowings or seedhead suppression would be required for six weeks. In the turf market, the application would be made by a commercial company, because the homeowner will not tolerate injury.

Project 6: Aquatic, Ditchbank, and Non-crop Weeds

Chairman - Randall K. Stocker

Topic: Eurasian watermilfoil control in British Columbia, Washington, and Idaho.

Chairman Stocker opened the discussion by introducing the topic and the panel members (3). Eurasian watermilfoil (Myriophyllum spicatum) is a commonly found submerged macrophyte in flowing and static water bodies of

North America. It was not until the 1970's, however, that Eurasian watermilfoil was noted in the Columbia River drainage in Canada and Washington.

Ron Pine (Washington State Department of Ecology) summarized the milfoil problem in Washington, starting with the discovery of the infestation (1975?) and including the early efforts to prevent spread of the pest. Because of tremendous public pressure not to use 2,4-D, the emphasis has been on use of mechanical control (Aquascreen, mechanical harvesting, barrier screens to prevent downstream movement of fragments) and public education (signs at boat ramps). The Washington State Department of Ecology is the lead state agency for the Eurasian watermilfoil control program. Ron has worked with Harry Gibbons (Washington State University) on developing increased effectiveness of chemical methods through the use of adjuvants (inverts, polymers, etc.), but the resistance of the public to the use of chemical control reduces the chances of implementing a successful chemical control program.

Bob Rawson (U.S. Army Corps of Engineers, Seattle District) described the involvement of the COE in the overall control program. The Seattle District, together with the USAE Waterways Experiment Station, Vicksburg, MS, conducted a field test of the effectiveness of mechanical barriers (screens, nets) to prevent downstream movement of plant fragments. Indications were that prevention of spread may play some role in future control programs, but that efforts in this case were only partially successful. The COE has also worked with mechanical control projects in the Seattle area. These have consisted primarily of mechanical harvesting and the use of Aquascreen.

Linda Edwards (University of British Columbia) has experience in both terrestrial and aquatic biological control programs. She reported that the milfoil problem in western Canada peaked in 1978 and has declined since. Canadian researchers are watching the association of pathogens with gradual declines in an attempt to determine potential biocontrol agents.

John Gallagher (Union Carbide) gave a summary of the recent meeting between his company and the US EPA to review the current 2,4-D label.

Points that came out during discussion that were of general interest:

1) The State of Idaho has not yet found milfoil within its borders, but representatives of Idaho State agencies agreed that a thorough monitoring program conducted now could dramatically reduce the cost of a control program later.

2) It would be of tremendous benefit for all concerned if someone investigated the usefulness of public education with regard to prevent spread of aquatic weeds and increasing the acceptance of chemical and biological control programs. No one now has any idea whether fishing bans, signs at boat ramps, billboards, TV spots, etc., have any real effect on aquatic plant management. Because some areas of Washington State have been posted and others not, there is real potential for conducting a valid piece of investigation. The results of such a study could change significantly the way in which state and federal agencies operate their control programs.

David Spencer (Aquatic Ecologist, USDA-ARS, Davis, CA) was elected to Chair Project 6 in 1986. The Chair for 1985 will be Carl Tennis (U.S. Bureau of Reclamation; 2800 Cottage Way, Sacramento, CA 95825).

Summary Report for Chemical and Physiological Studies
Section at WSWS 1984 Meeting

Lloyd C. Haderlie - Chairman
David Gealy - Vice-Chairman

At least 42 individuals participated. Dr. Louis V. Marquis, USDA-ARS, IAREC, Box 30, Prosser, WA 99350, was elected Vice-Chairman for 1984-85.

Radioisotope techniques used in studying the retention, absorption, translocation, and metabolism of herbicides in plants were discussed. Several of the pertinent points from the discussion are presented below.

Other isotopes are available, but ^{14}C-labeled herbicides are by far the most versatile and most used of all.

When studying uptake processes plants, it may be most useful to apply the herbicide in single drops and then maintain the leaf in a high humidity environment to ensure that the concentration gradient, which drives the herbicide into the leaf, stays fairly constant. Addition of humectants to herbicide solutions may have a similar effect on maintaining a consistent herbicide uptake rate.

Because we often formulate herbicides differently for radioisotope studies (e.g. in ethanol) than for field studies (e.g. in water), care must be taken that interpretation of radioisotope studies not be strictly extrapolated to the field situation.

Depending on the individual herbicide, different results may be obtained if the radiolabeled herbicide is applied alone at sublethal rates or applied along with field rates of unlabeled herbicide. Objectives must be clearly established so that the appropriate method of application can be chosen for a particular experiment.

When determining the amount of herbicide present on the leaf surface, selection of the proper leaf-wash solvent or solvents to remove the herbicide is critical. The solvent used must effectively solubilize the herbicide but should not excessively solubilize cuticle waxes or cell membranes. Likewise, duration of exposure to the wash must be long enough to ensure complete removal of the herbicide from the leaf surface but short enough to prevent extraction of absorbed herbicide. Preliminary experimentation must be conducted so that methods can be adapted to meet the specific objectives of any experiment.

Because of the environmental differences encountered, plants of the same species grown in the field, greenhouse, and growth chamber are distinctly different from one another even though no visible differences can usually be detected (e.g. field-grown plants usually have thicker cuticles and are exposed to some water stress daily). Therefore, the specific objectives of each experiment conducted will dictate the conditions under which plants must be grown. When specific mechanisms are being studied, the controlled environment of a growth chamber is desirable. But when direct applicability to a field situation is required (e.g. at what time of day do we get maximum uptake or control), field studies may be most appropriate.

High recovery of radiolabel is essential. We should be able to account for at least 80% of applied label for results to be meaningful. A balance sheet approach for expressing quantities of recovered herbicide must always be used so that they can be interpreted from the proper perspective.

Herbicide application through center pivot irrigation systems was discussed. Weed control from most herbicides has been surprisingly good with this method of application. The general feeling was that enhanced herbicide uptake from the soil solution, and not foliar uptake, was primarily responsible for the improved weed control.

The overall message from the discussion on these techniques seemed to be that no one method is always good or always bad. The method used depends on the specific objectives of the experiment and various constraints such as time, space, labor, instrumentation availability and funds. The pitfall which must be avoided in all cases is that of making unsound extrapolation of results and conclusions from an experiment of limited scope to include all possible situations. The limits of each experiment must always be kept in perspective.

The following Fellow and Honorary members were elected and awarded at the Spokane meeting.

Warren C. Shaw

Honorary Member Award
Western Society of Weed Science

Dr. Shaw received his B.S. and M.S. from North Carolina State University and his Ph.D. from Ohio State University. Warren began his career as a weed scientist with the Agricultural Research Service, USDA, in 1950 and was instrumental in the development of selective chemical weed control with 2,4-D in wheat, oats, and barley. Through his leadership, the Federal Noxious Weed Act was developed and passed in 1974. Dr. Shaw is currently National Program Leader for Weed Science and Agricultural Chemicals Technology in USDA-ARS. He has been very skillful at recognizing and documenting the needs and justifying increases in manpower and funding for Federal weed science. Under his guidance, ARS weed science programs have increased dramatically. He has been a leader in the concept of integrated weed management, and in 1981 presented the keynote address "Integrated Weed Management Systems Technology for the Future" at the annual conference of the Western Society of Weed Science. Dr. Shaw has had a direct impact on USDA-ARS weed research and has influenced weed research at the State level and in agricultural chemical companies. Dr. Shaw's enthusiasm for weed science is one of his strongest attributes. Weed science is fortunate to have a leader with his capabilities.

Larry C. Burrill

Fellow, Western Society of Weed Science

Larry C. Burrill was born in 1936 in Los Olives, California, but spent most of his early years on a farm near Newberg, Oregon. Larry attended Oregon State University and received his B.S. in Animal Science in 1959. He farmed in Oregon for 3 years before returning to OSU where he worked with the Weed Science group. In 1966 Larry began working under contract for AID and in 1969, when the International Plant Protection Center was formed, he joined the group working at the Center. Larry received his M.S. in Crop Science from Oregon State University in 1973.

Larry has served the Western Society of Weed Science in many capacities culminating in 1979-80 when he was President. He has also been active in the Weed Science Society of America and is a leader in the Asian-Pacific Weed Science Society and the International Weed Science Society. Larry is internationally known for his expertise in teaching and has taught Weed Science in many countries including Indonesia, Colombia, Philippines, and Pakistan. He is also an active member of the Weed Science teaching team at Oregon State University. Larry has had a major and positive impact on Weed Science and is very deserving of the Fellow award in the Western Society of Weed Science.

FELLOWS OF WSWS

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Lowell S. Jordan, 1982
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HONORARY MEMBERS OF WSWS

*Dick Beeler, 1976
Dale H. Bohmont, 1978
R. Phillip Upchurch, 1982
Virgil H. Freed, 1983
Warren C. Shaw, 1984

*Deceased

Membership List of the Western Society of Weed Science, June 1, 1984

Robert C. Ackerson
E.I. duPont de Nemours & Co.
Stine Laboratory, Elkton Rd.
Newark, DE 19714

Edward B. Adams
Wash. State Univ. Coop. Ext.
N 222 Havana
Spokane, WA 99202

James C. Adams
Monsanto Company
1201 10th Ave S., Suite 206
Great Falls, MT 59405

Norton Addy
Velsicol Chemical Corp.
146 Gold Creek Circle
Folsom, CA 95630

Harry S. Agamalian
California Extension Service
118 Wilgart Way
Salinas, CA 93901

I. Okezie Akobundu
Internat'l Inst. Tropical Agr.
Inst. International Education
809 U.N. Plaza
New York, NY 10017

W. E. Albeke
PPG Industries
318 N.W. Baily St., Apt. 1-B
Pendleton, OR 97801

Jack Aldridge
Nor-Am Chemical Company
P.O. Box 13
Caruthers, CA 93609

Donald G. Alexander
Washington State Dept. Agr.
406 General Adm. Bldg. AX-41
Olympia, WA 98504

Harold P. Alley
Plant Science Division
University of Wyoming
Laramie, WY 82071

Clark R. Amen
American Cyanamid Company
1445 N.W. 14th Place
Corvallis, OR 97330

David Anderson
Western Biochem
14760 S.W. Forest Drive
Beaverton, OR 97007

J. LaMar Anderson
Plant Science Department
Utah State University, UMC 48
Logan, UT 84322

Lars W. J. Anderson
USDA Aquatic Weed Lab
Univ. Calif., Botany Dept.
Davis, CA 95616

W. L. Anliker
Ciba-Geigy Corporation
811 S.E. 97th Avenue
Vancouver, WA 98664

Arnold P. Appleby
Crop Science Department
Oregon State University
Corvallis, OR 97331

Thomas F. Armstrong
Monsanto Company
800 N. Lindbergh Blvd, C35C
St. Louis, MO 63167

Jon H. Arvik
Monsanto Company
1600 E. Pioneer Parkway
Arlington, TX 76010

Floyd M. Ashton
Botany Department 0900
University of California
Davis, CA 95616

Alvin A. Baber
DuPont Company
673 Rosecrans Street
San Diego, CA 92106

Richard W. Bagley
MAAG Agrochemicals R&D
P. O. Box X
Vero Beach, FL 32961-3023

Richard B. Bahme
AgriDevelopment Company
3 Fleetwood Court
Orinda, CA 94563

Becky Baile
Fletcher/Mayo Associates
P.O. Box B, Station E
St. Joseph, MO 64505

John L. Baker
Fremont County Weed Control
County Court House, Basement
Lander, WY 82520

Robert B. Balcom
4720 44th St., N.W.
Washington, DC 20000

Daniel A. Ball
Nevada Coop Extension Service
P.O. Box 338
Minden, NV 89423

George E. Barrier
E.I. duPont de Nemours & Co.
Stine Lab, Bldg 51
P.O. Box 30
Newark, DE 19711

Tom Barta
Ag Chem, Inc.
P.O. Box 200
Rockford, WA 99030

Paul G. Bartels
Plant Sciences Department
University of Arizona
Tucson, AZ 85721

Mark Batchelor
Johnson Hall
Montana State University
Bozeman, MT 59717

Brooks Bauer
Zoecon Corporation
20592 Ayers Avenue
Escalon, CA 95320

William H. Bear
DuPont Company
28 Basil Ct.
Hockessin, DE 19707

Bruce Beardmore
ICI Americas
9 Polaris Drive
Newark, DE 19711

K. George Beck
Plant, Soil & Entomol. Sci.
University of Idaho
Moscow, ID 83843

Carl Bell
Univ. Calif. Coop. Extension
Court House, 939 Main
El Centro, CA 92243

Wayne S. Belles
Zoecon Corporation
1240 Joyce Rd
Moscow, ID 83843

Warren E. Bendixen
Univ. Calif. Coop. Extension
624 West Foster Road
Santa Maria, CA 93455

Charlie Benz
Monsanto Company
N.W. 210 Dillon
Pullman, WA 99163

E. Ray Bigler
Chemonics Industries
P.O. Box 21537
Phoenix, AZ 85036

Sheldon Blank
Monsanto Company
3805 S. Dennis
Kennewick, WA 99337

Janice A. Boganowski
Velsicol Chemical Corp.
351 E. Ohio
Chicago, IL 60611

Bert L. Bohmont
127 Shepardson Bldg.
Colorado State University
Fort Collins, CO 80521

Dale W. Bohmont
Park Tower
280 Island Avenue
Reno, NV 89507

Steven Bowe
Velsicol Chemical Corporation
Shandon Star Rt., Geneseo Rd.
Paso Robles, CA 93446

Raymond J. Boyd
USDA Forest Science Lab.
1221 S. Main Street
Moscow, ID 83843

Michael T. Braun
South Columbia Basin Irr. Dist.
P.O. Box 96
Mesa, WA 99343

Ronald G. Brenchley
Mobay Chemical Corporation
Rt #1, Box 31
Ashton, ID 83420

Bill D. Brewster
Crop Science Department
Oregon State University
Corvallis, OR 97331

Hugh C. Bringhurst, Jr.
Salt Lake County
1814 W. 6020 South
Salt Lake City, UT 84118

Bart Brinkman
Velsicol Chemical Corporation
5130 2nd Ave. S.E.
Salem, OR 97302

Jonathan Brown
Oregon Department of Agriculture
635 Capital NE, Attn: Weeds
Salem, OR 97310

Lawrence Brown
Rockford Grain Growers
Rockford, WA 99030

David L. Bruce
Stauffer Chemical Company
5785 Encina Rd, Apt. 104
Goleta, CA 93117

Henry Buckwalter, Jr.
ICI Americas, Inc.
1717 Heritage Ln # 422
Sacramento, CA 95815

J. W. Budzynski
Monsanto Company
601 University Ave., Suite 266
Sacramento, CA 95825

Lee Burge
1625 California Avenue
Reno, NV 89507

Donald L. Burgoyne
DuPont Company, Biochem Dept.
17075 Oak Leaf Drive
Morgan Hill, CA 95037

Dan Burkhart
Johnson Hall
Montana State University
Bozeman, MT 59715

Stephen T. Burningham
Utah Dept. of Agriculture
350 N. Redwood Road
Salt Lake City, UT 84106

John Burns
Washington Coop. Extension
310 N. Main
Colfax, WA 99111

Ronald J. Burr
Rhone-Poulenc Inc.
13446 Waldo Hills Dr. S.E.
Sublimity, OR 97385

Larry C. Burrill
IPPC, Gilmore Annex
Oregon State University
Corvallis, OR 97331

Steven Busse
American Cyanamid
1502 19th St. South
Moorhead, MN 56560

J. Hugh Butler
Crop Science Department
Oregon State University
Corvallis, OR 97331

Robert H. Callihan
Plant, Soil, Entomol. Science
University of Idaho
Moscow, ID 83843

Campbell County Weed & Pest
P.O. Box 191
Gillette, WY 82716

James Campbell
American Cyanamid
99 Elm Place
Nutley, NJ 07110

Kevin F. Cannon
Monsanto Company
12929 Sprague Ave, Suite 3
Spokane, WA 99216

Charles W. Carter
BASF Corp.
1796 Margo Drive
Concord, CA 94519

James E. Casey
Union Carbide
P.O. Box 12014
Research Triangle Park, NC
27709

John J. Cato
Walla Walla County Weed Board
314 W. Main Street
Walla Walla, WA 99362

Richard L. Chase
Plant Science Department
Utah State University, UMC 48
Logan, UT 84322

Tom Cheney
PPG Industries
517 East C Street
Moscow, ID 83843

Raouf Cherif
323 Crop Science Department
Oregon State University
Corvallis, OR 97331

Tim Chicoine
Plant & Soil Science Dept.
Montana State University
Bozeman, MT 59717

William Chism
Dept. Botany & Plant Science
University of California
Riverside, CA 92521

M. Dale Christensen
Ciba-Geigy Corporation
1951 Chateau Ct.
Walnut Creek, CA 94598

Dean Christie
ICI Americas, Inc.
8099 West 54th Place
Arvada, CO 80002

M. Brent Chugg
Del Monte Corporation
P.O. Box 59
Franklin, ID 83237

Peter B. Chykaliuk
Monsanto Chemical Company
1601 Elm Street
Hays, KS 67601

Donald R. Clark
Stauffer Chemical Company
P.O. Box 960
Mt. View, CA 94042

William T. Cobb
Lilly Research Labs
815 S. Kellogg
Kennewick, WA 99336

David Lee Coble
Plant & Soil Science Dept.
Montana State University
Bozeman, MT 59717

Donald R. Colbert
American Cyanamid Company
2133 Jackson Street
Lodi, CA 95240

Floyd O. Colbert
Lilly Research Labs
7521 W. California Avenue
Fresno, CA 93706

Jay Cole
Box 475
Choteau, MT 59422

J. Wayne Cole
Univ. Idaho Extension Service
P.O. Box 427
Preston, ID 83263

Craig Collins
Collins Agr. Consultants, Inc.
Rt. 2, Box 344
Hillsboro, OR 97123

Don M. Collins
Monsanto Company
800 N. Lindbergy Blvd. C35C
St. Louis, MO 63167

Ron Collins
Collins Agr. Consultants, Inc.
Rt. 2, Box 344
Hillsboro, OR 97123

Susan G. Colwell
University of Arizona
1915 E. 10th Street
Tucson, AZ 85719

Dale R. Comer
Nor-Am Chemical Company
135 W. Walnut Avenue
Visalia, CA 93277

Richard D. Comes
ARS/USDA
P.O. Box 30
Prosser, WA 99350

Robert J. Conner
Ciba-Geigy Corporation
P.O. Box 18300
Greensboro, NC 27419

Stephen Connor
Rohm & Haas Company
Independence Mall, West
Philadelphia, PA 19105

Colin Cook
WFS Inc.
Rt. 2, Box 82
Rosalia, WA 99170

Gilbert E. Cook
DuPont Company
S. 303 Barker Road
Greenacres, WA 99016

Alan S. Cooper
I.P.P.C.
Oregon State University
Corvallis, OR 97331

Fred Corbus
4633 N. 42nd Place
Phoenix, AZ 85018

Robert L. Corke
California Dept. Water Res.
1416 9th Street
Sacramento, CA 95814

Ronald W. Courtney
Range & Wildlife Mgt Dept.
Texas Tech University
Lubbock, TX 79409

Deborah K. Cowan
Union Carbide Agr. Products
2310 'D' Street
Sacramento, CA 94816

Everett Cowett
Ciba-Geigy Corporation
1822 New Garden Road
Greensboro, NC 27410

Carvin Crabtree
Horticulture Department
Oregon State University
Corvallis, OR 97331

Roe D. Crabtree
P.O. Box 3434
Spokane, WA 99220

Gary Cramer
BASF Corporation
3303 E. River Road
Tucson, AZ 85718

A. S. Crafts
Botany Department
University of California
Davis, CA 95616

Ron P. Crockett
Monsanto Company
2431 Country Place Drive
Maryland Heights, MO 63043

William S. Curran
Washington State University
P.O. Box 2915 CS
Pullman, WA 99163

Lee C Darlington
BASF Corporation
4609 Englewood Ave.
Yakima, WA 98908

Edwin A. Davis
Forest Service, USDA
Arizona State University
Tempe, AZ 85281

Jason Davison
Plant Science Department
University of Nevada
Reno, NV 89502

Jean H. Dawson
USDA, Research Center
P.O. Box 30
Prosser, WA 99350

Boysie E. Day
University of California
43 Western Drive
Richmond, CA 94801

Nathan Dechortez
USDA Aquatic Weed Res.
Botany Department
University of California
Davis, CA 95616

Howard Deer
Extension Pesticide Specialist
Utah State University, UMC 46
Logan, UT 84322

Bud Deerkop
Agronomy & Soils Department
Washington State University
Pullman, WA 99164

Brian D. Deeter
Union Carbide
2155 S. 14th Ave.
Yuma, AZ 85364

Donald L. DeLay
Nor-Am Chemical Company
35462 Road 150
Visalia, CA 93291

Dan Devlin
Washington State University
A18 Valley Crest
Pullman, WA 99163

Steven A. Dewey
Univ. Idaho Dist. Ext. Offic
1330 Filer Avenue East
Twin Falls, ID 83301

George Dickerson
13525 Durant N.E.
Albuquerque, NM 87112

Joseph E. Dorr
Ciba-Geigy Corporation
925 N. Grand Avenue
Covina, CA 91724-2091

Brian Drew
Crop Development Center
University of Saskatchewan
Saskatoon, Saskatchewan
CANADA S7N 0W0

Robert G. Duncan
Velsicol Chemical Corporatio
3223 S. Loop 289, Suite 266
Lubbock, TX 79423

Allen Dunlap
Arizona Agrochemical Company
P.O. Box 21537
Phoeniz, AZ 85036

Robert Dunlap
Union Carbide Ag. Products Co
3239 E. Vartikian Avenue
Fresno, CA 93710

Kenneth W. Dunster
Union Carbide Ag. Products Co
P.O. Box 2188
Fremont, CA 94536

Donal P. Dwyer
Nor-Am Agricultural Products
4190 North Sherman
Fresno, CA 93726

Matthew Ehlhardt
American Hoechst Corporation
P.O. Box 425
Palouse, WA 99161

Carl Eisinger
Cominco American
P.O. Box 8416
Moscow, ID 83843

Mahamoud H. El-Deek
Botany & Plant Pathology Dept.
Purdue University
West Lafayette, IN 47907

Ali F. M. El Mallah
University of Idaho
1330 Filer Avenue East
Twin Falls, ID 83301

Clyde Elmore
Botany Department
University of California
Davis, CA 95616

Donald B. Emenegger
Uniroyal-Leffingwell
1830 N.W. 17th Street
Corvallis, OR 97330

Lambert C. Erickson
University of Idaho
842 East 7th
Moscow, ID 83843

John O. Evans
Plant Science Department
Utah State University, UMC 48
Logan, UT 84322

Peter Fay
Plant & Soil Science Dept
Montana State University
Bozeman, MT 59717

John Fenderson
Velsicol Chemical Corporation
33 Chantilly
Grand Island, NE 68801

Steve A. Fennimore
ICI Americas Inc.
498 N. Mariposa Avenue
Visalia, CA 93277

Danny T. Ferguson
DuPont Company
1739 Julie Ln
Twin Falls, ID 83301

Mary P. Ferguson
University of California
IR-4 Program
Davis, CA 95616

Mark A. Ferrell
Plant Science Div
Univ. Wyoming, P.O. Box 3354
Laramie, WY 82071

Lewis L. Flanagan
INTER-CON Agri-Service
435 Palomino Ct.
Manteca, CA 95336

Duane Flom
Plant, Soil & Entomol. Science
University of Idaho
Moscow, ID 83843

Eugene Floyd
Sunnyside Valley Irr. Dist.
P.O. Box 239
Sunnyside, WA 98944

Donald H. Ford
Lilly Research Laboratories
7521 W. California Ave.
Fresno, CA 93706

Richard A. Fosse
Union Carbide Agr. Products
10144 E. French Camp Road
Manteca, CA 95331

John Foster
Velsicol Chemical Corporation
2809 Redwing Rd
Fort Collins, CO 80526

Ron J. Frank
Shell Development Company
10330 Regency Parkway Dr, Suite 302
Omaha, NE 68114

R. Ron Frazier
Nalco Chemical Company
1124 W. Escalon
Fresno, CA 93711

Virgil H. Freed
Agricultural Chemistry Dept.
Oregon State University
Corvallis, OR 97331

James S. Freeman
Cascade County
521 1st Avenue N.W.
Great Falls, MT 59404

Darlene M. Frye
702 South 68th Avenue
Yakima, WA 98908

C. W. Gaddis
Magna Corporation
Route 7, Box 425
Bakersfield, CA 93311

James M. Gaggero
Zoecon Corporation
8276 Canyon Oak Drive
Citrus Heights, CA 95610

Dean Gaiser
Plant, Soil & Entomol. Science
University of Idaho
Moscow, ID 83843

John Gallagher
Union Carbide Ag. Products Co.
P.O. Box 12014
Res. Triangle Park, NC 27709

Carol Garbacik
Oregon State University
3280 N.E. Lancaster #4
Corvallis, OR 97331

Allen Gardner
Cache County Weed Control
P.O. Box C
Logan, UT 84321

Leland Gardner
Jefferson County Weed Supervisor
Courthouse, Room 34
Ribgy, ID 83442

Don Gates
American Cyanamid
P.O. Box 400
Princeton, NJ 08540

David Gealy
USDA, Agronomy & Soils Dept.
Washington State University
Pullman, WA 99164

Jay Gehrett
Velsicol Chemical Company
Rt. 3, Box 27, Whitney Rd
Walla Walla, WA 99362

Richard D. Gibson
Arizona Coop. Extension Serv.
820 E. Cottonwood Lane, Bldg C
Casa Grande, AZ 85222

Greg Gillespie
North Dakota State University
P.O. Box 5051
Fargo, ND 58105

Jean Gleichsner
413 West Hall
Crop Sci, Oregon State Univ.
Corvallis, OR 97331

Susie Going
Bannock County Weed Control
5500 South 5th
Pocatello, ID 83204

Frank J. Gonzales
Union Carbide Ag. Products
P.O. Box 130
Hollister, CA 95024

James C. Graham
Monsanto Company, C35C
800 N. Lindbergh Blvd
St. Louis, MO 63167

Anthony L. Groble
Velsicol Chemical Corp.
341 E. Ohio
Chicago, IL 60611

Robert Gunnell
Plant Science Department
Utah State University, UMC 48
Logan, UT 84322

Keith Haagenson
Great Western Sugar, ARC
11939 Sugarmill Road
Longmont, CO 80501

Irving Hackett
University of Nevada
Box 443
Elko, NV 89801

Lloyd C. Haderlie
Univ. Idaho Res & Ext. Center
Box AA
Aberdeen, ID 83210

Larry H. Hageman
E.I. duPont de Nemours & Co.
Stine-Haskell Lab, Bldg 42
P.O. Box 30
Newark, DE 19714

Mary Hagemann
Johnson Hall, Room 207
Washington State University
Pullman, WA 99164-6420

Edmond W. Hale
Siskiyou County Dept. Agr.
525 S. Foothill Drive
Yreka, CA 96097

Delane M. Hall
Power County Weed Control Unit
P.O. Box 121
American Falls, ID 83211

Donald H. Hall
Brea Agricultural Services, Inc
Drawer I
Stockton, CA 95201

K.C. Hamilton
Plant Sciences Department
University of Arizona
Tucson, AZ 85721

Max W. Hammond
Cenex
Rt. 1, Box 398-6 NW
Ephrata, WA 98823

Robert W. Hammond
Pahrump Res & Ext Center
P.O. Box 1090
Pahrump NV 89041

Jack V. Handly
Dow Chemical Company
P.O. Box 240
Geneseo, IL 61254

Charles A. Hanson
Field Agr Chem & Tech Service
P. O. Box 9303
Whittier, CA 90608

David Hanson
Monsanto Company
623 E. Main Ave., Suite 201
West Fargo, ND 58078

Ronald H. Hanson
Union Carbide Ag Products
8172 Pollard Avenue
Fair Oaks, CA 95628

Del Harper
Monsanto Company
24551 Raymond Way, Suite 285
El Toro, CA 92630

W. A. Harvey
University of California
14 Parkside Drive
Davis, CA 95616

Mike Harrell
Cenex
P.O. Box 43089
St. Paul, MN 55164

Hans Hayden
Mid Crystal Farms
Arbon, ID 83212

Kathy Haynes
University of Idaho
207 Campbell Hall
Moscow, ID 83843

Louis C. Hearn
ICI Americas
P.O. Box 3959
Visalia, CA 93279

Stanley Heathman
Plant Sciences Department
University of Arizona
Tucson, AZ 85721

Albert R. Hegman
American Cyanamid
15 Hemlock Cove
Jackson, TN 38305

Eugene Heikes
Colorado State University
716 Garfield
Fort Collins, CO 80524

Bruce Heimbigner
Agronomy Dept, 201 Johnson
Washington State University
Pullman, WA 99164

Ole T. Helgerson
Oregon Cooperative Extension
1301 Maple Grove Drive
Medford, OR 97501

Larry W. Hendrick
BASF Corporation
20050 Dunbar Avenue
Farmington, MN 55024

Ray C. Henning
Chevron Chemical Company
5910 N. Monroe
Fresno, CA 93711

Ann Henson
DuPont Company
926 Yucca Ct
Longmont, CO 80501

Tim Herrman
Plant Science Department
University of Idaho
Moscow, ID 83843

James E. Hill
Agronomy & Range Sci. Dept.
University of California
Davis, CA 95616

Kenneth R. Hill
Nevada Coop. Ext. Service
P.O. Box 231
Tonopah, NV 89049

Larry K. Hiller
Hort. & LA Dept, Johnson 149
Washington State University
Pullman, WA 99164-6414

George F. Hittle
Wyoming Dept. of Agriculture
P.O. Box 5001
Cheyenne, WY 82003

Steve Holland
UI Group, Inc.
P.O. Box 2308
Tri Cities, WA 99302

Jodie S. Holt
Botany & Plant Sciences Dept.
University of California
Riverside, CA 92521

Ivan C. Hopkins
Univ. Idaho Coop Extension
P.O. Box 608
Shoshone, ID 83352

Sharon Hopkins
Monsanto Company
800 N. Lindbergh Blvd
St. Louis, MO 63117

Harry S. Howard III
AccuTech Associates
805 N. 7th Ave., # 150
Bozeman, MT 59715

Stott Howard
Agronomy & Soils Department
Washington State University
Pullman, WA 99164-6420

Don R. Howell
Arizona Coop Extension Service
1047 4th Avenue
Yuma, AZ 85364

Clair W. Hull
Franklin County Weed Control
Route 3
Preston, ID 83263

Steven B. Hull
DuPont Company
13123 E. 31st, #1
Spokane, WA 99216

Neil Humburg
1974 N. 17th Street
Laramie, WY 82070

David Humphrey
Oregon State Dept. Agriculture
635 Capital St. NE, Weeds
Salem, OR 97310

C. R. Hunt
Bob Hunt Assoc.
1514 Meadowlark Drive
Great Falls, MT 59404

Chuck Huston
Plant & Soil Science Dept.
University of Idaho
Moscow, ID 83843

Fernando A. Ibarra
USDA Arid Land Ecosystems
2000 East Allen Road
Tucson, AZ 85719

Mike Ingratta
Rohm & Haas
RR # 2
Okatoks, Alberta TOL 1T0
CANADA

Elwood Irwin
Rohm & Haas
Independence Mall West
Philadelphia, PA 19105

Karen Iverson
Stauffer Chemical Company
Suite 650, Lloyd Bldg
700 N.E. Multnomal Street
Portland, OR 97238

M. J. Jackson
Extension Agronomist
300 Johnson Hall, MT State Univ
Bozeman, MT 59717

Nelroy Jackson
Monsanto Company
1850 S. Belle Ave
Corona, CA 91720

Arthur O. Jensen
American Cyanamid Company
106 Las Vegas Road
Orinda, CA 94563

James I. Jessen
Stauffer Chemical Company
Box 1383
Glendive, MT 59330

D. E. Johnson
Rhone-Poulenc
P.O. Box 5416
Fresno, CA 93711

Doug Johnson
Cascade County Pesticides
521 1st Avenue N.W.
Great Falls, MT 59404

Janelle Johnson
University of Idaho
541 Pierce Street
Twin Falls, ID 83301

William B. Johnson
Wash. State Noxious Weed Bd.
1384 Highland Rd
Walla Walla, WA 99362

I. Blaine Jones
Utah State Univ. Coop. Ext.
160 North Main
Nephi, UT 84648

Carl E. Joplin
Mobay Chemical Corp.
Rt 7, Box 7165-D
Nampa, ID 83651

Lowell S. Jordan
Botany & Plant Sciences Dept
University of California
Riverside, CA 92521

Madan M. Joshi
DuPont Company
Experiment Station, Bldg 402
Wilmington, DE 19898

Donald N. Joy
Uniroyal Chemical
4205 Barge Street
Yakima, WA 98908

Larry K. Justesen
Carbon County Weed & Pest Dist
P.O. Box H
Rawlins, WY 82301

David S. Justice
Arizona Agrochemical Company
P.O. Box 21537
Phoenix, AZ 85036

Paul E. Keeley
USDA Cotton Research Station
17053 Shafter Avenue
Shafter, CA 93263

Todd Keener
N.W. Agric. Research Center
4562 Montana #35
Kalispell, MT 59901

Tom Kelly
U.S. Bureau of Reclamation
1140 West Wood Street
Willows, CA 95988

Bruce R. Kelpas
Sylvan Reforestation Consult.
2750 N.W. Royal Oaks Drive
Corvallis, OR 97330

Harold M. Kempen
Univ. Calif. Coop. Ext. Serv.
P.O. Box 2509
Bakersfield, CA 93303

Steven L. Kimball
Monsanto Company
800 N. Lindbergh Blvd
St. Louis, MO 63167

Wayne O. King
Department of Horticulture
Oregon State University
Corvallis, OR 97331

Garry Kinoshita
Cyanamid Canada
2255 Sheppard Ave. E.
Willowdale, Ontario M2J 4Y5
CANADA

Jim Klauzer
Rohm & Haas Company
P.O. Box 7154
Boise, ID 83701

Mary M. Kleis
American Hoechst Corporation
1010 South 6th Avenue
Bozeman, MT 59715

Paul Kneeshaw
Cyanamid Canada, Inc.
30 Brown Cres
Saskatoon, Sask. S7J 2R8
CANADA

Jeffrey C. Kollenkark
Lilly Research Laboratories
7521 W. California Avenue
Fresno, CA 93706

Michael E. Kotz
The Andersons
P.O. Box 119
Maumee, OH 43537

James M. Krall
Plant Science Department
University of Nevada
Reno, NV 89557

James Krall
Montana State University
P.O. Box 1498
Belgrade, MT 59714

Johnny Kubacak
Cibolo Manufacturing Inc.
P.O. Box 156
Jourdanton, TX 78026

Rennie Kubik
Stauffer Chemical Company
2409 W. Klamath
Kennewick, WA 99336

Elvin L. Kulp
Wash. State Univ. Coop. Ext.
Courthouse
Ephrata, WA 98823

Celestine Lacey
Johnson Hall
Montana State University
Bozeman, MT 59717

Arthur H. Lange
San Joaquin Res. & Ext. Center
9240 South Riverbend Avenue
Parlier, CA 93648

David Langland
Oregon State Dept. of Agric.
635 Capital Street NE
Salem, OR 97310

Tom Lauridson
USDA-ARS
1005 Skyline Drive
Fort Collins, CO 80521

M. P. Lavalleye
Rhone-Poulenc Inc.
Black Horse Lane
Monmouth Junction, NJ 08852

Lawrence W. Lass
University of Idaho
913 W. Palouse River Drive
Moscow, ID 83843

William H. Leach
Boundary County Weed Control
P.O. Box 267
Bonners Ferry, ID 83805

Gary A. Lee
Plant, Soil & Entomol. Science
University of Idaho
Moscow, ID 83843

Philip W. Leino
Univ. Idaho Research Center
P.O. Box AA
Aberdeen, ID 83210

Joah Lish
Plant, Soil & Entomol. Science
University of Idaho
Moscow, ID 83843

Bob Leonard
Rt. 1, Box 42
Soap Lake, WA 98851

Kerry Locke
University of Idaho
Courthouse
Rupert, ID 83350

John W. Long
Rohm & Haas Company
Independence Mall West
Philadelphia, PA 19105

Allan J. Luke
Union Carbide Ag. Products Corp
1446 Joseph Street
Idaho Falls, ID 83401

Earl E. Lukkes
Big Horn Weed & Pest Control
369 Oregon
Lovell, WY 82431

Rodney G. Lym
Agronomy Dept, P.O. Box 5051
North Dakota State University
Fargo, ND 58105

Bert C. Marley
The Marley Company
H.C. 75, Box 105
McCammon, ID 83250

Louis Y. Marquis
USDA-ARS
I.A.R.E.C., P.O. Box 30
Prosser, WA 99350

Ernest R. Marshall
Union Carbide Ag Products Co.
P.O. Box 3650
Salinas, CA 93912

Manny Martinez
Zoecon Corporation
11816 Sunburst Avenue
Yuma, AZ 85364

Hamid Mashhadi
Plant Science Department
Utah State University, UMC 48
Logan, UT 84322

Garry D. Massey
3M Company
653 E. Dovewood
Fresno, CA 93710

Bruce Maxwell
Plant & Soil Science Dept
Montana State University
Bozeman, MT 59717

Terry W. Mayberry
Nor-Am Chemical
Rt. 1, Box 218
Pendleton, OR 97801

Paul Mayland
American Hoechst Corporation
2962 Southgate Drive
Fargo, ND 58103

Tom McCaffrey
Stauffer Chemical Company
644 St. Ives Ct.
Walnut Creek, CA 94598

James T. McGhee
U.S. Army Crops of Engineers
P.O. Box 4970
Jacksonville, FL 32232

Hugh McEachen
S. Columbia Basin Irr. Dist.
P.O. Box 96
Mesa, WA 99343

W. B. McHenry
Botany Department, Coop. Ext.
University of California
Davis, CA 95616

James R. McKinley
Union Carbide Ag. Products Co.
1452 N.W. Skyline Drive
Albany, OR 97321

Stanley R. McLane
Union Carbide Ag. Products Co.
1600 Su Joan Road
Raleigh, NC 27607

Steve A. McMaster
Dow Chemical U.S.A.
Box 1706 Ag. Prod. Dept.
Midland, MI 48640

Vern McMaster
University of Idaho
223 N. Washington
Moscow, ID 83843

Wayne McNeil
American Cyanamid
P.O. Box 400
Princeton, NJ 08540

R. B. McReynolds
Ogregon State Univ. Extension
3180 Center Street NE
Salem, OR 97301

Alicia Melgoza
USDA Arid Land Ecosystems
2000 East Allen Road
Tucson, AZ 85719

Charles Melton
Rhone-Poulenc Inc.
1247 Millbrae Avenue
Fresno, CA 93711

Mari Mengel
University of Idaho
2316 Wallen Road
Moscow, ID 83843

Ben Oller
Mobay Chemical Corporation
1900 N. Gateway Blvd, Suite 152
Fresno, CA 93727

Chris Olsen
Union Carbide Agr. Products
1833 7th Avenue South
Fargo, ND 58103

Phillip D. Olson
American Hoechst Corporation
E 2655 Prairie Avenue
Post Falls, ID 83854

William B. O'Neal
Velsicol Chemical Corporation
800 Corporate Circle, Suite 101
Harrisburg, PA 17110

Jack P. Orr
Univ. California Coop. Ext.
4145 Branch Center Road
Sacramento, CA 95827

John E. Orr
ICI Americas
2018 Coloma Way
Boise, ID 83712

Charles E. Osgood
SDS Biotech Corporation
11134 Chickadee Drive
Boise, ID 83709

Joe L. Pafford
Lilly Research Laboratories
Cherry Creek Place 1
3131 S. Vaughn Way, Suite 111
Aurora, CO 80014

Harlan L. Palm
DuPont Company
7401 W. Mansfield Ave, Suite 300
Denver, CO 80235

Robert Parker
Washington State University
IAREC, P.O. Box 30
Prosser, WA 99350

Scott Parrish
Monsanto Company
800 N. Lindbergh Blvd.
St. Louis, MO 63167

Albert Parsells
DuPont Company
Agrichemicals Department
Wilmington, DE 19898

Robert R. Parsons
Park County Weed & Pest Control
P.O. Box 626
Powell, WY 82435

Warren Passey
Bear Lake County Weed Control
P.O. Box 218
Paris, ID 83261

Dwight V. Peabody
N.W. Wash. Res & Ext. Unit
3340 Martin Road
Mt. Vernon, Washington 98273

Glenn Pecor
Solano Irr. Dist.
508 Elmira Road
Vacaville, CA 95688

Glen Peel
Plant Science Department
Utah State University UMC 48
Logan, UT 84322

Timothy R. Peoples
American Cyanamid Company
P.O. Box 400
Princeton, NJ 08540

Phil J. Petersen
Univ Idaho Res. & Ext. Center
P.O. Box AA
Aberdeen, ID 83210

Terry D. Petersen
Champion International Corp.
P.O. Box 8
Milltown, MT 59802

P. L. Contoriero
Shell Development Company
6690 Amador Plaza Road
Suite 101, Enea Plaza
Dublin, CA 94568

David Prochaska
R&D Sprayers
790 E. Natches Blvd
Opelousas, LA 70570

C. L. Prochnow
Stauffer Chemical Company
11509 N.E. 3rd Avenue
Vancouver, WA 98665

J. Robert Pust
USDA
Rt. 1, Box 40
Pullman, WA 99163

Mickey Qualls
Stauffer Chemical Company
374 Dodson Road
Ephrata, WA 98823

Steven R. Radosevich
Forest Science Department
Oregon State University
Corvallis, OR 97331-5704

Dan W. Ragsdale
Zoecon
P.O. Box 10975
Palo Alto, CA 94303-0859

Hank Ramsey
Mobay Chemical Corporation
P.O. Box 410
Yakima, WA 98907-0410

Dennis Rasmusson
Monsanto Chemical Company
900 N. Broadway
Minot, ND 58701

Thomas A. Reeve
Utah State Univ. Ext. Service
Courthouse, Room 201
Manti, UT 84642

Roy Reichenbach
Converse County Weed & Pest Dist
P.O. Box 728
Douglas, WY 82633

Stephen A. Reinersten
McGregor Company
P.O. Box 769
Colfax, WA 99111

Michel D. Remington
Imperial Irrigation Dist
663 Lenrey Ave.
Brawley, CA 92227

Chuck Reyes
Colorado State University
Weed Research Lab
Fort Collins, CO 80523

Howard Rhoads
962 West Street
San Luis Obispo, CA 83401

Jesse Richardson
Agronomy & Soils Department
Washington State University
Pullman, WA 99164-6420

Jimmy A. Ridgway
University of Idaho
200 S. Asbury #20
Moscow, ID 83843

James D. Riggleman
DuPont Company, Biochem Dept
Barley Mill Plaza
Wilmington, DE 19898

Don E. Robinson
Lilly Research Labs
7521 West California Avenue
Fresno, CA 93706

Robert R. Robinson
ICI Americas Inc.
6900 E. Camelback, Suite 930
Scottsdale, AZ 85253

Laren R. Robison
College of Biol & Agriculture
Brigham Young University, WIDB
Provo, UT 84602

Matthew K. Rogoyski
Rogers Mesa Research Center
3060 Highway 92
Hotchkiss, CO 81419

Linda Romander
Agichemical Age
83 Stevenson Street
San Francisco, CA 94105

Jack Root
Zoecon Corporation
8127 E. Via Del Sol
Scottsdale, AZ 85255

Ed Rose
Stauffer Chemical Company
12150 East Kings Canyon Road
Sanger, CA 93657

Claude Ross
FMC Corporation
1012 Elbert Avenue
Loveland, CO 80537

Travis T. Rushing
DuPont
2180 Sand Hill Rd, Suite 280
Menlo Park, CA 94025

Louis Russo
Zoecon Corporation
1610 W. Sierra Avenue
Fresno, CA 93711

Frederick J. Ryan
USDA/ARS Aquatic Weeds
Botany Department
University of California
Davis, CA 95161

Donald J. Rydrych
Oregon State University
P.O. Box 370
Pendleton, OR 97801

Doug Ryerson
Monsanto Company
1768 Pomerelle Drive
Twin Falls, ID 83301

John L. Saladini
DuPont Company, Ag Chemicals
Barley Mill Plaza, Woodward Mill
Wilmington, DE 19898

Sue Sanders
USDA Weed Science
NE 910 Maple Street
Pullman, WA 99163

Robert C. Saunders
Idaho Dept Agr Weed Coordinator
P.O. Box 790
Boise, ID 87301

Bradley G. Schaat
Plant, Soil & Entomol Science
University of Idaho
Moscow, ID 83843

Roland Schirman
202 S. Second
Dayton, WA 99328

John T. Schlesselman
Rohm & Haas Company
726 E. Kip Patrick Drive
Reedley, CA 93654

Chuck Schmidt
Oregon State University
333 Crop Science Bldg.
Corvallis, OR 98321

R. A. Schnackenberg
Agri-Turf Supplies, Inc.
P.O. Box 4248
Santa Barbara, CA 93103

R. P. Schneider
Monsanto Company C3SC
800 N. Lindbergh Boulevard
St. Louis, MO 63167

Galen L. Schroeder
Velsicol Chemical Corporation
1233 4th Street North
Fargo, ND 58102

Tim W. Schultz
Agronomy & Soils Department
Washington State University
Pullman, WA 99164-6420

Thomas K. Schwartz
Union Carbide Ag. Products Co.
2452 Stover
Fort Collins, CO 80525

Richard A. Schwartzbeck
Farmland Industries
P.O. Box 7305
Kansas City, MO 64116

Edward E. Schweizer
USDA, Crops Research Lab
Colorato State University
Fort Collins, CO 80523

Allen C. Scoggan
Mobay Chemical Corporation
1900 North Gateway Blvd,Suite
Fresno, CA 93727

Dale Shaner
American Cyanamid Company
P.O. Box 400
Princeton, NJ 08540

Dan Sharratt
Oregon State Dept. Agriculture
635 Capital Street NE
Salem, OR 97310

Richard Shaw
Union Carbide Ag Products Co.
4926 Oak Park Road
Raleigh, NC 27612

Warren C. Shaw
ARS, USDA
National Program Staff
Beltsville, MD 20705

David A. Shields
BASF Wyandotte Corporation
P.O. Box 758
Dinuba, CA 93618

Fay L. Shon
13719 NE 258 Street
Battle Ground WA, 98604

Wayne A. Shull
USDA/ARS, 215 Johnson Hall
Washington State University
Pullman, WA 99163

Edwin E. Sieckert
Monsanto Company
601 University Way, Suite 266
Sacramento, CA 95825

H. G. Simkover
Shell Development Company
P.O. Box 4248
Modesto, CA 95352

Darryl E. Smika
Central Great Plains Res Sta.
P.O. Box K
Akron, CO 80720

Fred A. Smith
American Cyanamid Company
1232 W. Palo Verde Drive
Phoenix, AZ 85013

Leslie W. Sonder
Calif. Dept. Food & Agriculture
9026 La Valencia Ct.
Elk Grove, CA 95624

Ronald E. Sosebee
Dept. Range & Wildlife Mgt.
Texas Tech University
Lubbock, TX 79409

Marvin Spaur
Monsanto Chemical Company
800 North Lindberth Blvd
St. Louis, MO 63167

Davis F. Spencer
USDA/ARS Aquatic Weed Res Lab
Botany Department
University of California
Davis, CA 95616

Ralph D. Spilbury
Wilbur-Ellis Company
P.O. Box 699
Glendale, AZ 85311

Gil Stallknecht
Montana State University
Rt. 1, Box 131
Huntley, MT 59037

Charles E. Stanger
Malheur Exp. Station, OSU
Rt. 1, Box 620
Ontario, OR 97914

Sam Stedman
Univ. Arizona Extension Service
820 E. Cottonwood Lane
Casa Grande, AZ 85222

Vern R. Stewart
N.W. Agr. Res. Center
4570 Montana 35
Kalispell, MT 59901

Dan Stiffler
American Cyanamid Company
7614 S. Humboldt
Littleton, CO 80122

Lloyd L. Stitt
Field Seed Mgt
1085 Johnson Place
Reno, NV 89509

Randall K. Stocker
Imperial Irrigation District
4151 Highway 86
Brawley, CA 92227

Jim Stone
DuPont Company
Agricultural Chemicals
Wilmington, DE 19898

Robert F. Stovicek
Plant, Soil & Entomol. Science
University of Idaho
Moscow, ID 83843

R. Harry Strang
Mobay Chemical Corporation
P.O. Box 4913, Hawthorn Rd
Kansas City, MO 64120

Richard A. Stull
Nor-Am Chemical
4877 Chinook Avenue
Boise, ID 83709

Sumaryono
915 S.W. Adams #3
Corvallis, OR 97333

Dean G. Swan
Agron. Dept, 173 Johnson Hall
Washington State Univ. Ext.
Pullman, WA 99164-6412

Karin Tanphiphat
Crop Science Department
Oregon State University
Corvallis, OR 97331

Fred R. Taylor
PPG Industries
12920 Fillmore Ct.
Northglenn, CO 80241

Fred E. Temby
Pennwalt Corporation
6830 N. Chateau Fresno
Fresno, CA 93711

A. R. Templeton
American Cyanamid Company
P.O. Box 400
Princeton, NJ 08540

Carlyle R. Tennis
U.S. Bureau of Reclamation
2800 Cottage Way
Sacramento, CA 95825

Donn C. Thill
Plant, Soil & Entomol Science
University of Idaho
Moscow, ID 83843

W. T. Thomson
Thomson Publications
1118 W. Stuart
Fresno, CA 93711

Bruce Thornton
1507 Peterson
Fort Collins, CO 80521

Jeff Tichota
Velsicol Chemical Corporation
P.O. Box 70
Tea, SD 57064

Bary Tickes
Univ. Arizona Extension Serv.
1047 4th Avenue
Yuma, AZ 85364

Frank Tietjens
BASF
P.O. Box 758
Dinuba, CA 93618

Thomas Tillett
Rhom & Haas Company
1520 E. Shaw Ave., Suite 119
Fresno, CA 93710

F. L. Timmons
1047 North Caribe
Tucson, AZ 85710

D. C. Tingey
653 East 400 North
Logan, UT 84321

James M. Torell
Plant Science Department
Utah State University, UMC 48
Logan, UT 84322

Dan K. Toya
Stauffer Chemical Company
Route 2, Box 187 A
Blackfoot, ID 83221

Harvey D. Tripple
Monsanto Company
Dayton East Office Bldg, #420
9745 E. Hampden Avenue
Denver, CO 80231

Stuart W. Turner
Stuart W. Turner & Company
P.O. Box 10539
Bainbridge Island, WA 98110

R. Phillip Upchurch
College of Agriculture
University of Arizona
Tucson, AZ 85721

Bernal E. Valverde
Crop Science Dept. 323
Oregon State University
Corvallis, OR 97331

Lee Van Deren
Union Carbide Agr. Products Co.
P.O. Box 850
Carpinteria, CA 93013

J. R. van Diepen
PBI/Gordon Corporation
P.O. Box 4090
Kansas City, MO 64101

Ron Vargas
Univ. California Extension Serv
128 Madera Avenue
Madera, CA 93637

Tim C. Vargas
Stauffer Chemical Company
Rt. L, Box 1066
Jerome, ID 83338

Kurt C. Volker
ICI Americas Inc.
810 N. 76th
Yakima, WA 98908

Lloyd C. Warner
Lilly Research Laboratories
130 Palmer Drive
Fort Collins, CO 80525

Roderick W. Warner
E.I. duPont Company
502 Mountain View Drive
Bozeman, MT 59715

Jim Warnock
Western Farm Service
Rt. 2, Box 105
Walla Walla, WA 99362

G. F. Warren
1130 Cherry Lane
W. Lafayette, IN 47906

Jack Warren
Mobay Chemical Corporation
P.O. Box 97
Beavercreek, OR 97004

L. E. Warren
Dow Chemical Company
Rt. 1, Box 1313
Davis, CA 95616

Steve Watkins
ICI Americas, Inc.
2210 Lorie Lane
Yuma, AZ 85365

David Wattenbarger
Univ. Idaho Coop Extension
P.O. Box 267
Bonners Ferry, ID 83805

Steven R. Watts
McGregor Company
P.O. Box 769
Colfax, WA 99111

Robert P. Watwood
Mobay Chemical Corporation
65 Paseo Hermoso
Salinas, CA 93908

Jimmy Welch
Nor-Am Chemical Company
2665 Monroe
Fresno, CA 93700

Barbara H. Wells
Monsanto Company
723 E. Locust, Suite 120
Fresno, CA 93710

L. D. West
Rohm & Hass Company
3750 S. Verde Vista Drive
Visalia, CA 93277

Richard Westwood
Rohm & Haas Company
Winnipeg, CANADA R3 0S3

Drew Wenner
American Hoechst Corporation
W. 5542 Pacific Park Drive
Spokane, WA 99208

Steve Whisenant
Botany & Range Sci, 401 WIDB
Brigham Young University
Provo, UT 84602

Diane E. White
Forest Science Department
Oregon State University
Corvallis, OR 97331

Louis Whitendale
ICI Americas Inc.
498 North Mariposa Avenue
Visalia, CA 93277

Ralph E. Whitesides
Agronomy & Soils Department
Washington State University
Pullman, WA 99164-6420

Tom Whitson
Oregon State Univ Ext. Service
Crop Science Bldg
Corvallis, OR 97333

J. Wayne Whitworth
P.O. Box 3Q
New Mexico State University
Las Cruces, NM 88003

Duke C. Wiley
BASF
125 E. Keystone
Woodland, CA 59659

Michael Wille
Plant & Soil Science Dept.
Montana State University
Bozeman, MT 59717

Roger W. Willemsen
Lilly Research Laboratories
7521 W. California Avenue
Fresno, CA 93706

Ray D. William
Horticulture Extension
Oregon State University
Corvallis, OR 97331

M. Coburn Williams
Biology Department UMC 45
Utah State University
Logan, UT 84322

Michael Willis
American Cyanamid Company
P.O. Box 400
Princeton, NJ 08540

Linda L. Willitts
ICI Americas Inc.
5047 Olean Street
Fair Oaks, CA 95628

Ronald D. Wilson
PBI/Gordon Corporation
1217 West 12th Street
Kansas City, MO 64101

Mark E. Winkle
Monsanto Company
800 N. Lindbergh Bldv C3NG
St. Louis, MO 63167

Winn Winkyaw
Salt River Project
P.O. Box 1980
Phoenix, AZ 85001

Lawrence E. Wittsell
Shell Development Company
P.O. Box 4248
Modesto, CA 95352

Bob Wix
DuPont Company
P.O. Box 249
Selah, WA 98942

Steven Wright
Univ. Calif. Coop Extension
Farm & Home Advisors Office
Visalia, CA 93291

Ching-pa Yang
USDA-ARS, IAREC
P.O. Box 30
Prosser, WA 99350

Samuel P. Yenne
Plant, Soil & Entomol Science
University of Idaho
Moscow, ID 83843

Alvin L. Young
1498B Edwards Place
Bolling AFB
Washington, DC 20336

Frank Young
USDA/ARS 215 Johnson Hall
Washington State University
Pullman, WA 99164

David Zamora
Plant, Soil & Entomol Science
University of Idaho
Moscow, ID 83843

Robert L Zimdahl
Weed Research Lab
Colorado State University
Fort Collins, CO 80523

Richard K. Zollinger
Plant Science Department
Utah State University UMC 48
Logan, UT 84322

David G. Austin
P.O. Box 3276
Thousand Oaks, CA 91359

Robert M. Menges
USDA-ARS
P.O. Box 267
Weslaco, TX 78596

Robert Merz
Monsanto Company
800 N. Lindberg
St. Louis, MO 63167

Raymond W. Meyer
Route 1
Box 754
Pullman, WA 99163

Robert J. Meyer
Weed Control Consultant
156 Pasatiempo Drive
Bakersfield, CA 93305

Reao H. Mickelson
Caribou County Weed Control
159 South Main
Soda Springs, ID 83276

Nebuo Miki
University of California
991 Blaine St., #27
Riverside, CA 92507

Monty G. Miller
Monsanto Company
P.O. Box 1176
Moses Lake, WA 98837

Stephen Miller
Plant Science Div
University of Wyoming
Laramie, WY 82071

Larry W. Mitich
Botany Department
University of California
Davis, CA 95616

Gaylin F. Morgan
Morgan & Assoc.
146 E. Milwaukie
Jefferson, WI 53549

Don W. Morishita
Plant, Soil & Entomol. Science
University of Idaho
Moscow, ID 83843

Sud Morishita
Bonneville County Weed Control
605 N. Capital
Idaho Falls, ID 83402

Larry A. Morrow
USDA, Agron. & Soils Dept.
Washington State University
Pullman, WA 99164

Howard L. Morton
USDA-ARS
2000 East Allen Road
Tucson, AZ 85719

Stephen R. Muench
Monsanto Company
800 N. Lindbergh Blvd
St. Louis, MO 63167

Barbra Mullin
Montana Dept. of Agriculture
6th & Roberts, Ag/Livestock Bld
Helena, MT 59620

W. R. Mullison
Dow Chemical Company
Midland, MI 48640

Glen A. Mundt
American Hoechst Corporation
Rt #202-206 North
Sommerville, NJ 08876

Derril Munson
BASF
6405 Metcalf Ave., Suite 317
Shawnee Mission, KS 66205

John Murphy
PBI/Gordon
1217 W. 12th Street
Kansas City, MO 64101

Thomas J. Muzik
4805 Whiskeyjack Road
Sand Point, ID 83864

Lyle Nagle
Agronomy & Soils Department
Washington State University
Pullman, WA 99164

John D. Nalewaja
Agronomy Department
North Dakota State University
Fargo, ND 58105

Tom Neidlinger
Rohm & Haas Company
13016 N.E. Pacific Court
Portland, OR 97230

W. Richard Neilson
PPG Industries, Inc.
2852 Viejas View Place
Alpine, CA 92001-9535

Nevada Department of Agriculture
P.O. Box 11100
Reno, NV 89510

Michael Mewton
Forest Science Department
Oregon State University
Corvallis, OR 97331

Richard S. Nielsen
American Cyanamid Company
2727 W. Bluff Ave, #108
Fresno, CA 93711

Wesley O. Noel
Velsicol Chemical Corporation
P.O. Box 3852
Bozeman, MT 59772

Robert F. Norris
Botany Department
University of California
Davis, CA 95616

Francis Edward Northam
Plant, Soil & Entomol. Science
University of Idaho
Moscow, ID 83843

Alex Ogg, Jr.
USDA/ARS
I.A.R.E.C. P.O. Box 30
Prosser, WA 99350

Paul J. Ogg
American Cyanamid Company
3619 Mountain View
Longmont, CO 80501