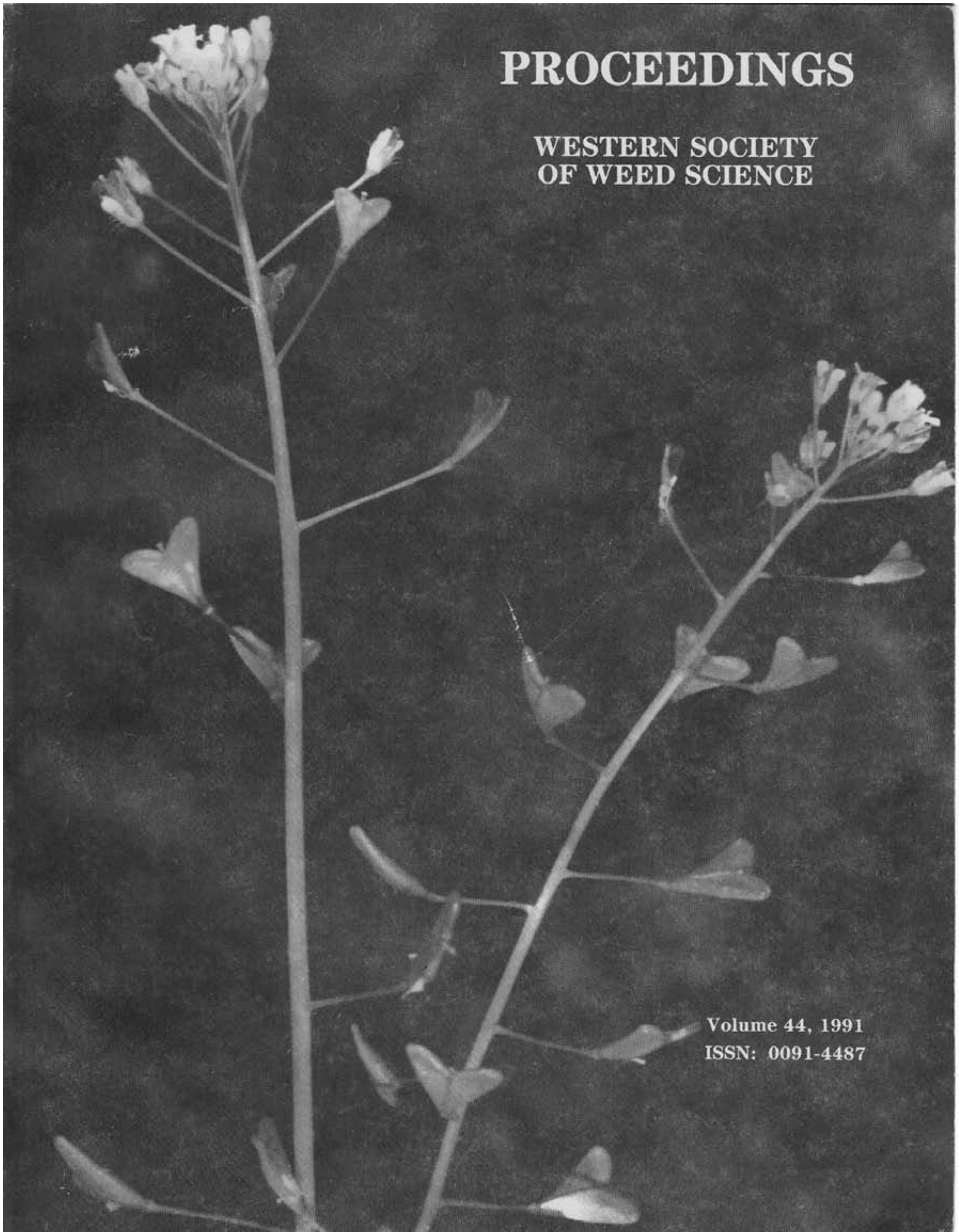

PROCEEDINGS

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WESTERN SOCIETY OF WEED SCIENCE

1991 - 1992

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MARCH 12, 13, 14, 1991

THE STOUFFER MADISON HOTEL

SEATTLE, WASHINGTON

PREFACE

The Proceedings contain the written summary of the papers presented at the 1991 Western Society of Weed Science Annual Meeting plus summaries of the research discussion groups and of the business transacted by the Executive board. Authors submitted either abstracts or full papers of their presentations.

In these Proceedings, herbicide application rates are given as acid equivalent or active ingredient unless otherwise specified. Chemical names of the herbicides mentioned in the text are given in the herbicide index. Botanical names of crops and weeds are given in the appropriate index and are not repeated in the text unless their omission may cause confusion. Common and potanical names follow those adopted by the Weed Science Society of America as nearly as possible and Hortus third.

Copies of this volume are available at $15.00 per copy from Wanda Graves, WSWS Business Manager, P.O. Box 963, Newark, CA 94560.

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GENERAL SESSION

PRESIDENTIAL ADDRESS

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Members, honored guests, Fellows, visitors, ladies and gentlemen--Welcome to the 44th meeting of the Western Society of Weed Science. Jim McKinley and the local arrangements committee have done their job well so I hope all of you will enjoy the next 2-1/2 days as we discuss the subject of weeds.

Our society continues to operate in the black as we maintain a financial reserve in excess of a two year operational budget. Our cash reserve is approximately $81,000 at this time. Wanda Graves, our treasurer/business manager, is doing an excellent job and has been a great pleasure to work with for the past year.

Attendance at this year's meeting is well ahead of last year with 250 people preregistered. The program contains 53 papers and 24 posters. Your program chairman, Paul Ogg, and his committee, Frank Young and Bob Parker, and the project chairmen, have assembled an interesting program. I know how hard Paul and his committee have worked and we all appreciate their efforts.

In May, I traveled with Paul Ogg to Washington, DC to represent the WSWS as part of a team from the WSSA to lobby legislators and others for weed science. We visited a number of Senators and Representatives, and presented five WSSA position papers on the issues of sustainable agriculture, IR-4, noxious weeds, groundwater contamination, and food safety. We visited several program leaders at USDA and EPA. We spent half a day with representatives from the environmental community. It was a very worthwhile experience.

I would like to take a minute to discuss several of the accomplishments of the WSWS in 1990:

Research Section Realignment. For several years, the Research Section chairmen have voiced concerns about the deficiencies in project sections. The project sections were formed many years ago and many feel that a realignment was in order. The Executive Committee met in Seattle in June and established the following realignment:

The Old Alignment	The New Alignment
Project 1: Perennial Herbaceous Weeds	Weeds of Range and Forest
Project 2: Herbaceous Weeds of Range and Forest	Weeds of Horticultural Crops
Project 3: Undesirable Woody Plants	Weeds of Agronomic Crops
Project 4: Weeds in Horticultural Crops	Extension, Education and Regulatory
Project 5: Weeds in Agronomic Crops	Weeds of Aquatic, Industrial and Non-Crop Areas
Project 6: Aquatic, Ditchbank, and Non-Crop Weeds	Basic Sciences: Ecology, Biology, Physiology, Genetics and Chemistry
Project 7: Chemical and Physiological Studies	Alternative Methods of Weed Management

Publications Committee (ad hoc) - Tom Whitson and his committee, Larry Burrill, Dave Cudney, Steve Dewey, Richard Lee, and Robert Parker have completed "Weeds of the West." This weed identification book contains over 300 plants and fills a major need for many of us in the west. I urge all of you to purchase a copy.

Sustaining Members Committee (ad hoc) - Donn Thill and his committee, Steve Kimball, Jesse Richardson, Jill Schroeder, and Jeff Tichota, initiated a drive to enlist sustaining members for the first time in the history of the WSWS. We welcome our 14 sustaining members to the WSWS and appreciate their support.

Placement Service - If you have position openings or are seeking employment, don't forget to use our Placement Service in Room 404. My thanks to Steve Orloff and his committee for a good job.

Awards Committee - Stott Howard and his committee, Jack Evans and Alex Ogg, were able to get a number of excellent candidates from both the public and private section for this year's Outstanding Weed Scientist Award. This marks the first time we've given an award to someone in the private sector.

I would like to turn our attention to a topic that is important to me: The state of weed science at the academic level. The views I will express are my own. They come from my experience in a remote state as one of two weed scientists. My state, Montana, is a "low herbicide use" state. In addition, we don't have a strong anti-herbicide faction to deal with so my views are probably different from yours.

Weed science is a modest discipline and very few universities have a critical mass of weed scientists. I think this is our own fault. In contrast, most of our land grant universities have fully staffed plant pathology and entomology departments that are well integrated and contain various subdisciplines. These departments were formed over the years one position at a time in response to one crisis at a time. We have failed to respond to crises because of our mindset. My goal is to challenge two mindsets many of us have.

Historically, we have not responded to crisis. For instance, the IPM movement was a policy crisis. Few weed scientists ever received IPM funds. While millions of dollars were available for IPM, most went to entomologists. IPM became, and continues to be, a cornerstone of entomology. The research funds associated with another crisis, the groundwater contamination "crisis," did not go to weed scientists but to hydrologists, soil scientists, and geologists. Groundwater contamination in agriculture is largely a herbicide problem but most of us did not compete for those funds so they have gone to other disciplines. There are 12 scientists in Montana working on groundwater contamination and my only role has been to apply herbicides for those people. I contend that every weed science program could have been increased by at least two permanent positions if we had been prepared to respond to those crises. We didn't because we were too busy killing weeds. Those are opportunities now lost.

We have several weed-related crises looming on the horizon which I hope we will be ready to respond to. They are:

The decline of the herbicide industry. The once robust herbicide industry is imploding. The mergers have left us without the great employer of the past so jobs are few. The great research companies of the past are now marketing companies who put old products in new packages. Markets have matured, patents have expired and generic products abound. Our discipline which has always been a graduate student oriented field is now faced with a scarce job market.

Resistant weeds. We were the last pest discipline to taste resistance however the number of resistant species is growing rapidly. With the imidazolinones and the sulfonylureas entering the corn and soybean markets, resistance will continue to be a problem.

I originally felt that genetically engineered herbicide tolerant crops (HTC) would represent a large step forward for weed science. I attended the HTC Symposium at the WSSA meeting in Louisville in February and was convinced that HTC's will simply serve as short term market capturing strategies which will ultimately hasten the development of, and spread of herbicide resistance.

Reduced herbicide use is going to be mandated by law. We don't have viable substitutes and, worse yet, most of us don't have the proper mindset to conduct non-chemical research.

In Holland, laws were recently passed which require Dutch farmers to reduce pesticide use 50% by 1995, and 70% by the year 2000. The laws will be enforced through a series of licenses to chart pesticide use on an acre basis with the loss of subsidies to those who do not comply. Since effective pesticide substitutes do not exist, the government of Holland has pledged $1.7 billion toward research into alternative pest control strategies over the next ten years. I think similar efforts are well under way in the U.S. My question is: do we, as a discipline, have the mindset to respond to these research needs? Will we let these funds go to others? I hope not.

One of my closest colleagues in Weed Science recently said: "I know of no scientific discipline where the public took away the tools of today (meaning herbicides) and asked the research community to work with the tools of 1939 (meaning tillage tools). They didn't work then and they won't work now." My response is: If herbicides had never been developed, the tools of 1939 would have evolved through research and would be working well today. There is no question in my mind that we can make alternative strategies work. It will take close collaboration with agricultural engineers however, many of us don't know how to collaborate because we've never had to. We are going to need to modify equipment that was designed to prepare seedbeds so that it kills weeds. We cannot sit by idly protecting herbicides and let some other discipline respond to our crisis.

We have recently won approval for two new weed science positions at Montana State University. Both positions will deal with non-chemical approaches to weed control. Our efforts were supported by testimony from the Montana Grain Growers Association, the Montana Agricultural Business Association and four environmental groups. It was the strong coalition of diverse groups that led to almost unanimous legislative approval. We presented the concept of mandated reduction in herbicide use as a crisis to each group who then agreed that an urgent need exists for non-chemical research. As a result, we will have a new weed biology position in our department, and a research second position in the Plant Pathology department using pathogens to control weeds in cultivated agriculture. The point is: stop resisting the future. Form coalitions, get new positions, and broaden weed science so it can respond to the needs of today and tomorrow.

Molecular Biology. The next real progress in weed science will be made by molecular biologists. If we don't train our students to be truly functional molecular biologists, we will, as a discipline, leave this arena to others. Molecular biology will then only be conducted by chemical companies who will develop herbicide tolerant crops. Herbicide tolerant crops do not represent long-term solutions to weed problems. They will only be hasty measures to temporarily capture market share and will accelerate weed resistance.

Let me present two examples which I think represent promising research.
N_2 fixing nodules on wheat. Scientists in Australia, stimulated by research done in China, have induced wheat plants to produce para-nodules which are colonized by a bacterium, *Azospirillum*. This was the first "pie in the sky" idea that I ever heard linked to molecular biology and, just 21 yr later, it's approaching reality. The ironic thing is, the paranodules are induced by low rates of 2, 4-D.

Boll weevil resistant cotton bolls. Scientists have taken the Bt gene and put it into cotton. What's unique is they've added a floral promoter so the Bt protein is only expressed in floral tissue. The rest of the plant is completely susceptible to insect attack. The strategy is: only boll damage is economically important so restrict the resistance to the boll and preserve the susceptible insects. This reminds me of Steve Radosevich's suggestion that we try to save the "susceptible allele." The need for that strategy is becoming very clear to me.

I would like to see this level of creativity in weed science. Molecular biology is progressing daily and within a short time we will be able to say "If you can dream it, you can do it" for the fact is DNA is DNA. If you want to make a sunflower variety that would produce oil with the exact qualities of sperm whale oil, it will be possible. Take DNA from the sperm whale and put it into sunflowers. The day is coming.

My point is: The future of weed science rests with weed scientists. If we are to derive great benefits from molecular biology, not just herbicide tolerant crops, the research will need to be done by weed scientists located in the academic community where "capturing value," a commercial concept, plays a secondary role. I think it is impossible to make weed science research a top priority for non-weed scientists. For this reason, we must permit our students to work closely with molecular biologists doing molecular level research. Taking classes and simply learning lingo is not enough. I'm proof of that. I took all the plant physiology classes available, learned the lingo, and went straight to the field after graduation. We must train weed scientists to be laboratory oriented molecular biologists. The combination of these skills and a weed science mindset will permit us to conduct creative research. What are some of the things we might be able to do in the next twenty years? Lets take a minute and dream up some "pie in the sky."

Defective pollen. The idea of spreading pollen from defective weeds to cross pollinated weed species to make them uncompetitive has occurred to all of us at one time. Perhaps that time is near. There is a defective gibberellic acid gene that plant breeders are putting into vegetables. One example, which is coming to market soon, is a miniature, single serving head of lettuce for gourmet diners. Perhaps we could put the miniature gene into cross pollinated weeds like Russian thistle and kochia and produce miniature Russian thistle and kochia.

Host specific pathogens. Foliar pathogens which only attack specific weeds: engineered pathogens which contain promoters from the plant host so that only the host can "turn on" pathogen virulence.

Weed seed germination stimulation. There are chemicals produced by specific crop plants which stimulate parasitic weed seeds to germinate. Perhaps we could isolate the DNA responsible and put it into soil microorganisms which over-produce the compounds causing witchweed seeds to germinate in the absence of a suitable host suicidely.

These are but a few of the kinds of ideas that are nearly possible with the emerging technology. I hope that in the next twenty years we will see the adoption of far reaching new strategies in weed science. Let us all examine our mindset and determine if we are on-line or in the way.

I have thoroughly enjoyed serving as President of the Western Society of Weed Science. I hope you enjoy the meeting.

UNIQUE OPPORTUNITIES AND CHALLENGES FOR WEED SCIENCE BIOTECHNOLOGY. Alvin L. Young, U.S. Department of Agriculture, Office of Agricultural Biotechnology, Office of the Assistant Secretary for Science and Education,Washington, DC 20250.

We are a nation, indeed a world, where products of one hundred years of research have resulted in a food supply of great diversity and of high quality. In the United States, the establishment of Land-Grant Universities and State Agricultural Experiment Stations resulted in an unprecedented investment in basic and applied research in agriculture and food sciences. The planning and actual investment by the nation in that research was a conscious and continuing activity. So it must be today as we look to the challenges of the new biology and its application to Weed Science.

The application of the new tools of biotechnology to agriculture is growing at an unprecedented rate. The agricultural biotechnology revolution presents choices and challenges for the scientific community and policy makers. In presenting a perspective on this subject, I would like to stress four major points.

First, this new technology will affect nearly all aspects of agriculture and food and fiber processing in the future. There are a multitude of potential agricultural applications for the tools of biotechnology: improving yields, quality, and consumer acceptance of traditional agricultural products; producing new products; and reducing adverse environmental impacts of current technology. The United States is investing in research for the future.

Second, as with any new technology, how is it applied affects the risks. Public safety and environmental protection are of paramount importance. However, the implementation of any new technology, particularly one that has diverse and widespread applications, may create new risks to the environment and public health. In the United States, we have in place laws and regulations that will assure that products of biotechnology are efficacious, safe, and compatible with the environment. Through research guidelines, providing readily accessible data bases, and continuing research on biosafety, the system for control of biotechnology research will be strengthened further. How well that system works will depend in part on continuing research that helps us to better understand the interactions of organisms in the environment.

Third, in our democracy the public is very involved in how we increase agricultural productivity and the consequences of those choices on health and the environment. Public understanding of the new technology and its confidence in the regulatory system is essential if the benefits possible from biotechnology are to become reality in the marketplace.

Fourth, we believe in a free market system of fair trade practices that honors intellectual property rights. Product safety standards are important to consumers worldwide, but those standards should be science-based, not politically-based. We are committed to the process of international harmonization of standards, including those for emerging products of agricultural biotechnology. We encourage cooperation and sharing of information on biosafety and ecological research in pursuing these goals.

AGRICULTURE PRODUCTIVITY AND THE ENVIRONMENT

The growth in agricultural biotechnology in the United States has averaged about 2.5% annually since 1947, while the farm commodity part for consumer food cost has fallen steadily and accounted for 25% of consumer expenditures in 1987 (2). Growth in productivity is sustained through the adoption of new technologies, including the agricultural reliance on chemicals. But the cost/benefit to consumers who rely on agrochemicals is being offset by environmental concerns.

The application of biotechnology will likely be necessary to sustain the rates of productivity gain we have enjoyed in the past. If properly applied, biotechnology can have a significant impact on cost reduction and the quality of products delivered to the consumer. Biotechnology also offers alternative choices in our strategies for the preservation and conservation of natural resources. Let me give you some examples.

The public is concerned about agricultural chemicals contaminating the soil and their effects on wildlife, the impact on the quality of water and aquatic life, and perhaps most importantly, the leaching of those chemicals over time into ground water and aquifers. Water conservation is becoming a major problem in parts of our country that are highly dependent on irrigation for agricultural production. As the population expands, we have choices to make about land use. Crops engineered for growth in land currently considered marginal for agriculture can make some of these choices less difficult. Consumers are concerned about pesticide and drug residues in food, the safety of food and color additives, and the nutritional content of their diet. Biotechnology offers the potential to provide alternatives in addressing these important issues. All of these concerns are current topic areas for the United States Department of Agriculture's (USDA) funded research programs.

BIOTECHNOLOGY RESEARCH IN THE UNITED STATES

Traditionally, the United States has relied on the Federal government to support long-term, high-risk basic research, and to sustain a healthy university system. The United States relies largely on private industry to identify technology needs and to develop products for commerce. The Technology Transfer Act of 1986 strengthens the partnership between government, academia and industry by allowing cooperative research and sharing of intellectual property rights.

The United States investment in research and development in 1989 was approximately $145 billion, approximately $80 billion in the private sector and $65 billion supported by the Federal government (1). The biotechnology part of the investment is just under $5 billion, most of which is devoted to biomedical research. In fact $2.7 billion is funded by the National Institute of Health (NIH) which accounts for 40% of their research.

The private sector involvement initially was dominated by small venture capital companies, but has more recently expanded to the larger agribusiness companies, which are now making major commitments in their long-term marketing strategies. Thus, not only are we at USDA conducting research in-house, but we are actively conducting research with the private sector. Currently, we have cooperative research and development agreements with 66 companies and are negotiating projects with 35 additional companies. More than 50% of these projects are biotechnology related.

In the area of crop production, the private sector activities are spread across an array of improvements including improved crops (19%), propagation techniques (17%), genetic engineering (13%), biological herbicides and insecticide controls (13%), pesticide and disease resistance (12%), nitrogen fixation and other soil enrichments and inoculants (7%), and stress resistance (4.6%)(2).

For livestock, the largest share of activities are in vaccines (24%), therapeutics (17%) and diagnostics (14%). These products forecast healthier food animals (2). New opportunities for breed selection and diet can generate leaner products of a nutritional content sought by our health conscious public. Although scientists are working to produce transgenic animals, commercialization probably will take much longer than for transgenic plants.

About 10% of the Department of Agriculture's research budget or about $120 million dollars annualy, is being spent for agricultural biotechnology. Currently, the investment in plant reserach is about twice that for livestock. About 40% of the budget is being allocated to the Agricultural Research Service (ARS) for research conducted in Federal laboratories and about 60% goes to universities -- half of that is being awarded as competitive grants and half to State Agricultural Experiment Stations associated with our land-grant universities.

Major breakthroughs in plant engineering will depend in part on advances in tissue culture technology to regenerate cells into whole, reproducing plants; a technique not yet perfected for some of the most important crop plants. For example, one of the many areas being investigated by Federal scientists is engineering the hormone and nutrient balances necessary for tissue culture propagation for soybeans. Federal scientists are successfully growing tobacco, originating from tissue culture, which contains recombinant hormone and promoter genes from cauliflower, inserted through use of a bacterial vector.

Scientists from ARS were the first to engineer disease resistance into a woody plant. Peach trees produced through tissue culture, in addition to having resistance to a toxin produced by a disease causing bacterium, produced 10 times the number of peaches per tree. Much research is underway to identify genes and their functions. To speed up the process in a systematic way, the Administration is proceeding in a major effort on plant genome mapping. This project will provide basic knowledge, opening new avenues for genetic engineering.

Environmental choices are inherent in the research and development investment strategy. Politicians will wrestle with the questions of what share of finite resources should be allocated to alternate strategies for low-input sustainable agriculture and integrated pest management where payoffs in biotechnology research hold promise. Politicians will also decide how much money and resources should be directed toward competing priorities such as the cleanup of toxic waste sites, global warming and acid rain.

Realistically, we are many years away from the time when products of biotechnology will significantly change the agricultural system to a degree that becomes evident in the quality of the environment. On the road to progress we can learn from the experience of the industrial and chemical revolutions what must be done in harnessing the tools of biotechnology to benefit society. One lesson is clear. We are only beginning to scratch the surface of understanding the complex interactions of organisms in micro-and macro-cosms. So we must proceed cautiously in wielding the powerful new tools of changing life forms, while continuing to increase our understanding of ecology.

Unlike the development of products of biotechnology where intellectual property rights are involved, basic research in ecology must be a global endeavor because cooperation and sharing of information is mutually beneficial. The future of agricultural biotechnology will depend on continuing environmental research and the guidance it provides.

THE PUBLIC'S ROLE

The commercial future of biotechnology and its promise for a better tomorrow depends upon public acceptance and trust. Public education is essential to prevent a dangerous gap between the rapid progress in biotechnology and the public's understanding of the science. Some people seem to see only danger in technological change. None of us would advocate pushing the frontier of this new biology blindly forward, throwing caution to the wind. But we, as a nation, want to make decisions based on science and logic, not based on oratory and unwarranted fear. As an educated public is the key to effective public policy. This is why the Department of Agriculture held an international conference on biotechnology in 1987, four regional conferences in 1988, held live video conferences across the country in 1989, and an international symposium on biosafety in 1990.

A high school curriculum has been developed for educating our young people. As part of continuing educational efforts, we publish a monthly newsletter entitled Biotechnology Notes which is widely distributed.

The Office of Agricultural Biotechnology, the Agricultural and Plant Health Inspection Service (APHIS), the Cooperative State Research Service (CSRS), and the Agricultural Research Service (ARS) have all sponsored conferences intended to inform the public and various other special groups about the Department's biotechnology activities.

To build public trust, we must be up front with the public about the risks and benefits of new technology. We should also have in place a credible system of oversight for research and control over the release of new products into the environment. We have learned that we cannot spend too much effort in public education and interaction.

The public must understand that there are choices and consequences involved in policy and decision-making. Biotechnology may offer one of the best means of addressing agricultural productivity, food safety and environmental problems, but if regulation were to become unnecessarily oppressive, beneficial products may never emerge. Laws and regulations dealing with biotechnology should protect public health and the environment as well as allow useful products to reach the public. The key is balance.

NATIONAL AND INTERNATIONAL HARMONIZATION OF POLICY

Since so many different parts of the Federal government are involved in biotechnology research and regulation, coordination has been vital in developing a consistent policy and resolving jurisdictional matters. This has been achieved largely through the Biotechnology Science Coordinating Committee of the White House. This Committee is comprised of a representative from the President's Office of Science and Technology Policy, the National Science Foundation, and top administration officials responsible for the research and regulation with the Departments of Agriculture, Health and Human Services and the Environmental Protection Agency.

Policies for biotechnology must be concerned internationally if we are to avoid discriminatory trade practices and realize the benefits this new technology can provide. The scientific community can and should lead the way. For example, the United States provided a discussion paper on "Good Developmental Practices for Small Scale Field Research" to the Organization for Economic Cooperation and Development (OECD) for consideration by an OECD group of national experts on safety issues in biotechnology. We at the Department of Agriculture have recently published a brochure entitled Guidance for U.S. Researchers Involved in International Exchange on Agricultural Biotechnology, and have sponsored with Purdue University a major publication on Agrcultural Biotechnology - Issues and Choices.

We must continue to work toward international agreement on issues of safety and the environment. We must also continue to join together in the development and sharing of information on biosafety. The importance of the environmental choices and challenges for biotechnology demand no less. Environmental policies should permit research that helps find new alternatives to sustain agricultural productivity while preserving precious natural resources.

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THE 3 D's: DROPLET SIZE, DEPOSITS AND DRIFT. Loren E. Bode, Agricultural Engineering Department, University of Illinois, Urbana, IL 61801.

INTRODUCTION

Drift of herbicide sprays has been an important topic and will likely remain so, partly because of increased public concern about water quality, food safety and other environmental issues. Drift deposits can cause crop damage at considerable distances downwind depending on the susceptibility of plants to the herbicide. There are a large number of published papers describing crop damage caused by low doses of herbicides but only a relatively small amount of reported research regarding the levels of spray drift occurring from normal applications of herbicides (1, 11). However, studies have been undertaken to gain a better understanding of the effect of the many variables which influence airborne sprays and drift deposits.

Drift of herbicides is a complex process involving the interaction of such factors as the spray atomizer, physical characteristics of the spray liquid, droplet evaporation and sedimentation, climatic conditions, and droplet deposition. Considerable research has been conducted to improve application efficiency but no techniques are presently available to completely confine pesticide sprays within the target areas.

Because spray drift problems are complex, many researchers have studied only one or two variables which they felt were important with regard to controlling downwind spray deposits. Smith has reviewed research that evaluates the effect of several variables on spray drift (8). Most of the studies related to equipment evaluations have compared commercially available application devices which are currently used by applicators. Spray additives, which were developed to either increase droplet size or reduce evaporation, have also been studied relative to drift deposits by several researchers (7, 11).

Relatively little effort has been devoted to modeling of the drift process in terms of predicting either absolute deposits or indices of drift. A drift model predicts loss of chemical using three parameters: meteorological conditions, formulations, and application parameters (7). Because larger droplets have less drift potential, droplet size distribution is considered to be the most important parameter in predicting drift. Most drift models reported in the literature use multiple regression techniques instead of physical mathematical methods. Considerable research has been done to determine the dominant parameters (2, 3, 9). Nozzle height, horizontal wind velocity, and atmospheric stability are known to be important parameters. Work is presently underway to develop models for forecasting the acceptability of applying pesticides under a given set of climatic and operating conditions.

DISCUSSION

<u>Droplet size and drift</u>. A basic understanding of droplet size effects on the efficacy of herbicides is important when studying the major causes of spray drift. The relationship between droplet size and the resulting coverage on the target is complex resulting in several common misconceptions regarding droplet size and deposits on plants. For example, it is generally believed that applying small droplets at high spray pressures will provide increased control with low volumes of spray solution. Research data, as well as a study of particle dynamics, do not substantiate this theory. It is true that atomizing a known amount of spray solution into smaller droplets will increase the coverage possible, but you must also consider evaporation, drift potential, canopy penetration and deposition characteristics.

The coverage or density of droplets on a surface which can be theoretically achieved with uniform droplets of various sizes when applied at 1 gallon/A is shown in Table 1. Decreasing the droplet size from 200 to 20 microns will increase coverage 10 fold. Results of many studies indicate that spray density required for effective weed control varies considerably with plant species, plant size and condition as well as herbicide type, additives and carrier used. From Table 1 it is obvious that droplet density becomes small for droplets above 200 microns at low application rates. Although excellent coverage can be achieved with extremely small droplets, decreased deposition and increased drift potential limit the minimum size that will provide effective weed control.

Table 1. Spray droplet size and its effect on coverage and drift.

Droplet diameter	Type of droplet	1 gal/ A application: Droplets per in^2	Coverage relative to 1000 micron	Drift distance in 10 ft. fall with 3 mph wind
(microns)		(No.)		(ft)
5	Dry fog	9,220,000	200	15,800
10		1,150,000	100	4,500
20	Wet fog	144,000	50	1,109
50		9,220	20	178
100	Misty rain	1,150	10	48
150		342	7	25
200	Light rain	144	5	15
500		9	2	7
1000	Heavy rain	1	1	5

[a]Air temperature of 86 F and 50% relative humidity

Table 2. Evaporation and deceleration of various size droplets.[a]

Droplet diameter	Deceler-ation distance	Terminal velocity	Time to evaporate	Fall distance	Final drop dia.
(microns)	(in)	(ft/sec)	(sec)	(in)	(microns)
20	>1	0.04	0.3	<1	7
50	3	0.25	1.8	3	17
100	9	0.91	7	96	33
150	16	1.7	16	480	50
200	25	2.4	29	1,512	67

[a]Conditions assumed: 90 F, 36% relative humidity, 25 psi, 3.75% pesticide solution.

Table 3. Droplet size comparisons at 40 psi.

Nozzle	Size	Flow rate	Volume median diameter	Vol. < 100 microns
		(gpm)		(%)
Whirl-	2	0.2	145	23.0
chamber	5	0.5	175	18.0
	10	1.0	235	10.5
Flooding	1	0.2	185	15.5
	2.5	0.5	225	11.5
	5	1.0	310	8.5
Raindrop	2	0.2	330	1.0
	5	0.5	590	0.6
	10	1.0	980	0.4

Drift potential of various size droplets is also shown in Table 1. It can be seen that a non-evaporating 100 micron droplet will move 48 feet horizontally in a three mile per hour wind while falling 10 feet. Droplets under 50 microns are nearly invisible in the air and can remain suspended for long periods of time.

With water carriers, spray droplets will decrease in size due to evaporation during their fall. Figure 1 shows the trajectories of evaporating spray droplets falling through stable air having 50% relative humidity and a 1 mph crosswind. Droplets less than 100 microns in size obtain a horizontal trajectory in a very short time and the water in the droplet rapidly disappears. The active ingredient in these droplets become very small aerosols most of which will not fall out until picked up in falling rain. Table 2 shows the life time of evaporating water droplets and the distance they would fall in still air before disappearing. Water droplets less than 20 microns in diameter will evaporate in less than one second while falling less than one inch. Droplets over 100 microns in size resist evaporation much more than smaller droplets due to their larger ratio of volume to surface area.

From these and other research results, we can conclude that there is a rapid decrease in drift potential of droplets as they increase to about 150 or 200 microns. The size where drift potential decreases depends on wind speed, but generally lies in the range of 150 to 200 microns for wind speeds of 1 to 7 mph (1, 11). For typical ground applications of herbicides with water carriers, droplets of 50 microns or less will completely evaporate to a residual core of pesticide before reaching the target. Droplets greater than 150 microns will have no significant reduction in size before deposition on the target. Evaporation of droplets between 50 and 150 microns are significantly affected by temperature, humidity, and other climatic considerations. Mathematical techniques are now available that can predict the trajectories of droplets after they are emitted from a nozzle (4, 6, 10).

Deposits and drift. Several factors determine if a spray particle will be deposited and captured by the natural surfaces of a particular weed. These include: 1) the size and content of the droplets; 2) the size, shape and density of the target; 3) the wind speed and other meteorological conditions; and 4) the nature of the deposition surface.

Mechanisms by which airborne particles are deposited include sedimentation, inertial impaction and eddy diffusion. Some misconceptions arise from the idea that sedimentation is the only mechanism of particle deposition and that only the top of horizontal surfaces will collect particles within a certain size, density, and shape. Consider a droplet in an airstream approaching a plant target. As it approaches the target, the droplet is deflected from its initial approach angle by the air flowing around the body. Depending on particle size, speed and aerodynamics drag, the droplet may be impacted directly on the target or deflected away from the surface by the dynamic air velocities.

In general, the deposition efficiency of droplets on a weed surface increases with droplet size and wind speed and decreases as the size of the target increases. Very small droplets (less than 50 microns) are collected efficiently by insects or by neddles on coniferous plants, but because of their small size they tend to remain in the airstream and are carried around plant parts such as stems and leaves.

Medium size droplets that are applied when there is some air velocity will deposit more efficiently on stems and narrow vertical leaves such as grasses while large droplets will deposit most efficiently on large flat surfaces such as broadleaved weeds. When turbulent wind conditions exist, deposition of small droplets may be dominated by eddy diffusion. Very little is really known about eddy deposition in the field except that it can be a dominant factor in droplet deposition. In reality, a range of droplet sizes is required to effectively deposit spray particles on the variety of weed sizes, shapes, and orientations that occur in actual field conditions.

The actual range of droplet sizes needed for effective control of weeds from postemergence herbicides depends on the specific herbicide being applied, the kind and size of the target weed, and the weather conditions. There have been conflicting reports regarding the ideal spray volume, pressure, and nozzle type needed to obtain the most consistent weed control. Most of the conflict is due to the large variation in the parameters mentioned above during the actual application.

Considerable research has been done to evaluate the biological performance of several postemergence herbicides when applied with a variety of nozzle types. A general summary statement can be made that experimental results to date suggests that any nozzle type that produces a droplet size spectrum in the range of 100 to 400 microns does not greatly influence biological performance over a range of conditions unless application volumes are extremely high or very low. Exceptions to this exist for specific herbicides.

Droplet size spectrums. The amount of particle drift depends mainly on the number of small driftable particles produced by the atomizer. Most hydraulic nozzles produce a wide range of droplet sizes; from less than 10 microns to over 1000 microns depending on the type and size of nozzle selected. The actual size distribution of droplets produced by a nozzle or atomizer needs to be known in order to make adjustments concerning coverage, deposition and drift. New laser imaging and defraction technology allow rapid and accurate measurement of droplet spectrums.

Complete spectrums are generally presented as plots of the cumulative spray volume or droplet numbers (Figure 2). For ease of presentation, the relative size is generally given as the Volume Median Diameter ($D_{V0.5}$). This is the diameter which divides the spray into two equal portions by volume. However, for assessing drift potential a second parameter is needed to fully describe the droplet spectrum. The cumulative volume of spray less than a critical diameter such as 100 microns is frequently used to represent the driftable fraction of

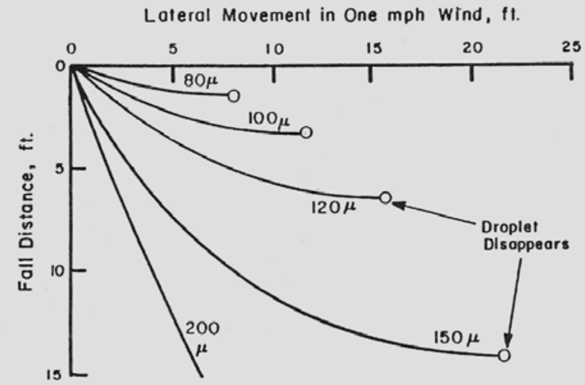

Figure 1. Lateral Movement of Spray Droplets in a One Mile Per Hour Wind.

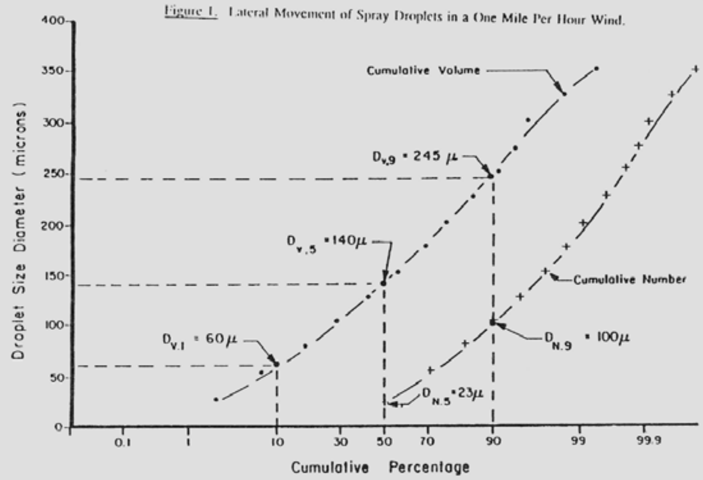

Figure 2. Cumulative Number and Volume Curves for a Typical Spray Nozzle.

spray in a droplet spectrum. Table 3 shows a summary of droplet spectrums for typical nozzles used to apply herbicides. As shown in the table, there is a wide range of spray volume contained in droplets less than 100 microns depending on nozzle type, nozzle size, and spray pressure. For each application, the operating parameters must be selected to provide the coverage required while maintaining the drift potential within acceptable limits.

Spray drift deposits. Ground sprayers utilize a variety of atomizers, carriers, and herbicides. This makes it difficult to predict the level of downwind spray deposits for a specific set of climatic conditions. Measurements of ground and airborne drift deposits have been made by several researchers but few have attempted to obtain a mass balance for spray applications. A comprehensive set of drift experiments have been conducted by Maybank and his coworkers in Canada (5). As expected, they found noticeably less drift off-target with larger flow rates and lower pressure. They also showed air-borne drift and fallout at distances downwind increased as the area being sprayed was enlarged. The total amount of pesticide that deposited on a section of land downwind from a sprayed section was 0.09% of the total applied.

Bode et al. (2) studied the effect of several nozzle types, system conditions, and spray additives on downwind drift deposits. Their work showed that extended-range flat-fan and Raindrop nozzles gave much less drift than did the regular flat-fan or the flooding type. Lowering pressure at the nozzle also gave reduced drift deposits. Drift control agents added to the spray solution reduced drift deposits with low shear nozzles to about one-tenth to one-third that with no additive. The results in over 100 drift tests indicate that downwind drift deposits reduce very rapidly away from the swath. When spraying back and forth in swaths up to 1320 feet upwind, the amount of spray deposit has been reduced to less than 1% of the application volume in the first 20 feet from the swath.

Results from 80 spray deposit measurements having an average wind speed of 9.6 mph indicate that the total downwind drift deposits averaged 9.2%. A variety of equipment and techniques were used in these tests. With reasonable care this can be reduced to less than 5%, and by using the best available technology, drift deposits of less than 2% are possible. In the same tests, the total spray depositing more than 8 feet beyond the edge of the target field was 2.6%. With reasonable care this could be reduced to under 1% of the application volume.

Experiments, such as those discussed, have established that variations occur depending on the spraying conditions, but in general, the total down-wind drift deposits average about 3 to 5% of the sprayer application rate during the first pass along the edge of the field.

Approximately one half of the off-target deposits occur in the first 25 feet downwind and decrease very rapidly with distance. Although it is impossible to contain all the spray to the target field, attention to all the pertinent details of equipment and applications will limit spray drift to within acceptable limits.

RECOMMENDATIONS FOR MINIMIZING SPRAY DRIFT DAMAGE

Techniques used when applying pesticides greatly determine the amount of spray drift that occurs. Table 4 is a summary of recommended procedures for reducing damage from spray drift. The type of nozzle, pressure, height and spray volume all affect the off-target movement. The ability to reduce drift is no better than the weakest component in the spraying procedure.

Nozzle type must be selected depending on the potential for drift. Of the many nozzle types available for applying pesticides, a few are specifically designed for reducing drift. The Raindrop nozzle, for example, is a hollow cone nozzle with a secondary swirl chamber at the tip. The manufacturer estimates the exit pressure is less than 5 psi when the line pressure is 40 psi, and less than 1% of the spray volume is contained in droplets smaller than 100 microns in diameter. The nozzles should be oriented at an angle of 15 to 30 degrees from vertical and operated within a pressure range of 20 to 40 psi.

The extended-range flat-fan nozzle is also designed to reduce drift. The nozzle produces a full fan angle at pressures as low as 10 psi. In direct comparisons, the regular flat-fan nozzle produced about twice the spray drift deposits as did the extended-range flat-fan nozzle. Flooding nozzles are commonly used for herbicide application. For effective drift control, low boom height and low pressure are required. Pressure should be maintained within 10 to 25 psi.

Spray height is an important factor in reducing drift losses. The closer the boom is kept to the ground, the less chance of drift. Correct spray height for each nozzle type is determined by nozzle spacing and spray angle. Wide-angle nozzles can be placed closer to the ground than can nozzles producing narrow spray angles. On the other hand, wide-angle nozzles also produce smaller droplets, a consideration which partly offsets the advantages of lower boom height.

Spray volume is a means of minimizing drift. Increasing the spray volume results in larger droplets that are less likely to move off-target. The only effective means of increasing spray volume is to increase the nozzle size. Increasing the pressure or adding more nozzles on a boom will result in more fine particles being produced and actually increase drift. In windy conditions, increasing water volumes from a normal 15 gallons/A to 30 gallons/A by using larger nozzles will reduce the potential of damage due to drift deposits.

Weather conditions can have a major impact on the amount of off-target drift. Meteorological factors that affect drift include wind speed (the most critical factor) and wind direction, temperature, relative humidity, and atmospheric stability. The maximum wind speed for safely applying pesticides cannot be given, because a number of other factors also influence the amount of drift. For example, an application made in a 1 or 2 mph breeze in which a larger number of small drops are applied may result in more drift than an application made in a 10 mph wind utilizing good drift control procedures. Another consideration in determining a maximum wind speed is the presence of sensitive crops immediately downwind. Temperature and humidity also influence drift loss and must be considered along with the wind conditions. Common sense and good judgement are important in assessing a maximum wind speed for a given application.

Table 4. Summary of recommended procedures for reducing drift damage.

Recommended Procedure	Example	Explanation
Select a nozzle type that produces coarse droplets.	Use Raindrop, wide-angle full cone, or flooding nozzles.	Use the largest droplets possible while providing necessary coverage. Larger droplets cannot be carried downwind as easily as smaller ones.
Use the lower end of the nozzle's pressure range.	Use 20 to 40 psi for Raindrop and less than 25 psi for other nozzle types.	Higher pressures generate many more small droplets (less than 100 microns).
Lower boom height.	Use the lowest boom height possible while maintaining uniform distribution. Use drops for systemic herbicides in corn.	Wind speed increases with height. Lowering boom height by a few inches can reduce off-target drift.
Increase spray volume.	If normal gallonage is 15 to 20 GPA, increase to 25 to 30 GPA.	Larger capacity nozzles will reduce spray deposited off-target.
Spray when wind speeds are less than 10 MPH and when wind direction is away from sensitive plants.	Leave a buffer zone if sensitive plants are downwind. Spray buffer zone when the wind changes.	More of the spray volume will move off-target as wind increases.
Do not spray when the air is completely calm or when an inversion exists.	Inversions or calm air generally occur in early morning or near bodies of water.	Inversions reduce vertical air mixing, causing spray to form clouds at the lower air levels, which can move downwind.
Use a drift control agent when needed.	Several long-chain-polymer products are available.	Agents increase the average droplet size produced by nozzles.

Wind direction relative to sensitive crops is also important in minimizing damage from drift. Applicators often overlook the presence of sensitive vegetation downwind. Leaving a buffer zone at the downwind edge of a field will greatly reduce damage to sensitive plants. After the wind has died down or changed direction, the buffer zone can be sprayed safely. Temperature and humidity also affect the amount of drift that occurs through evaporation of spray particles. Although some evaporative loss of spray occurs under all atmospheric conditions, these losses are less pronounced in cool and damp conditions. Temperature also influences atmospheric air turbulence, stability, and inversions.

Atmospheric stability is determined by measuring the vertical temperature and wind profiles. Under standard conditions, the temperature decreases by 3.2 F for every 1,000 feet increase in height. Under this normal "lapse", the air is unstable because of air turbulence, and vertical mixing occurs in the atmosphere. Under these conditions, the opportunity for off-target crop injury is very small, because the pesticide is diluted into the atmosphere.

On the other hand, problems can arise when the atmosphere is highly stable. Small suspended particles do not rise, but remain confined to the lower layers of air. Because these particles do not dissipate vertically, they hang together as a cloud that can drift off-target and injure sensitive plants. Because it is difficult to determine the direction and amount of drift under stable conditions, it is recommended not to spray if the air is calm. The presence of stable atmosphere or "inversion" can be recognized by observing a column of smoke. If the smoke doesn't dissipate, or if it moves downwind without vertical mixing, conditions are not good for spraying. The best way to avoid drift associated with atmospheric conditions is to eliminate the formation of small (100 micron or smaller) particles from the spray. Without these particles in the spray, weather stability factors can essentially be ignored.

One of the best tools available for minimizing drift damage is the use of spray additives to increase the spray droplet size. Tests indicate that downwind drift deposits are reduced from 50 to 80% with the use of these long-chain polymers. A number of drift control agents are available commercially, but they must be mixed and applied according to label directions in order to be effective. Drift control additives cost less than 50 cents/A to use. They do not eliminate drift, however, and common sense must still remain the primary factors in reducing drift damage.

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THE "BIG GREEN" INITIATIVE - PUBLIC PERCEPTION BECOMES POLITICAL REALITY IN CALIFORNIA. Mr. Henry Voss, Director, California Department of Food and Agriculture, Sacramento, CA 95814.

We are all aware that public perception of risk has an ever increasing impact on the way we conduct our business, whether that be in the private sector or government. Today I'd like to talk to you about the California experience, the initiative on last November's ballot, Big Green. I want to share with you (1) what the initiative attempted to do, (2) some background on what led up to it, (3) why it failed, and (4) a bit of a post mortem - how I think things will go from here.

Proposition 128, the California Environmental Protection Act of 1990, most commonly known as Big Green was a broad measure which dealt with pollution and environmental degradation. Let me take a few minutes and give you just the highlights of the six areas it addressed:

1) Ozone depletion - It accelerated the phase out of chloroflourocarbons and other ozone-depleting chemicals barring their manufacture by 1995.

2) Global warming - It mandated a 20% reduction in carbon dioxide emissions by the year 2000 and a 40% reduction by 2010.

3) Bay and Ocean Protection - It banned oil drilling and exploration within three miles of the coast. It called for oil spill prevention and response plans and provided for a $500 million clean up fund with a 25-cent-a-barrel fee on oil moved on or under state waters. Strict standards were set for pollutant dischargers with short time frames for implementation.

4) Forestry - It banned for one year, logging of "ancient redwoods" on stands of 10 acres or more. It provided for a $300 million bond issue to be used for the acquisition of "ancient redwood" stands and for urban and rural reforestation projects. It also required the planting of one tree for every 500 square feet of development and mandated that by 1996, half the state money spent on paper would go for recycled products.

5) Environmental Advocate - It created this elected position to enforce the provisions of the initiative and other state environmental laws.

And finally,

6) Pesticides - It proposed to ban all pesticides registered for use on food which are "known to cause cancer or reproductive harm". This included all those active ingredients and inerts so identified as a result of the passage of California's Proposition 65, The Safe Drinking Water and Toxic Enforcement Act of 1986. It would have also included all carcinogens listed on EPA's B2 ("Probable" carcinogens) list and possibly many on the C list ("possible" carcinogens). It was uncertain whether formulation containing inert ingredients contaminated with these carcinogens were also banned. Estimates of the number of chemicals affected ranged from 20 to 350, or some critics contended, up to 65% of all pesticides.

It required the review and resetting of pesticide residue tolerances at "no significant risk" levels for all domestic and imported foods and prohibited the import of food with residues of banned pesticides. Under the initiative all data evaluation functions, tolerance setting and worker safety standard setting would have been transferred from the Department of Food and Agriculture to the Department of Health Services. The minimization of worker safety risk was addressed but not well defined.

Big Green lost by a margin of 64% to 36%. The magnitude of the defeat, however, is misleading as many factors, including the mideast problem and the economy, contributed to its demise.

Let us take a look at some of the incidents that molded the perception of the '80's and led up to Big Green. Just to put California's pesticide program in perspective, I'd like to note that in 1980, it consisted of pesticide registration, pesticide worker safety, environmental monitoring, applicator licensing, use enforcement and testing of between seven and eight thousand produce samples for pesticide residue.

Probably the first food safety incident with any major impact occurred in 1984 when traces of ethylene dibromide, or EDB, were found in muffin mix. Although the use of EDB in most food processing was ultimately banned, EPA's process of reevaluating registered pesticide products was highly criticized. The agency was suffering severe image problems when Rucklshaus took over that year. He has been generally credited for providing national leadership in environmental risk communication. He separated the agencies mandates into three aspects of risk: defining what is hazardous, deciding how to deal with it, and explaining the process to the concerned public.

That next year, the Natural Resources Defense Council released it's publication, "Pesticides in Food - What the Public Needs to Know (Survey and Report)". The report was highly critical of federal and state pesticide residue monitoring programs and identified some of their weak areas. Its authors translated some uncertainties into greatly exaggerated risks and indicated that data showed unanswered questions about the occurrence of residues. This report seems to have served as a blueprint for reports and pronouncements which continue today.

Next came a report by the Commission on California State Government Organization and Economy (commonly referred to as the Little Hoover Commission) which identified shortcomings in our state program and offered recommendations to correct them. The report was followed by legislation and a $2.5 million budget enhancement to expand the pesticide residue sampling program to address many of the problems the Commission and the NRDC had identified.

In 1985 we had the aldicarb incident with contaminated watermelons hitting the market on the fourth of July weekend. Although this incident was attributable to isolated instances of illegal use, it made little difference in the face of real illnesses and public fears. Government's ability to protect its citizens from harmful pesticides was in question.

I believe that it was about this time that advocacy groups with varying interests unified behind the food safety issue as a vehicle to gain public support for greater restrictions on pesticide use.

In 1986, the previously mentioned anti-toxics Proposition 65 won by a landslide. In 1987, the National Academy of Sciences released their report, Regulating Pesticides in Food, The Delaney Paradox. Advocacy groups persistently misinterpreted information presented in this publication. Despite Academy disclaimers, theoretical risks and uncertainty factors presented in the report were translated into actual risks. Body counts were projected. Popular media universally accepted these misinterpretations and the phrase "cancer causing pesticides" has been applied to many of the chemicals discussed in the report.

The Governor's Scientific Advisory Panel began its hearings to establish a list, as required by Prop 65, of chemicals "known to the State to cause cancer and reproductive harm". Within 12 months of listing, businesses are required to provide "clear and reasonable" warnings to any person they cause to be exposed to a listed chemical. Regulated industries which would be considered liable if they did not provide the appropriate information or "warning", took the most conservative approach. Warnings began to appear practically everywhere - on packaging, in food stores, restaurants, bars, in workplaces and even in model homes proclaiming the possible presence of "Prop 65 chemicals". It was also about this time that the United Farm Workers decided that food safety was the best way to focus attention on worker safety issues.

In 1988 and 1989 attempts by the California legislature to pass "Food Safety" bills were unsuccessful. This legislation was largely based on the theory that food is not safe and will not be safe until all pesticides used on food which have produced tumors or reproductive toxicity in animal studies are banned. No serious attempt was made to reach a compromise which would reintroduce some science back into the equation. The production and agricultural chemical industry chose instead to bottle up the bills which were unreasonable in their original form. This legislation authored by Assemblyman Connelly of Sacramento became the cornerstone of Big Green's pesticide provisions.

NRDC continued to publicly discuss theoretical risks emphasizing uncertainties and worst case scenarios. Failure to negotiate a comprehensive, compromise pesticide bill at the federal level gave us "FIFRA Lite". This reauthorization of the federal legislation omitted many of the reforms which various advocate groups felt strongly about, expecially in the areas of worker safety, pesticide applicator certification and training.

The controversy over the apple pesticide, alar, had an effect on the public that even those who orchestrated this press event had not anticipated. The event was staged by the NRDC in early 1989 probably to gain support for potential federal and state legislation. The credibility of government regulators was again in question.

Later that year, the discovery of Chilean grapes tainted with cyanide added to the public's outrage. The Exxon Valdez accident rekindled oil spill worries which have affected Californians for over two decades. Earth Day had its twentieth anniversary. There was growing scientific consensus on the greenhouse effect and a widening hole was discovered in the ozone layer.

Then Attorney General John Van de Kamp, who was running for Governor, was the impetus behind the consolidation of these issues in California. Various environmental groups, burning the midnight oil, gave birth to the "Big Green" initiative which Van de Kamp intended to use as a major element in his campaign to bring out the votes. He was defeated in the June primary but the initiative had a momentum of its own. In fact, had the proposition been before the electorate in the primary, rather than on the November ballot, it would have most certainly won!!

Assemblyman Tom Hayden joined the effort and was so closely associated with the proposition that it was frequently referred to as the Hayden Initiative. Despite the downside to his association, based on his previous antiwar activities he brought in a well oiled political organization, Campaign California, and provided connections to Hollywood stars and wealthy Southern California liberals.

Meanwhile, the opposition which had stood by flat-footed while Prop 65 swept to victory, got organized. The chemical industry sponsored a well run, well financed campaign - NO on 128. Production agriculture, which early on separated itself from the chemical industry, took another tact and sponsored a counter initiative, Proposition 135. This measure, if it succeeded, would have overriden the pesticide provisions of Big Green. This campaign was also well supported in money and effort from throughout the entire country.

Throughout the campaign, the proponents of Big Green continued to rely on emotional appeals. When scientists made completely opposite claims, the proponents asked, "who do you trust, the people or big business"? They never met head on the estimated cost of implementation, which was considerable.

With the polls, just prior to election, indicating a slight edge to No with 15-20% undecided, why the defeat? With 28 initiatives (only 6 passed) and a 250 page voter pamphlet, most voters felt the initiative process was out of control. One environmentalist likened the election to a drive by shooting with Big Green just happening to be closest to the door.

Its authors tried to do too much. The proposition contained 16,000 words which no one could claim to fully understand. It was unclear! The language was vague and conflicting; there were mandates without direction for achieving them, and goals without clarity such as "minimize storm drain runoff". The LA Times suggested it was a "Throw back to Earth Day" - A cry for somebody to do something, rather than a well thought out plan of action.

The Economy was a factor. With the possibility of a recession, it should be no surprise that voters got tight fisted. The legislative analyst estimated an annual price tag for state and local government at $90 million and over $340 million in one time costs. There was a great disparity in estimates of cost to industry and consumers. There was uncertainty over our dealings with Iraq. There were budget hassles in D.C. Voters got the NO message - it tries to do too much!!

<u>IT IS MOST IMPORTANT THAT THE DEFEAT OF BIG GREEN NOT BE TAKEN AS AN ANTI-ENVIRONMENTAL VOTE!!</u> Voters still consider themselves environmentalists. One of every three Californians polled characterized themselves as strong environmentalists. Elected officials with poor environmental records will still go down. Fifteen house incumbents were defeated. Five of these were

environmental targets rated at the bottom by the League of Conservation Voters. Californians voted the way they did not because they were anti-environment but because they didn't like the approach.

Finally, a few minutes on a post mortem. One U.C. Professor of Political Science says the defeat may embolden economic interests to resist environmental reform. I HOPE NOT! We need to get to the forefront with feasible reforms! I think we'll see advocates trying to work more closely with the legislature to get some of the changes they want. In California Big Green proponents, who backed Diane Feinstein, will patch things up with the Governor. They've expected to have better access to Wilson than they had to Deukmejian.

Al Meyerhoff didn't rule out another initiative but said: "in the short term, we will press for this kind of relief in Congress into the state legislature and in the courts". Next time the issues will be better focused, simpler, and presented in smaller parcels. Food safety is merely the watershed issue for a host of environmental and health concerns. Because it excites more emotion, it will probably always be used to a certain extent to carry other, less exciting issues.

The best way to combat the food safety hysteria is to deal with the underlying causes. We need to obtain the data to complete risk assessments and then act on them. We must deal with pesticide worker safety concerns, real and perceived. We need to get the appropriate data, reevaluate it and assume our responsibility in regards to air, water, and endangered species.

We must continuously strive to do a better job at risk communication. Those who are responsible for this effort should have the ear of the policy makers and have input on when information, even if its incomplete information, should be released. Time and time again government has put itself in the position of saying nothing until it feels it has the complete and palatable answer. Consequently, we have been upstaged by others who would present information in a light most advantageous to their goals thus putting us on the defensive. Government in this posture has no credibility.

Industry must work with advocates and through government to strengthen the regulatory framework on a national as well as a state basis. For in order to establish a credible food safety message we must establish credibility in the regulatory agencies. We need to be sensitive to public perception. We must listen to public concerns, and conscientiously address those concerns giving rise to its outrage, regardless of whether we feel they have scientific validity.

Big Green has shown advocates that there is a limit to what the voters will swallow at one sitting. If such sweeping measures continue to come at them, there may well be a backlash. Our challenge together is to make the essential bite-sized reforms so that no one again feels that need to force-feed which was so evident in Big Green.

POSTER SESSION

HAIRY NIGHTSHADE (*SOLANUM SARRACHOIDES*) INTERFERENCE IN DRY BEANS (*PHASEOLUS VULGARIS*). R. E. Blackshaw, Weed Scientist, Agriculture Canada, Lethbridge, AB T1J 4B1.

INTRODUCTION

The Solanum complex consists of about 30 species worldwide. Hairy (*S. sarrachoides*), black (*S. nigrum*), eastern black (*S. ptycanthum*), and cutleaf (*S. triflorum*) nightshade occur as weedy species in Canada. Hairy nightshade is the predominate nightshade species in southern Alberta and is considered the most important weed in dry beans in this region. Despite this, little information is available on hairy nightshade interference in dry beans.

Experiments were conducted to a) determine the effect of varying densities of hairy nightshade and varying periods of interference on the aboveground biomass and seed yield of dry beans, and b) estimate potential seed production of hairy nightshade with these varying densities and interference periods.

MATERIALS AND METHODS

Hairy nightshade density. To simulate inter-row cultivation, hairy nightshade plants were restricted to a 30-cm band over the bean (Pinto 'UI 111') row. Densities of 0, 2, 5, 10, 20, 50, and 100 plants/m of bean row were established by hand thinning a natural infestation within 1 week of bean emergence. Hairy nightshade plants were spaced as evenly as possible on both sides of the bean row and were identified with small plastic stakes. Subsequent flushes of hairy nightshade and other weed species were removed by hand pulling and/or hoeing on a weekly maintenance schedule. Plots consisted of four rows of beans, 5 m in length. Plots were arranged in a randomized complete block design with four replicates.

At maturity, beans were clipped at the soil surface from a 4 m length of the two center rows of each plot, oven dried at 35 C, weighed to determine aboveground dry matter yield and subsequently threshed to obtain seed yield. At harvest, five hairy nightshade plants were randomly selected from each plot to estimate weed seed production. The number of berries/plant was counted and the number of seeds/berry was determined from 25 randomly chosen berries from these plants. Estimates of hairy nightshade seed production were then calculated for each plot.

Weed-free maintenance and weed-interference periods. To determine the effects of duration of weed-free maintenance, beans were kept weed-free for 0, 3, 6, 9, and 12 weeks after crop emergence before allowing hairy nightshade plants to become established. A full-season weed-free treatment was also included. Conversely, to measure the effects of early-season weed interference, hairy nightshade was allowed to infest beans for 0, 3, 6, 9, and 12 weeks after crop emergence before they were removed by hoeing and hand-pulling. A full-season hairy nightshade infested treatment was also included.

Like the density study, hairy nightshade was restricted to a 30-cm band over each bean row. The natural infestation density of hairy nightshade averaged 78 and 66 plants/m of bean row in 1988 and 1989, respectively. At maturity, bean plants were harvested and threshed in a similar manner to that of the density study. Where possible, 50 hairy nightshade berries were collected from each plot of the weed-free maintenance experiment to determine whether viable seed was produced by plants emerging at varying times throughout the growing season.

Statistical analyses. All data was initially subjected to analyses of variance. Nonlinear regression by means of the NLIN procedure of SAS was subsequently used to analyze data from both years of the density and duration of interference experiments. The most appropriate regression models were then fit to the data.

RESULTS AND DISCUSSION

Hairy nightshade density. Bean biomass and seed yield decreased as the density of hairy nightshade increased (Figure 1). However, bean seed yields were reduced to a greater extent than biomass yields in both

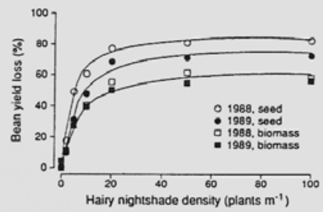

Figure 1. Bean biomass (B_b) and seed yield (B_s) reductions as a function of hairy nightshade density (d) and the fitted hyperbolic curves. 1988: B_b = 509 [1-(.1001 d)/100(1 + .1001 d/.571)], R^2=0.90; 1989: B_b = 670 [1-(.1 d)/100(1 + .1 d/.543)], R^2=0.90; 1988: B_s = 201 [1-(.088 d)/100(1 + .088 $d^{1.539}$/.821)], R^2=0.98; 1989: B_s = 236 [1-(.034 d)/100(1 + .034 $d^{1.678}$/.725)], R^2=0.94.

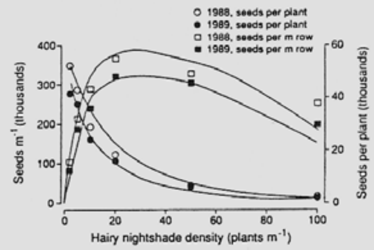

Figure 2. The number of hairy nightshade seeds produced per plant (N_s) and per meter of row (N_{sr}) as a function of hairy nightshade density (d) and the fitted hyperbolic curves. Seeds/plant: 1988, N_s = 62994 [1-(0.1007 d)/(1 + (0.1007/1.0727) d)], R^2=0.95; 1989, N_s = 52397 [1-0.1007 d)/(1 + (0.1007/1.0727) d)], R^2=0.96. The fitted function of N_s on d was multiplied by d to give hairy nightshade seeds per m row (N_{sr}) in 1988 and 1989.

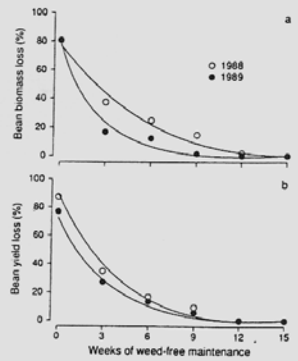

Figure 3. Bean biomass (B_b) (a) and seed yield (B_s) (b) reductions as a function of weeks of hairy nightshade-free maintenance (t) in 1988 and 1989 and the fitted curves. 1988: (B_b = 532 - 0.635$(15-t)^{2.392}$), R^2=0.91; 1989: (B_b = 618 - 0.000038$(15-t)^{6.051}$), R^2=0.94; 1988: (B_s = 186 - 0.00664$(15-t)^{3.741}$), R^2=0.93; 1989: (B_s = 228 - 0.00664$(15-t)^{3.741}$), R^2=0.94.

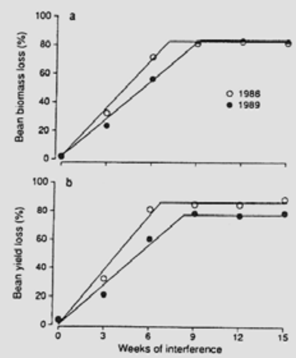

Figure 4. Bean biomass (B_b) (a) and seed yield (B_s) (b) reductions as a function of weeks of hairy nightshade interference (t) in 1988 and 1989 and the fitted curves. 1988: (B_b = 564 - 66.09 t if time (t) $\leq$ 7.0 wks), R^2=0.96; 1989: (B_b = 663 - 60.09 t if t $\leq$ 9.10 wks), R^2=0.98; 1988: (B_s = 201 - 26.22 t if t $\leq$ 6.61 wks), R^2=0.97; 1989: (B_s = 245 - 23.194 t if t $\leq$ 8.27 wks), R^2=0.96.

yr. As few as 2 hairy nightshade plants per meter reduced dry bean yields in both yr. The nonlinear responses of bean biomass and seed yield to increasing densities of hairy nightshade indicated intraspecific competition among hairy nightshade plants at the higher densities.

Estimates of hairy nightshade seed production are presented in Figure 2. Seed production/plant decreased from 52,200 and 41,500 to 2500 and 1900 seeds in 1988 and 1989, respectively, as density increased from 2 to 100 plants/m of bean row. This decreased seed production/plant was largely due to a reduction in the number of berries/plant as the number of seeds/berry ranged from 16 to 30 seeds with an average over all densities of 26 seeds/berry. Seed production peaked at about 30 hairy nightshade plants/m of row at 320,000 (1989) to 380,000 (1988) seeds (Figure 2).

Weed-free maintenance. Reductions in bean biomass and seed yield decreased as the number of weeks of weed-free maintenance increased in both years (Figure 3). Consistent over both yr, 9 weeks of weed-free maintenance was required for beans to attain seed yields comparable to beans kept weed-free for the entire season.

The germination percentage of seed collected from hairy nightshade plants that emerged after 0, 3, and 6 weeks of weed-free maintenance was 89, 87, and 81% in 1988 and 86, 90, and 17% in 1989. The difference between yr in germination of seed produced by plants that emerged after 6 weeks of weeding is likely attributable to the length of the growing season of each year. In 1988, a killing frost did not occur until early October while in 1989 a frost of -4 C occurred on September 9. Thus, plants emerging after the 6 week weeding period (approximately July 20) had 9 to 10 weeks to produce viable seed in 1988 but only 6 to 7 weeks in 1989.

Weed interference periods. Reductions in bean biomass and seed yield increased as the number of weeks of hairy nightshade interference increased for a certain duration beyond which additional losses were minimal (Figure 4). Reductions in biomass and seed yield progressively decreased up to about 6 to 7 and 8 to 9 weeks after emergence in 1988 and 1989, respectively. During this period of interference, bean biomass and seed yields were reduced by an average of 63.1 and 24.7 g/m^2, respectively, for each week of interference after crop emergence. Beans were unable to compensate after 7 to 9 weeks of hairy nightshade interference in this study.

CONCLUSIONS

1. Hairy nightshade is capable of causing large reductions in dry bean yields. As few as 2 plants/m of bean row reduced bean yields by 13%.
2. Hairy nightshade is a prolific seed producer (45,000 seeds/plant). This contributes to its rapid spread and increasing populations once initial infestations become established.
3. Hairy nightshade interference during the first 3 weeks after crop emergence can reduce bean yields. If herbicides are used they should be applied preplant, preemergence, or early postemergence to prevent yield reductions.
4. Dry beans must be kept free of hairy nightshade for up to 9 weeks after emergence to prevent bean yield losses and production of viable hairy nightshade seed before a killing fall frost.

TERBACIL-RESISTANT POWELL AMARANTH. Rick A. Boydston and Kassim Al-Khatib, Plant Physiologist and Research Associate, USDA-Agricultural Research Service, and Washington State University, Irrigated Agriculture Research and Extension Center, Prosser, WA 99350.

INTRODUCTION

Terbacil is a commonly used preemergence herbicide in several perennial crops including tree fruits, blueberries, mint, alfalfa, citrus, and sugarcane. Because its primary use is in perennial crops, terbacil could potentially be used repeatedly for several years, increasing selection pressure for terbacil-resistant biotypes. Field cases of terbacil resistance have been reported in Oregon but have not been confirmed in laboratory experiments (3).

Several incidences of terbacil failure on redroot pigweed were reported in 1990 in Washington mint fields. Growth chamber trials conducted on redroot pigweed seed collected from these mint fields confirmed that the new pigweed biotype was more resistant than the normal susceptible biotype.

Triazine resistant weed biotypes often exhibit cross-resistance to bromacil (3). A metribuzin-resistant Powell amaranth biotype collected in Idaho demonstrated a high level of cross resistance to terbacil in preliminary growth chamber trials. These studies were conducted to confirm terbacil and bromacil cross resistance in a Powell amaranth biotype collected in Idaho.

MATERIALS AND METHODS

Growth Chamber Trials. Ten seeds of a Powell amaranth terbacil-resistant biotype collected in Idaho or a susceptible biotype from Washington were seeded in 8 cm diameter plastic pots containing a Warden silt loam soil (mesic xerollic camborthids). Technical grade terbacil or bromacil was mixed with air dried soil at 0, 0.125, 0.25, 0.5, 1, 2, and 4 ppmw prior to filling pots. Plants were grown in growth chambers at 30/20 C (day/night) with a 16 h photoperiod. Light intensity was $320\mu E\ m^{-2}\ sec^{-1}$. Plants were harvested at 3 weeks after planting and dry weight determined. Each study contained four replications per treatment and was repeated.

Photosystem II activity and thylakoid binding. Leaves from greenhouse-grown terbacil resistant and susceptible Powell amaranth biotypes were harvested at 3 weeks after planting and thylakoids were extracted in 330 mM sorbitol, 40 mM Hepes-NaOH (pH 7.8), 30 mM KCL, and 3 mM M_gCl_2 (1). Chlorophyll content of thylakoid preparations was measured by the method of Arnon (2). Photosystem II (PSII) activity was determined in the presence of various concentrations of technical grade terbacil or bromacil using an oxygen electrode with 2,5-dimethyl-p-benzoquinone (DMBQ) as the electron acceptor. Treatments were sequentially replicated four times. Binding of terbacil was determined by incubation of thylakoids with 0, 0.033, 0.05, 0.066, 0.1, 0.133, 0.2, 0.285, or $0.4\mu M$ ^{14}C-terbacil (specific activity 1.81 Bq/mg) for 10 minutes in 60 mM NaCl, 4 mM Mg Cl_2, 40 mM tricine-KOH (pH 7.8) at a light intensity of 200 lE $m^{-2}\ sec^{-1}$. The incubated medium was then centrifuged at 20,000 g for 30 min and free herbicide in the supernatant assayed by liquid scintillation counting.

RESULTS

Growth Chamber Trials. Dry weights of the terbacil-susceptible biotype were reduced 59% by 0.125 ppmw terbacil in the soil and all plants were killed at concentrations above 0.25 ppmw at 3 weeks after planting (Figure1). Terbacil reduced dry weights of the resistant biotype by 19% at 0.25 ppmw and some plants survived concentrations as high as 4 ppmw. Similarly, bromacil reduced the dry weight of the susceptible biotype by 63% at 0.125 ppmw, but a concentration of 4 ppmw was required to reduce the dry weight of the resistant biotype by 72% (Figure 2).

Photosystem II activity and thylakoid binding. PSII activity of isolated thylakoids from resistant and susceptible biotypes responded differently to the presence of terbacil. The terbacil concentration required to inhibit PSII activity by 50% (I50) in the susceptible biotype was $0.24\mu M$ while the I_{50} for the resistant biotype was $13.33\mu M$ (Figures 3 and 4). Bromacil also inhibited PSII activity of susceptible and resistant biotypes differently with I_{50} values of 0.33 and $18.36\mu M$, respectively (Figures 5 and 6).

Binding studies revealed that more ^{14}C-terbacil was bound to isolated thylakoids of the susceptible biotype than in the resistant biotype with binding constants (Kb) of 0.26 and 12.9 lM, respectively (Figure 7).

These results confirm the resistance of this Powell amaranth biotype to terbacil and bromacil and indicate that the resistance is at the thylakoid level. Resistance is probably a result of an altered binding site on the Qb protein, resulting in less binding of terbacil. Cross resistance of this biotype to bromacil is likely the result of similar reduced binding to the altered Qb protein, but has not been confirmed.

These results suggest that treating fields containing confirmed triazine-resistant weed biotypes with uracil herbicides, such as terbacil or bromacil, could result in poor weed control as cross resistance could be present.

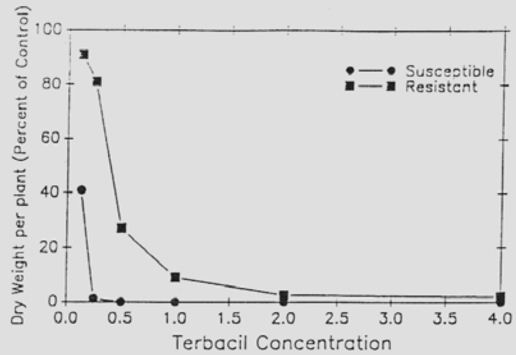

Figure 1. Dry weight of two Powell amaranth biotypes grown in soil treated with various concentrations of terbacil.

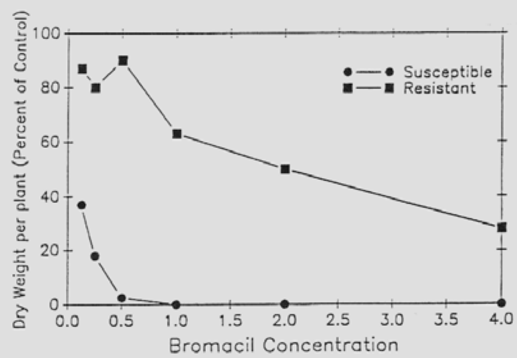

Figure 2. Dry weight of two Powell amaranth biotypes grown in soil treated with various concentrations of bromacil.

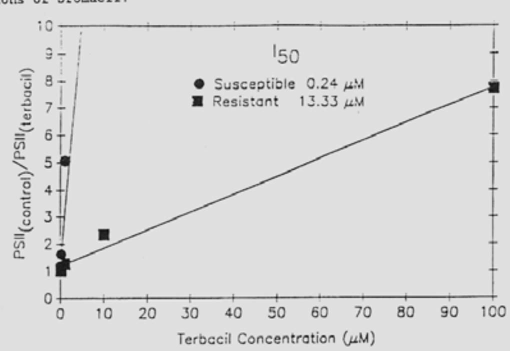

Figure 3. Inhibition of PSII activity by terbacil in isolated thylakoids from two Powell amaranth biotypes.

SUMMARY

1. A Powell amaranth biotype was found to be resistant to terbacil and bromacil when compared to a normal susceptible biotype when grown in herbicide-treated soil.
2. PSII activity of isolated thylakoids from the resistant biotype was 55 times more resistant to terbacil and bromacil than PSII activity of the susceptible biotype.
3. Isolated thylakoids from the resistant biotype had a lower binding affinity for ^{14}C-terbacil than thylakoids from the susceptible biotype.

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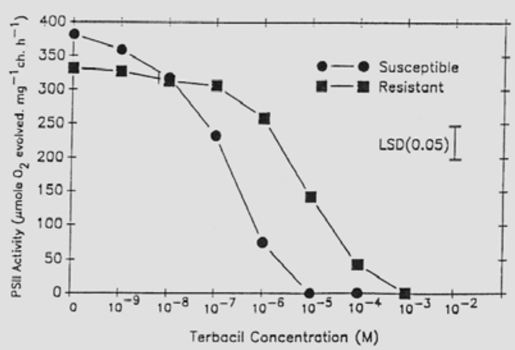

Figure 4. Inhibition of PSII activity by terbacil in isolated thylakoids from two Powell amaranth biotypes.

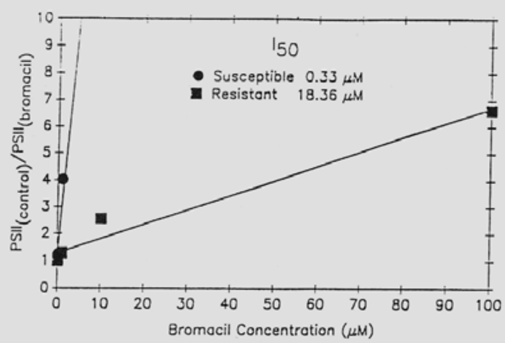

Figure 5. Inhibition of PSII activity by bromacil in isolated thylakoids from two Powell amaranth biotypes.

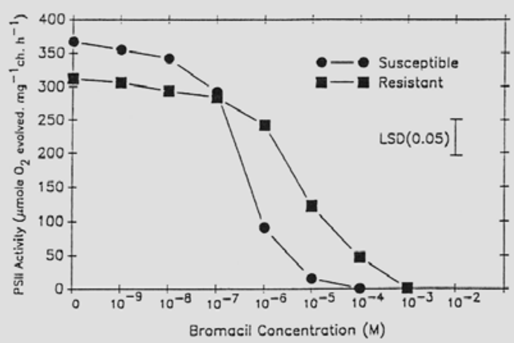

Figure 6. Inhibition of PSII activity by bromacil in isolated thylakoids from two Powell amaranth biotypes.

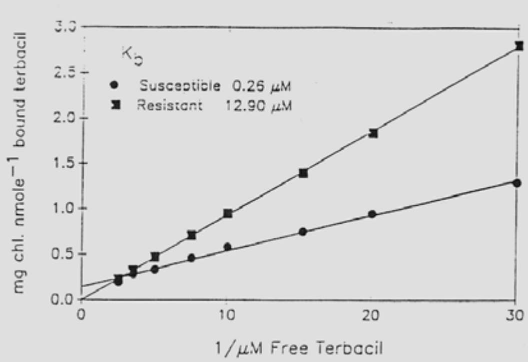

Figure 7. Terbacil binding to isolated thylakoids from two Powell amaranth biotypes.

A BIOASSAY TO MEASURE THE FREQUENCY OF SULFONYLUREA RESISTANCE IN WEED POPULATIONS. E. S. Davis and P. K. Fay, Research Associate and Professor, Department of Plant and Soil Science, Montana State University, Bozeman, MT 59717.

INTRODUCTION

Chlorsulfuron resistance developed rapidly and has been confirmed in 5 weed species. A system for determining the frequency of resistance within unchallenged weed populations would provide an early warning signal before resistance occurs in the field. The purpose of this study was to develop a greenhouse bioassay for determining the frequency of chlorsulfuron resistance within weed populations. Three systems of seedling growth were evaluated.

MATERIALS AND METHODS

Soil system. Greenhouse soil 6 cm deep was placed in 1.2 m by 1.2 m by 0.3 m deep fiberglass tubs. Approximately 250,000 kochia and redroot pigweed seeds were planted in individual tubs. Fifteen seeds from chlorsulfuron resistant kochia plants were added to one tub to challenge the bioassay. Chlorsulfuron (355 g/ha) was applied postemergence when seedlings were 3 cm tall. Seedling density was determined at application. Chlorsulfuron resistant plants were counted 14 DAT, transplanted to individual pots and sprayed a second time with 355 g/ha chlorsulfuron to confirm resistance.

Vermiculite system. A 3 cm deep layer of medium grade vermiculite was used as a germination medium. Greenhouse flats (27.5 cm by 55 cm) were seeded with either 50,000 or 100,000 kochia, Russian thistle, redroot pigweed, common lambsquarters, tansy mustard, or wild mustard seed. Chlorsulfuron (355 g/ha) was applied once postemergence to seedlings in the cotyledon stage. Uninjured, potentially resistant plants were counted 14 DAT.

Hydroponic system. Four hundred fifty four grams of seed of alfalfa, kochia and redroot pigweed was rinsed with tap water and soaked for 8 h. Imbibed seeds were uniformly spread 0.5 cm deep on filter paper lining 27.5 by 55 cm plastic flats. Seedlings were submerged in water containing 100 ppm chlorsulfuron for 15 min every 8 h for 10 days.

RESULTS AND DISCUSSION

Soil system. The large tub-soil system detected resistant (R) kochia plants when the frequency range was 1R:100 to 1R:10,000 susceptible (S) seedlings. Seedling mortality from disease and competition occurred when seedling densities were greater than 4 to 5 seedlings per cm^2. Resistance was not detected in 500,000 redroot pigweed seedlings. The system operates continuously receiving pigweed seed and chlorsulfuron every 35 days to increase chances of detecting resistance. If frequency of resistance was 1R:1 million S, a continuous assaying system could detect resistant plants in as few as 5 cycles (6 months).

Vermiculite system. Large populations of seedlings were produced in small greenhouse flats with vermiculite as the germination medium. Fungicides were effective at reducing mortality. Resistance could be measured in kochia and Russian thistle if the frequency of resistance fell in the range of 1R:100S to 1R:10,000S seedlings.

Hydroponic system. Alfalfa seedlings grew well in the hydroponic system and 100,000 seedlings could be screened at once. Resistance was not detected in alfalfa. Kochia seedlings were extremely prone to disease when cultured hydroponically. Fungicides helped but mortality was still excessive. Redroot pigweed seed had low germination and high seedling mortality in hydroponic culture.

CONCLUSIONS

Healthy seedling growth was maintained long enough for selection of plants resistant to chlorsulfuron in the soil and vermiculite systems. In these two systems, resistant kochia seedlings were detected at a frequency as low as 1R:10,000S.

The hydroponic system failed with kochia due to fungal contamination. The advantage of a hydroponic system is that large numbers of seedlings could be grown in a limited space.

Chlorsulfuron resistance was not been detected in populations of redroot pigweed, tansy mustard, wild mustard, or common lambsquarters seed. A soil system continually replenished with seeds and periodically retreated with chlorsulfuron could detect resistance at a frequency as low as 1R:1,000,000S.

The frequency of resistance in populations of kochia unchallenged with sulfonylurea herbicides was 1R:100S to 1R:1,000S depending upon seed lot, a much higher frequency than expected. It is possible that cross-pollination with chlorsulfuron resistant kochia plants from adjacent fields could account for this high frequency. Another possibility is that the occurrence of resistance in unchallenged populations is much higher than previously assumed.

SPERMOSPHERE COLONIZATION OF DOWNY BROME SEED BY PLANT-SUPPRESSIVE BACTERIA.
J. A. Doty and A. C. Kennedy, Research Assistant and Soil Microbiologist, Washington State University, USDA-ARS, Pullman, WA
99164-6421.

Abstract. Early seed colonization by plant-suppressive bacteria is essential to subsequent root colonization and maximum inhibition of downy brome growth for weed biocontrol. *Pseudomonas fluorescens* strain D7rif, which inhibits downy brome seed germination, was tested for its ability to colonize winter wheat and downy brome seeds at three different soil moisture levels using spermosphere competence methods.

Winter wheat supported greater numbers of bacteria than did downy brome on a per seed basis, however downy brome supported greater numbers of bacteria per seed surface area. Bacterial populations on the seed varied with soil moisture. In laboratory assays and greenhouse studies, bacteria colonized roots better and reduced downy brome growth more in moist soil near field capacity (25%) than in soil at low moisture content (4%). Downy brome seed supported a greater percentage of introduced bacteria at the lower soil moisture content than did winter wheat. A critical time period for colonization by introduced bacteria occurs within 6 hr of seed imbibition.

ANALYTICAL PYROLYSIS-A METHOD FOR THE CHEMICAL CHARACTERIZATION OF WEED BIOTYPES. John O. Evans, James M. Torell, Ron Valcarce, and Grant G. Smith, Professor and Research Assistant, Plants, Soils, and Biometeorology Department, and Research Assistant and Professor, Chemistry and Biochemistry Department, Utah State University, Logan, UT 84322-4820.

INTRODUCTION

Many of our most troublesome weeds are genetically diverse species and the existence of distinct biotypes has been demonstrated for several of them. Biotypes have been described with respect to various plant characteristics including morphology, chemistry, herbicide tolerance, and susceptibility to natural enemies as biocontrol agents.

Chemical data have been employed to resolve systematic and ecological problems, but data acquisition by traditional methods is slow, tedious and expensive because extraction and quantification procedures for most chemicals are complex. For these reasons, few studies have dealt with more than a single class of chemical compounds. Greater inferences could be made if patterns of overall chemical variation covering the entire range of chemical components present in a sample could be determined. These multi-variate comparisons could then be used to explain systematic and ecological relationships. A greater understanding of weed biology may provide broader foundations for effective weed control strategies and programs. Analytical pyrolysis is an emerging technology that promises to provide this kind of data.

MATERIALS AND METHODS

Pyrolysis is the thermal degradation of chemical compounds in the absence of oxygen. When pyrolysis is conducted under carefully controlled conditions, the molecules thermally fragment in a reproducible way to produce a series of volatile, low-molecular weight molecules (pyrolyzate). These volatile components can be separated with a gas chromatograph or analyzed by mass spectrometer or both to investigate complex mixtures of biological molecules.

The method of separation defines the two basic modes of analytical pyrolysis: pyrolysis-gas chromatography (py-gc) and pyrolysis-mass spectrometry (py-ms). Both methods have similar goals of producing a profile (pyrogram or pyrolysis mass spectrum) that is chracteristic of the original material.

Analytical pyrolysis produces extremely complex profiles and patterns of variation are not usually discernable by visual inspection. In a typical data st for a pyrolysis experiment, each sample (object) is described by ore than twenty variables (peak areas or mass intensities). Each object exists in a multidimensional hyperspace that is impossible to represent graphically. Objects in this multidimensional hyperspace are visualized by employing multivariate pattern recognition procedures such as hierarchical cluster analysis (HCA) and principal components analysis (PCA).

HCA is a procedure for recognizing groups (clusters) in multidiemensional space. The data vector from a pyrogram or pyrolysis mass spectrum exists in an n-dimensional space where n is the number of variables (peaks or masses). In HCA the data matrix is searched for the most similar pair of objects which are combined and the process is repeated may times until all the points are comined into a single custer. The result is graphed as a two-dimensional dendrogram.

Principal component analysis (PCOMP) uses correlations in the data to reduce dimensionality. This is done by constructing orthogoanl linear combinatons of the adata such that the first linear combination (principal component) acouunts for the greaters proportion of variance and each succeeding principal component accounts for progressively lower amount of variance. If a large proportion of variance is accounted for by the first two or three principal components, then the high-dimensional space can be quite accurately represented by graphing the points within the first two or three principal component axes.

RESULTS AND DISCUSSION

Both modes of analytical pyrolysis (py-gc and py-ms) are capable of producing a charactristic profile for a substance of interest and both sypstems have their advantages and disavantages as follows: **Pyrolysis Gas Chromatography** a) relatively inexpensive equipment, b) peak identification is ambiguous and manual peak matching is usually necessary, c) labor intensive, d) long analysis time, e) unstable baselines are common. **Pyrolysis Mass Spectrometry** a) very expensive equipment, b) peaks (masses) are unambiguous, c) less labor intensive and easily automated, d) short analysis time, e) stable baselines. Pyrolysis gas chromatography requries relatively inexpensive euqipment. If a gas chromatograph is available, the only major requirment is to replace one of the inlet ports with a curie-point pyrolyzer at a modest cost. Due to slight deviations in retention times between different runs, peak matching must be done on complex chromatograms. This is a tedious and timeconsuming task. Analysis times are long because of the time needed for some components to elute through the column and unstable baselines are somewhat common. Pyrolysis mass spectrometry requries very expensive equipment but is much more amneable to automated operation and computerized data acquisition. Anlaysis time is short, there is no need for peak matching as masss are unambiguous, and a stable baseline exists. Thus, the choice of system may be made based on resources and expertise present in indiviual laboratories.

Analytical pyrolysis has been used in both modes (py-gc and py-ms) to characterize and differentiate a wide variety of biological organisms. The firt biological applicatons were in micorbial taxonomy becuase chemical differentiation was particularly different in the absence of good morophological characters. Some microbes have been differentiated to the serotype level. We have used analytical pyrolysis for the chemical

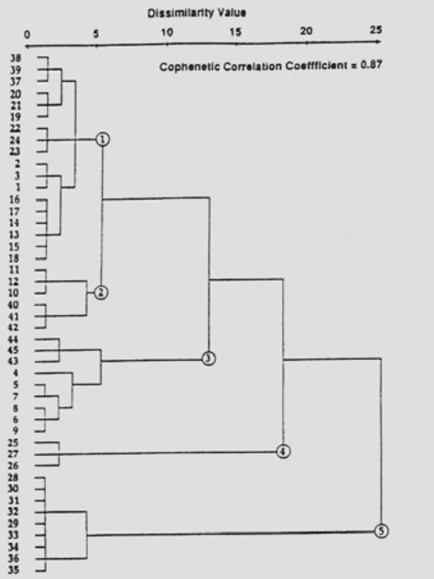

Figure 1. Dendrogram representing hierarchial cluster analysis of pyrolysis mass spectra from leafy spurge latex samples.

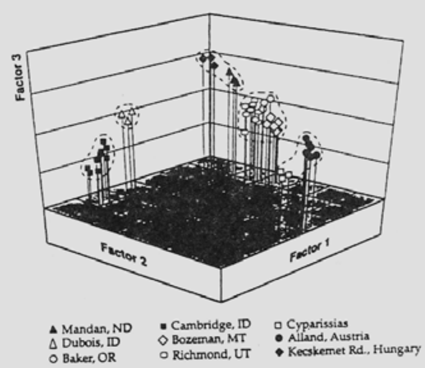

Figure 2. Plot of the first three principle components for analysis of pyrolysis mass spectra from leafy spurge latex samples.

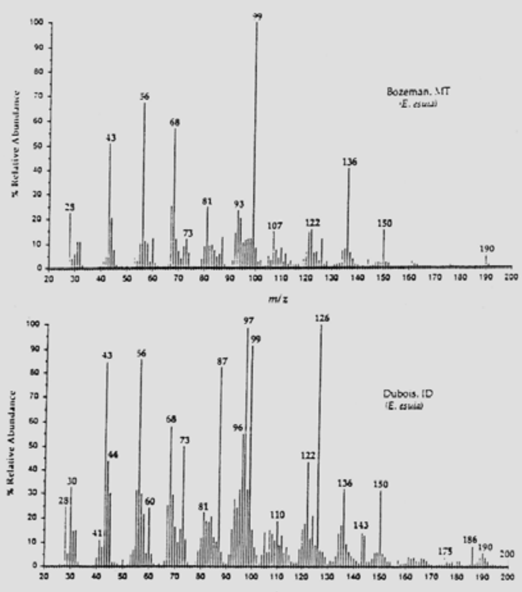

Figure 3. Typical pyrolysis mass spectra profiles of latex samples from leafy spurge assessions in Bozeman, MT and Dubois, ID and cultured under uniform greenhouse conditions in Logan, UT.

charactrization of leafy spurge (*Euphorbia esula* L.). We chose to analyze the latex because it contains a complex mixture of chemical components that are thought to be related to systematic and ecological relationships.

Examination results and a large number of accession within *Euphorbia esula* L. as well as a distinct but closely related species (*Euphorbia cyparissias* L..), demonstrated analytical pyrolysis to be an effective tool for chemical characterization and differentitation. Leafy spurge and cypress spurge separate into major clusters as expected based on their divergent morpholgy and cytology (Figures 1 and 2). Analysis of leafy spurge alone indicated separation of populations according to principal components analysis, typical py-ms spectra for leafy spurge samples are shown in Figure 3. We interpret these data as supporitng the diposition of leafy spurge as a single highly variable species.

CONCLUSIONS

Leafy spurge is a candidate for biocontrol and the relationship of chemical composition to herbivore preference is of considerable interest. These reltionships have not been established between biocontrol organisms and leafy spurge. However, other investigators have established a mulitvariate correlation between py-ms data and insect feeding preference for selected forage grass lines. Clusters were also consistant with genetic relationships among the grasses as determined by genetic analysis. We believe that these procedures can be used to predict the efficacy of biocontrol agents on prospective target weed populations and to produce inferences relative to taxonomic affinities among species.

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CONTROL OF SPURRED ANODA IN VALENCIA PEANUTS WITH IMAZETHAPYR. G. F. Goddard, R. D. Lee, and R. D. Baker, Senior Research Agriculturist, American Cyanamid Company, Plainview, Tx 79072, Extension Weed Specialist, New Mexico State University, Las Cruces, NM 88003, and Extension Agronomist, New Mexico State University, Clovis, NM 88101.

Abstract. Valencia peanuts are grown on approximately 7,290 ha of New Mexico farmland and contribute approximately $16.5 million to New Mexico's economy. Of these 7,290 ha, approximately one-half are infested with spurred anoda which is currently controlled only by repeat applications of contact herbicides or by hand weeding. Preliminary tests conducted in 1989 showed imazethapyr to have good activity against spurred anoda and good selectivity for Valencia peanuts. During 1990, three tests were conducted to investigate the effects that various application timings of imazethapyr had on spurred anoda efficacy and peanut phytotoxicity. All tests were applied with a CO_2 propelled back pack sprayer and consisted of three replications of treatments made on 5 by 10 m plots in a randomized complete block design.

Ratings made throughout the growing season showed imazethapyr applied at 53 and 71 g/ha to have given from 93 to 100% spurred anoda control when applied preemergence or at cracking to the peanuts. Early postemergence treatments of imazethapyr made when the spurred anoda ranged from cotyledon to four leaf stage resulted in 75 to 96% control. Control from postemergence treatments generally increased as time progressed from application to harvest but was not as good as when applied preemergence or at cracking. Peanut phytotoxicity, although slight, increased as the rate of application increased but decreased with the timing of application in the order preemergence > cracking > postemergence. Peanut phytotoxicity decreased as the season progressed with none being present at harvest. Peanut yields from all imazethapyr treatments were higher than the untreated check or the standard herbicide treatments when averaged over the three tests.

FACTORS AFFECTING THE BIOCONTROL EFFICACY OF A RHIZOBACTERIUM DELETERIOUS TO DOWNY BROME. B.N. Johnson, A.C. Kennedy and A.G. Ogg Jr., Research Associate, Research Scientist and Research Leader, Weed Science Research Unit, USDA-ARS, Pullman, WA, 99164.

Abstract. Field studies have indicated that an isolate of *Pseudomonas fluorescens* applied to soil may suppress the growth of downy brome while enhancing winter wheat growth in Eastern Washington. The efficacy of this biological control (biocontrol) agent is inconsistent however, perhaps owing to the sensitivity of root colonization or phytotoxin production to soil water content and temperature. The present study was initiated to determine if such environmental parameters influence the downy brome biocontrol system. Seeds sown on a silt loam soil were inoculated with a spontaneous rifampicin-resistant mutant of *P. fluorescens* strain D7 (D7rif) and grown for 14 days in chambers before being harvested.

Recovery of D7rif indicated that it is a vigorous rhizosphere competitor in a variety of conditions. Colonization, expressed on a root length basis, differed among the treatments. D7rif populations per plant were nearly 2 fold higher in wet soil (250 g H_2O kg^{-1}) than in dry soil (100 g kg^{-1}). Total populations per plant were 100 times higher at 10 C than at 18 and 25 C.

Root masses of inoculated plants were generally lower than non-inoculated control plants. The inoculum reduced root growth in dry soil by 11% and in wet soil by 27%. Growth room temperature also influenced biocontrol efficacy; among temperatures tested, root inhibition by the bacterium was maximal at 18 C. Root growth suppression of plants grown at 18 C and 250 g H_2O kg^{-1} correlated with root colonization (R^2 = 0.76).

The early suppression of downy brome growth by the pseudomonad is possible in different soil water and air temperature regimes although to a variable extent. In particular, dry soil and high temperatures were least conducive to root growth suppression. As the isolate is efficacious in cool or wet soil, it may be suitable for downy brome control during the autumn growth period.

EFFECT OF CROP MANAGEMENT ON THE DISTRIBUTION OF PLANT-SUPPRESSIVE BACTERIA. A. C. Kennedy, T. L. Stubbs, and F. L. Young. Research Scientist, Research Technologist and Research Scientist, USDA-ARS, Pullman, WA, 99164-6421.

Abstract. An increased awareness of the risks associated with the use of chemical herbicides has stimulated the search for alternative methods of weed control. Plant-suppressive rhizobacteria (PSB) exert a subtle, often fleeting, negative effect on plant growth and have the potential to be used in the biological control of weeds. We have isolated PSB that specifically inhibit downy brome, but do not affect the small grain crop. These bacteria, as biological control agents, colonize the seed and emerging root and deliver plant suppressive compounds during a critical stage in the growth of the weed which allows the crop to be more competitive. For PSB to be the most effective biological control agent of weeds, a better understanding of their distribution and survival in agricultural systems is needed. The ultimate research goal is to develop PSB for a low-cost, effective means of weed control with minimal impact to the environment. Downy brome and jointed goatgrass are target weed species for this study because they infest 14 million acres of small grain lands in western United States and no effective herbicide is available for their control. The objective of this study was to determine the effect of plant species, sampling time and management on the occurrence of bacteria inhibitory to winter wheat, downy brome and jointed goatgrass. Plant roots were sampled in March, June and November of 1989, placed in 0.1% $CaSO_4$, shaken, serially diluted and plated on pseudomonad selective agar medium. Bacterial isolates were randomly selected from the agar surface, stored in cryostorage until assayed for plant growth inhibition. Those isolates noninhibitory to winter wheat and inhibitory to the weeds were further tested in the greenhouse. A Ritzville silt loam and sand mix (4:1) was seeded with downy brome, winter wheat or jointed goatgrass and inoculated with individual isolates at 10^9 cfu pot^{-1}. Soil was maintained at 24% moisture and fertilized with Peter's solution. Plants were harvested after three weeks. In laboratory studies, more than half of the 2400 naturally-occurring soil bacteria investigated were inhibitory to downy brome or jointed goatgrass seedling growth. Only 6% of these isolates inhibited downy brome and not winter wheat, while less than 4% inhibited jointed goatgrass and not the crop in the *in vitro* bioassay. Winter wheat was less susceptible than downy brome and jointed goatgrass to the plant-suppressive bacteria. Conventional and minimum tillage systems maintained the highest populations of inhibitory bacteria. The number of weed inhibitory bacteria decreased from March to November. Nitrogen fertilization increased the number of inhibitory bacteria found. Less than 0.3% of the isolates tested inhibited weed growth in greenhouse studies. While the prescreening of the bacteria for production of plant-suppressive compounds is necessary, understanding the survival and competitive ability of these bacteria in soil systems is critical to the development of PSB as biological control agents.

DOSE-RESPONSE CONFIRMATION OF SENSITIVE CROPS TO SULFOMETURON. L.W. Lass, R.H. Callihan, and L.K. Hiller, Univ. of Idaho, Dept. of Plant, Soils, and Ent. Sci., Moscow, ID, 83843 and Washington State University, Dept. of Horticulture and Landscape Architecture, Pullman, WA 99163.

Abstract. Pre-emergence treatments of sulfometuron ranging between 1.5 and 0.008 g/ha were applied to a Shano silt loam to develop dose-response curves and to characterize injury induced in five dicot crops. Crop heights and shoot symptom expressions were recorded several times during the season, and yields were measured. Statistical no-effect threshold levels of sulfometuron were reached in peas at 0.5 g/ha for shoot biomass, 0.26 g/ha for shoot chlorosis, 0.13 g/ha for pod number, and 0.06 g/ha for shoot height, flower number, and pod weight. In lentils, no-effect thresholds were reached at 0.26 g/ha for shoot chlorosis and 0.06 for shoot height. No-effect thresholds in alfalfa increased through the growing season and were reached at 0.13 g/ha for shoot biomass, 0.008 g/ha for flowering and 0.016 g/ha for seedling height. No-effect thresholds in potato tuber physical characteristics were 0.26 g/ha for knobs per tuber, 0.131 g/ha for tubers less than 7.5 cm, and 0.262 g/ha for tuber with cracks. In sugar beets, early-season no-effect thresholds were not reached for number of plants emerged and seedling shoot height, although this no-effect threshold increased to as much as 0.262 g/ha later in the growing season. Temporal changes in perception of apparent no-effect thresholds of sulfometuron in all of the crops were observed throughout the growing season. In the first month after application sugar beet height was significantly reduced at the lowest dose (0.008 g/ha). Late-season recovery may be due to degradation or less uptake in proportion to plant size, because of an expanded root system outside the herbicide zone, or other unknown factors. It is clear that a series of observations during plant

development is necessary to ensure detection of transient effects. Response thresholds are dependent upon evaluative criteria, temporal effects, and environment. Statistically significant no-effect levels reported here are considered to be higher than actual differences since effects, though not consistent, were found at lower dose levels.

LEAFY SPURGE CONTROL WITH GLYPHOSATE PLUS 2,4-D: A REGIONAL RESEARCH PROJECT.
Rodney G. Lym, K. George Beck, Peter K. Fay, Mark Ferrell, and Mark Peterson, Associate Professor, Crop and Weed Sciences Department, North Dakota State University, Fargo, ND 58105, Assistant Professor, Department of Plant Pathology and Weed Science, Colorado State University, Fort Collins, CO 80523, Professor, Department of Plant and Soil Science, Montana State University, Bozeman, MT 59717, Extension Pesticide Coordinator, Department of Plant, Soil, and Insect Sciences, University of Wyoming, Laramie, WY 82071, and Senior Development Biologist, Dow Chemical Co., Fargo, ND 58102, respectively.

Abstract. Glyphosate plus 2,4-D has been registered as a fall applied treatment for leafy spurge control in pasture and rangeland. Research data are limited concerning weed control and potential grass injury with glyphosate in pasture and rangeland. Members of the Great Plains Agricultural Conference (GPAC) established a regional research project to evaluate various formulations of glyphosate plus 2,4-D for leafy spurge control and grass injury. The experiment was established in Colorado, Montana, North Dakota, South Dakota and Wyoming in dense stands of leafy spurge with several grass species present (Table 1). Treatments were applied on or near August 15 or September 15, 1989 using 8 to 20 gpa at 35 psi. Plots were 10 by 30 feet and treatments were replicated four times in a randomized complete block design at all locations.

Leafy spurge control and grass injury varied by location and treatment date. Glyphosate plus 2,4-D at 0.38 plus 0.65 lb/A provided an average of 79% leafy spurge control when applied in September in Colorado, North Dakota and South Dakota but only 63 and 13% control in Montana and Wyoming, respectively, 9 months after treatment (MAT) (Table 2). However, grass injury also was higher in Colorado and the Dakotas and averaged 77% compared to no injury in Montana and Wyoming. Leafy spurge control and grass injury was higher when treatments were applied in September compared to August at all locations except Montana.

Leafy spurge control was similar 9 MAT when glyphosate at 0.38 lb/A was applied with 2,4-D at 0.34 or 0.65 lb/A or with dicamba at 0.172 lb/A (Table 2). Glyphosate plus 2,4-D or glyphosate plus dicamba provided better leafy spurge control than glyphosate alone when applied in August, but control was similar when applied in September. Picloram applied at 0.5 lb/A provided 94% leafy spurge control with minimal grass injury averaged over both application dates and all locations except Montana and Wyoming where control averaged 70 and 32%, respectively. Leafy spurge control from picloram plus glyphosate was similar to picloram alone but grass injury was higher especially when applied in September.

Glyphosate plus 2,4-D provided less than 35% leafy spurge control 12 MAT averaged over both application dates and all locations except South Dakota (Table 3). No treatment provided satisfactory control 12 MAT in Montana, North Dakota or Wyoming. Glyphosate plus 2,4-D at 0.38 plus 0.34 lb/A applied in August in South Dakota provided 88% leafy spurge control which was similar to picloram at 0.5 lb/A.

Leafy spurge control and grass injury varied by region and application date. In general, glyphosate plus 2,4-D or dicamba provided 60 to 70% leafy spurge control with 30 or 70% grass injury 9 MAT when applied in August and September, respectively. Glyphosate plus 2,4-D is an economical treatment and will be useful in a long-term leafy spurge control program, especially in areas with a dense leafy spurge infestation and sparse grass cover.

Table 1. Location, cooperators, and application data for 1989-90 GPAC regional glyphosate study.

	Location/principal investigator									
	Wyoming		Montana		S.Dakota		N.Dakota		Colorado	
	M. Ferrell		P. Fay		M. Peterson		R. Lym		K. G. Beck	
Application date (1989)	7 Aug	12 Sept	7 Aug	15 Sept	15 Aug	16 Sept	16 Aug	14 Sept	18 Aug	15 Sept
Air temperature (F)	80	48	62	70	73	75	78	68	81	77
Relative humidity (%)	37	55	66	72	75	40	43	51	44	34
Soil temp. 1 inch (F)	110	65	55	52	75	77	79	67	66	52
Cloud cover	clear	clear	clear	5%	hazy	clear	clear	clear	85%	clear
Soil pH	6.3		6.4		7.6		7.4		7.5	
Soil organic matter (%)	1.8		9		3.7		2.3		4.1	
Leafy spurge stage	seed-set	dormant	seed-set	dormant	seed-set green	seed-set green	fall branching	green & red leaves dropping	post seed-set	post seed-set
Grasses present	Intermediate wheatgrass Bluegrass spp.		Timothy Sandburg bluegrass		Smooth brome Kentucky bluegrass		Western wheatgrass Bluegrass spp.		Western wheatgrass Kentucky bluegrass Smooth brome	

Table 2. Leafy spurge control and grass injury 9 months after treatment.

Application time/ treatment	Rate	Wyoming		Montana		S.Dakota		N.Dakota		Colorado		Mean[a]	
		Control	Grass injury	Control	Grass injury	Contol	Grass injury	Control	Grass injury	Control	Grass injury	Control	Grass injury
	(lb/A)	----------------------					(%)						----------------------
August 1989													
Glyphosate	0.38	10	0	11	0	48	46	29	40	33	8	36	31
Glyphosate+2,4-D[b]	0.38+0.34	35	3	67	0	89	35	52	29	68	20	70	28
Glyphosate+2,4-D[c]	0.38+0.65	23	0	61	0	77	49	55	16	64	16	65	27
Glyphosate+dicamba[d]	0.38+0.172	48	3	67	0	70	48	63	46	64	20	65	38
Picloram	0.5	30	0	80	0	90	0	85	18	99	23	91	13
Picloram+glyphosate	0.38+0.5	33	0	83	1	99	47	90	9	90	36	93	31
Picloram+glyphosate +2,4-D	0.5+0.38+0.65	23	7	78	0	98	29	68	30	99	31	88	30
September 1989													
Glyphosate	0.38	53	5	0	0	63	43	52	70	70	85	62	66
Glyphosate+2,4-D[b]	0.38+0.34	38	0	16	0	82	71	55	72	73	50	70	64
Glyphosate+2,4-D[c]	0.38+0.65	33	0	8	0	80	50	67	83	71	71	73	68
Glyphosate+dicamba[d]	0.38+0.172	63	9	13	0	92	69	66	85	79	77	79	77
Picloram	0.5	33	0	61	0	99	5	100	18	90	28	96	17
Picloram+glyphosate	0.38+0.5	40	3	62	0	99	70	99	97	97	66	98	78
Picloram+glyphosate +2,4-D	0.5+0.38+0.65	60	8	65	0	99	78	100	98	88	67	96	81
LSD (0.05)		29	5	14	NS	16	26	29	28	15	19	12	14
Location mean													
LSD (0.05) Control = 6		35	2	44	0	79	42	65	47	72	40		
Grass injury = 5													

[a]South Dakota, North Dakota, and Colorado data only. [b]Landmaster II [c]Landmaster BW [d]Fallowmaster

Table 3. Leafy spurge control and grass injury 12 months after treatment.

Application time/ treatment	Rate	Wyoming		Montana		S.Dakota		N.Dakota		Colorado		Mean[a]	
		Control	Grass injury	Control	Grass injury	Control	Grass injury	Control	Grass injury	Control	Grass injury	Control	Grass injury
	(lb/A)	-----	-----	-----	-----	-----	-----	(%)	-----	-----	-----	-----	-----
August 1989													
Glyphosate	0.38	0	0	5	0	38	31	4	0	9	3	3	0
Glyphosate+2,4-D[b]	0.38+0.34	8	0	38	0	88	33	5	6	28	15	17	2
Glyphosate+2,4-D[c]	0.38+0.65	10	0	28	0	58	35	13	8	31	10	17	3
Glyphosate+dicamba[d]	0.38+0.172	23	0	45	0	60	40	9	9	33	28	25	3
Picloram	0.5	5	0	48	0	82	5	9	0	88	20	21	0
Picloram+glyphosate	0.38+0.5	13	0	44	0	83	54	16	0	84	33	24	0
Picloram+glyphosate +2,4-D	0.5+0.38+0.65	3	0	28	0	92	36	9	3	78	25	13	1
September 1989													
Glyphosate	0.38	28	0	0	0	63	20	26	83	26	79	18	28
Glyphosate+2,4-D[b]	0.38+0.34	30	0	0	0	44	61	8	71	30	58	13	24
Glyphosate+2,4-D[c]	0.38+0.65	18	0	5	0	57	33	14	75	31	71	12	25
Glyphosate+dicamba[d]	0.38+0.172	45	0	9	0	64	56	16	84	55	74	23	28
Picloram	0.5	8	0	35	0	88	5	49	3	72	29	30	17
Picloram+glyphosate	0.38+0.5	13	0	29	0	87	73	54	70	75	49	32	23
Picloram+glyphosate +2,4-D	0.5+0.38+0.65	18	0	19	0	92	73	43	82	63	64	26	27
LSD (0.05)		21	..	12	..	29	30	20	14	11	14	NS	NS
Location Mean													
LSD (0.05) Control = 12 Grass injury = 14		15	0	22	0	65	37	18	33	47	37		

[a]Montana, North Dakota, and Wyoming data only. [b]Landmaster II [c]Landmaster BW [d]Fallowmaster

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MONITORING BROOM SNAKEWEED INFESTATIONS USING COARSE-RESOLUTION SATELLITE IMAGERY ON NEW MEXICO, USA RANGELANDS. K. C. McDaniel, Professor, Department of Animal and Range Sciences; M. Eve, Graduate Student, Department of Earth Sciences; A. Peters and B. Reed, Assistant Professors, Department of Earth Sciences, New Mexico State University, Las Cruces, NM 88003.

Abstract. Coarse-resolution satellite data was found useful for delineating areas of rangeland with varying levels of the invasive weed, broom snakeweed. Reflectance data recorded by the AVHRR (Advance Very High Resolution Radiometer) system on board the National Oceanic and Atmospheric Administration (NOAA) operational polar orbiting satellites was obtained for twelve dates throughout the 1989 growing season. The AVHRR system has a ground resolution of 1100 m at nadir, meaning that each picture element (pixel) covers approximately 122 ha. This is very coarse spatial resolution, making the data useful for studying large regions. The study used red and near-infrared reflectance to calculate the normalized difference vegetation index (NDVI). NDVI is a normalized ratio of infrared to red reflectance that is an indicator of photosynthetic activity and biomass production.

Ten large training sites were established on rangeland near Vaughn and Yeso, New Mexico, USA. Each training site was categorized based on its level of snakeweed infestation. NDVI values were calculated by training site and areas with relatively high and low infestation levels of broom snakeweed were separated. The

early season (May and June) NDVI was consistently higher for areas with more snakeweed because the plant was green but other herbage was mostly dormant. Conversely, mid- and late- season values were similar across training sites, except during peak flowering (September) when NDVI was reduced for areas highly infested with broom snakeweed.

Using this information, a statistical clustering (image classification) test was conducted to extrapolate NDVI values from the training sites to nearby surrounding areas (Figure 1). An unsupervised classifier was first used to separate out grassland from other vegetation types, such as pinyon and juniper woodlands. Several supervised and unsupervised classifiers were then applied on grasslands in order to isolate and identify areas heavily infested with snakeweed.

The procedure used showed it is possible to locate areas of snakeweed with a reasonable level of accuracy and the approach is applicable to other invasive weeds. Obtaining satellite data over time is useful for monitoring and possibly predicting weed infestations on rangelands.

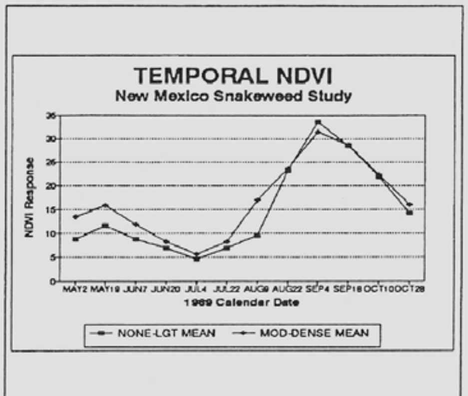

Figure 1: Temporal curves of mean NDVI values within the study area training sites.

WINTER WEED CONTROL IN GRAIN LUPINE. Larry W. Mitich, Thomas E. Kearney, John A. Roncoroni, and Guy B. Kyser, University of California, Department of Botany, Cooperative Extension, Davis, CA 95616.

Abstract. Grain lupine, a cool-season legume crop, provides an alternative to small grains and sugarbeets in California's Central Valley. Lupine seed, green chop, and silage are used as livestock feed; seed is used in poultry feed with minimal processing. In California, lupine is planted in fall and grows slowly during the cool season. Winter weeds can outgrow lupine during this critical period, reducing seed yields 25% to 80%.

Preemergence herbicide treatments provide most effective weed control and best crop safety when applied postplant preemergence and incorporated by sprinklers or rainfall. The most successful herbicide treatments include linuron (2 lb/A), metolachlor plus linuron (2 plus 1 lb/A or 1 plus 2 lb/A), pendimethalin plus linuron (1 plus 1 lb/A), and imazethapyr (0.094 lb/A). Linuron is the most effective herbicide for controlling the spectrum of winter broadleaf weeds found in grain lupine, particularly mustards. Pendimethalin and metolachlor provide some control of annual bluegrass, a common winter grass problem. Imazethapyr shows potential for controlling several problem species, though it has been tested at Davis only during the past 2 yr.

Most postemergence treatments injure grain lupine, except for some grass herbicides (sethoxydim, fluazifop, and cloproxydim), which are useful for controlling grasses such as volunteer cereals. However, these do not control annual bluegrass.

Lupine weed control research at UC Davis has contributed to the registration of pendimethalin and metolachlor, separately and in combination, for grain lupine. These herbicides are the only treatments registered for weed control in lupine; they control many winter weeds but fail to control mustards and most winter grasses adequately. Registration of linuron, alone or with these herbicides, would be an important step toward making grain lupine economically feasible. Registration of a postemergence grass herbicide would be a useful adjunct.

WESTERN EXPERT EDUCATIONAL DIAGNOSTIC SYSTEM (WEEDS). R.R. Old, R.T. Dobbins, P.J. Hine, R.H. Callihan, and F.E. Northam, Extension Associate, Programmer/Analyst, Computer Application Specialist, Extension Weed Specialist and Research Associate, University of Idaho, Moscow, ID 83843.

Abstract. The WEEDS computer program offers a unique approach to identification of any species in **Weeds of the West.** Unlike dichotomous keys where a series of questions must be answered, the WEEDS user selects questions he can answer, and does so in any order he chooses. The field of remaining possibilites is reduced with each selection and the display shows the number of species remaining. At any stage of the process the user can list the species remaining (listed by scientific and common names) with the corresponding page numbers in **Weeds of the West.**

Examples of the way in which a species such as henbit or spotted catsear might be identified using this program together with Weeds of the West follow:

Table 1. Example of identification of an unknown plant sample (henbit).

Decision No.	Your selected Menus	Your selection	# of Species remaining
1.	Non Grass-like or Grass-like	Non Grass-like	304
2.	Leaf Arrangement	opposite	69
3.	Leaf shape	round	8
4.	Stem cross section	square	3
5.	Life cycle	annual	2
6.	You are now to the point where you may find it quickest to simply compare your sample with the photos of these 2 species in Weeds of the West. In this case the choice is between: henbit (page 362) and deadnettle (page 364)		

Table 2. Example of identification of an unknown plant sample (spotted catsear).

Decision No.	Your selected menus	Your selection	# of Species remaining
1.	Non Grass-like or Grass-like	Non Grass-like	304
2.	Flower color	yellow	116
3.	Juice	milky	18
4.	Leaf arrangement	all basal	5
5.	Leaf margin	lobed	3
6.	Height range	4 in - 8 in	2
7.	You are now to the point where you may find it quickest to simply compare your sample with the photos of these 2 species in Weeds of the West. In this example, the choice is between: spotted catsear (page 144) and dandelion (page 187)		

The menus contain a diversity of technical and non technical characters as well as characters associated with senescent, fruiting, flowering or vegetative stages. This diversity allows the user to describe (select) characteristics consistent with his skill level and with the condition of the specimen to be identified.

Program features include:

1. select for characteristics : = A
2. select against characteristics : does not = A
3. select multiple characteristics : A or B
4. select multiple characteristics : A and B
5. list characteristics of selected species
6. show "moot" characters; i.e. after selection of milky juice, the "aromatic" menu is marked as "moot" since no plant in the database with milky juice is aromatic.

The program format allows it to be modified for any set of attributes. It could be used to identify soils, insects, pathogens etc. The following databases using this program are currently being prepared:

1. Pacific Northwest Noxious Weeds
2. Identification and clinical symptomology of poisonous plants of the United States
3. Selected Weeds of Oregon
4. California Growers Guide
5. Southern Society of Weed Science identification manual
6. Turf weeds of the Southern U.S.
7. Common weeds of Kansas
8. Weeds of the North Central States

The program can be adapted to refer any customized set of species to several reference books. The WEEDS program is accompanied by a manual which explains program operation and illustrates the characteristics used in plant identification.

A THREE YEAR STUDY OF SOLANUM SPECIES CONTROL IN PROCESSING TOMATOES. Jack P. Orr and Robert J. Mullen, Farm Advisors, University of California Cooperative Extension, Sacramento County, 4145 Branch Center Road, Sacramento, CA 95827, and San Joaquin County, 420 South Wilson Way, Stockton, CA 95205.

INTRODUCTION

Hairy nightshade (*Solanum sarachoides* Sendter) and black nightshade (*Solanum nigrum* L.) are widespread major weed problems in California processing tomatoes causing sever economic loss to growers. This loss amounts to greater than $68 million due to hand hoeing costs and yield reductions. The present experiments show metham applied preplant subsurface; calcium cyanamide applied preplant pre-emergence; metribuzin applied postemergence as a split application; and ethiozin applied pre-emergence can be effective for control of *Solanum* and other weed species.

METHODS

Metham, calcium cyanamid, and ethiozin were applied in a randomized complete block design with four replications. Rates ranged from 23 L/ha to 1,866 L/ha. The 233 L/ha treatment was applied as a 50:50 ratio with water. All rates above this were applied in concentrated form. Metham was applied with a V-shaped spray blade 5.08 cm below the soil surface and capped with 7.62 cm of soil. Ten to 14 days later, caps were removed, beds reshaped, and tomatoes planted. Calcium cyanamide at rates of 9076 kg/ha and 1,210 kg/ha and ethiozin at 0.121 to 1.21 kg/ha were applied as surface treatments and sprinkler irrigated. Tomatoes were drilled immediately into the ethiozin treatments and 10 to 14 days later in the calcium cyanamid treatments.

Metribuzin in a split plot design was applied postemergence to tomatoes in the first to second true-leaf stage and *Solanum sp.* in the cotyledon to first leaf stage. Rates ranged from 0.096 to 0.54 kg/ha at the first treatment stage. A second application was made 5 to 7 days later at rates of 0.42 and 0.6 kg/ha to tomatoes in the 2 to 4 leaf stage and *Solanum sp.* in the 1 to 3 leaf stage. This application was in addition to the first treatments. Tomato and weed control efficacy data was taken visually and also by count. Treatments were harvested by hand and weighed to determine differences.

RESULTS

Results from a number of field trials, with good soil moisture, show metham is very effective in controlling *Solanum sp.* at rates from 233 to 1,866 L/ha. The most effective use rate economically and efficaciously is 466 L/ha. *Solanum sp.* control of 98% was obtained. Hand hoeing time required to remove nightshade was reduced by 70%. Many common annual weed species were not controlled by metham.

Calcium cyanamid gave 89% *Solanum sp.* control at the 1,210 kg/ha rate and a yield of 91.2 T/ha compared to the control at 61.4 T/ha. Metribuzin at 0.21 kg/ha followed by a second application six days later of 0.42 kg/ha resulted in 98% control of hairy nightshade, 100% lambsquarter and malva species control, and a tomato yield of 54.6 t/ha versus 47.7 T/ha single application and 23 T/ha in the control. Ethiozin gave 100% control of redstem filaree and redroot pigweed with excellent tomato tolerance.

CONCLUSION

Tomatoes showed excellent tolerance to ethiozin as a pre-emergence herbicide. Other studies show it is very effective in controlling *Solanum nigrum*. This could prove to be very beneficial to tomato growers economically through enhanced yield and reduced hoeing costs. Metham as a subsurface, preplant treatment under good moisture conditions and metribuzin as a postemergence, split application to *Solanum sp.* in the cotyledon stage and tomatoes in the first to second leaf stage can be very effective herbicide treatments.

OXYFLUORFEN FOR POSTEMERGENCE WEED CONTROL IN CHILE PEPPERS. Jill Schroeder, Assistant Professor, Department of Entomology, Plant Pathology and Weed Science, New Mexico State University, Las Cruces, NM 88003.

Abstract. No herbicides are currently registered in chile peppers (*Capsicum annuum* L.) for the control of broadleaf weeds that emerge after thinning. Oxyfluorfen is a contact herbicide registered as a postemergence-directed treatment in cotton. Preliminary research indicated that oxyfluorfen may be effective for postemergence weed control in chile peppers as well. Experiments were conducted at Las Cruces and Artesia, NM in 1990 to determine if late season broadleaf weed infestations are detrimental to chile production and to determine the optimum rates and timing of oxyfluorfen application for maximum weed control with minimum crop damage. Chile peppers were planted in mid-March at both locations and thinned in late May (10 cm height). Plots were 4 rows (100 cm spacing) by 7.6 m and were cultivated and hand-weeded prior to thinning. After thinning, two rows of each plot were hand-weeded and two rows were not. Sethoxydim was applied as needed to control grasses in the plot area. Oxyfluorfen at 0, 0.14, 0.28 and 0.14 followed by 0.14 kg/ha plus a nonionic surfactant at 0.125% (v/v) was applied to all four rows/ plot 1, 2, or 4 weeks after thinning or at layby (1 month prior to green pod harvest). The weed-free rows were evaluated for crop injury and the weedy rows were evaluated for weed control by species. One weed-free row and one weedy row/ plot were harvested by hand for red chile. Oxyfluorfen caused no visual injury or yield reduction at either location. At Artesia, weed infestation was moderate with prostrate pigweed as the primary species. Chile red pod yield in the nontreated controls averaged 4200 and 2800 kg dry weight/ha under hand-weeded and weedy conditions, respectively. All sequential herbicide applications (0.14 kg/ha at 1, 2, or 4 weeks after thinning followed by 0.14 kg/ha as needed) controlled the weeds and the yields in the weedy rows equalled yields in the weed-free rows (4200 kg/ha). At Las Cruces, weed infestation was heavy with primarily wright groundcherry and Palmer amaranth. Chile yield in the nontreated controls averaged 2200 and 675 kg/ha under hand-weeded and weedy conditions, respectively. Oxyfluorfen applied as a sequential treatment at 0.14 kg/ha (2 weeks after thinning) followed by 0.14 kg/ha (4 weeks after thinning) provided equivalent yields in the weedy and hand-weeded plots (3200 kg/ha).

SURVIVAL OF A SOIL BACTERIUM FOR WEED CONTROL. H.D. Skipper, A. C. Kennedy, and A. G. Ogg, Jr. Visiting Scientist and Research Scientists, Clemson University, Clemson, SC 29634-0359 and USDA-ARS, Pullman, WA 99164-6421.

Abstract. Plant-suppressive bacteria have the potential to inhibit weeds in agroecosystems. These biocontrol agents may be available as commercial products in the future. They may be active or stimulated via sustainable agricultural practices such as crop rotations or cover crops. To be an effective weed management agent, rhizobacteria must survive long enough to become established (colonize) on host-crop or weed roots. Crop roots may serve as live carriers for biocontrol agents. The objectives of this research were: 1) to monitor survival of *Pseudomonas fluorescens* strain D7rif in Palouse and Ritzville soils under greenhouse conditions; 2) to ascertain survival and colonization of wheat roots in the field by D7rif when applied in the seed furrow at planting; 3) to determine survival of D7rif when applied postemergence at three field sites.

Application of D7rif bacterium at 0.5 to 2 inch depth to simulate placement in a seed furrow increased its survival to >21 days in the Ritzville soil. The bacterium was not detected beyond 3 days when applied to the soil surface. D7rif was not detected in the Palouse soil after 3 days when applied to the soil surface or at 0.5 to 2 inch depths. Under field conditions, D7rif survived in the wheat seed furrow and colonized both seminal and crown roots and constituted 59 to 86% of the total pseudomonad population. These colonized wheat roots may serve as a carrier to transfer D7rif to downy brome roots that could inhibit the weed. A late season postemergence application under cold, damp conditions improved the movement of D7rif into the soil for protection against UV light and desiccation and onto roots of established wheat or downy brome. To date, D7rif has been detected on a limited number of downy brome roots. Postemergence efficacy of D7rif and its efficacy upon transfer from wheat roots to downy brome roots need confirmation.

DOWNY BROME COMPETITION IN PAIRED-ROW NO-TILL WINTER WHEAT. F. L. Young, A. G. Ogg, Jr., and V. L. Cochran, Research Agronomist, Plant Physiologist, and Soil Scientist, USDA/ARS, Rm. 215 Johnson Hall, Washington State University, Pullman, WA 99164-6421.

Abstract. Downy brome is a troublesome winter annual grass weed in dryland winter wheat where it infests approximately 5.7 million ha. In the past decade, growers have shown increased interest in no-till wheat production systems. One of these systems utilizes a paired-row concept that places a band of fertilizer between paired wheat rows. A 3-year field study was conducted to evaluate the competitiveness of downy brome on growth, development, and seed production of winter wheat. Downy brome was seeded in several locations relative to the deep banded fertilizer. The competitiveness of paired-row winter wheat on downy brome was determined also. Fertility rate was 112 kg/ha or 0 kg/ha of ^{15}N depleted NH_4NO_3. Weed-free winter wheat that was fertilized produced 40, 0, and 20% more grain than unfertilized wheat in 1986, 1987, and 1989 respectively. In 1987, when there was no yield response to fertilizer, soil moisture was the limiting factor. Fertilized wheat that year produced 23% more heads/m for but, seed weight was 21% less than unfertilized wheat. Depending on the growing season, downy brome reduced the yield of unfertilized wheat 9 to 32% whereas yield of fertilized wheat was reduced 10 to 36%. Downy brome produced 34% more seed in fertilized conditions than in unfertilized conditions. In general, more seed was produced by downy brome located between sets of paired rows than when grown either over the fertilizer band or in the crop row.

FITNESS STUDIES OF ITALIAN RYEGRASS RESISTANT TO DICLOFOP-METHYL: 1. SEEDLING DEMOGRAPHY AND PLANT GROWTH. M.L. Roush, C.M. Ghersa, M.A. Ghersa, and S.R. Radosevich, Research Assistant Professor, Visiting Professor, Research Assistant, and Professor, Forest Science Department, Oregon State University, Corvallis, OR 972331.

Abstract. The spread of herbicide resistance and the potential for its management are extremely sensitive to differences in fitness between resistant and susceptible biotypes. Fitness of a biotype can be influenced at any point in its life cycle; however, few herbicide resistance studies address more than relative competitiveness of biotypes in vegetative growth. Field experiments were conducted over 2 yr to compare demographic and growth traits of seeds and seedlings of Italian ryegrass biotypes that are resistant and susceptible to diclofop-methyl.

In 1989, seeds of each biotype were planted in pure stands and in mixture with winter wheat. Permanent quadrats were established in each plot and the seeds in each quadrat were mapped and counted. We monitored the quadrats daily, then weekly, bi-weekly, and monthly, to follow seedling emergence, plant establishment, and plant mortality. Plants were harvested periodically from outside the quadrats to measure plant growth and reproductive output. The populations were grown through maturity, and then followed into a second yr.

The first obvious difference between the biotypes was that the resistant ryegrass germinated later and over a longer period of time than the susceptibles. The resistant biotype continued to be developmentally delayed compared to the susceptible, through flowering and seed set. Growth (biomass, leaf area, growth rate) and reproductive yield of resistant plants was similar to susceptible plants. Over the entire growing season, susceptibles were slightly larger and leafier than resistant plants. Mortality (self thinning) occurred primarily in Spring and was sensitive to ryegrass density and to the presence of wheat. Patterns of mortality differed between biotypes and were strongly influenced by increasing density or adding a wheat crop.

FITNESS STUDIES OF ITALIAN RYEGRASS RESISTANT TO DICLOFOP-METHYL: 2. POLLEN PHENOLOGY AND GENE FLOW. C.M. Ghersa, M.A. Ghersa, M.L. Roush, and S.R. Radosevich, Visiting Professor, Research Assistant, Research Assistant Professor, and Professor, Forest Science Department, Oregon State University, Corvallis, OR 972331.

Abstract. In Italian ryegrass, self fertilization is prevented by enzymatic mechanisms and by differences in pistil maturation. The timing of pistil production is determined by the rates of tiller and spike production; however, since ryegrass anthers mature later than gynecia, effective fertilization is primarily limited by the rate of pollen production and liberation. Field experiments were conducted to evaluate pollen demography and the potential for crossing among individuals that are susceptible and resistant to diclofop-methyl.

Pollen demography of both biotypes was followed in plots where ryegrass was sown in pure stands and in mixture with wheat. Tillers bearing spikes that had already emerged from the flag leaf and before the anthers started to appear were bagged to collect anthers and pollen. Groups of tillers were covered sequentially until the end of the growing season. Tillers covered at a given date were sampled, weekly, over 4 weeks. The sampled bags were opened to count anthers and to estimate pollen liberation.

Pollen were dispersed 1 week earlier in the susceptible biotype than in the resistant; moreover, susceptible plants produced greater volumes of pollen over most of the growing season. Differences between the biotypes were even more marked when the biotypes grew in competition with wheat. Because of the discontinuity in pollen timing and abundance, resistant plants in this experiment had a high probability of being fertilized by pollen from the susceptible biotype and susceptible plants had a very low probabiltiy of being fertilized by resistant pollen.

FITNESS STUDIES OF ITALIAN RYEGRASS RESISTANT TO DICLOFOP-METHYL: 3. SELECTION PRESSURES FOR RESISTANCE AND GERMINATION TIME. C.M. Ghersa, M.A. Ghersa, M.L. Roush, and S.R. Radosevich, Visiting Professor, Research Assistant, Research Assistant Professor, and Professor, Forest Science Department, Oregon State University, Corvallis, OR 972331.

Abstract. Like most plant species, natural populations of ryegrass are made up of subpopulations characterized by different germination requirements; therefore, germination is spread through time. In a wheat cropping system, seedlings can be divided into two groups: those emerging before the wheat sowing date and those that emerge after the sowing date. We hypothesized that the ryegrass subpopulations that most frequently encounter selection pressure from the herbicide (diclofop-methyl) are those that emerge later in the season, because seedlings that emerge early would be eliminated by tillage during seedbed preparation. If so, we would predict that the herbicide resistant biotype (selected subpopulation) should display later emergence patterns than susceptible (wild) biotypes.

The hypothesis was tested in field experiments. In 1989, Italian ryegrass seed were sown in pure stands and in combination with wheat. Although first-year emergence patterns were consistent with the prediction that resistant seedlings should emerge later, there was no resident seedbank to test whether early germinators (prior to wheat sowing) are primarily susceptible to diclofop-methyl. Beginning in August, 1990, and continuing until Spring 1991, soil was disturbed in plots that had contained populations of resistant and susceptible ryegrass in the previous year. Field rates (1.12 kg/ha) of diclofop-methyl were sprayed on cohorts of newly emerged seedlings when they reached the two-leaf stage, to test for resistance. In the period prior to typical wheat sowing (August and September), four times more susceptible seedlings (wild type) emerged than resistant (selected). Thereafter, seedling recruitment was similar for both types. These results support our hypothesis. The difference between the two types in germination pattern during late summer and early fall may be due to more severe inhibition of germination by high temperatures in the resistant (selected) biotype than in the susceptible (wild).

EVALUATING THE SUSTAINABILITY OF A REGIONAL AGRICULTURE USING GIS AND AN INTERDISCIPLINARY, SYSTEMS APPROACH. M. L. Roush, S. M. Cordray, C. M. Ghersa, and S.R. Radosevich, Research Assistant Professor, Assistant Professor, Visiting Professor, and Professor, Departments of Forest Science and Sociology, Oregon State University, Corvallis, OR 97331.

Abstract. A holistic, spatially explicit, systems approach has been developed that links ecology, sociology, and economics to explore issues around sustainability of agriculture in Western Oregon. Central to the approach is a model that integrates across scales (field to regional to global) and among the disciplines of ecology (including soils, climate, biology, and agronomy), sociology, and economics. The model serves several purposes: (1) define the forces that determine how land use patterns and cropping systems evolve, (2) explain historical changes in land use patterns based on these forces, and (3) predict future changes in land use patterns and cropping systems.

Focusing on the regional scale, three clusters represent the factors or limitations to production that are defined by these disciplines. The ecology, sociology, and economics clusters interact with each other and with a cluster of external factors (environmental, biological, and societal) to determine the sustainability of cropping systems in a region. The Geographic Information System (GIS) organizes the multiple factors and their limitations to production, within an explicit spatial context. Obviously spatial factors, such as soil type and climate, are mapped into GIS from existing databases, such as the US Geological Survey. For sociological and economic factors that are not obviously spatial in nature, such as labor availability or production costs, we index limitations in a manner similar to the definitions of soil series. We then map the region into units of area with homogenous indices for a limitation. Separate maps are constructed for each factor or family of factors. GIS then overlays the maps to define the multiple forces acting on regional agricultural production, and to explain or predict land use patterns or cropping systems in the region.

The forces acting on agriculture, and therefore the predicted land use patterns and cropping systems, are changed or updated by feedback through the external factors cluster. Through this cluster, various "what if" scenarios can be explored. For example, the model can explore the impacts on cropping systems in Western Oregon if water limitations lead to restricted water rights, if public sentiment leads to legislation against burning field residues, or if a herbicide or family of herbicides become unavailable as a tool in crop management.

NOXIOUS RANGE WEEDS, PROCEEDINGS OF THE NOXIOUS RANGE WEED WORKSHOP. Michael Ralphs, USDA-ARS, Logan, UT 84322.

Paper not submitted for publication.

WSWS WEEDS OF THE WEST. Tom D. Whitson, Larry C. Burrill, Steven A. Dewey, David W. Cudney, B.E. Nelson, Richard D. Lee and Robert Parker, University of Wyoming, Laramie, WY 82071, Oregon State University, Corvallis, OR 97331, Utah State University, Logan, UT 84322, University of California, Riverside, CA 92521, University of Wyoming, Laramie, WY 82071, New Mexico State University, Las Cruces, NM 88003, and Washington State University, Prosser, WA 99350.

Abstract. Learning to identify unwanted plants around the home, farm or ranch will be much easier with a new book published by the Western Society of Weed Science and co-sponsored by cooperative Extension of the Western States. **Weeds of the West** is an extensive publication which can help you identify plants that compete with native plants, horticultural and agricultural crops as well as those that can poison livestock and people.

This extensive, easy-to-use guide contains more than 900 color photographs showing the early growth stages, mature plants and features for positive identification of each weed discussed. Descriptions, habitats, and characteristics of each plant are also included in this 650 page book.

WEEDS OF RANGE AND FOREST

CANADA THISTLE CONTROL AT TWO STAGES OF PLANT GROWTH WITH CLOPYRALID. Lynne L. Bixler, A. Wayne Cooley, and Vanelle F. Carrithers, Columbia River Chemical Inc., Rainier, OR 97048 and Technical Service & Development Specialist, DowElanco, Mulino, OR 97042.

INTRODUCTION

Canada thistle is a herbaceous perennial plant of the temperate regions. It is a severe problem because of its ability to invade cropland, pastures, and roadsides (1). This plant is extremely successful because of its ability to reproduce vegetatively from buds at nodes on rhizomes and adventitious buds on underground stems.

Canada thistle has been historically difficult to control because of its extensive root system and ability to regenerate. Canada thistle plants are most susceptible to herbicide control a) when the food reserves in the plants are at their lowest levels, and b) when sugars in the plant are moving basipetally so that translocation is greatest to the roots. In Canada thistle, food reserves are lowest 4 to 7 weeks after the plants emerge in the spring (usually the early bud stage) and downward movement of sugars in Canada thistle is greatest at full bloom (1). Therefore, herbicide treatments when Canada thistle are at early bud to full bloom will take advantage of these two physiological factors.

Control of Canada thistle in an undisturbed area is thought to be more difficult than in an agricultural setting where practices such as tillage, crop shading, competition, and previous herbicide treatments might reduce the vigor of the plant. Undisturbed Canada thistle populations were chosen for these trials in order to investigate the potential herbicide control under the most demanding conditions of plant vigor.

MATERIALS AND METHODS

The 1988 trial was located on an industrial site near Kelso, WA. Canada thistle covered 32% to 45% of the test area with the remainder of the area covered with field horsetail and grasses. The trial was laid out in a randomized block design with three replicates. The applications were made at 50 gpa using a handgun with a Teejet[1] 9515E nozzle. Treatments were applied at 50 psi pressure at the tank and the applicator traveled 2.5 mph. Applications were made at two stages of Canada thistle growth: (A) when plants were actively growing but before bud stage (prebud, May 11, 1988); and (B) when plants were in full bud to early bloom (bud, June 16, 1988). The thistle averaged 1 ft in height at the first application and 3 ft in height at the second. Clopyralid (formulated as the monoethanolamine salt) was evaluated at 2, 4, and 8 oz/A. Clopyralid plus 2,4-D was applied at 2 oz plus 0.625 lb, 4 oz plus 1.25 lb and 8 oz plus 2.5 lb/A. These were compared with metsulfuron at 1 oz/A and an untreated check. R-11[2], a nonionic surfactant, was added to the clopyralid treatments at 0.5% v/v and R-11 was added to the metsulfuron treatments at 0.25% v/v.

The 1990 test was located on a pasture site in Longview, WA. This test was also laid out in a randomized block design with three replicates. Canada thistle covered 35% to 53% of the plots with the remainder of the vegetation a mixture of pasture grasses.

The treatments were applied with a CO_2 sprayer mounted on the back of an all terrain vehicle with a three nozzle boom (Teejet XR8008 nozzles). Treatments were applied at the same volume, 50 gpa, as the 1988 test. The pressure was 45 psi at the CO_2 tank and the speed was 2.2 mph. Applications were made at the same timings as the 1988 test. The prebud stage application was applied May 25, 1990, when the Canada thistle averaged 18 inches in height. The bud application was made June 23, 1990, when the Canada thistle averaged 32 inches in height.

Clopyralid was evaluated at 2, 4, and 8 oz/A and compared with clopyralid + triclopyr amine (formulated as the triethylamine salt) at 2 oz plus 2.25 lb/A, and 4 oz plus 2.25 lb/A, clopyralid plus chlorsulfuron at 2 oz plus

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[1]Trademark of Spraying Systems, Inc.
[2]Trademark of Wilbur-Ellis Company

0.38 oz/A, and 4 oz plus 0.38 oz/A, triclopyr ester (formulated as the butoxyethyl ester) plus 2,4-D LVE at 1 lb plus 1.9 lb/A, chlorsulfuron at 0.38 oz/A and 1.5 oz/A. All were compared with an untreated check. R-11 surfactant was added to all mixtures at 0.25% v/v. Percent control of thistles was determined by visual observation of reduction in plant cover after treatments in both cases.

RESULTS AND DISCUSSION

1988 Trial. Five weeks after the prebud application significant (>58%) top kill of Canada thistle was obtained with all treatments except clopyralid at 2 oz/A where only 13% control was obtained (Table 1). Percent control increased with time, and when all treatments were evaluated 3 months after treatment, all of the prebud treatments except clopyralid at 2 oz/A gave 100% control of the thistle present at application. At 3 months after treatment, the prebud treatments were also evaluated for percent regrowth. Regrowth from roots was used to evaluate percent regrowth. Canada thistle regrowth in the clopyralid plus 2,4-D treatments and clopyralid at 4 and 8 oz/A treatments was least (less than 13%).

The treatments applied at bud were evaluated for percent control 8 weeks after treatment. Like the prebud applications, all the bud treatments except clopyralid at 2 oz/A provided excellent control (>68%) of the Canada thistle present. Generally, the clopyralid plus 2,4-D tended to provide a quicker knockdown of the thistle than the clopyralid alone. However, over time, the clopyralid alone controlled the Canada thistle as well as the clopyralid plus 2,4-D at similar rates of clopyralid.

In order to evaluate the long term control of Canada thistle, evaluations were made in the spring of 1989 after the plants had fully emerged. All combinations of clopyralid plus 2,4-D and clopyralid at 4 and 8 oz/A provided excellent control (>83%) of Canada thistle 1 yr after application when applied at the prebud stage. Clopyralid at 2 oz/A did not control Canada thistle initially or the year after treatment when applied at the prebud stage. Metsulfuron at 1 oz/A had an average of 33% control for this application timing. The addition of 2,4-D to clopyralid did not appear to significantly increase long term control.

The bud treatments generally showed less control the year after treatment than the prebud treatments. There was a definite relationship between the rate of clopyralid and percent control. Greater control was obtained as the rate of clopyralid increased whether applied alone or with 2,4-D. Metsulfuron applied at the bud stage had 25% control of thistle the second year. Treatments applied prebud provided better control the second year than treatments applied at bud.

1990 Trial. At 1 month after the prebud application all of the treatments provided from 77% to 97% control of Canada thistle (Table 2) except chlorsulfuron at 0.38 oz/A which averaged 65% control. At two months after application, all treatments provided >84% control of Canada thistle (Table 2).

To evaluate seasonal control and to get an indication of long term control, all treatments were evaluated by counting the number of Canada thistle plants in each plot at 3 months after each application. Since all treatments controlled foliage present at the time of application, counts were made of newly emerged plants. The number of plants to regrow varied considerably among treatments. Clopyralid at all rates and chlorsulfuron at 1.5 oz/A had the fewest number of thistle plants to regrow when applied at the prebud stage.

The addition of chlorsulfuron to clopyralid did not seem to enhance or inhibit the activity of clopyralid on Canada thistle control when applied prebud. There was slightly more regrowth of Canada thistle when the combinations of chlorsulfuron and clopyralid were used than when clopyralid was applied alone at similar rates. When treatments were applied prebud, triclopyr ester plus 2,4-D at 1 lb plus 1.9 lb/A resulted in a similar amount of regrowth as clopyralid plus triclopyr amine at the rates tested.

The number of Canada thistle plants regrowing from the applications made at bud stage were less than the number regrowing from applications made at prebud. Very little regrowth was observed with clopyralid at 2, 4, and 8 oz/A, clopyralid plus triclopyr amine at 4 oz plus 2.25 lb/A, and clopyralid plus chlorsulfuron at 4 oz plus 0.38 oz/A. Chlorsulfuron at 1.5 oz/A and clopyralid plus triclopyr amine at 2 oz plus 2.25 lb/A and clopyralid plus chlorsulfuron at 2 oz plus 0.38 oz/A had a similar amount of regrowth of Canada thistle plants 3 months after the bud application.

Table 1. Canada thistle control at two stages of plant growth using clopyralid and combinations in 1988 trial.

Treatment	Rate	Average control			Average regrowth	Average control	
		Prebud[a] 5 WAT[b]	Prebud 3 MAT	Bud 8 WAT	Prebud 3 MAT	Prebud 1 YAT	Bud 1 YAT
	(A)	--------	--------	--------	%	--------	--------
Clopyralid + 2,4-D	2 oz + 0.625 lb	70 ab	100	90 a	8	90 a	53 ab
Clopyralid + 2,4-D	4 oz + 1.25 lb	75 ab	100	98 a	13	78 a	55 ab
Clopyralid + 2,4-D	8 oz + 2.5 lb	93 a	100	100 a	6	92 a	80 a
Clopyralid[c]	2 oz	13 c	27	30 b	5	20 b	38 ab
Clopyralid[c]	4 oz	58 b	100	68 a	8	83 a	68 a
Clopyralid[c]	8 oz	77 ab	100	95 a	8	87 a	75 a
Metsulfuron[d]	1 oz	68 ab	100	82 a	53	33 b	25 bc
Untreated check		0 c	0	0 c	--	0 c	0 c

[a]Prebud application date: 5-11-88. Bud application date: 6-16-88.
[b]Evaluations: 5 and 8 weeks (WAT), 3 months (MAT), and 1 year after treatment (YAT).
[c]R-11 (Trademark of Wilbur-Ellis) added at 0.5% v/v.
[d]R-11 (Trademark of Wilbur-Ellis) added at 0.25% v/v.
Numbers followed by different letters are statistically different. Mean separation by Student-Newman-Keul's Multiple Range Test at 5% level.

Table 2. Canada thistle control at two stages of plant growth using clopyralid and combinations in 1990 trial.

Treatment[a]	Rate	Average control			Regrowth (No. of plants)	
		Prebud[b] 1 MAT	Prebud 3 MAT	Bud 2 MAT	Prebud 3 MAT	Bud 3 MAT
	(A)	--------	%	--------		
Clopyralid	2 oz	77 c	94	95 a	4.0	2.7
Clopyralid	4 oz	87 ab	100	95 a	4.6	3.0
Clopyralid	8 oz	95 ab	100	99 a	6.3	0.3
Clopyralid + triclopyr amine	2 oz + 2.25 lb	98 a	100	88 a	20.0	10.0
Clopyralid + triclopyr amine	4 oz + 2.25 lb	97 a	100	97 a	13.3	1.3
Clopyralid + chlorsulfuron	2 oz + 0.38 oz	90 ab	100	84 a	9.3	7.3
Clopyralid + chlorsulfuron	4 oz + 0.38 oz	97 a	100	85 a	8.6	1.3
Triclopyr ester + 2,4-D LVE	1 lb + 1.9 lb	93 ab	97	97 a	19.0	17.0
Chlorsulfuron	0.38 oz	65 d	100	96 a	36.6	23.7
Chlorsulfuron	1.5 oz	85 b	100	99 a	5.6	9.3
Untreated check		0 c	0	0 b	0	0

[a]R-11 (Trademark of Wilbur-Ellis) was added to all treatments at 0.25% v/v.
[b]Prebud application date: 5-25-90. Bud application date: 6-23-90.
Numbers followed by different letters are statistically different. Mean separation using Student-Newman-Keul's Multiple Range Test at 5% level

Triclopyr ester plus 2,4-D LVE at 1 lb plus 1.9 lb and chlorsulfuron at 0.38 oz/A showed the most regrowth of Canada thistle plants 3 months after application of treatments applied at bud (Table 2). Evaluations of regrowth will be made in the spring of 1991 after emergence of Canada thistle. These evaluations should provide a better indication of how well each of these treatments controls Canada thistle regrowth.

CONCLUSIONS

Clopyralid at 4 and 8 oz/A, clopyralid combinations with 2,4-D, triclopyr amine and chlorsulfuron, metsulfuron and chlorsulfuron all provided good to excellent seasonal control of Canada thistle regardless of timing. Clopyralid at 2 oz/A provided poor control of Canada thistle in the 1988 trial, however, this rate provided acceptable seasonal control in 1990. This inconsistent control with clopyralid at 2 oz/A may be the breaking point for Canada thistle control. Clopyralid at 2 oz/A plus 2,4-D, triclopyr amine or chlorsulfuron caused the thistle foliage to burn down more rapidly than when clopyralid at 2 oz/A was applied alone.

Clopyralid at 4 and 8 oz/A and clopyralid plus 2,4-D provided superior long term (one year after treatment) Canada thistle control in the 1988 trial. Control of thistle 1 year after treatment was optimal with clopyralid at 4 and 8 oz/A applied at the prebud stage. The addition of 2,4-D to clopyralid at 2 oz/A at the prebud stage significantly increased control of thistle through the year after treatment compared to clopyralid at 2 oz/A alone.

In the 1990 trial, Canada thistle regrowth 3 months after application was considerably less in the clopyralid at 2, 4, and 8 oz/A and chlorsulfuron at 1.5 oz/A than most other treatments. The only exceptions were clopyralid plus triclopyr amine at 4 oz plus 2.25 lb/A and clopyralid plus chlorsulfuron at 4 oz plus 0.38 oz/A when applied in the bud stage. Control of undisturbed Canada thistle populations with clopyralid proved to be similar to rates necessary for control in agricultural settings. Clopyralid at 3 to 4 oz/A has been the standard rate for controlling Canada thistle regrowth into the year after application in disturbed sites (Dean Gaiser, personal communication). Clopyralid at 4 and 8 oz/A proved to be very active on Canada thistle and generally provided better long term results than other treatments in these tests. However, direct comparisons between the 1988 and 1990 trials will be more meaningful once the 1990 test has been evaluated in the spring of 1991 (1 year after treatment).

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FACTORS AFFECTING PICLORAM ABSORPTION BY BROOM SNAKEWEED. Tracy M. Sterling and Norman K. Lownds, Assistant Professor and Assistant Professor, Entomology, Plant Pathology and Weed Science Department and Department of Agronomy and Horticulture, New Mexico State University, Las Cruces, NM 88003.

Abstract. Broom snakeweed is a suffrutescent shrub widely distributed in the western United States. Picloram is the major herbicide used for broom snakeweed control. The conditions during which this weed is most susceptible to picloram have not been defined. Therefore, research was conducted to increase picloram use efficiency by understanding how factors such as stage of plant growth, picloram concentration, relative humidity and spray additives influence picloram uptake by leaf tissue. Picloram uptake was determined using excised stems from greenhouse- or field-grown plants. Droplets (0.25 μL) of ^{14}C-picloram (2-40 μCi/mL; 16.3 mCi/mmole) and ^{12}C-picloram to reach a final picloram concentration of 6.2 mM were applied to individual leaves. Final picloram concentrations for the concentration experiments ranged from 0 to 25 mM. Following treatment, excised stems were placed in a growth chamber (11 h photoperiod, 28/20 C day/night; 50% relative humidity) except in the relative humidity experiments where excised stems were placed in enclosed chambers containing saturated salt solutions (10 to 95% relative humidity). After 24 h, surface picloram residue was removed with a 50% aqueous methanol rinse. Tissue was oxidized and radioactivity in each sample quantitated

using liquid scintillation spectrometry. Picloram uptake by leaves from greenhouse-grown and field-grown plants was similar. Picloram uptake by leaves from field-grown plants collected throughout the year (January to November, 1990) ranged from 5 to 15% of applied. Increasing picloram concentration resulted in a linear ($r=0.914^{***}$) increase in picloram uptake (nmol picloram/g fresh weight). Picloram uptake (% of applied) increased quadratically ($r=0.921^{***}$) with increasing relative humidity. Picloram uptake increased 10-fold from 10 to 95% relative humidity. Adding a crop oil concentrate to the picloram formulation increased picloram uptake six-fold. Apparently, several factors, other than stage of plant growth, influence picloram uptake by broom snakeweed leaves.

THE LIGHT REQUIREMENT OF DORMANT SPOTTED KNAPWEED SEEDS IN SOIL.

J. L. Lindquist, P. K. Fay, and E. S. Davis, Research Assistant, Professor, Research Associate, Department of Plant and Soil Science, Montana State University, Bozeman, MT 59717.

INTRODUCTION

More than 110 yr ago, in 1880, Dr. W. J. Beal buried seed of 23 species in order to periodically determine viability. Ten yr later, the seeds of 11 species were viable, and 90 yr later seeds of three species were still viable (4). One important characteristic used to classify a plant species as a weed is persistance in soil seed banks (1). Spotted knapweed seeds have been shown to persist in the soil seed bank for at least 7 yr (3).

Weed seedling emergence from soil tends to decrease as planting depth increases, a trend that has been shown to occur in at least 8 weed species, including spotted knapweed (5). This trend in seedling emergence appears to mean that seeds are capable of recognizing the distance to the soil surface, and therefore, when to remain dormant. At least five factors may control germination regulation by depth: light, soil weight, soil moisture, soil oxygen and carbon dioxide level, and soil temperature. The purpose of this research was to determine the role several of these factors play in the germination behavior of dormant seeds in soil.

MATERIALS AND METHODS

The effect of planting depth on the germination of spotted knapweed seeds was determined. Twenty-five spotted knapweed seeds were spread evenly between two fine-mesh nylon screens. The screens were then buried at five depths in soil, either on the soil surface, at 0.6, 1.3, 2.5, or 5.1 cm deep. Pots were placed on greenhouse benches and watered under an automatic misting system delivering approximately 0.8 cm of water per day at regular intervals. After 17 days, pots were moved to a dark room equipped with a green safelight, where screens were removed from the soil, germinated and ungerminated seeds were separated and counted. Each depth treatment was replicated eight times.

Percent light requirement of dormant seeds exhumed from all four planting depths of the previous experiment was determined. Germinated and ungerminated seeds exhumed from all four planting depths were separated and counted as described above. The ungerminated seeds were then placed in petri dishes and treated under light (380 umol m^{-2} s^{-1} PAR, 12 hr photoperiod) and dark conditions for 10 days.

Percent light requirement of dormant seeds exhumed from soil after 7 yr of burial was determined. In 1982, Chicoine (2) buried 100 spotted knapweed seeds 1.3 cm deep in a large number of 118 cm^3 PVC rings. Rings were then buried in the field such that the upper edge was flush with the soil surface. In October, 1990, eight of these 7 yr old burial rings were excavated from soil, immediately wrapped in aluminum foil, and placed in the dark room. Under green safelight, seeds were separated from soil by sieving, counted, placed in petri dishes, and then treated under light and dark conditions for 8 days.

Percent seedling emergence from five planting depths was determined before and after the removal of soil weight. Twenty five spotted knapweed seeds were planted at 0.6, 1.3, 2.9, 4.4, or 5.1 cm deep in 5.7 cm deep PVC pots. Pots were then placed in greenhouse flats filled with coarse sand. After 17 days on a greenhouse bench, percent seedling emergence was calculated, then pots were inverted, so that seeds formerly planted 5.1

or 4.4 cm deep were 0.6 or 1.3 cm deep. After pot inversion, seedling emergence was counted for another 17 days. Each depth treatment was replicated 10 times.

RESULTS AND DISCUSSION

Spotted knapweed germination decreased significantly with increasing planting depth (Figure 1). Ninety-five percent germination occured when seeds were placed in the light on the soil surface, and germination decreased with each increase in planting depth. Light had a minor influence on the germination behavior of buried spotted knapweed seeds. Dormant seeds exhumed from all four planting depths germinated 95± 7% in light, and 77± 13% in darkness. Thus, only 18% of the dormant seeds exhumed from soil after 17 days of burial had a light requirement.

Seeds buried for 7 yr in soil displayed similar behavior. Twenty-nine percent of the seeds exhumed from 7 yr-old burial rings were viable, the rest had either germinated or died in the field. Of the viable seeds, 100± 1% germinated in the light, and 70± 22% germinated in the dark. Thus, only 30% of the viable seeds exhumed from soil after 7 yr of burial were light requiring. From these data, it can be concluded that a high percentage of buried spotted knapweed seeds remain dormant due to factors not associated with a light requirement. A second factor which may cause the decrease in germination with increasing planting depth was the differential weight of the soil overburden on the seed. It is possible that different amounts of overlaying soil exert pressure upon the seed coat which may constrain radicle extension.

During the 17 day prior to pot inversion, percent seedling emergence was 94%, 96%, 58%, 21%, and 34%, from planting depths of 0.6, 1.3, 2.9, 4.4, and 5.1 cm, respectively. It was expected that, after pot inversion, the percent seedling emergence from the lower two initial planting depths would increase significantly, since these seeds were no longer under the same overburden pressure. However, no additional seedling emergence occurred from any depth following pot inversion. It appears that buried spotted knapweed seeds remain dormant due to factors unrelated to soil weight.

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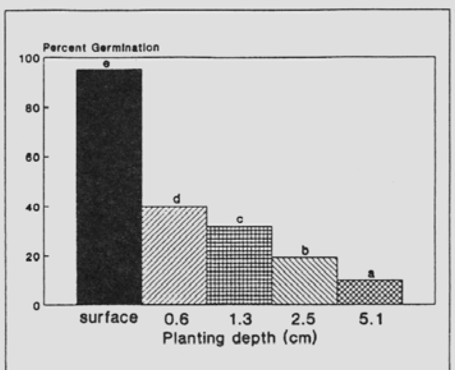

Figure 1. Percent germination of spotted knapweed seeds during burial at five depths in soil. Paired bars with different letters differ significantly at the 5% level according to the Student's T.

EFFICACY OF CUT STUMP TREATMENTS FOR CONTROLLING BIGLEAF MAPLE. E. C. Cole and M. Newton, Senior Research Assistant and Professor, Department of Forest Science, Oregon State University, Corvallis, OR 97331-5705.

INTRODUCTION

Bigleaf maple is commonly found in Douglas-fir stands in the Pacific Northwest. Its rapid juvenile growth makes it a major competitor in young conifer plantations. An experiment was initiated to examine efficacy of various herbicide cut stump treatments for controlling sprouting of bigleaf maple.

The site selected was located approximately 5 miles north of Corvallis, Oregon. The study stand consisted primarily of bigleaf maple, approximately thirty years old. Stem diameters ranged from 5 to 13 inches, and trees were approximately 40 to 50 feet tall at the time of cutting.

TREATMENT PROCEDURES

All treatments included 9 sample trees in three groups of three trees. Treatments were randomly assigned to each group of 3 trees. Treatments are listed in Table 1. Applications were made at two times, April 7 and August 11, 1989.

Herbicide application was made by cutting the trees down by chainsaw. Then within 30 minutes after cutting, aqueous herbicide mixtures, as listed in Table 1, were applied to the cut stumps. Concentrations were based on percent product, and no oil or surfactant was added. Applications were made with syringes at the rate of 1 ml solution or emulsion per inch of stump diameter. Solution was dripped from the syringe in a ring just inside the cambium of the stump. For ease of application, the stand was divided into two units, one for each season of application.

RESULTS

Cut stumps were evaluated in July 1990. Each sprout clump was measured for width in two directions and height. Vigor of sprouts was also ocularly rated with the following scale: 0--excellent vigor; 1--slight signs of injury; 2--significant signs of injury, including yellowing and stunting of leaves; 3--sprout stunting and dieback; and 4--no sprouting.

Only one treatment (picloram plus triclopyr amine in April) resulted in no sprouting of all sample stumps (Tables 2 to 6). Sprouting among the other treatments was highly variable. All treatments except for the untreated stumps and the triclopyr ester 75% in April had at least 1 stump with no sprouts. Treatments in April generally resulted in greater crown volumes than those in August. Since this was also true for the untreated stumps, part of this response is due to the timing of the cutting rather than to the timing of the herbicide treatments. When making comparisons, it is best to compare the April herbicide treatments to the April controls and the August herbicide treatments to the August controls. The exceptions to this trend were the imazapyr, triclopyr amine at 67%, and picloram plus 2,4-D at 50% treatments. These three treatments along with the picloram plus triclopyr amine treatments resulted in the best overall inhibition of sprout development.

Most of the sprouts in the picloram, imazapyr, and triclopyr amine treatments exhibited reduced vigor (Tables 5 and 6). These sprouts showed symptoms of herbicide injury, such as stunting of foliage, yellowing of foliage, and in some cases foliage necrosis. The majority of sprouts in the 2,4-D and triclopyr ester treatments were healthy-looking.

Sprouting on some of the clumps occurred one to two feet back along the stem. Trees had been cut horizontally to leave about a 1-foot stump. Since the study was on a 70% slope, some of the trees had trunks that extended horizontally for two to three feet uphill of the place where a horizontal cut could be made. This increased the distance that the chemical needed to be translocated to kill active buds, thus increasing the probability of sprouting. It was also noted that sprouts originating further back on the stump had better vigor than those arising from closer to the cut area.

Table 1. Treatments for bigleaf maple cut stumps.

Treatment	Formulation	Solution	Month
	(ai/gal)	%	
Picloram (K salt)	2 lbs	12.5, 25, 50	Apr, Aug
Picloram + 2,4-D	0.54 lb+2 lbs	50, 100	Apr, Aug
Picloram +	2 lbs +	25 +	
triclopyr amine	3 lbs	33	Apr, Aug
Triclopyr amine	3 lbs	33, 67, 100	Apr, Aug
2,4-D amine	4 lbs	100	Apr, Aug
Triclopyr ester	4 lbs	25, 50, 75	Apr, Aug
Imazapyr	4 lbs	25	Apr, Aug
Felled control			Apr, Aug

Table 2. Average crown dimensions by treatment.

Chemical	%	Month	W1	W2	Ht[a]
			----(cm)----		
2,4-D	100	April	67	82	89
	100	Aug	64	55	84
Imazapyr	25	April	5	4	4
	25	Aug	11	11	11
Picloram	12.5	April	46	39	58
	12.5	Aug	46	27	41
	25	April	49	42	52
	25	Aug	16	28	24
	50	April	20	33	30
	50	Aug	13	21	17
Triclopyr amine	33	April	101	91	84
	33	Aug	47	36	55
	67	April	3	2	8
	67	Aug	10	7	9
	100	April	31	18	28
	100	Aug	26	11	30
Triclopyr ester	25	April	104	79	121
	25	Aug	63	68	79
	50	April	95	81	126
	50	Aug	64	52	89
	75	April	129	106	186
	75	Aug	28	23	50
Picloram+2,4-D	50	April	6	7	10
	50	Aug	7	7	10
	100	April	27	32	34
	100	Aug	14	9	8
Picloram+	25+33	April	0	0	0
triclopyr amine		Aug	9	9	21
Untreated		April	228	269	317
		Aug	184	189	144

[a]W1 and W2 are crowns widths in two perpendicular directions; Ht is the height of the sprout clump.

CONCLUSIONS

Several treatments caused inhibition of sprout development. These included picloram plus triclopyr amine, picloram plus 2,4-D, imazapyr, and the higher concentrations of triclopyr amine. All treatments except for the picloram plus triclopyr amine were highly variable in individual cut stump response to sprouting.

Table 3. Average volume and percent of felled control for bigleaf maple cut stumps for April treatments.

Chemical	Rate	Month	Crown volume		Felled control
	(%)		--(cm^3)--		(%)
2,4-D	100	April	1090000[a]	b	10
Imazapyr	25	April	2750	b	0.02
Picloram	12.5	April	569000	b	5
	25	April	297000	b	3
	50	April	291000	b	3
Triclopyr amine	33	April	1630000	b	15
	67	April	2440	b	0.02
	100	April	247000	b	2
Triclopyr ester	25	April	1360000	b	12
	50	April	1860000	b	17
	75	April	1890000	b	17
Picloram + 2,4-D	50	April	3740	b	0.03
	100	April	297000	b	3
Picloram + triclopyr amine	25+33	April	0	b	0
Felled		April	11300000	a	100

[a]Means followed by the same letter are not significantly different at alpha=0.05 using least squares means comparisons.

Table 4. Average volume and percent of felled control for bigleaf maple cut stumps August treatments.

Chemical	Rate	Month	Crown volume		Felled control
	(%)		--(cm^3)--		(%)
2,4-D	100	Aug	287000[a]	b	10
Imazapyr		Aug	3920	b	0.1
Picloram	12.5	Aug	102000	b	4
	25	Aug	144000	b	5
	50	Aug	36200	b	1
Triclopyr amine	33	Aug	173000	b	6
	67	Aug	25100	b	0.9
	100	Aug	132000	b	5
Triclopyr ester	25	Aug	407000	b	14
	50	Aug	255000	b	8
	75	Aug	68600	b	2
Picloram + 2,4-D	50	Aug	5150	b	0.2
	100	Aug	18300	b	0.6
Picloram + triclopyr amine	25+33	Aug	17900	b	0.6
Felled		Aug	2870000	a	100

[a]Means followed by the same letter are not significantly different at alpha=0.05 using least squares means comparisons.

Table 5. Average sprout vigor and percent mortality for bigleaf maple cut stumps for April treatments.

Chemical	Rate	Month	Sprout vigor	Mortality
	(%)			(%)
2,4-D	100	April	1.89	22
Imazapyr	25	April	3.88	88
Picloram	12.5	April	2.67	44
	25	April	2.75	50
	50	April	3.33	78
Triclopyr amine	33	April	1.00	22
	67	April	3.56	89
	100	April	3.11	78
Triclopyr ester	25	April	0.89	22
	50	April	1.33	38
	75	April	0.33	0
Picloram + 2,4-D	50	April	3.11	67
	100	April	3.11	78
Picloram + triclopyr amine	25+33	April	4.00	100
Felled		April	0	0

[1] Means followed by the same letter are not significantly different at alpha=0.05 using least squares means comparisons.

Table 6. Average sprout vigor and percent mortality for bigleaf maple cut stumps for August treatments.

Chemical	Rate	Month	Sprout vigor	Mortality
	(%)			(%)
2,4-D	100	Aug	1.00	11
Imazapyr	25	Aug	2.78	44
Picloram	12.5	Aug	2.44	12
	25	Aug	3.25	75
	50	Aug	3.33	67
Triclopyr amine	33	Aug	1.78	33
	67	Aug	3.67	89
	100	Aug	3.11	78
Triclopyr ester	25	Aug	0.89	22
	50	Aug	1.22	22
	75	Aug	2.44	44
Picloram + 2,4-D	50	Aug	3.33	78
	100	Aug	3.44	78
Picloram + triclopyr amine	25+33	Aug	3.33	78
Felled		Aug	0	0

[1] Means followed by the same letter are not significantly different at alpha=0.05 using least squares means comparisons.

GROUND-APPLIED HERBICIDE METHODS FOR RED ALDER CONTROL: HERBICIDE EFFICACY, LABOR COSTS, AND TREATMENT METHOD EFFICIENCY. Paul F. Figueroa, Weyerhaeuser Company, Centralia, WA 98531.

INTRODUCTION

The 1988 Washington Administrative Codes, WAC 222.38.020(5) was added to the Forest Practice Act as a result of the Timber, Fish and Wildlife agreements. This statute placed restrictions on aerial herbicide application in proximity to flowing waters. It requires that herbicides be kept from entering streams. It also requires a 50-foot buffer strip to protect class 1, 2, 3 and flowing class 4 and 5 streams, and 100 and 200-foot aerial spray buffers adjacent to other landowners and residences, respectively.

Implementation of these statutes has significantly affected hardwood control operations in conifer plantations. These new restrictions affect herbicide applications in the following ways: 1) normal helicopter flight paths had to be altered to less efficient patterns, increasing application costs; 2) there are increased planning and general application costs; 3) additional drift control agents are required in the herbicide formulations; and, 4) conifer production may be reduced when red alder cannot be treated by conventional aerial herbicide application. This has left extended acres of productive conifer land under severe red alder competition. Red alder can significantly lower conifer yields on those buffer acres, if not subsequently controlled.

Ground-applied hardwood control systems offer alternative methods to maintain these acres in conifer production. There have been several trials testing ground-applied red alder control techniques in the northwest that offer alternatives to aerial herbicide application in these situations. Manual cutting of alder has been tested for alder control, but Roberts (10) showed that red alder aggressively resprouts after manual cutting. Her data indicated that red alder stumps can sprout within one year and regain height dominance giving negligible release to the conifers.

Hoyer and Belz (6) determined that a combination of factors, including age, high plant moisture stress, and low carbohydrate reserves are influential in limiting red alder's ability to resprout after cutting. June and July control treatments were most effective minimizing cut alder resprouting. DeBell and Turpin (3) further tested the effects of cutting red alder at different times to reduce sprouting. They showed that sprouting was minimized if cutting treatments were timed between 60 and 120 days after red alder bud break. Alder cut outside that window would require herbicide treatments to cut stumps to prevent resprouting.

Carrithers (2) reported on a low-volume basal application technique that used solutions of 20 to 30% triclopyr in diesel oil. It is applied to stem surface by spraying to give a light paint coat appearance to the lower 18 inches of bark surface. This method provides an advantage over conventional basal applications because less solution is required and application time is reduced, thus increasing productivity. Melichar, Hall and Hendler (8) reported 80 to 100% control of several southern hardwoods using this technique.

The thin-line application method dispenses a solid stream of undiluted triclopyr to band each stem. At least two sides of each stem are treated. A very quick pass of the herbicide stream is sprayed across the each stem. This has been tested on red alder by Paul Lauterbach and Bryon Loucks (personal communication) on the Weyerhaeuser, Pe Ell District, giving almost 100% alder control. They observed lower alder control with a 25% triclopyr solution with a September application date. Hibbs and Landgren (5) found good red alder control was obtained using thin-line applications as a dormant application on stems less than 1 inch diameter at breast height (DBH) with dilutions of 15 to 60% triclopyr in kerosene. They reported lower success on stems 1 to 2 inches DBH.

The stream-line method is a variation of the thin-line technique. Triclopyr, diluted 10 to 50%, is applied as a 2 to 4 inch band on a single side of the stem. A diagonal or downward stroke of the wand is used to allow the solution to run down the stem. Application to one side of the stem reduces the time needed to treat the stem. Efficacy of this treatment appears to be similar to thin-line and is being investigated in Oregon and Washington (personal communication, Vanelle Carrithers, the DowElanco Company).

Stem injection is another ground-applied control method that has been tested. Mitchell and Ezell (9) reported on the use of tree-injection application methods. Tree-injection is usually limited to trees greater than 2 inches DBH. Typical injectors, like basal tube and Hypo-hatchet injectors, are expensive and can cause operator fatigue. However, use of light-weight tools could be just as effective, when low cost and accurate equipment can be developed.

A newly developed system for tree-injection, the Monsanto EZject herbicide lance, dispenses an unprimed 0.22 caliber rimfire cartridge case filled with 0.15 g of glyphosate. The lance injects the rim of the cartridge into the bark of trees. The glyphosate (depending on the formulation used) is activated by humidity in the air that rehydrates the glyphosate, or high temperatures that liquefy the herbicide into the cut in the bark made by the cartridge rim. This method has been used for pre-commercial thinning in Douglas-fir, western hemlock and lodgepole pine in Canada (1). Figueroa (4) reported 100% red alder and cottonwood control using this method in northern Washington.

While efficacy data was available for various ground control methods, no comprehensive comparison had been made of the efficacy of treatments and methods for use in streamside buffer areas. A study was established to compare current ground application methods using various herbicide solutions. The study was established in typical streamside buffer zones where red alder was the primary competitor and the management goal was to manage the unit for conifer production.

OBJECTIVES

There were two objectives for this study. The first objective was to develop the cost estimates for ground-applied manual control methods in variable density alder stands. The second objective was to evaluate efficacy of the various herbicide formulations for each system.

METHODS

The experimental design for herbicide efficacy was a completely randomized design. Herbicide solution effects were tested within each site (by treatment method) on alder mortality, DBH, and height. No statistical comparisons were made between sites. The local site conditions within each drainage, where the treatments were applied, were not considered uniform enough to make direct site to site comparisons. Treatments were analyzed using an analysis of variance and were considered different if the p-value exceeded a 0.10 probability level. When treatment differences were significant, differences amongst treatment means were separated using Duncan's New Multiple Range T-test. Individual treatment regression models were fit to determine the relationship of application time to alder density. Similarly, regressions were fit for the volume of herbicide solution used by red alder density.

The study was located in three plantations located on Weyerhaeuser Company land located in southwest Washington. Two test sites were established in six-year-old Douglas-fir plantations that had streamside buffer zones remaining from the previous years operational herbicide spray program. The third site was in a thirteen-year-old Douglas-fir plantation where red alder had not been treated due to the proximity of active research plots and was not in a streamside buffer area. This latter site was chosen since the mean DBH of red alder was suitable for stem injection treatments (i.e., greater than 2 inches DBH). Site descriptions are summarized in Appendix 1.

One set of 10 plots was installed in each of two drainages at each location. Plots varied in size according to alder density to encompass 15 to 30 red alder stems. Plot installation was designed to have samples representing alder stand densities between 100 and 3000 stems/A. Plots were located to fall within the streamside buffer area, but were situated such that no herbicide could enter any water regardless of treatment applied. In each plot, all conifers and hardwoods were tagged. Diameter, height, and damage was recorded for each tree. In addition, tree vigor was assessed to help identify herbicide efficacy on hardwoods and toxicity to conifers. Trees having at least 50% of their original foliage were classed as high vigor. Trees with less than 50% of their original foliage and live were classed as low vigor. The treatment method was randomly assigned to the drainages, and herbicide treatments were randomly assigned within each drainage.

The treatment methods tested were as follows:

Cut-surface: Chain-saw-felling of red alder, leaving a 4 to 6-inch stump cut at 15 to 30 degree angle to facilitate directional falling. Herbicides were applied to the cut stump surface within 5 minutes of cutting.

Low-volume basal: Spray to paint the herbicide solution from the ground to 18 inches in height on all sides of the stem.

Thin-line: Apply a 1 to 2-inch wide band at 6 to 12 inches height on two sides of every stem and a complete 360 degree band on trees with DBH greater than 3 inches.

Stream-line: Apply a band 3 to 4 inches wide from 18 inches in height down to 12 inches in height to allow solution to drip down the stem. Application made to one side of the stem.

Hack-and-squirt: Apply a cut with a hatchet 0.5 to 1.5 inches deep, at a 45 degree angle to the stem, and 2 to 4 feet above groundline. Inject 1 ml imazapyr herbicide solution into the bottom of the cut.

Capsule injection: Using a Monsanto EZject stem injector lance, inject a single glyphosate capsule at a 45 degree angle into each stem at 18 to 24 inches above groundline. Stems less than one inch diameter, inject at 6 inches above groundline. Capsules were placed on a vertical plane up the stem when more than one was used.

All treatments were applied by the same individual to maintain consistency of application between methods. The applicator was a licensed contractor with more than 20 yr experience in pre-commercial thinning and ground-applied herbicide treatments. The speed of treatment was set at a rate typifying a standard working pace for a contractor during a 6 to 8 hr work day.

Herbicide spray treatments were applied using the Weed Systems HQ300 backpack sprayer with a Spray Systems Y3 adjustable cone nozzle. Pressure was 30 psi (at the tank) for all treatments except for the thin-line treatment (20 psi). A Jecta-matic automatic syringe was used to dispense herbicide for the hack-and-squirt treatment. A Monsanto EZject lance injector was used for the capsule stem injection.

Herbicide application time, by plot, was recorded for both cutting and herbicide treatments. The herbicide solution volume used for each plot was measured and recorded for each plot. This data was later used to develop economic treatment relationships.

A stocking survey was made in both the Cambell and Stillwater Creek drainages. No other data was available to describe average densities or variability of alder in streamside buffer areas. A series of ten sample points were systematically established that transected the entire length of each drainage basin. At each sampling point, two 0.004 A plots were established. One plot was established 10 feet from the waters edge while the other was established 30 feet from the water's edge. This plot placement scheme would show density variation at various distances from the water's edge.

RESULTS

HERBICIDE EFFICACY

Cut-surface method. There were no significant differences in alder control amongst herbicide treatments for the cut-surface application (Table 1). None of the treatments exhibited any symptoms of herbicide flash-over toxicity to Douglas-fir. The herbicide treatments for the cut-surface treatments were balanced to reflect different herbicide solutions applied at a similar price per gallon of solution.

A few alder did resprout after treatment, but were of poor quality and low vigor and are not expected to be competitors with the conifers. Alder cut stumps off the plots, not treated with herbicides, had 100% resprouting, regaining their height dominance of the conifers in two years. Observations of one and two-year stump decay of treated stumps suggests lower levels of herbicides solutions could have been used while maintaining acceptable alder control. Lower herbicide solution levels would lower total treatment costs and be more comparable with other methods tested.

Low-volume basal method. Significant differences exist in herbicide control for triclopyr and imazapyr using the low-volume basal application method (Table 2). All triclopyr solutions had at least 98% alder control, while the imazapyr treatments had only 17 and 15% alder control, respectively. There was a trend toward higher control with increased imazapyr solution levels, but increasing the imazapyr concentration would increase costs greater costs for all triclopyr solutions that gave better control.

Table 1. Herbicide solution efficacy and phytotoxicity data for the cut-surface treatments.

Treatment		Mean DBH Age 6	Mean DBH Age 8	Mean Height Age 6	Mean Height Age 8	Vigor (age 8) High	Vigor (age 8) Low	Vigor (age 8) Dead
		(in)	(in)	(ft)	(ft)	%	%	%
RED ALDER								
Triclopyr	50%	2.1	0.3	20.7	4.0	0	1	99
Glyphosate	45%	1.6	0	18.7	0	0	0	100
Imazapyr	10%	1.7	0	18.9	0	0	0	100
DOUGLAS-FIR								
Triclopyr	50%	0.7	1.9	8.6	13.5	89	7	4
Glyphosate	45%	0.5	1.5	7.8	11.4	83	9	8
Imazapyr	10%	0.6	1.7	8.6	12.5	89	6	5

Table 2. Herbicide and solution efficacy and phytotoxicity data for the low-volume basal treatments.

Treatment		Mean DBH Age 6	Mean DBH Age 8	Mean Height Age 6	Mean Height Age 8	Vigor (age 8) High	Vigor (age 8) Low	Vigor (age 8) Dead
		(in)	(in)	(ft)	(ft)	%	%	%
RED ALDER								
Triclopyr	5%	1.1	0	13.6	0 a	0	0 a	100 a
Triclopyr	10%	1.8	0	18.9	0 a	0	0 a	100 a
Triclopyr	15%	1.9	1.0	19.0	7.9 b	0	2 a	98 a
Imazapyr	2%	1.2	1.9	14.7	15.1 b	36	47 b	17 b
Imazapyr	4%	1.2	1.5	14.8	13.8 b	8	77 b	15 b
DOUGLAS-FIR								
Triclopyr	5%	0.9	2.0 a	9.1	14.5 a	98 a	1 a	1
Triclopyr	10%	0.7	1.4 b	8.3	9.7 b	62 b	38 b	0
Triclopyr	15%	1.0	2.2 a	10.1	15.6 a	97 a	3 a	0
Imazapyr	2%	0.6	1.1 b	7.5	10.2 b	50 b	50 b	0
Imazapyr	4%	0.5	1.2 b	7.2	8.8 b	52 b	28 b	20

Treatments without letters and treatments with similar letters within a species are not significantly different using analysis of variance using Duncan's New Multiple Range T-test at P=0.10.

Several Douglas-fir on the triclopyr 10% treatment plots had lower tree vigor. Many of those trees were hit with herbicide splatter during spray application causing lower vigor. Both imazapyr treatments appear to cause higher conifer injury than the triclopyr treatments. An additional possible explanation for this damage could be uptake by conifers of imazapyr directly from the soil, or conifer roots absorbing material from decomposing alder roots.

Thin-line method. There were significant differences between herbicides used in the thin-line treatment as shown in Table 3. All triclopyr treatments showed better alder control over the imazapyr treatments. There was increasing alder mortality using higher imazapyr levels, but increasing imazapyr beyond 40% solution would raise herbicide costs higher than those for all triclopyr treatments.

The contractor found it difficult to identify every conifer mixed in with the alder. For the typical thin-line operation, as in bigleaf maple control, the operator sprays a solid stream of solution across the sides of stems in a single horizontal motion. In alder stands, this type of treatment increases accidental exposure to the non-target trees. Several conifer stems received accidental herbicide treatment. Douglas-fir was more sensitive to imazapyr than triclopyr and there was some evidence that conifers were picking up imazapyr through soil absorption or root contact on this treatment also.

Stream-line method. There were significant differences between herbicide solutions for the stream-line method (Table 4). However, only lowest imazapyr solution had different control rates. There were no significant differences among herbicide solutions on conifer impacts, except imazapyr gave a higher risk for non-target conifer injury.

Hack-and-squirt method. All imazapyr hack-and-squirt treatments were effective controlling red alder. There was no improvement of alder control when the solution was applied in two cuts (on opposite sides of the stem) compared to the same volume solution applied to one cut (Table 5). The hatchet cut size was of sufficient size and depth to hold a 1 ml solution. A second cut would only be necessary for small trees where a 1 ml solution would overflow the cut.

No dose/size relationship was evident on the hack-and-squirt treatments (diameter range of 1 to 5 inches breast height). The larger trees died at the end of the second growing season on the 0.25 ml imazapyr solution treatment. Trees treated with 0.75 ml imazapyr died during the first growing season. This suggest there may be a dose/size relationship for stems larger than 5 inches.

The age and density of this stand was at a point where the Douglas-fir had been experiencing significant mortality and growth reduction prior to the herbicide application. After 2 yr, Douglas-fir did not exhibit any signs of imazapyr toxicity on any hack-and-squirt treatment plots with the rates of imazapyr used.

Glyphosate capsule method. The two glyphosate capsule treatments were not successful controlling red alder as shown in Table 6a. However, more important than the overall control, a relationship between alder mortality and alder size and numbers of capsules applied per stem was identified. As shown in Table 6b, there was 97% alder mortality when the number of capsules injected was equal or greater than the alder diameter (inches) minus one. This relationship shows that alder receiving less than DBH-1 capsules have a high risk of not being controlled.

There was less alder mortality for similar sized trees when two capsules were injected into the stem. At the time this study was initiated, the recommended capsule placement was on a vertical plane up the stem. Personal observations from other hardwoods and conifers treated with vertically placed capsules have also shown poor alder control. The glyphosate from the upper capsule appears to destroy cell tissue preventing full utilization of glyphosate in the lower capsule. Based on results from this study, it is recommended that placement of additional capsules be placed horizontally on the stem.

Table 3. Herbicide and solution efficacy and phytotoxicity data for the thin-line treatments.

Treatment	Mean DBH Age 6	Mean DBH Age 8	Mean Height Age 6	Mean Height Age 8	Vigor (age 8) High	Vigor (age 8) Low	Vigor (age 8) Dead
	(in)	(in)	(ft)	(ft)	%	%	%
RED ALDER							
Triclopyr 50%	1.7	1.5	19.3	12.6	0	12 a	88 a
Triclopyr 75%	1.6	1.5	18.7	11.7	3	3 a	94 a
Triclopyr 100%	1.6	1.2	20.4	10.9	0	8 a	92 a
Imazapyr 20%	1.5	2.0	18.3	17.1	0	83 b	17 b
Imazapyr 40%	1.4	2.1	17.5	15.3	0	57 b	42 ab
DOUGLAS-FIR							
Triclopyr 50%	1.1	2.2	9.6	15.1	97 a	3 a	0
Triclopyr 75%	1.2	2.2	10.4	15.8	80 a	20 ab	0
Triclopyr 100%	1.2	2.2	11.8	17.4	100 a	0 a	0
Imazapyr 20%	1.3	2.2	12.0	11.6	42 b	42 b	6
Imazapyr 40%	0.8	1.5	8.7	10.4	17 b	50 b	33

Table 4. Herbicide and solution efficacy and phytotoxicity data for the stream-line treatments.

Treatment	Mean DBH Age 6	Mean DBH Age 8	Mean Height Age 6	Mean Height Age 8	Vigor (age 8) High	Vigor (age 8) Low	Vigor (age 8) Dead
	(in)	(in)	(ft)	(ft)	%	%	%
RED ALDER							
Triclopyr 10%	1.1	1.0	14.2	8.5 a	0	4 a	96 a
Triclopyr 30%	1.0	0	13.7	0 b	0	0 a	100 a
Triclopyr 50%	2.0	0	21.1	0 b	0	0 a	100 a
Imazapyr 4%	1.2	1.6	14.8	15.0 a	0	81 b	19 b
Imazapyr 20%	0.9	0.9	13.3	4.3 ab	0	3 a	97 a
DOUGLAS-FIR							
Triclopyr 10%	1.1 a	2.5 a	10.8 a	15.9 a	87	13	0
Triclopyr 30%	0.7 b	1.9 ab	8.8 a	14.3 a	77	18	5
Triclopyr 50%	0.2 c	0.7 c	5.2 b	7.9 b	50	50	0
Imazapyr 4%	0.2 c	0.7 c	4.5 b	7.5 b	47	53	0
Imazapyr 20%	0.7 b	1.5 bc	8.4 b	8.8 b	21	67	12

Treatments without letters and treatments with similar letters within a species are not significantly different using analysis of variance using Duncan's New Multiple Range T-test at P=0.10.

LABOR AND HERBICIDE SOLUTION RELATIONSHIPS

Linear regression models were fit without an intercept (7) to fit the following form:

Application $\text{time}_{(hours/A)}$ = B_1 * red alder density (stems/A)

Herbicide $\text{solution}_{(gals/A)}$ = B_2 * red alder density (stems/A)

Correlation coefficients were significant at the 1% probability level. Regression coefficients and statistics are detailed in Appendix 2. "Stems per acre" is defined as all main stems and major forks larger than 0.5 inches at breast height that were turned up and growing more as a separate stem than a lateral branch.

Figure 1 shows the relationship between red alder density and application time by treatment method. The capsule injection treatments required the least treatment time, while cut-surface and low-volume basal methods required the most time. Methods that minimized operator movement were least time consuming (i.e., capsule injection, hack-and-squirt, and stream-line). The low-volume basal, stream-line and hack-and-squirt (2 cuts) required additional time to complete since movement was required to treat the entire stem surface area. The cut-surface treatment required the greatest time due to the two-step operation of first directional felling, then treating each cut stump's surface with herbicide solution.

The volume of herbicide solution required to treat an acre is shown in Figure 2. The hack-and-squirt injection treatment requires the least amount of solution for treatment. The hack-and-squirt treatment uses a 1 ml solution rate per stem. The glyphosate capsules have the next lowest amount of herbicides. The capsules are approximately 0.75 ml each and with packaging take up about 2.75 ml each. The volumes increase for the thin-line (3.3 ml/stem) and the cut-surface (4.6 ml/stem). The stream-line (10.8 ml/stem) and the low-volume basal (11.4 ml/stem) required the greatest volumes of herbicides per acre.

The higher herbicide solution volumes required by the stream-line and low-volume basal treatments could have significant indirect affects on treatment costs. A 3 gallon backpack mix in a streamside buffer zone with 1000 stems/A would treat only 1 A, or a strip 50 by 871 feet. If pre-planning the treatment area was not done carefully, the contractor may have to spend additional time carrying extra herbicide solutions into the working area. Contractor fatigue resulting from carrying higher volumes may be an additional factor to consider in estimating total treatment costs.

TOTAL TREATMENT COST

Total treatment cost is a combination of application cost (labor) and cost of the most effective herbicide solution for each method. An hourly rate of $15 per man-hour is used to represent an average of expected labor rates for licensed contractors. Actual herbicide prices were based on 1990 average prices (Appendix 3).

Figure 3 compares the total costs of each of the treatment methods. The 1-cut hack-and-squirt had the lowest per acre treatment cost followed by the stream-line treatment. The 2-cut hack-and-squirt treatment had similar total cost as the low-volume basal, thin-line, and 1-capsule treatments. The highest total cost treatments were the cut-surface and 2-capsule injection treatment.

The high costs of the cut-surface method results from it having two separate treatments; mechanical cutting costs and the secondary herbicide treatment. Efficacy data from this study suggests that lower herbicide rates for the cut-surface treatments are possible. Those lower rates would bring the cut-surface treatment more in line with thin-line and low-volume basal applications. The individual capsule cost is the single most important factor in making this treatment the most expensive. It is evident that as the mean diameter of alder increases beyond 3 inches the cost for control becomes significantly greater than other treatments.

A cost comparison among treatments is shown in Table 7 for a stand averaging 500 alder stems/A. The 1-cut hack-and-squirt would have the lowest total cost at $22/A. The range of total treatment costs is $22 and $60/A.

Table 5. Herbicide solution and application method efficacy data for the hack-and-squirt treatments.

Treatment		Mean DBH Age 13	Mean DBH Age 15	Mean Height Age 13	Mean Height Age 15	Vigor (age 15) High	Vigor (age 15) Low	Vigor (age 15) Dead
		(in)	(in)	(ft)	(ft)	%	%	%
RED ALDER								
Imazapyr 1 cut	.25ml	3.1	0	35.9	0	0	0	100
Imazapyr 1 cut	.50ml	2.7	1.5	28.2	14.9	0	2	98
Imazapyr 1 cut	.75ml	2.4	0	27.3	0	0	0	100
Imazapyr 2 cut	.25ml	2.8	2.5	31.8	13.1	0	3	97
Imazapyr 2 cut	.50ml	3.0	5.0	29.9	13.9	1	6	93

Table 6a. Herbicide efficacy data for the glyphosate capsule injection treatments.

Treatment	Mean DBH Age 13	Mean DBH Age 15	Mean Height Age 13	Mean Height Age 15	Vigor (age 15) High	Vigor (age 15) Low	Vigor (age 15) Dead
	(in)	(in)	(ft)	(ft)	%	%	%
RED ALDER							
1 Glyphosate Cap	2.8	4.0	32.1	11.4	0	50 a	50 a
2 Glyphosate Cap	2.6	4.3	32.8	11.3	2	21 b	77 b

Table 6b. Alder morality relative to stem diameter (inches) with capsule and 2 capsules, vertically placed on the stem.

Application Rate	Red Alder Mortality 1 Cap/stem	Red Alder Mortality 2 Caps/stem
DBH + 1 capsules	100	100
DBH 1 capsules	100	94
DBH - 1 capsules	97	81
DBH - 2 capsules	34	27
DBH - 3 capsules	6	0
DBH - 4 capsules	0	0

Treatments without letter, or treatments with similar letters are not significantly different using analysis of variance at P=0.10.

Table 8 shows the relative total cost differences among treatments for a stand averaging 1500 alder stems/A. Total cost range from $76 to $180/A.

Survey cruise data specific to red alder density in streamside buffer zones is shown in Figure 4. Red alder mean density ranged between 1075 and 3328 stems/A. Personal observations of other streamside buffer areas suggest densities of 500 to 1500 would be more typical averages and a 3000 stem density would an atypical average in many streamside buffer zones.

DISCUSSION

The goal of this study was to develop total treatment system costs for several ground-applied methods that could be used to control red alder in streamside buffer zones. Test sites were selected to give case study comparisons. A single experienced contractor was used, and before each treatment, the equipment and treatment techniques were first tested. Each herbicide solution was pre-batched at the plot. Mechanical problems, batching problems, and time to walk into the site with additional reserve herbicides were not factored into this study. This was necessary to allow comparison of the basic treatment effects and limit variation that would affect total cost comparisons. Adjustments need to be made to the costs presented here, as appropriate, to reflect additional logistics costs that would be expected in an operational treatment.

It is essential that these and other factors be considered in planning any operational treatment. Other factors would include worker safety, worker fatigue, adverse weather effects, traversing difficult terrain, or vegetation. Any of these might substantially affect total treatment cost.

Treatments designed to eliminate all red alder in a buffer zone is not always justified or necessary in every case. Within these streamside drainages in this study, we found 5 to 30% of the area did not contain any competing hardwoods. In other cases, we found areas stocked in excess of 4000 alder/A. The sizes of these hardwood clumps or "islands" varied from 0.001 A up to 0.1 A. A large proportion of the red alder clumps with the very high alder densities had virtually no live conifers. These areas would not need hardwood control. These non-conifer areas could be managed to hardwood production by giving these islands a stocking regulation to leave the best quality hardwoods as crop trees.

The ground-applied treatments tested in this study have more potential utility than just their use in streamside buffer zone situations. They could be used to control hardwoods in areas where issues of wildlife concerns, or public issues warrant alternatives to aerial herbicide application. Use of ground-applied treatment methods also could lessen the impact of using helicopters to treat sensitive areas. These ground treatments also offer opportunities to treat a broader range of hardwood species during one application and may reduce reentry aerial treatment costs.

The capsule injection system, while the most expensive, offers advantages not found in other ground treatment methods. The herbicide is completely contained in the cartridge, and the packaging tubes almost eliminate any potential of a spill, worker or other non-target exposure. These benefits can, in the right place, override the higher total treatment costs.

Ground application treatments also have their drawbacks. The most significant is the current lack of trained, licensed, and insured herbicide application contractors. A major shift to ground-applied treatments would require development of an additional contract labor force.

Further testing of application equipment needs to be continued to determine if we are using the most effective equipment or methods. This study did not develop the lowest level of herbicide solution required to control red alder for the cut-surface, low-volume basal, streamline, and hack-and-squirt treatments. Additional work needs to be completed to establish the lowest herbicide threshold for alder control.

Table 7. Comparison of labor rates, and total treatment costs for controlling 500 red alder per acre (assume $15/hour labor rates and 1990 herbicide prices).

Treatment	Cost /A ($) Labor	Total	Herbicide solution[a]
Hack-and-squirt (1 cut)	12	22	0.25 ml Imazapyr
Stream-line	11	23	10% Triclopyr
Hack-and-squirt (2 cuts)	19	29	0.25 ml Imazapyr
Low-volume basal	24	30	5% Triclopyr
Thin-line	14	32	75% Triclopyr
Capsule injection (1 cap)	7	33	$0.05 / capsule
Cut-surface	24	38	50% Triclopyr
Capsule injection (2 caps)	10	60	$0.05 / capsule

[a]Herbicide solution with a high probability of obtaining 90 to 100% red alder control.

Table 8. Comparison of labor rates, and total treatment costs for controlling 1500 red alder per acre (assume $15 / hour labor rates and 1990 herbicide prices).

Treatment	Cost / A ($) Labor	Total	Herbicide solution[a]
Hack-and-squirt (1 cut)	36	67	0.25 ml Imazapyr
Stream-line	33	68	10% Triclopyr
Hack-and-squirt (2 cuts)	47	88	0.25 ml Imazapyr
Low-volume basal	72	91	5% Triclopyr
Thin-line	42	96	75% Triclopyr
Capsule injection (1 cap)	22	97	$0.05 / capsule
Cut-surface	72	114	50% Triclopyr
Capsule injection (2 caps)	30	180	$0.05 / capsule

[a]Herbicide solution with a high probability of obtaining 90 to 100% red alder control.

Herbicide efficacy. This study developed several base-line herbicide recommendations for red alder ground control treatments. These include:

System	Herbicide formulation
Cut-surface	50% triclopyr, or 45% glyphosate, or 10% imazapyr.
Low-volume basal	5% triclopyr
Thin-line	75% triclopyr
Stream-line	10% triclopyr
Hack-and-squirt	0.25 ml imazapyr
Capsule injection	DBH - 1 capsule per stem

Additional testing is recommended to develop the lowest threshold of herbicide solution needed to control alder for the cut-surface, low-volume basal, stream-line, and hack-and-squirt treatments.

Total treatment costs. Labor and herbicide costs for ground-applied alder control treatments are directly related to the density of stems treated. Total treatment costs for the range of treatments tested range between $22 and $60 for 500 stems/A and $76 to $180/A for 1500 alder stems/A. These figures are based on $15/hr contractor costs and average 1990 herbicide prices.

These total treatment costs reflect a best case scenario and do not include operational logistics costs (e.g., transport of herbicide solution, pre-planning, downtime etc.), equipment depreciation or the impact of other competing vegetation that would affect operator productivity. Actual operational costs will be higher when these factors are included.

Ground application treatments can provide advantages over aerially applied treatments. Some of these advantages include being able to treat lands where conventional application using helicopters may cause unwanted public sensitivity, and where other environmental risks needs to be minimized.

ACKNOWLEDGMENTS

The author would like to extend his appreciation to Greg Jones, Dick Ford and John Keatley who were the key clients who provided the operational funding and support to this project. The author also would like to extend appreciation to the following persons for their help and assistance on this project: Dennis McNelly for treatment application; Tom Terry, Ron Heninger, Will Littke, Fred Fallis, Yasu Tanaka, Byron Carrier, and Nick Wheeler for their manuscript review and comments; Vanelle Carrithers and the DowElanco Company, Ron Crockett and the Monsanto Agricultural Chemicals Company, and Tom Nishimura and the American Cyanamid Company for their support.

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Figure 1. Application time (man-hours/Ac) for applying ground control treatments for red alder control in streamside buffer zones with varying alder densities.

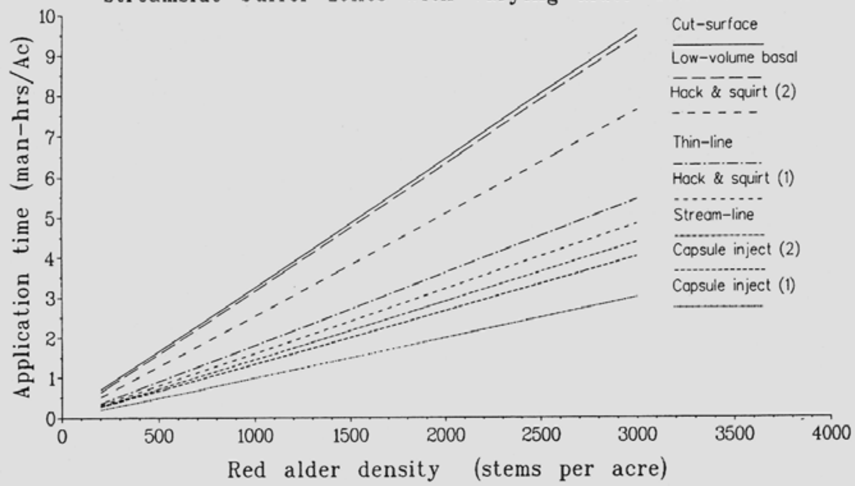


Figure 2. Herbicide solution volume used to control varying densities of red alder with ground applied treatments in streamside buffer zones.

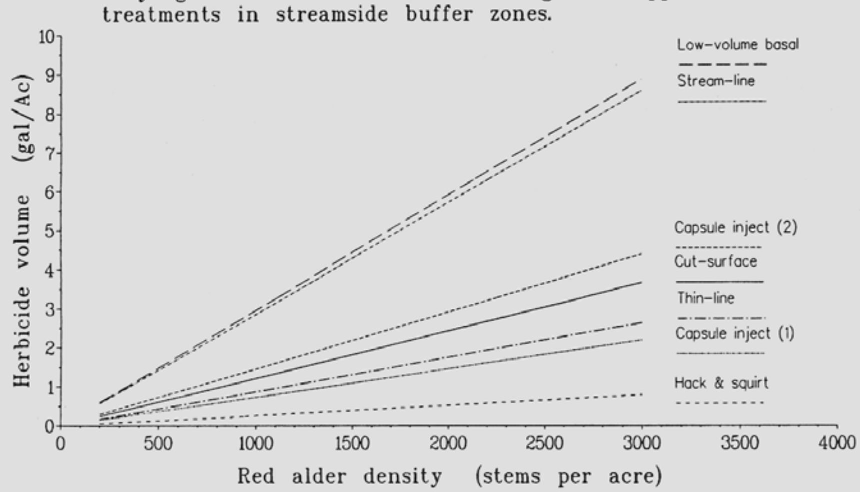


Figure 3. Total treatment costs per acre for controlling varying densities of red alder with ground applied methods in streamside buffer zones.

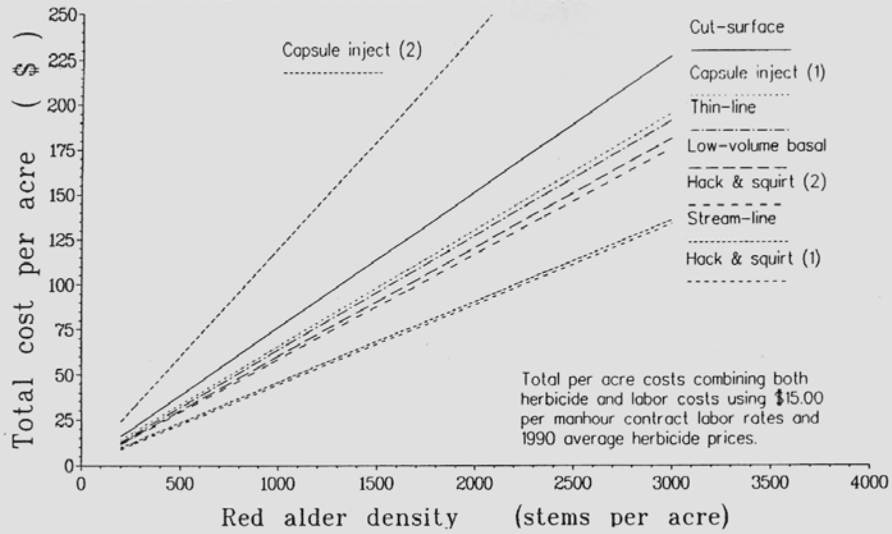
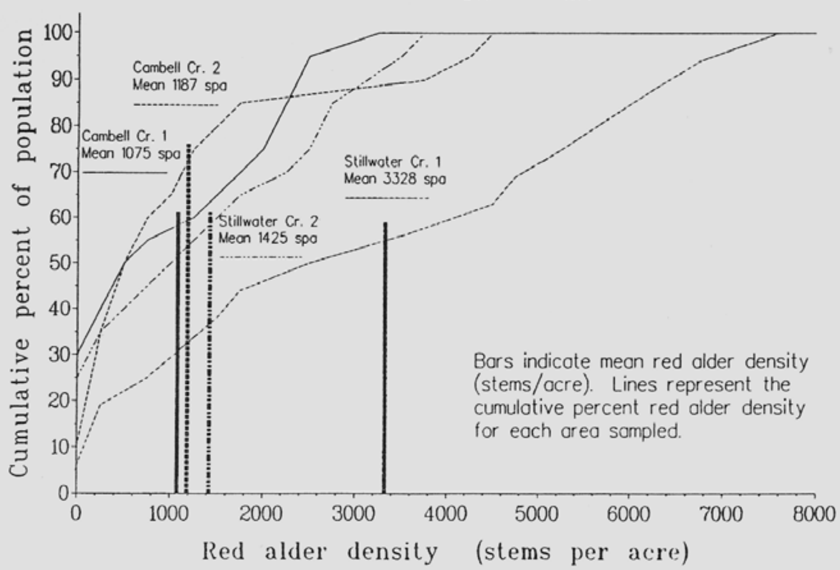


Figure 4. Mean and cumulative red alder density in four streamside buffer zone basins.



Appendix 1. Site descriptions for the 1989 streamside buffer zone study areas used to evaluate labor and herbicide costs for ground-applied red alder control treatments.

	Cambell Cr.	Cambell Cr.	Stillwater Cr.	Stillwater Cr.	1803 Road	1803 Road
Treatments	Cut-surface	Low-volume basal	Thin-line	Stream-line	Hack-&-Squirt	Capsule injection
Treatment date	4/11/89	4/13/89	4/18/89	4/18/89	4/20/89	5/17/89
Herbicide	Triclopyr 50% w/water Glyphosate 45% w/ water Imazapyr 10% w/ water	Triclopyr 5,10,15% w/ diesel Imazapyr 2, 4% w/ diesel	Triclopyr 50,75,100% w/ diesel Imazapyr 20, 40% w/ diesel	Triclopyr 10,30,50% w/ diesel Imazapyr 4, 20% w/ diesel	Imazapyr 0.25;0.5; 0.75ml/stem 1 and 2 cuts/stem	Glyphosate 1 and 2 capsules/stem
Planted	Jan 1983	Jan 1983	Jan 1983	Jan 1983	Feb 1971	Feb 1971
Stock type	2+1	2+1	2+1	2+1	2+1	2+1
Plantation age	6	6	6	6	13	13
Red alder:						
mean DBH (se)	1.7 (0.1) in	1.4 (0.2) in	1.5 (0.1) in	1.2 (0.2) in	2.7 (0.2) in	2.7 (0.1) in
mean HT. (se)	18.0 (0.7) ft	15.1 (1.0) ft	17.5 (0.9) ft	14.3 (1.3) ft	28.3 (1.1) ft	30.1 (0.7) ft
density range	150-2400 tpa	413-2600 tpa	167-2800 tpa	325-3200 tpa	440-3000 tpa	440-2900 tpa
Soil Series	Incline	Incline	Vader	Vader	Rought	Rought
DF soil site index	130 ft	130 ft	130 ft	130 ft	120 ft	120 ft
Elevation (ft)	1200	1200	1100	1100	1000	1000

Appendix 2. Regression equation coefficients(B_1,B_2), correlation coefficients, and coefficient of determinations for the correlation of red alder density levels to herbicide application time and herbicide usage.

APPLICATION TIME

where: Hours/acre = B_1 * red alder density (stems per acre)

Treatment	B_1	r	F-value	r^2	SEE
Cut-surface (Combine cut and herbicide treatment)	0.003206	.987	.0001	.97	0.79
Low-volume basal	0.003153	.988	.0001	.98	0.90
Thin-line	0.001811	.988	.0001	.98	0.50
Stream-line	0.001458	.987	.0001	.97	0.41
Hack-and-Squirt 1 cut per tree	0.001607	.994	.0001	.99	0.33
Hack-and-Squirt 2 cuts per tree	0.002541	.979	.0001	.96	0.90
Capsule injection 1 capsule per tree	0.000996	.996	.0001	.99	0.17
Capsule injection 2 capsules per tree	0.001333	.996	.0001	.99	0.22

HERBICIDE SOLUTION DISPENSED

where: Gallons solution/acre = B_2 * red alder density (stems per acre)

Treatment	B_2	r	F-value	r^2	SEE
Cut-surface	0.001012	.983	.0001	.97	0.29
Low-volume basal	0.002925	.968	.0001	.94	1.36
Thin-line	0.000679	.986	.0001	.97	0.20
Stream-line	0.002909	.999	.0001	.99	0.21

Appendix 3. Baseline treatment application rates and herbicide prices.

Baseline Treatment	Herbicide Treatment
Capsule injection	DBH - 1 Glyphosate capsules per stem
Cut-surface (cut-stump) 4.6 ml (0.7 se) /stem	50% Triclopyr (Garlon 3A) 50% Water
Hack-and-Squirt 1 cut per stem	Imazapyr (Arsenal AC) 0.25 ml per stem
Low-volume basal 11.4 ml (0.9 se) /stem	5% Triclopyr (Garlon 4) 95% Diesel oil
Stream-line 10.8 ml (0.5 se) /stem	10% Triclopyr (Garlon 4) 90% Diesel oil
Thin-line 3.3 ml (0.4 se) /stem	75% Triclopyr (Garlon 4) 25% Diesel oil

Average 1990 Herbicide Prices:

Imazapyr	Arsenal AC	4 lb /gal	$ 312 / gallon
Imazapyr	Chopper	2 lb /gal	$ 165 / gallon
Triclopyr	Garlon 3A	3 lb /gal	$ 54 / gallon
Triclopyr	Garlon 4	4 lb /gal	$ 72 / gallon
Glyphosate	Roundup	4 lb /gal	$ 62 / gallon
Glyphosate capsules		0.15 gr	$ 0.05 / capsule
Diesel oil			$ 1.00 / gallon

COMBINATIONS OF GLYPHOSATE AND IMAZAPYR FOR CONTROL OF DECIDUOUS WOODY SPECIES IN WESTERN OREGON AND ALASKA. Michael Newton and Elizabeth C. Cole, Professor and Senior Research Assistant, Department of Forest Science, Oregon State University, Corvallis, OR 97331.

INTRODUCTION

Vegetation management products used for site preparation and conifer release must be able suppress a wide array of species without leaving harmful residues for the crop species. Weaknesses exist in most herbicide prescriptions in that optimum timing and dosages for the major species leave potentially troublesome resistant weeds. Alternatively, use of high-potency products may leave soil residues that cause contact injury or require delay in planting. This research is directed toward the discovery of prescriptions that broaden the array of species controlled without conifer injury through direct contact or residues.

Glyphosate is a well established herbicide for use in control of deciduous woody plants and most herbs. It is an inhibitor of an enzyme system that is involved in formation of essential aromatic amino acids. At certain phenological stages, it is effective on species that are difficult to control while conifers are dormant and resistant, but it also causes severe damage to the conifers. Damage occurs primarily during the period of active terminal elongation. Selective use of glyphosate for woody plant control in the presence of conifers is limited to about 1.1 lbs/ac ae, and treatment must be in late summer if injury is to be largely avoided. At this rate and time, several weed species, including the maples and alders, are often resistant.

Imazapyr is also an inhibitor of essential amino acids with herbicidal activity on a broad spectrum of forest weed species, including the maples and alders. It is also injurious to conifers at low rates of application. We postulate that the complementary action of glyphosate and imazapyr would permit an increase in the spectrum of control while using low rates of both products. This research seeks to determine whether rates of imazapyr low enough to avoid conifer injury can be added to glyphosate to increase the spectrum of activity of glyphosate, and hence provide more effective and selective forest weed control.

METHODS

Mixtures of glyphosate and imazapyr were applied in two seasons (three in one experiment), and in ranges of rates for each herbicide for controlling several species of concern for site preparation in western Oregon and Alaska. Vine maple, hazelnut, and red alder were treated in western Oregon; Sitka alder and salmonberry were treated on the Alaska coast, Kenai Peninsula, and quaking aspen was treated in the interior. Oregon vine maple plots were treated in June in one site preparation experiment, in July and September in another and July and August in another. Red alder was treated in July and August; hazelnut was treated in July and September. All Alaska plots were treated in late August. Conifers were observed where present.

RESULTS AND DISCUSSION

In the vine maple experiments treated in May, July and August, (Wildwood) weather detracted from treatment effects. About 0.1 inch of rain fell immediately after the July application. In this particular study, there was a substantially greater level of effect in all May and August treatments than in July (Table 1). In the later July and September (Lyons) series the difference between seasons was almost a complete reverse (Table 2). During the more effective season in both series, imazapyr was added to glyphosate in amounts ranging from 0 to 0.125 lb/A. With each increment of imazapyr, efficacy improved when glyphosate rates were 0.5 and 0.75 lb/A. Even 0.05 lb/A imazapyr added significantly to efficacy of glyphosate. Fall applications of this combination did not injure Douglas-fir measurably, but higher rates did do so.

Control of hazelnut was excellent with imazapyr rates of 0.1 lb/A with or without glyphosate in July whereas control with glyphosate alone was fair to poor at 0.5 to 0.75 lbs/A (Table 3).

Red alder control was poor in July and August at 0.5 lb/A of glyphosate, but 68%or better at 0.75 or 1 lb/A. Addition of 0.01 lb/A imazapyr or more to 0.5 lb glyphosate improved efficacy in both July and August. When glyphosate rates were 0.75 to 1 lb/A, additive effects of imazapyr were inconsistent (Table 4). In this experiment, there was a strong pattern of shading of small alders by large trees. Dominant saplings were more

Table 1. Crown reduction of vine maple as a function of season and dosage of glyphosate and/or imazapyr. Wildwood, Oregon

Herbicide and rate		Crown reduction[a]		
Glyphosate	Imazapyr	May	July	September
(lb/A	(lb/A)	---%		
0	0.125	72 cde	23 hij	84 abcd
0	0.188	74 bcde	7 ij	100 a
0	0.25	66 de	---	97 a
0.5	0	---	5 j	58 ef
0.75	0	---	28 gh	73 cde
1.0	0	---	14 hij	65 de
0.5	0.01	---	10 hij	61 ef
0.5	0.05	---	13 hij	97 a
0.5	0.125	---	46 fg	94 ab
0.75	0.01	---	24 hi	75 bcde
0.75	0.05	---	9 hij	85 abc
0.75	0.125	---	8 ij	96 a
1.0	0.01	---	18 hij	86 abc
1.0	0.05	---	9 hij	91 abc
1.0	0.125	---	15 hij	99 a
1.0	0.188	---	---	99 a

[a]Tukey's HSD Test, $p<0.05$.

Table 2. Crown reduction of vine maples as a function of season and dosage of glyphosate and/or imazapyr. Lyons, Oregon

Chemestry and rate		Crown reduction[a]	
Glyphosate	Imazapyr	July	September
(lb/A)	(lb/A)	---%	
0	0	0	0
0	0.125	27 jkl	--
0	0.25	74 abcde	--
0.5	0	57 defg	11 lm
0.75	0	---	14 klm
2.25	0	90 a	--
0.5	0.05	69 bcdef	19 kl
0.5	0.10	76 abcd	17 klm
0.5	0.125	83 abc	27 jkl
0.75	0.05	63 defg	24 kl
0.75	0.10	87 ab	41 hij
0.75	0.125	73 abcdef	62 defg

[a]Tukey's HSD Test $p<.05$.

effectively controlled than those present beneath them. This will be a problem in alder stands dense enough to form substantial canopy stratification.

In both interior Alaska, addition of imazapyr at 0.125 lbs/A or more to glyphosate at 0.75 lb/A decreased suckering of aspen while providing near total top kill (Table 5). Efficacy on coastal Sitka alder and salmonberry was similarly enhanced (Table 6).

Injury to Douglas-fir and Sitka spruce was not significantly greater than random necrosis at any rate of imazapyr up to 0.125 lb/A where we had adequate sample size to observe (Tables 3 and 6). When using glyphosate at effective rates, it may be possible to observe minor injuries more frequently than the same symptoms are observed on untreated seedlings. Similarly, the addition of imazapyr at low rates appears to increase the frequency of minor symptoms above those observed with glyphosate alone. As long as rates of the mixed products remain at or below 0.75 lb/A (1 quart of Accord product) plus 0.125 lb imazapyr, (4 fluid ounces Arsenal), and the conifers are visibly threatened by potentially overtopping vegetation, it appears that the above mixtures may be used to good effect to improve conifer dominance in Oregon and coastal Alaska. There were too few white spruce in the interior samples to evaluate for selectivity. However, the above treatments are promising for site preparation, and should not give rise to concern for residual injury.

Effects of these two materials appear to be complementary; there is no evidence of synergism. They do, however, provide control of a broader range of species in a single application, and at rates with attractive cost structure and tolerance by crop species.

Table 3. Responses of 3-year-old hazelnut sprouts and planted Douglas-fir to glyphosate and/or imazapyr as a function of season and dosage. Lyons, Oregon.

Chemistry and rate		Crown reduction		Douglas-fir 0 to 5 rating	
Glyphosate	Imazapyr	July	Sept	July	Sept
(lb/A)	(lb/A)	----------%-------			
0	0	0	0	0.14	0.14
0	0.125	95	--	3.0	---
0	0.25	100	--	2.22	---
0.5	0	75	25	2.0	0.75
0.75	0	--	5	---	1.0
1.0	0	93	--	3.0	---
0.5	0.01	90	--	2.33	---
0.5	0.05	--	25	3.00	0.0
0.5	0.125	--	65	2.00	0.67
0.75	0.01	78	50	2.67	0.0
0.75	0.05	94	45	2.00	1.67
0.75	0.125	100	--	2.67	1.00

Note: Sample size too small for means comparison.

Table 4. Response of red alder to glyphosate and/or imazapyr as a function of season and dosage. Wildwood, Oregon.

Chemistry and rate		Crown reduction[a]		
Glyphosate	Imazapyr	May	July	September
(lb/A)	(lb/A)		%	
0	0.125	60 efgh	75 abcdef	87 abcd
0	0.188	85 abcd	--	97 ab
0	0.25	79 abcdef	--	91 abcd
0.5	0	--	32 h	39 gh
0.75	0	--	85 abcd	68 defg
1.0	0	--	83 abcde	85 abcd
0.5	0.01	--	68 defg	90 abcd
0.5	0.05	--	93 abc	81 abcde
0.5	0.125	--	56 fghi	89 abcd
0.75	0.01	--	70 cdefg	90 abcd
0.75	0.05	--	90 abcd	75 bcdef
0.75	0.125	--	46 ghi	99 a
1.0	0.01	--	86 abcd	92 abcd
1.0	0.05	--	93 abc	90 abcd
1.0	0.125	--	95 ab	95 ab
1.0	0.188	--	--	94 ab

[a]Tukey's HSD Test $p<.05$

Table 5. Crown reduction of 6-year-old quaking aspen suckers treated with glyphosate and/or imazapyr. New Fairbanks, Alaska.

Chemistry and rate		Crown reduction[a]	
Glyphosate	Imazapyr	May	August
(lb/A)	(lb/A)	%	
0	0	9 j	9 j
.75	0	---	82 abc
1.12	0	---	93 abc
0	.125	---	21 ij
0	.25	---	34 ghi
0	.4	27 hij	53 efg
0	.6	78 bcd	74 bcd
.75	.125	---	94 ab
.75	.25	---	100 a
.75	.4	---	100 a
Manual		29 hij	72 cde

[a]Tukey's HSD Test $p<.05$.

Table 6. Effects of combinations of glyphosate and imazapyr on Sitka spruce, Sitka alder, salmonberry and devils club on the southern Kenai Peninsula, Alaska.

Chemistry and rate		Spruce	Crown reduction[a]		
Glyphosate	Imazapyr	rating	Alder	Salmonberry	Devil's club
(lb/A)	(lb/A)			%	
0	0	.13 d	2 d	0 d	0 c
0.5	0	.23 d	82 c	96 a	83 a
0.75	0	.27 d	83 bc	99 a	99 a
1.0	0	.39 d	85 bc	99 a	83 ab
1.25	0	.83 bcd	92 abc	97 a	100 a
0	0.125	.57 cd	93 abc	65 c	0 c
0	0.25	1.67 a	97 ab	80 b	100 a
0	0.5	1.44 ab	100 a	99 a	23 bc
0.5	0.125	.31 d	94 abc	98 a	91 a
0.75	0.125	1.13 abc	92 abc	92 ab	50 ab

[a]Tukey's HSD Test $p<0.05$

WEEDS OF HORTICULTURAL CROPS

COMPARISON OF ALTERNATIVE WEED CONTROL PRACTICES IN TRANSPLANTED STRAWBERRIES. Harry S. Agamalian, Weed Science Farm Advisor, University of California Cooperative Extension, 118 Wilgart Way, Salinas, CA 93901.

Abstract. Annual plantings of strawberries *Fragaria x ananassa* in California are normally planted in pre-fumigated soil. This practice effectively controls most annual weeds. The interest for alternative methods for weed control stimulated interest in plastic mulch, selective herbicides and hand weed control.

Replicated field experiments were conducted on newly transplanted strawberries to compare white opaque plastic, black mulch, clear plastic mulch, DCPA, napropamide, and hand weeding.

Effective weed control was obtained with black mulch, but opaque white mulch allowed weeds to grow, which affected yields. Clear plastic mulch encouraged weeds to grow and was lifted, weeded, and replaced, resulting in 300 man hr/A.

The herbicide napropamide controlled burning nettle and little mallow, but crop suppression reduced the initial yields. DCPA controlled little mallow and burning nettle with comparable yield to the hand weeded control. Strawberry yields from the clear plastic treatment were significantly better than all treatments for the first 4 weeks of harvest. Early growth response relating to warmer temperatures was a significant factor.

KIKUYUGRASS AND SIX TURFGRASS CULTIVARS AFFECTED BY HERBICIDE TREATMENTS. D. W. Cudney, V. A. Gibeault, J. S. Reints, and C. L. Elmore, Weed Science Specialist, Turfgrass Specialist, Staff Research Associate, and Weed Science Specialist, University of California, Riverside CA 92521 and Davis CA 95616.

Abstract. Kikuyugrass has been found to be one of the most serious problems for turf production in the coastal areas of southern and central California. Currently, no chemical control method has proved adequate. However, repeated applications of herbicides which limit the growth of kikuyugrass relative to the desirable turf species may prove helpful. For this reason, the following trial was established.

Six turfgrass cultivars (perennial rye, tall fescue, bluegrass, common Bermuda, hybrid Bermuda, and zoysia) were plugged into a 9 month old stand of established kikuyugrass. Four 4-inch plugs were placed in 5 by 5 ft sections of the sward. After a 6 week establishment period, the plots received their first herbicide treatment.

The herbicide treatments consisted of MSMA , triclopyr, and MSMA plus triclopyr. The application rate of MSMA and triclopyr was 2 and 0.5 lb/A. Treatments were made on August 23, September 13, and October 12, 1990. Treatments were applied at a spray volume of 30 gal/A with a constant pressure CO_2 backpack sprayer. Treatments were replicated four times.

Three evaluations were made, 3 weeks after each of the three herbicide treatments. Evaluation was made by measuring the diameter of the plugs to distinguish the competitive relationship between the kikuyugrass and the six turf species. Where kikuyugrass was most competitive, plug diameters decreased and where the turf variety was more competitive, plug diameter remained constant or increased depending on whether the turf cultivar was a bunch type or formed rhizomes. Factorial analysis showed significant differences for herbicide treatment, turf cultivars and the interaction of turf cultivars and herbicide treatments. All of the herbicide treatments reduced the competitiveness of the kikuyugrass relative to the turf species. Common Bermuda was injured by triclopyr treatment, however, none of the other turf species was injured by herbicide treatment. This trial indicated that sequential herbicide treatment could be used to alter the competitive relationship between kikyuyugrass and turf species and could be effective for kikuyugrass control.

BEHAVIOR OF DITHIOPYR IN TURF AND SOIL ENVIRONMENTS. Nelroy E. Jackson, Jeffery M. Higgins, John E. Kaufmann and John E. Cowell, Product Development Associate, Commercial Development Manager - Turf and Ornamentals, Science Fellow, Senior Group Leader - Environmental Science, Monsanto Company, 400 S. Ramona Blvd. #212, Corona, CA 91719.

Abstract. Dithiopyr, tested under the code name MON 15100, is a selective herbicide under development by Monsanto Company for the control of many annual grasses and broadleaf weeds in established cool and warm season turfgrass.

Dithiopyr controls weeds by inhibiting cell division and cell growth in both shoot and root meristems. Meristems that are exposed to dithiopyr in sufficient concentrations are susceptible and thus arrested. Unexposed or "protected" meristems are not affected by dithiopyr and are tolerant to the herbicide. This is the basis of selectivity, accounting for its excellent safety on established turfgrasses, and exceptional activity on surface-germinating weeds such as crabgrass.

The physical properties of dithiopyr are good indicators of its behavior in the environment. Dithiopyr has very low water solubility and vapor pressure. These two properties, coupled with molecular weight constitute Henry's Constant, which is an estimate of the ability of a compound to be partitioned between air and water. Dithiopyr has a low Henry's Constant; and therefore, exhibits relatively low potential for volatilizing from saturated soil or wet surfaces.

The estimated Log K_{ow} and K_{oc} values for dithiopyr indicate that it is highly lipophilic, with a strong affinity for soil. This accounts for dithiopyr's immobility in the soil. Lateral and vertical mobility in the thatch and soil is minimal. In soil dissipation studies, vertical mobility of dithiopyr and its metabolites through the soil was frequently in the range of 9 to 12 inches, and was found not to exceed 24 inches, even in conditions highly susceptible to herbicide leaching (sandy soil texture, low organic content, and 98 inches of irrigation). In no instance was dithiopyr or its major metabolites detected above the lower limit of detection (0.10 ppm) between a soil depth of 24 and 96 inches.

The half-life in soil of an EC formulation of dithiopyr (MON 15151), applied to turf under field conditions, was found to be 17 days. In laboratory studies, volatile material identified as dithiopyr constituted 24 to 29% of the total applied dithiopyr under flooded anaerobic conditions, and 8 to 26% of total applied dithiopyr under aerobic conditions. Thus, volatility appears to be a significant pathway for dissipation of the EC formulation.

The primary method of degradation of dithiopyr is photolysis and aerobic metabolism. Photolysis studies conducted in a buffered aqueous solution at pH 7 without photosensitizers indicated that dithiopyr was readily degraded with an approximate half-life of 17 days. In the vapor phase, dithiopyr was found to be photolabile with a half-life of 41 days. Photodegradation of dithiopyr in soil is insignificant, with only 5% of parent dithiopyr being lost to photolysis; however, dithiopyr readily dissipates from the soil. Microbial degradation may be a secondary means of degradation in soil. Data indicates that hydrolysis is not a major method of degradation.

PICKLING CUCUMBER PRODUCTION WITH HERBICIDES, HAND WEEDING, OR COMBINATIONS. W. Thomas Lanini and Michelle Le Strange, Cooperative Extension Specialist and Farm Advisor, Department of Botany, University of California, Davis 95616 and Visalia, CA 93291.

Abstract. Field studies were conducted at Five Points and Davis, California, to evaluate yield and harvest efficiency of pickling cucumbers (var. 'Early Pik 14') in addition to weed control costs and weed control relative to treatment. Treatments included plots kept weed free by hand hoeing at 2 week intervals, for 0, 2, 4, 6 weeks after cucumber emergence or full season. Treatments also included naptalam at 4.5 kg/ha, bensulide at 4.50 kg/ha, a combination of naptalam and bensulide each at 4.5 kg/ha, and a combination of naptalam and bensulide each at 2.25 kg/ha. Each herbicide treatment was applied alone or with a hand cultivation at 3 weeks. Cucumber yields were greatest when weeds were excluded for six weeks or longer. Cucumber yields were reduced by over 50% if naptalam or bensulide were used alone or in combination without any cultivation.

Bensulide at the full rate with or without naptalam combined with a cultivation at three weeks produced cucumber yields equal to or greater than hand weeding for full season. Weed cover at cucumber harvest was 30% or less when cultivation was continued for at least four weeks or bensulide was used with a cultivation at 3 weeks. Naptalam alone provided inadequate control of grasses, resulting in dense grass cover at harvest. Harvest efficiency (yield/time) was greatest on plots producing the highest yield ($r = 0.899^{***}$), but negatively relatived to weed cover ($r = -0.776^{***}$).

PROGRESS OF BIOLOGICAL CONTROL OF GORSE IN HAWAII. Ernest R. Yoshioka, Myron O. Isherwood, and George P. Markin, Entomologist, Hawaii Department of Agriculture, 16 E. Lanikaula St., Hilo, HI 96720; Branch Chief, Plant Pest Control Branch, Hawaii Department of Agriculture, P. O. Box 22159, Honolulu, HI 96822; and Research Entomologist, USDA Forest Service, 1643 Kilauea Ave., Hilo, HI 96720.

INTRODUCTION

Gorse is a spiny, dense growing shrub native to England and western Europe. Originally considered beneficial as browse for sheep and goats, or as a hedgerow to contain livestock before barbed wire (7), it was spread by European settlers to many parts of the world where it soon escaped from cultivation to become another introduced weed. The thick, impenetrable stands formed by this plant limit access by man and domestic animals, replace native vegetation and grasses on rangeland (4, 11) and interfere with reforestation and forest management (1, 3, 12). The shrub is highly flammable and an infestation adjacent to and on vacant lots within the town of Bandon, Oregon, is credited with carrying a wildfire that destroyed the town in 1932 (5).

On a worldwide basis, gorse is found in 17 countries or island groups outside of its original range in western Europe. It is considered a serious problem in New Zealand, Hawaii, Australia, Chile and the northwest coast of the United States (6). In Hawaii, gorse is establishe on only two islands (2). On Maui, the infestation is scattered over 5,985 ha with a dense core area of 1,277 ha. On the island of Hawaii, it is distributed over 8,262 ha with a dense core infestation of 2,834 ha (8). On the northwest coast of North America, approximately 1,000 ha are infested in northern California and Washington, but the bulk of the infestation (15,378 ha) is on the southern coast of Oregon in Coos, Curry and Lane Counties.

In Hawaii, efforts at biological control began in 1926 with an unsuccessful attempt to introduce the gorse seed weevil. A major effort was conducted in the 1950's that evaluated many potential biological control agents, three of which were eventually released; a gall forming weevil, a large seed weevil, and a small seed weevil. Of the three, only the small seed weevil became established (8). However, continual spread of this weed and a new awareness of its potential threat to other parts of Hawaii created another attempt at biological control. This report reviews the progress to date of our biological control effort.

RESULTS

Gorse seed weevil. After four unsuccessful attempts between 1926 and 1953 to introduce an English strain of this weevil to Hawaii, it was concluded that the failures were possibly due to the strain not being suitable to Hawaii's climate. In 1955 and 1956 a more "southern" strain was obtained from France and released. By 1962, it was reported established on both islands and on Maui by 1972 was found throughout the range of gorse. We conducted a survey for this weevil on Maui in 1984. Adults were found over the entire range of gorse and approximately 52% of pods were being attacked (range 7.1% to 80.6%). Subsequent surveys over the next six years have shown major fluctuations with declines to as low as 1.5% that appear to be neither seasonal nor due to parasitism. During three of the population collapses, adult seed weevils in the field were observed to be infected with a fungus which we now believe is responsible for the weevil decline, and has reduced its effectiveness to halt seed production.

On the island of Hawaii, an intense survey was conducted in the winter of 1983 through 1984, but no sign of the seed weevil was found, although we identified and resurveyed the original release site. The release site was a small island of soil surrounded by fresh lava flows and was 3 km from the main gorse infestation. It was subsequently learned that the site had been treated with herbicides in 1976 through 1977 and then burned. Since then, gorse has regenerated, probably from seeds in the soil. Apparently, the weevil did not migrate to the main gorse infestation and was eliminated in the isolated stand of gorse during the control program. In 1984 the weevil was successfully reestablished on the island of Hawaii from weevils collected on Maui. Monitoring the weevil population at the nine release sites, Table l, showed a steady population build up for the first 4 years, but it has leveled off for the last 2 years. This is not to indicate a problem (no sign of parasites or the fungus have been detected yet), but rather that the population has begun to disperse from the original release sites into the surrounding area.

Gorse tip moth. This small moth, the larvae of which feed on new gorse shoots, was received from New Zealand Division of Science and Industrial Research (DSIR) in 1986, but had originated from Silwood Park near London, England. Comprehensive host specificity tests of the moth had already been conducted in New Zealand, and further tests in Hawaii on economic and native plants also proved negative. Official approval to release the gorse tip moth was granted in September 1988, and the first release was made in November 1988. The moth was then propagated in a mass rearing facility in Hilo on the island of Hawaii, and numerous releases were made at various sites on both the island of Hawaii and Maui in 1989. Followup surveys in June 1990 disclosed that the moth was established at 8 of the 9 release sites on the island of Hawaii (Table 2) and to have increased somewhat by the fall of 1990. However, future effectiveness of this agent is in doubt since it was found to be heavily attacked by several pupal parasites. On Maui, the gorse tip moth is well established at two sites in higher portions of the gorse range (± 1,800 m) but failed to become established at the three lower sites (± 1,000 m). By fall of 1989 and 1990 conspicuous dieback of gorse terminals were observed on heavily infested plants. Biological studies of this defoliator under Hawaiian field conditions continue on both islands.

In England, the gorse tip moth overwinters as unmated adults which emerge in April or May to mate and lay eggs on the older spines and stems. New larvae migrate to the ends of the shoot to feed on developing spines. Pupation occurs in July and adults emerge in August or September. In fall, adults move back to the center of the gorse plants to spend the winter in diapause. The lack of a cool, distinct winter needed to break diapause may have prevented its establishment at the lower sites on Maui. To correct this a new, warmer adapted strain of the gorse tip moth from central Portugal has been obtained and is being prepared for release this spring at the lower elevations on Maui. The gorse tip moth was also recommended for release on the mainland in Oregon. Its release was denied by the USDA since they felt it posed a potential threat to scotch broom, a plant very closely related to gorse and on which the gorse tip moth would feed under laboratory conditions.

Gorse gall weevil. This weevil restricts the growth of developing shoots by forming a gall in which its larvae lives. The insect was originally released in 1962 at the low elevation sites on the island of Maui. Subsequent surveys in the 1960's and our new survey between 1984 to 1987 indicated this insect had failed to become established. In the present program the insect was reconsidered after its failure was concluded to its being incompatible with the warm, wet climate at low elevations on Maui. Accordingly the insect was reintroduced in 1990 when over 700 adults were released at two sites at higher elevations ranging from 1,800 to 2,000 m on the island of Hawaii. To date it is too early to determine whether the weevils have become established.

Gorse thrips. This small, wingless thrips is one of the more common defoliators of gorse seen throughout its range in western Europe. This insect was released in December 1990 in New Zealand. After three years of testing in quarantine, we are confident that this insect is specific to gorse and have petitioned for permission to release it in Hawaii. We expect the petition to be approved and plan to begin releasing this insect in the spring of 1991.

Red Gorse Mite. We are presently studing the possibility of introducing a mite which was released in New Zealand in August 1988 (fall New Zealand). The mites successfully overwintered and are now established at 116 release sites in New Zealand. According to Richard Hill, DSIR entomologist in charge of the gorse project at Christchurch, gorse plants have died and/or are dying from the mites at many older release sites. In New Zealand which has a much larger and older biological control program for gorse, the mite appears to be the most promising organism they have studied to date. We will be watching closely this release in New Zealand for any activity on non-target plants including species we have sent them from Hawaii.

Table 1. Percentage of gorse pods successfully attacked by the gorse seed weevil for 6 years following its release on the island of Hawaii. Samples based on 200 or 400 pods collected at each of 9 locations where the weevils were released in 1984.

Sampling location	% of pods successfull attacked x & SE 1985	1986	1987	1988	1989	1990
Within 10 m of point of release	2.05 ±1.0	5.7 ±2.3	21.5 ±7.1	34.5 ±8.7	30.9 ±6.9	21.3 ±6.4
100 m. from point of release	NS[a]	NS	0.52 ±.28	14.6 ±5.1	23.4 ±6.8	21.2 ±6.0

[a]No samples

Table 2. Number of gorse tip moth feeding shelters found in one hour of search at release sites on the island of Hawaii. Original release made in spring 1989.

Release site	September 1989	June 1990	September 1990
1	92	27	17
2	101	101	88
3	10	40	71
4	38	85	103
5	0	0	0
6	70	40	84
7	115	133	126
8	72	107	78
9	11	10	62
Mean	56.5	60.3	69.1

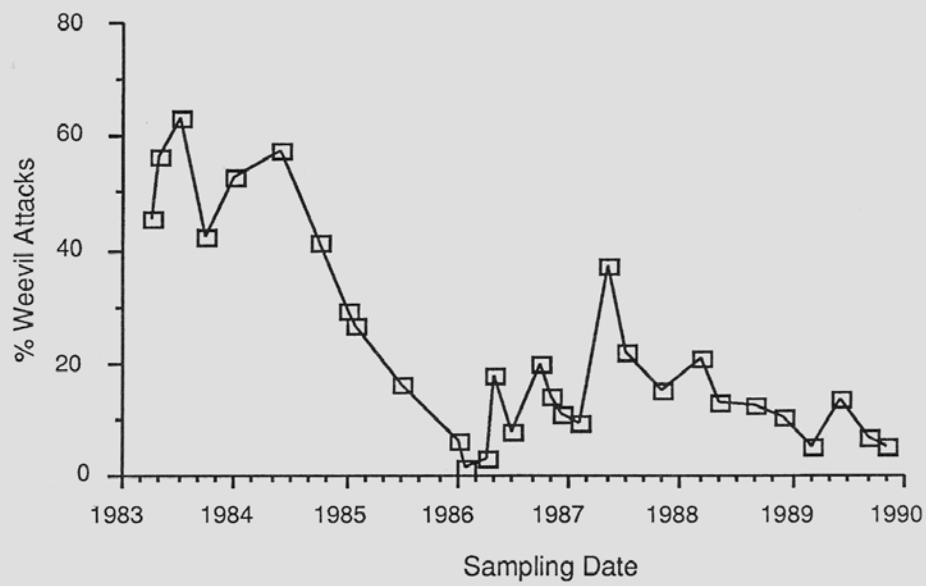


Figure. Population of the gorse seed weevil over a seven year period on the island of Maui, as indicated by the percentage of seed pod found successfully attacked at three sampling sites.

Other insects being considered. Presently in quarantine we have a colony of a seed attacking caterpillar. With the problem of the seed weevil's populations being reduced by a fungus, we are presently investigating the possibility of bringing in this second seed attacking insect to supplement it. It will take several years of quarantine work to determine whether this insect is compatible with the seed weevil, and to complete the necessary host range studies to determine whether it can be safely released into our environment.

Also in quarantine, we have a second defoliating caterpillar which is undergoing host specificity testing. This insect would not compete with the present defoliator, the gorse tip moth, since its caterpillar is active during winter and feeds on the old gorse spines and bark, often killing shoots by girdling them. Finally under contract with New Zealand, Hawaii is supporting the study of a third moth for possible introduction. This is not a defoliator, but the caterpillar mines under the bark of the large gorse shoots often girdling them. In New Zealand where this insect is native, the caterpillar causes significant mortality of gorse branches and often kills the entire plant.

CONCLUSION

While the total area infested by gorse in Hawaii is relatively small (only 15,000 ha), continual cost of control, the steady expansion of its range and the threat it poses to ranchland and native ecosystems on the other islands has generated support for a new program. Historically, Hawaii has attempted biological control of 21 species of weeds, and obtained partial or complete control of over half of them (8). Based on the large number of potential natural enemies of gorse that are known to exist, the strong cooperation we are obtaining from a similar program in New Zealand, and a new insect quarantine facility at Hawaii National Park and a new plant pathogen quarantine facility at the Hawaii Department of Agriculture's complex in Honolulu, both working on the problem, we expect that this weed biological control program will also be successful.

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WEEDS OF AGRONOMIC CROPS

EFFECTS OF CULTURAL AND CHEMICAL WILD OAT CONTROL ON MAXIMUM ECONOMIC YIELD OF SPRING BARLEY. David L. Barton and Donald C. Thill, Graduate Assistant and Professor, Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83843.

Abstract. Idaho crop producers spend about $45 million each yr to control wild oat. Wild oat control costs barley producers alone about $14 million annually. Crops should be managed to provide growers with the maximum economic yield (MEY). A randomized block factorial split-plot design was employed to determine the effect of barley seeding rate and row spacing, and wild oat herbicide and herbicide rate on wild oat control, barley grain quality and yield, and subsequent net return above variable seed and herbicide costs. 'Morex' spring barley was seeded at 67, 134, and 201 kg/ha on 9 and 18 cm row spacings near Bonners Ferry, Idaho. Triallate, diclofop, and difenzoquat were applied preplant incorporated (0, 0.7, and 1.4 kg/ha), to three leaf wild oat (0, 0.6, and 1.1 kg/ha), and to five leaf wild oat (0, 0.6 and 1.1 kg/ha), respectively. Plant number and herbage dry weight were determined for barley and wild oat at the barley soft dough stage. Average wild oat density at Bonners Ferry was 82 plants/m^2. Barley grain was harvested at maturity. Row spacing had no effect on barley grain yield or wild oat control. Wild oat density and biomass decreased with increased seeding rates. Grain yield of barley seeded at 134 kg/ha was greater than barley seeded at 67 kg/ha and justified the additional seed cost. Grain yield was equal for barley seeded at 134 and 201 kg/ha and the increased cost of seed was not justified. Therefore, the 134 kg/ha seeding rate was used to compare net return over variable herbicide cost. Grain yield was not different among herbicides. Averaged across herbicides, half and full herbicide rates reduced wild oat plant number 60 and 76%, respectfully, and reduced wild oat biomass 68 and 86%, respectfully, compared to the untreated control. The half and full rates of diclofop and difenzoquat reduced wild oat density and biomass equally, but more than triallate. Barley grain yield was not different between half and full rates, but was 26% greater compared to the untreated check. Average net return for triallate, diclofop, and difenzoquat treatments was $175, $180, and $160/ha, respectively. The MEY was attained using the half rate of herbicide which reduced input cost and provided equal grain yield compared to the full herbicide rate. The production economics presented reflect 'short run' economic results at Bonners Ferry. Since wild oat control was reduced by using the half rate of herbicide, we need to consider how 'long run' economics are affected if wild oat control costs are higher in subsequent crops. Future projects include the development of bioeconomic models that predict wild oat and broadleaf weed control strategies that are most economical for both the short and long run.

PROGRESS IN THE DEVELOPMENT OF HERBICIDE-RESISTANT PEAS AND LENTILS. Z. L. Cai, C. M. Stiff, E. P. Fuerst, C. M. Boerboom, P. F. Lurquin, A. Kleinhofs, and F. J. Muehlbauer, Department of Crop and Soil Science and Program in Genetics and Cell Biology, Washington State University, Pullman, WA, 99164.

Abstract: Peas and lentils are important seed legumes in the Pacific Northwest. One of the major constraints in their production now is obtaining satisfactory weed control, due to the recent withdrawal of herbicide, dinoseb. One of the alternatives is to develop herbicide resistant crops which will allow the use of broad spectrum herbicides for weed control. A project has been initiated to transform herbicide resistance into peas and lentils using the *Agrobacterium tumefaciens* vector. Seeds of a few commercial varieties of peas and lentils were sterilized and germinated *in vitro*. Explants from 1 week-old epicotyls, leaflets, and immature embryos were cultured on Murashige-Skoog (MS) medium containing various concentrations of auxin and cytokinin. Calli have been obtained from pea epicotyls and leaflets and lentil leaflets and immature embryos. Calli from pea epicotyls and lentil leaflets are undergoing differentiation. Upon establishment of regeneration system, transformation experiments will be followed. As a second approach, sliced mature embryos from imbibed pea and lentil seeds were cocultivated with *A. tumefaciens* C58 and EHA105, both containing the beta-glucuronidase reporter gene under control of the CaMV 35S promotor. After 3 to 4 weeks incubation on MS medium, seedlings were assayed for GUS gene expression. A few of chimeric transgenic pea and lentil plants were obtained. This system will need to be optimized to achieve transformation of a higher proportion of the tissues and to induce shoot regeneration from transgenic cells.

THE RESIDUAL PROPERTIES OF TRIASULFURON IN MONTANA. Kristi M. Carda, Dawit Mulugeta, Peter K. Fay, and Edward S. Davis, Research Assistants, Professor, and Research Associate, Plant and Soil Science Department, Montana State University, Bozeman, MT 59717.

INTRODUCTION

Sulfonylurea herbicides have been used in Montana since their introduction in 1982. Chlorsulfuron provided broad spectrum weed control and excellent crop safety. However, this herbicide has a long soil residue which led to the development of resistance in five weed species: prickly lettuce, kochia, Russian thistle, annual ryegrass and common chickweed. Chlorsulfuron was removed from the market in areas where resistance is a problem in early 1991.

Triasulfuron is a sulfonylurea herbicide being labeled for use in Montana and other areas. Because triasulfuron is similar to chlorsulfuron in structure and activity, it is important to determine if triasulfuron also has a long period of activity in soil.

Research was conducted to determine the residual period of soil activity of triasulfuron. Greenhouse studies were conducted to determine if cross resistance occurs to triasulfuron in chlorsulfuron-resistant kochia and Russian thistle accessions.

METHODS AND MATERIALS

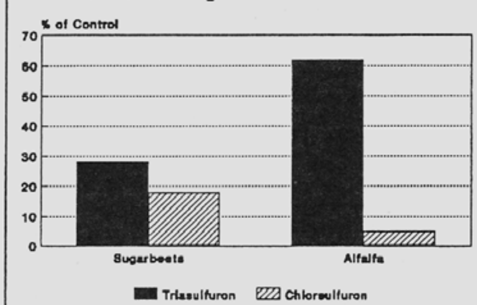
Triasulfuron plantback study. Triasulfuron was applied at 14, 25, 35, and 59 g/ha and chlorsulfuron at 19 g/ha to 3.7 m by 15.4 m plots seeded to 'Pondera' spring wheat on June 5, 1987. The experimental area was arranged in a randomized complete block design with three replications. The soil was a Bozeman silty clay loam with 2.2% organic matter and a pH of 7.7. Eleven important rotational crops in Montana were seeded into the experimental area in early June 1988 through 1990. The crops seeded were lentils, sugarbeets, alfalfa, sunflower, safflower, flax, durum, pinto bean, barley, oats and corn. Four of the crops, lentils, sugarbeets, and alfalfa (chosen for their extreme sensitivity to both herbicides) and oats (chosen for its lack of sensitivity) were harvested in August of each year and dry weights were determined.

Sulfonylurea herbicide susceptible and resistant kochia and Russian thistle accessions were planted into greenhouse flats and sprayed with 17 and 170 g/ha triasulfuron and 32 and 320 g/ha chlorsulfuron three weeks after emergence. Plants were harvested 20 days after treatment, dried and dry weight as percent of control was measured.

RESULTS

Dry weight production of sugarbeet and alfalfa was reduced significantly by chlorsulfuron and triasulfuron in 1989 and 1990 (Figure 1). Lentils were severely injured by both herbicides in 1990. The data shows that triasulfuron, like chlorsulfuron, is a long term residual herbicide.

Figure 1. Dry Weight Yields as % of Control for Sugarbeet and Alfalfa-1989



Resistant and susceptible accessions of both species showed greater sensitivity to triasulfuron than to chlorsulfuron, however chlorsulfuron resistant accessions were not killed by triasulfuron. Susceptible chlorsulfuron accessions showed similar responses when sprayed with each herbicide.

CONCLUSION

Triasulfuron degraded slowly under Montana conditions. While it degraded faster than chlorsulfuron, both herbicides reduced lentil biomass three years after application. Therefore, triasulfuron like chlorsulfuron is a long soil residual herbicide.

While kochia and Russian thistle accessions are differentially tolerant to triasulfuron and chlorsulfuron, the level of triasulfuron resistance among the chlorsulfuron resistant accessions will permit them to produce seed and increase under field conditions. In our opinion, if triasulfuron replaces chlorsulfuron, selection pressure toward additional resistant weed species will continue in Montana.

FITNESS AND ECOLOGICAL ADAPTABILITY OF CHLORSULFURON RESISTANT AND SUSCEPTIBLE KOCHIA BIOTYPES. Pedro J. Christoffoleti and Philip Westra, Graduate Student and Assistant Professor, Department of Plant Pathology and Weed Science, Colorado State University, Fort Collins, CO 80523.

Abstract. In Colorado, many cases of triazine resistance and 15 cases of sulfonylurea resistance have been reported for kochia. Preliminary herbicide resistance research was conducted in the greenhouse during the spring of 1990 to analyse the growth of chlorsulfuron resistant and susceptible biotypes of kochia. The experiment was carried out with the plants growing under non-competitive conditions. The results showed that the susceptible kochia grew better and produced more biomass than did the resistant kochia.

During the summer of 1990, chlorsulfuron susceptible and resistant kochia biotypes were grown in the field at different densities and proportions in an additional series experiment. The plants were distributed in the field at different densities to provide different levels of competition. Kochia dry weight analysis at final harvest confirmed the lower competitive ability of the resistant compared to the susceptible. Kochia dry weight per plant can be estimated by a linear regression equation of the transformed data as follows:

$$DW = 2.92 - 0.74.(D) + 0.074.(R.S) + 0.00001.(D).(R.S)$$

where:

DW = dry weight of resistant or susceptible kochia.
D = total density of kochia.
R.S = density of resistant or susceptible kochia.

Mathematical evaluation of these results allowed the calculation of the number of years for the population of resistant kochia to switch from a very low frequency to 30% of the total population. According to the data obtained from the experiment, this time period is 6.74 yr.

INHERITANCE OF RESISTANCE TO THE SULFONYLUREA HERBICIDES IN *KOCHIA SCOPARIA* L. (SCHRAD). Dawit Mulugeta, Peter K. Fay, Willam E. Dyer, and Luther E. Talbert, Research Assistant, Professor, and Assistant Professors, Plant and Soil Science Department, Montana State University, Bozeman, MT 59717.

Abstract. Resistance to the sulfonylurea herbicides has spread rapidly among accessions of kochia. In order to manage this resistance we will need to know how the resistance trait is spread and inherited. The objectives of

this study were to evaluate the response of different kochia collections to several sulfonylurea herbicides, and to establish the mode of inheritance of the R trait. Field collections of kochia were made in Montana during the 1988 and 1989 crop season. The whole plant response of each collection to field application rates of chlorsulfuron, metsulfuron-methyl, DPX-L5300, DPX-L5300 plus DPX-M6316, DPX-V9360, and triasulfuron was determined in the greenhouse. Three weeks after herbicide treatment visual ratings, stand reduction, and biomass accumulation were recorded. The experiment was conducted twice and arranged in a randomized complete block design with three or four replications. The level of resistance to each herbicide varied among accessions. Several accessions with a high level of resistance to chlorsulfuron were susceptible to metsulfuron-methyl and DPX-L5300. Others were resistant to all of the herbicides tested indicating several different mutations exist in the collection.

In order to determine the mode of inheritance of resistance, resistant and susceptible plants were grown adjacent to each other. Prior to flowering branches of resistant and susceptible plants were bagged alone and together. Seeds were harvested separately, grown in the greenhouse and treated with 277 g/ha of chlorsulfuron. Percent survival (indicating resistance) was determined 3 weeks after treatment. All progeny from susceptible selfed plants were killed, susceptible branches that were bagged with resistant plants produced 19% resistant progeny. On the other hand 90% of the progeny from self-pollinated branches from resistant plants were 90% resistant. The level of resistance decreased to 74 % when resistant plants were bagged with susceptible plants. From 21 resistant self-pollinated plants came 6 plants whose progeny were completely resistant to chlorsulfuron. Progeny from 9 plants were 80% resistant which agrees with a 3:1 ratio of segregation of a single dominant gene in the F_1 generation. Of the remaining six plants, 87% of the progeny were resistant. The F_2 progeny of homozygous resistant plants responded consistently, showing 96% or more of the progeny were resistant. In summary, resistance to the sulfonylurea herbicides appears to be a dominant or semi-dominant trait under the control of single gene.

CHARACTERISTICS OF DIVERSE SULFONYLUREA-RESISTANT AND SUSCEPTIBLE *KOCHIA SCOPARIA* L. ACCESSIONS. K. Sivakumaran, D. Mulugeta, S.A. Gerhardt, P.K. Fay and W.E. Dyer, Graduate Research Assistants, Research Associate, Professor, Assistant Professor, Department of Plant and Soil Science, Montana State University, Bozeman, MT 59717.

ABSTRACT. The continuous use of chlorsulfuron to control broadleaf weeds in small grains has resulted in the occurrence of resistant kochia populations. These populations have probably arisen independently in geographically widespread areas. To study the mechanism of resistance to chlorsulfuron and other ALS inhibiting herbicides, kochia seeds were collected from Bozeman, Power, Chester, MT and Minot, ND. Since kochia shows substantial phenotypic diversity and variability in other species adapted to different geographic locations has been attributed to changes in ploidy level, we examined chromosome number in these four Kochia accessions. Cytogenetic studies revealed no differences in the chromosome number (2n=18). Greenhouse studies were undertaken to determine the GR_{50} values of these accessions for chlorsulfuron and triasulfuron. The Bozeman accession was susceptible to field use rates of both herbicides. Power was tolerant to 2X the normal field use rate of chlorsulfuron, whereas Chester and Minot were equally tolerant to more than 40X the field use rate. However, Chester showed a substantially higher level of tolerance than Minot when treated with triasulfuron. To correlate the different whole plant responses of Chester and Minot with target enzyme activity, ALS I_{50} values were determined. Although ALS from both resistant accessions showed high levels of tolerance to chlorsulfuron, Chester was at least 2X more tolerant to triasulfuron compared to Minot. The similar responses of these accessions to chlorsulfuron and their differential responses to triasulfuron suggest that different mutations in gene(s) encoding ALS may be responsible for the varying patterns of cross-resistance. Studies are currently underway to determine the molecular basis for these differences in cross-resistance.

EFFECTS OF WEED COMPETITION ON ONION GROWTH, YIELD, AND QUALITY. Claudio M. Dunan and Phil Westra. Department of Plant Pathology and Weed Science, Colorado State University, Co. 80523.

Abstract. Bioeconomic models for weed control decisions require the use of yield loss reduction functions. In most cases, an empirical regression model that predicts crop yield losses as a function of weed density is used. The assumption is that weed density controls crop-weed competition and that a critical period exists where the presence of weeds does not reduce crop yield. It is already recognized that crop density, time of crop and weed emergence, fertilization, irrigation, competition duration, and spatial distribution of weeds and crops affect weed-crop competition.

Weed removal experiments based on the accumulation of onion degree days over 45 F, were conducted in three commercial onion fields to assess the impact of competition duration on onion yield and quality (size). Growth analysis experiments for onions and weeds were performed to calculate parameters to be used in a mechanistic simulation model of weed-crop competition.

Weed competition reduced onion yield and size from the beginning of the growing season, without any indication of the existence of a critical period. Weed density and weed time of emergence affected the shape of the response. The duration of the competition function was used to calculate economic thresholds for weed control operations and showed that when some operations could be applied, the potential maximum yield was already reduced. Analysis of sensitivity of the simulation model showed that onion yield and quality were more affected by time of weed emergence than weed density. These results show that using only weed density and critical period to calculate an economic threshold may be misleading and could result in important economic losses when control measures are applied.

INTERACTION BETWEEN BUCKWHEAT AND CANADA THISTLE. S.R. Eskelsen and G.D. Crabtree, Graduate Research Assistant and Professor, Department of Horticulture, Oregon State University, Corvallis, OR 97331.

Abstract. Buckwheat, whether grown as an economic crop or a cover crop, generally suppresses the growth of Canada thistle. A field experiment was conducted to determine if allelopathy is one mechanism by which buckwheat suppresses Canada thistle. In a field experiment, allelopathy may be suspected if the relative total yield (RTY) of a mixture of two species is less than one (1). If RTY=1 then competition for resources is the mechanism by which growth is suppressed. Therefore, the objective of this experiment was to determine if the RTY of the mixture of Canada thistle and buckwheat is less than one (RTY < 1).

An addition series experiment was established at the OSU Horticulture Research Farm located near Corvallis, Oregon. The experiment was a randomized complete block design with eight blocks. A 4 by 4 factorial set of treatments was determined using different densities of Canada thistle and buckwheat (Table 1). Canada thistle roots were harvested from soil of a site heavily infested with Canada thistle. Root pieces were cut into two-inch lengths and were later used to propagate Canada thistle plants in treatments. Blocks 1 to 4 were planted on June 21, 1990 and blocks 5 to 8 were planted on August 22 and 23, 1990. The experimental area was fertilized with 613 lb/A of 12-29-10-8 (N-P-K-S) and irrigated as needed. Each plot was 1 m^2. Blocks 1 to 4 were harvested on August 2 and 3, 1990. Blocks 5 to 8 were harvested on October 25 and 26, 1990. The center 0.75 m^2 was harvested from each plot. At harvest, shoots were severed at soil surface, separated by species, and placed in paper bags. The paper bags were placed in a drying oven for 72 hr. Bags were then weighed to determine shoot biomass. RTY was determined for all the mixture treatments using the following equation:

$$RYT = \frac{CTYIELD_{MIX}}{CTYIELD_{MONO}} + \frac{BYIELD_{MIX}}{BYIELD_{MONO}}$$

RTYs for each mixture were subjected to analysis of variance according to factorial set of treatments used in Table 2. The LOG(RTY) transformation was used to satisfy the assumptions for analysis of variance

(ANOVA). Since LOG(1) = 0, it was necessary to determine if LOG(RTY) is less than 0 (The untransformed hypothesis is that RTY is less than 1).

The ANOVA determined that RTY was influenced by buckwheat density. Canada thistle density and Canada thistle by buckwheat density interaction were not significant. The means of LOG(RTY) for each buckwheat density are shown in Table 3. The means at densities 9 and 100 are not significantly different from each other. However, these means are significantly different than the mean at the 400 density . The mean LOG(RTY) are significantly different from 0 at the 9 and 100 buckwheat densities. The mean LOG(RTY) is not significantly different from 0 at the 400 buckwheat density. RTY is only correct when the plant densities in the monocultures are high enough to reach constant final yield (2). Monoculture data of buckwheat (data not shown) showed that at 100 plants/m^2 of buckwheat, buckwheat had not reached constant final yield whereas at the 400 density, constant final yield was approached. Therefore, RTY is only valid at the 400 buckwheat density. At this density, LOG(RTY) did not significantly differ from 0 (RTY = 1). Within the 400 buckwheat density there was a treatment that included Canada thistle at 200 plants/m^2. At this density of Canada thistle, constant final yield was approached. The LOG(RTY) for this treatment (Canada thistle density-200 plants/m^2 and Buckwheat density-400 plants/m^2) was not significantly different from 0. This (LOG(RTY) = 0 or RTY = 1) indicates that the suppression of Canada thistle by buckwheat may just be due to competition for resources and not allelopathy.

A future repeat of this experiment will include more treatments where the constant final yield for both buckwheat and Canada thistle is reached for more than one treatment. Also, growth parameters will be monitored for both species.

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Table 1. The densities of Canada thistle and buckwheat used in the experiment.

Factor A Buckwheat (plants/m^2)	Factor B Canada thistle (plants/m^2)
0	0
9	9
100	60
400	200

Table 2. The densities of buckwheat and Canada thistle used to determine the dependence of RTY on density of the two species.

Canada thistle density (plants/m^2)	Buckwheat density (plants/m^2)
9	9
60	100
200	400

Table 3. The mean LOG(RTY) at different densities of buckwheat. Also, the probability that these means are equal to 0.

Buckwheat density (plants/m^2)	Means LOG(RTY)	[a]Pr > 't' HO:Mean=0
9	0.393 a	0.0001
100	0.235 a	0.0024
400	-0.076 b	0.3060

[a]The probability that the means LOG(RTY) are equal to zero.

SENSORY PHYSIOLOGY OF DODDER SEEDLINGS PRIOR TO HOST ATTACHMENT. M. A. Haidar, P. Westra, and G. Orr, Graduate Student, Assistant and Associate Professors, Department of Plant Pathology and Weed Science, Colorado State University, Fort Collins, CO 80523.

Abstract. Dodder is an obligate stem parasite. Characteristic of seedlings of holoparasitic higher plants, early detection of potential hosts is essential for survival. An array of sequential environmental cues control early morphological development of dodder seedlings thereby enhancing potential for successful host attachment. Seeds of dodder remain dormant in soil for many years. Scarification of hard seed and imbibition result in germination. Emerging seedlings are ecotyledonous with filiform or thread-like yellow stems. Formation of an apical "hook" protects meristematic tissue from mechanical injury as the negatively gravitropic seedling grows through soil. Emergence of the seedling from the soil surface into light stimulates hook opening. Hook opening is controlled by phytochrome (photomorphogenesis). In white light dodder accumulates chlorophyll and begins nutating "in search" of a host. Sensing of neighboring plants (i.e., potential hosts) by dodder is detected initially by changes in light quality. Within the sphere of influence of a neighboring plant, an environment enriched in blue and far-red light potentiates a change in state of the thread-like organ of dodder to that of its parasitic mode of growth. It is unclear whether phytochrome alone can account for this effect or whether a specific blue light photoreceptor (cryptochrome) is involved. High fluence rates are required, but potentiation can be reversed with a final brief exposure to red light. Threads are (at least momentarily) no longer negatively gravitropic or phototropic, but become susceptible to mechanical stimulation (thigmomorphogenesis) and will form tight coils around the host stem and soon initiate development of prehaustoria (an early stage of infection structure) on the concave side of coils. Auxin/cytokinin ratios likely influence development of these structures. Ethylene is without effect at this stage. Data from laboratory experiments with excised dodder threads will be presented in support of this scenario.

INTERFERENCE BETWEEN TWO RANGELAND GRASSES AND RUSSIAN KNAPWEED. D. Eric Hanson and K. George Beck, Former Graduate Research Assistant and Assistant Professor, Department of Plant Pathology and Weed Science, Colorado State University, Fort Collins, CO 80523.

Abstract. Russian knapweed is an herbaceous, creeping perennial which can form single-species stands over time. It competes well and is allelopathic. It is abundant in the western United States especially in semi-arid areas and is spreading 8 to 11% annually. It has been observed that Russian knapweed infestations decreased in mesic areas with perennial grass competition but increased in dry areas. Experiments were conducted to evaluate interference between western wheatgrass or smooth brome and Russian knapweed grown in a common pot.

The study was conducted with four treatments in each replication and four replications. Treatments were: 18 grass plants per pot (treatment one), 21 grass plants per pot (treatment two), 18 grass and 3 knapweed plants per pot (treatment three), and 3 knapweed plants per pot (treatment four). Experiments were conducted separately for each grass species. Germinated western wheatgrass or smooth brome seeds were planted into a potting mix in 30-cm pots, using a cardboard template to insure proper spacing. Russian knapweed plants were propagated from root buds and grown in containers filled with potting mix. Russian knapweed plants then were transplanted, using the cardboard template, into the filled 30-cm pots. Plants were placed in rows marked outside, middle, inside, and center. Grasses were always in the outside, middle, and inside rows. The center row contained nothing (treatment one), grass (treatment two), or knapweed (treatments three and four). Any extra plants were thinned. Fifty kg N ha^{-1} and 10 kg P ha^{-1}, were added to the potting mix. Plants grew for 6 weeks in the greenhouse under metal halide lamps, set to a 14 hr photoperiod. Plants were allowed to grow for 14 days, then harvested at weekly intervals. At harvest, roots were washed to remove soil, then plants were dried at 60 C for 48 hr. Each row was harvested separately. Roots and shoots then were separated and dry weights taken.

Statistical analysis was conducted as if there were two separate experiments because no meaningful comparisons could be made between treatments one or two and treatment four. With respect to grass, the study was a split plot arrangement with 3 (treatments) by 5 (harvests) factorial as the whole plots and rows in the pot as the subplots, and 2 (treatments) by 5 (harvests) factorial arrangement, with respect to Russian knapweed.

Treatments one, two, and three were included in the grass experiments with treatment one as the control. Treatments three and four were included in the Russian knapweed experiment with treatment four as the control. Regression analysis was conducted on each treatment over all harvest and the slopes compared.

Grasses responded differently to Russian knapweed competition. Western wheatgrass root and shoot growth was unaffected by either inter- or intraspecific competition. Smooth brome root and weight growth was equally reduced by inter- and intraspecific competition. The response of Russian knapweed to competition also varied depending upon the competing grass species. Competition with western wheatgrass did not affect Russian knapweed root or shoot growth. Russian knapweed shoot and root growth were reduced by smooth brome competition.

VESICULAR-ARBUSCULAR MYCORRHIZAE FUNGI INTERACTIONS WITH LEAFY SPURGE. James D. Harbour, J. Allen White, Stephen D. Miller, and Stephen E. Williams, Research Associate, Department of Plant, Soil, and Insect Sciences, University of Wyoming, Soil Consevation Service, USDA, Cheyenne, WY 82001, Professors, Department of Plant, Soil, and Insect Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Leafy spurge is a noxious perennial weed which infests millions of acres of rangeland in the northcentral United States. Leafy spurge is infected with vesicular-arbuscular mycorrhizae (VAM) fungi. VAM fungi are widely accepted as beneficial organisms in the majority of plant families. The objectives of this work were to determine how VAM fungi impact the growth and development of leafy spurge and determine if such information can be used to generate a strategy for control of this noxious weed. Plants were collected from different sites in Wyoming and exhibited varying degrees of infection. Results thus far indicate a slower regrowth rate of clipped plants infected with VAM fungi compared to noninfected clipped plants. The decreased regrowth may be explained by the VAM fungi using the root's stored carbohydrates for energy and further depleting the reserves. Leafy spurge was inoculated with 9 VAM fungi endophytes and *Glomus mosseae* Colorado isolate, *G. mosseae* Arizona isolate, and *G. macrocarpum* had the greatest levels of infection. The leafy spurge roots were analyzed total nonstructural carbohydrates and the shoots were analyzed for total phosphorus to determine the interaction between VAM fungi and leafy spurge.

WILD MUSTARD INTERFERENCE IN SUGARBEETS. Abdelouhab Mesbah, Stephen D. Miller, and David Legg, Graduate Assistant, Professor and Assistant Professor; Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY 82071.

INTRODUCTION

Weed competition is one of the major problems that prevent the achievement of maximum crop yields. No data are available on wild mustard competition in sugarbeets, however wild mustard has been reported to reduce yield of other crops such as wheat and sunflower . Shebeski (7) reported that wheat yields were reduced by 17, 36, and 45%; respectively, by wild mustard densities of 50, 100, and 200 plants m^{-1}. Similarly, Collins (1) reported that 16 wild mustard plants m^{-1} of row reduced sunflower yield 13%. Further sunflower achene yield reductions from wild mustard competition were similar whether wild mustard competed for four weeks or season-long.

The objectives of this research were to determine: a) the influence of several wild mustard densities on sugarbeet yield (top and root) and sucrose content, b) the duration of time after sugarbeet emergence that wild mustard can compete with sugarbeet before yields reduced, c) the lowest density of wild mustard that will significantly reduce yield, and d) sugarbeet yield loss for each week of wild mustard competition.

MATERIALS AND METHODS

Two experiments were conducted at the Research and Extension Center, Powell, Wyoming in 1990 on a Garland clay loam (fine, mixed, mesic typic Haplargid) with 1.2% organic matter and pH 7.2. Sugarbeets were seeded in a wild mustard infested area on April 18, 1990. Individual plots were established immediately after the emergence of both wild mustard and sugarbeet seedlings. Experimental units consisted of three sugarbeet rows 5m in length and spaced 56 cm apart. Both experiments had a randomized complete block design with four replications.

Season-long competition from several wild mustard densities. Wild mustard densities of 0, 0.2, 0.4, 0.8, 1.6, and 3.2 plants m^{-1} of row were established in an 8 cm band over the sugarbeet row. Sugarbeet seedlings were thinned to one plant every 25 to 30 cm. All experimental units were maintained free of other weeds throughout the growing season by cultivation between rows and hand pulling in the row. The experimental area was furrow irrigated. The height of wild mustard and sugarbeet plants as well as light measurements were recorded in mid-June.

Duration of wild mustard competition. A wild mustard density of 1.6 plants m^{-1} of row was established in an 8 cm band over the sugarbeet row immediately after emergence. A weed free plot was established at this time. Wild mustard plants were removed 2, 4, 8, and 10 weeks after sugarbeet emergence. All experimental units were maintained free of other weeds throughout the growing season by cultivation and hand weeding.

In mid-September, one sugarbeet row per plot was harvested and sugarbeet roots sent to Western Sugar Company (Lovell) to be weighed and analyzed for sugar content. Sugarbeet top and wild mustard weights were determined in the field at this time. The experimental data were analyzed using a randomized complete block design and means were compared using Fischere's Least Significant Difference (LSD) test at the 5% probability level. To estimate the lowest density or duration of wild mustard competition that reduced sugarbeet yield, a simple linear regression equation was developed for the data.

RESULTS AND DISCUSSION

Season-long competition from several wild mustard densities. Total biomass decreased as wild mustard densities increased (Table 1). Total biomass averaged 59.8, 54.9, 56.8, 41.5, and 32.5 T ha^{-1} at wild mustard densities of 0, 0.2, 0.4, 0.8, 1.6, and 3.2 plants m^{-1}. The reduction in sugarbeet top and root production that resulted from wild mustard competition was not offset by the gain in weed growth. Schwizer (4, 5, 6) studying common lambsquarters , velvetleaf and other broadleaf weed competition in sugarbeets, similarly found that total biomass decreased as weed densities increased. In competition studies with giant foxtail in corn and soybeans, Knake (3) found that the total biomass produced remained constant at different weed densities. According to Zimdahl (8), no generalization can be made concerning biomass production for specific weed-crop communities, because biomass production is dependent on plant species and environment.

Sugarbeet root yield decreased as wild mustard density increased (Table 2). Wild mustard reduced sugarbeet root yield 24, 11, 11, 45, and 62%; respectively, at densities of 0.2, 0.4, 0.8, 1.6, and 3.2 plants m^{-1}. Similarly sugarbeet top yield decreased as wild mustard density increased from 0 to 3.2 plants m^{-1}. The notable exception was at the 0.2 wild mustard plants m^{-1} where the top yield exceeded that of the control. The top yield averaged 25.9, 25.5, 23.8, 20.1, and 16.4 T ha^{-1}; respectively, at densities of 0, 0.2, 0.4, 0.8, 1.6, and 3.2 plants m^{-1}. Sucrose content was not influenced by wild mustard densities.

Sugarbeet root yield was regressed against wild mustard densities, and the (Figure 1) data fit a first-order linear regression model $Y=31.6-6.12X$ with an R^2 value of 0.84. Using this regression equation, the minimum number of wild mustard plants that will reduce sugarbeet root yield was calculated to be 0.3 plants m^{-1} of row. At this density, root yield will be reduced by an average of 5%.

According to Donald (2) in any cropping system where water and nutrients are available, light becomes the only limiting factor to plant growth. During this experiment sugarbeets were irrigated to avoid water stress and nutrients were applied. Based on wild mustard height and light measurements (Table 3), it appears that wild mustard competition with sugarbeets may be primarily for light.

Duration of wild mustard competition. Sugarbeet root yield decreased as duration of wild mustard competition after sugarbeet emergence increased (Table 4). Root yields were reduced 7, 24, 21, 28, and 35%; respectively, at 2, 4, 6, 8, and 10 weeks of wild mustard competition. Sugarbeet root yield regressed against duration of wild mustard competition (Figure 2) indicated that the data fit a linear regression equation of $Y = 52.4 - 1.81X$ with an R2 value of 0.91. From this equation the minimum time wild mustard must compete with sugarbeets is 0.9 weeks before yields are reduced. Duration of wild mustard competition did not influence sugarbeet top yield or sucrose content.

Table 1. Effect of season-long competition from several wild mustard densities on biomass production.

	Biomass production			
Wild mustard density	Wild mustard	Sugarbeets Tops	Sugarbeets Roots	Total biomass
plants m^{-1}	(T ha^{-1})			
0	..	25.9	33.9	59.8
0.2	0.9	28.3	25.7	54.9
0.4	1.1	25.5	30.2	56.8
0.8	1.8	23.8	30.1	55.7
1.6	2.6	20.1	18.7	41.4
3.2	3.3	16.4	12.8	32.5
LSD (0.05)	0.8	6.5	8.9	14.0

Table 2. Sugarbeet root yield and sucrose percentage as influenced by season-long competition of various wild mustard densities.

Wild mustard densities	Root yield	Yield reduction	Sucrose content
plant m^{-1}	T ha^{-1}	--------%----------	
0	33.9	..	15.1
0.2	25.7	24	14.7
0.4	30.2	11	15.0
0.8	30.1	11	15.1
1.6	18.7	45	14.8
3.2	12.8	62	14.8
LSD (0.05)	8.9	—	NS

Table 3. Effect of season-long competition from several wild mustard densities on wild mustard height and light at the top and bottom of sugarbeet leaves.

Wild mustard density	Wild mustard height	Sugarbeet height	Light	
			Top	Bottom
plants m^{-1}	----------(cm)----------		----(Q x 10^3)----	
0	___	34.0	2.3	0.4
0.2	69.2	33.0	1.1	0.5
0.4	64.9	31.4	1.3	0.3
0.8	74.4	33.8	1.0	0.2
1.6	74.7	32.7	1.0	0.1
3.2	73.2	27.5	1.2	0.1
LSD (0.05)	6.3	4.1	0.2	0.2

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Table 4. Sugarbeet yield as affected by weeks of wild mustard competition.

Duration of competition	Sugarbeet root yield	Yield reduction	Sugarbeet top yield	Sucrose content
weeks	T ha^{-1}	%	T ha^{-1}	%
0	53.7	0	38.4	15.3
2	49.9	7	34.8	15.2
4	40.8	24	31.9	15.8
6	42.3	21	36.7	15.4
8	38.6	28	44.2	14.9
10	34.8	35	38.4	15.1
LSD (0.05)	10.3	___	NS	NS

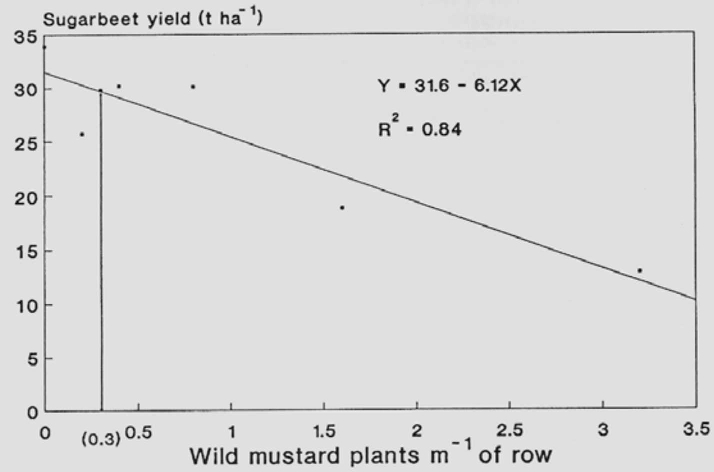

Figure 1: Sugarbeet root yield regressed against various wild mustard densities.

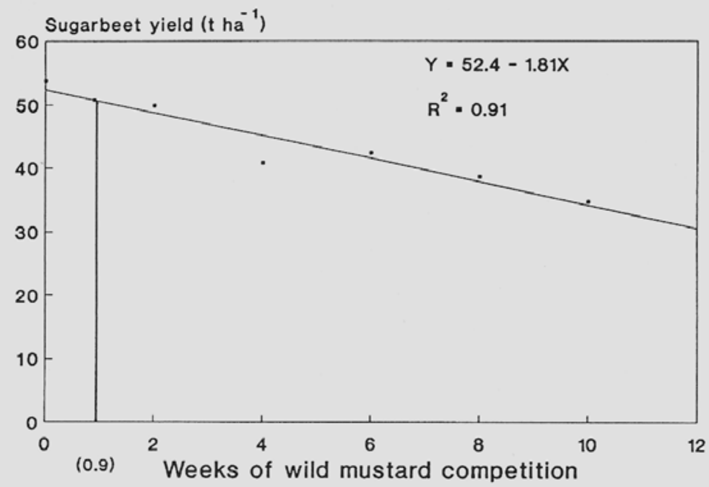

Figure 2: Sugarbeet root yield regressed against duration of wild mustard competition.

THE ACTIVITY OF THE HERBICIDE SAFENER BENOXACOR IN SUSPENSION CULTURES OF CORN.

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Abstract. A common mechanism for the *in vivo* detoxification of acetanilide herbicides is conjugation of the herbicide molecule with glutathione, an endogenous tripeptide, to form an inactive herbicide-glutathione conjugate. This reaction is facilitated by the enzyme glutathione S-transferase (GST). Benoxacor (CGA-154281) is a safener used to protect corn and sorghum against injury from acetanilide herbicides such as metolachlor. It is hypothesized that benoxacor confers protection to corn plants by increasing the activity of the GST family of enzymes. Research was initiated using a model system of suspension cultures of corn (*Zea mays* cv. Black Mexican Sweet) to study the effects of benoxacor uptake, metabolism, and subsequent correlation to the induction of GST activity.

GST induction kinetics were determined by treating middle log-phase cultures with 10 uM benoxacor and harvesting the cells at 2, 4, 6, 12, 24, and 48 hr after treatment. Total GST activity in crude extracts was determined by measuring the *in vitro* conjugation of glutathione to ^{14}C-metolachlor. Benoxacor-induced increases in GST activity were measured at the earliest time points and continued to increase until 24 hr after treatment.

Uptake and metabolism kinetic studies were conducted by treating middle log-phase cultures with 10 uM ^{14}C-benoxacor and harvesting the cells at 15 min., 30 min., 1, 2, 3, 6, 12, 24, and 48 hr after treatment. The cells were extracted with 80% acetonitrile (v/v) and assayed for radioactivity via liquid scintillation counting to determine uptake. Thin layer chromatography was used to assay metabolism. A significant quantity of benoxacor is taken up, and metabolism initiated in as little as 15 min. Considerable metabolism of the parent molecule appears to occur after 48 hr.

THE EFFECTS OF INTENSIVE GRAZING ON OX-EYE DAISY. Roseann T. Wallander, Bret E. Olson, Peter K. Fay, Kathrin Olson-Rutz, Graduate student, Assistant Professor of Range Science, Professor of Plant and Soil Sciences, Research Associate, Montana State University, Bozeman, MT 59717.

INTRODUCTION

Green Mountain Ranch near Bozeman, MT uses an intensive cattle grazing system to control extensive patches of ox-eye daisy in a 180 A summer pasture. This system which uses a high number of cattle to graze a small area over a short time period was initiated in 1989. In 1990 we began a study to assess the effects of this grazing system on ox-eye daisy and associated grasses.

Ox-eye daisy is an introduced perennial that reproduces vegetatively along a woody rhizome and also produces abundant seed. Cattle tend to avoid the daisy because of its acridity (1). Under high stock density in an intensive grazing system, cattle may eat the daisy even though it is not a preferred forage.

Intensive grazing during flowering could impact the daisy in several ways. First, if the cattle eat the flower before it produces seed, that seed production is eliminated. If cattle eat a flower head containing viable seed, 60% of the viable seed may be destroyed by digestion (1). Second, grazing and trampling the daisy plants may reduce subsequent growth and reproduction. Finally, soil disturbance through hoof action may bring new seeds to the surface which will germinate following summer thundershowers, but die shortly thereafter.

While intensive grazing may provide control of ox-eye daisy, it may also negatively impact forage in the pasture. Dominant forage grasses present were smooth brome and timothy. Kentucky bluegrass and orchardgrass were also present in the pasture.

The objectives of our study were to: 1) assess the effects of intensive grazing on yr to yr changes in the density of ox-eye daisy and associated perennial grasses, and 2) determine when and to what extent cattle begin to graze ox-eye daisy and associated perennial grasses.

MATERIALS AND METHODS

Study design. The 180 A pasture was divided into six, 30 A paddocks. Paired transects (10 m long) were permanently established in areas of high daisy density in paddocks two and four. Transects in each set were parallel to each other and approximately four meters apart. Four sets of transects were marked in each paddock. One of each pair was exclosed from grazing, the other was open to grazing. Stem densities and plant frequencies were determined along these transects to assess the impact of intensive grazing on ox-eye daisy and associated grasses.

Two hundred and sixteen animals (cow-calf pairs) were introduced into the first paddock on June 28, 1990. They were moved across the pasture, paddock by paddock until they left paddock six on July 30, 1990. The animals grazed each paddock for 5 to 6 days before they were moved. Stock densities in each paddock were about 7.2 animal units (AUs)/A. The ox-eye daisy was flowering during this period. Smooth brome was in early seed formation and timothy was in early anthesis. Paddock two was grazed from July 5, through July 11, paddock four was grazed from July 16 through July 21.

Stem densities and plant frequencies. A Daubenmire frame (20 cm by 50 cm) was placed at 1 m intervals along each transect and permanently marked perpendicular to the transect. Within each frame, stems of ox-eye daisy were counted and assigned to three size categories - seedlings, rosettes, and adults. Shoots of smooth brome, timothy and dandelion were counted. The presence or absence of Kentucky bluegrass and orchardgrass was noted.

Utilization. Four grass tillers and four daisy stems were marked at each frame along grazed transects. The height of each was measured before grazing. During and immediately after the grazing period, each plant was relocated, measured, and noted whether it had been grazed, trampled, or removed.

After grazing, rooted biomass was clipped from five Daubenmire frames placed at 2 m intervals along each grazed and ungrazed transect. The clipped frames did not interfere with those areas permanently marked for stem densities and plant frequencies. Clipped material was separated into daisy and other, dried at 60 C for 24 hr and weighed. Other vegetation included all grasses and forbs, except ox-eye daisy. Utilization was calculated from biomass remaining in the grazed plots relative to ungrazed plots.

RESULTS AND DISCUSSION

Yr to yr changes of ox-eye daisy and grasses. Prior to grazing in 1990, stem densities and plant frequencies along grazed transects were similar to ungrazed transects. The impact of intensive grazing on yr to yr changes in density of ox-eye daisy and associated grasses will be measured just before the 1991 grazing season.

Impact on daisies and associated vegetation: Paddock two. Cattle grazed less than 20% of the marked plants in the daisy patches during the first two days of the grazing period (Figures 1 and 2). After day two, grazing and trampling increased. The lack of impact during the first 2 days may indicate cattle avoided the daisy patches during the first days in this paddock. Overall cattle grazed grasses more than daisies, and they trampled and removed daisies more than grasses.

Paddock four. Some of the marked daisies were trampled by pregrazing sampling in this paddock so that before grazing we did not have 100% untouched daisies (Figure 3). From the initial day of the grazing period, cattle primarily grazed grasses (Figure 4) whereas they trampled and grazed daisy. This indicates that the cattle did not avoid the daisy patches in this paddock. They may have been more accustomed to the plant since they had been forced to eat it in the three previous paddocks, or daisy palatability may have changed over time (this paddock was grazed 11 days later than paddock two), or the results may reflect differences in the paddocks that our sampling does not detect. Grass grazing increased from day 2 to 4. After day 4 they stopped grazing the grasses and increased grazing of the daisy.

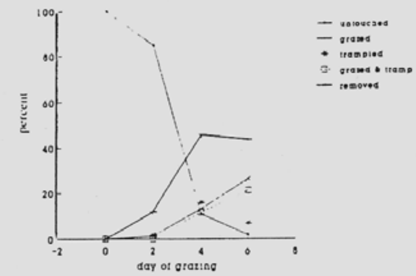

Figure 1. The impact of six days of intensive cattle grazing on ox-eye daisy in Paddock 2.

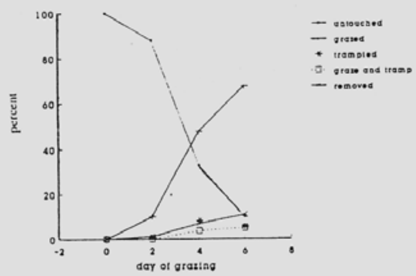

Figure 2. The impact of six days of intensive cattle grazing on perennial grasses in Paddock 2.

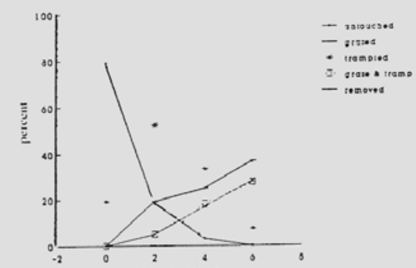

Figure 3. The impact of six days of intensive cattle grazing on ox-eye daisy in Paddock 4.

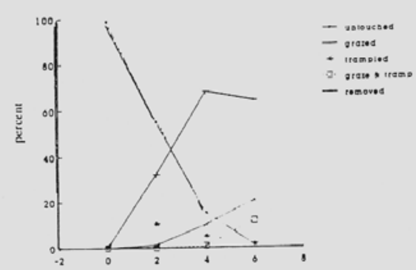

Figure 4. The impact of six days on intensive cattle grazing on perennial grasses in Paddock 4.

Cattle use of daisy and associated vegetation. Cattle use of the daisy and associated vegetation in daisy patches was quantified by measuring heights of marked tillers or shoots at days 0 (just prior to grazing), 2, 4, and 6, and clipping and weighing plots in grazed and ungrazed areas immediately after the cattle left the paddock. In paddock two, daisy heights increased from day 0 to day 2, indicating growth or little grazing. In paddock four, daisy height declined slightly from day 0 to day 2, probably because growth was slowing down, or the cattle were accepting the daisy more readily, or both. From days 2 to 6, cattle reduced daisy and grass height by grazing, trampling or both, except in paddock four where grass height changed little from day 4 to 6. During this interval, grass height averaged 10 cm which may have reduced grass availability to the cattle, and thus minimized further grazing of the stubble.

Overall, production along the ungrazed transects in both paddocks averaged 2100 kg ha-1. Dry weights of clipped material from grazed transects compared with ungrazed transects indicate high impact of cattle on the daisy and other vegetation. The 'other' vegetation is primarily smooth brome and timothy. In paddock 2, cattle removed 72% of the daisy biomass and 69% of the 'other' vegetation. In paddock four, cattle removed 81% of the daisy and 78% of the 'other' vegetation. Since we clipped rooted plants only, removed material may have been removed by grazing or trampling. The high amount of daisy and 'other' vegetation removed during these growth stages is probably detrimental to survival of both groups of vegetation (2, 3, 4). The actual impact will be measured in 1991.

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PRELIMINARY STUDIES ON THE INTRODUCTION OF HERBICIDE RESISTANCE INTO SAFFLOWER (*Carthamus tinctorius L.*). M. Ying, S. A. Gerhardt, and W. E. Dyer, Graduate Research Assistant, Research Associate, and Assistant Professor, Department of Plant and Soil Science, Montana State University, Bozeman, MT 59717.

Abstract. Safflower is an important oilseed crop in North America, India, and Mexico. It is also a valuable alternative crop to small grains particularly in Montana. Safflower oil is desirable for human nutrition due to its high degree of polyunsaturation and elevated levels of α-tocopherol. Since there are few herbicides labeled for safflower production, introduction of herbicide resistance into safflower would be highly desirable. This research was designed to develop an efficient regeneration and transformation system for safflower. Twenty-three safflower cultivars were evaluated for their response to tissue culture conditions. Safflower seeds were surface sterilized and germinated for one week, after which seedlings were excised and cultured on agar medium. Callus was formed from about 90% of 'Centennial' cotyledons. Calli were grown on MS basal salts medium with 1 mg/L 6-benzylaminopurine (BAP) and 1 mg/L 1-naphthaleneacetic acid (NAA). Calli containing 'green islands' were selected and transferred to fresh medium. Shoots were induced after about 10 days growth; however, frequency of shoot formation was about 19%. Safflower cotyledon and leaf segments were transformed using *Agrobacterium tumefaciens* strain LBA4404 carrying the Ti plasmid pBI121 which contains the β-glucuronidase (GUS) reporter gene and confers kanamycin resistance. After 2 days of co-cultivation, the tissue was transferred to selective medium containing 25 mg/L kanamycin sulfate. About 13% of the resulting calli tested positive for GUS activity, demonstrating the first report of successful safflower transformation. Future goals of this project include the introduction of genes for herbicide resistance and regeneration of transgenic plants.

AGRICULTURAL FIELD RESEARCH CHEMICAL STORAGE UNIT-A NEW TOOL FOR FIELD RESEARCHERS. Ted Alby, Tom J. Hartberg, and Dan VanWinkle, Field Research Agriculturists, and Operations Coordinator American Cyanamid Company Princeton, NJ 08540.

Abstract. Over the past several years, state and federal agencies, as well as the agricultural industry, have paid increasing attention to the management of agricultural chemicals in the farming community. In 1989, American Cyanamid's Agricultural Research Division choose a proactive posture to update and standardize facilities for the storage of pesticides used by its field research staff on farms across the U.S. Inspections of field research sites and a questionnaire were used to determine storage requirements and the feasibility of placing upgraded facilities at on-farm research sites. Personal health and safety, environmental concerns and good laboratory practices (GLP) guidelines were considered in the design of a chemical storage unit. Plans and specifications were developed jointly by American Cyanamid and the University of Wisconsin. Prototype units were manufactured and evaluated at five research locations. Design modifications were made prior to final manufacture and delivery to remaining research sites. Currently, all field research staff have been provided with these state-of-the-art chemical storage units. These units have proven to be efficient, safe new tools for the storage of agricultural chemicals by Cyanamid's field research agriculturists at on-farm locations.

WEED CONTROL IN SEEDLING ALFALFA; HERBICIDE EFFICACY AND CROP BIOMASS EFFECTS. C. E. Bell, Farm Advisor, Cooperative Extension, University of California, Holtville, CA 92250.

Abstract. Alfalfa is seeded in the fall in the Imperial Valley in southeastern California. Winter annual weeds germinate with the crop and persist through the mild winter until the first or second harvest in the following spring. In three trials over 2 yr; bromoxynil, oxyfluorfen, imazethapyr, and 2,4-DB amine were compared for weed control and crop injury. Data on crop biomass, weed biomass, and weed composition were collected in these trials. Trial One, initiated in 1988, and Trial Two, initiated in 1989, were completely randomized design with three replications. Trial Three, initiated in 1989, was a randomized complete block design with four replications.

In Trial One, weeds present were nettleleaf goosefoot and common lambsquarters. Weed control ranged from 100% for bromoxynil at 0.25 lb/A and imazethapyr at 0.063 lb/A plus bromoxynil at 0.25 lb/A to 45% for 2,4-DB amine at 1 lb/A to 0% for the untreated control. Oxyfluorfen, bromoxynil, imazethapyr, and 2,4-DB amine all caused some visually apparent injury to the alfalfa. At the first spring harvest, 93 days after treatment (DAT), alfalfa biomass ranged from 146 grams dry weight per square meter (g/m^2) for the imazethapyr at 0.063 lb/A plus bromoxynil at 0.25 lb/A to 66 g/m^2 for the untreated control. Weed biomass for the untreated control was 151 g/m^2 at this harvest, and ranged from 0 g/m^2 for bromoxynil at 0.25 lb/A to 74 g/m^2 for imazethapyr at 0.063 lb/A. At the third crop harvest, taken 184 DAT, there were no weeds present, nor was there any significant difference between crop biomass for any treatment and the untreated control. A harvest was taken 432 DAT, which showed no significant difference between treatments and the untreated control. There were no weeds present at this harvest.

Imazethypyr was the only treatment in Trial Two, applied at 0.063 and 0.125 lb/A, either with no surfactant, crop oil concentrate (COC) at 1 qt/A, or non ionic surfactant at 0.25% (v/v). All treatments controlled london rocket, the only weed present at application. Some crop injury was observed with treatments at 0.125 lb/A when either surfactant was used. Alfalfa biomass 63 DAT, according to single degree of freedom orthogonal comparisons, was significantly higher for treated plots versus the untreated control. Average london rocket biomass was 411 g/m^2 for untreated plots compared to 0 g/m^2 for all treated plots. Alfalfa biomass was also higher for the low herbicide rate compared to the high rate and for no surfactant compared to either COC or NIS. At the second harvest, 135 DAT, alfalfa biomass was lower and weed biomass higher in the untreated control plots. Weeds present at this harvest included london rocket, little mallow, littleseed canarygrass, nettleleaf goosefoot, annual sowthistle, and prickly lettuce. There were no significant differences between the treated plots for alfalfa or weed biomass. There were no weeds present at the third or the fourth harvests (170 and 206 DAT, respectively). Alfalfa biomass was significantly lower at the third harvest compared to the treated plots, but there was no difference at the fourth harvest.

Trial Three compared imazethapyr at one rate, 0.063 lb/A, applied when weeds had 2 to 4 leaves on November 21, 1989, or on December 12, 1989, when weeds had 6 to 8 leaves. Applications on both dates include treatments with COC, NIS, or no surfactant. One additional treatment at the 6 to 8 leaf stage included 2,4-DB amine at 1 lb/A with the imazethapyr. Weed control ranged from 98% for three imazethapyr treatments at the 6 to 8 leaf stage to 69% for imazethapyr without surfactant at the 2 to 4 leaf stage. Crop injury was most evident for the imazethapyr plus 2,4-DB amine treatment. Imazethypyr at the later application date also caused greater visible injury to the crop compared to the early date. At the first harvest, on February 12, 1990, there was no difference between the imazethapyr alone treatments, nor between the imazethapyr plus 2,4-DB amine treatment and the untreated control for alfalfa biomass. These two treatments had significantly lower crop biomass then the other six treatments. Weed biomass for the untreated control was higher then all of the treatments. At the second harvest, on April 5, 1990, treated plots had significantly greater alfalfa biomass and lower weed biomass then the untreated control. By the third harvest on May 10, 1990 and the fourth harvest on June 15, 1990, there were no weeds in any plot. Crop biomass in the untreated control was significantly lower at the third harvest, but there was no difference at the fourth harvest. Weeds present in this trial were; wild oats, wild beet (*Beta maritima* L), volunteer wheat, littleseed canarygrass, annual sowthistle, london rocket, little mallow, nettleleaf goosefoot, and rescuegrass.

COMPARISON OF 2,4-DB ESTER AND AMINE FOR BROADLEAF WEED CONTROL IN SEEDLING ALFALFA. S. B. Orloff and D. W.Cudney, Farm Advisor and Weed Science Specialist, University of California Cooperative Extension, Lancaster, CA 93535 and University of California, Riverside, CA 92521.

Abstract. 2,4-DB ester has been the standard herbicide used for the control of broadleaf weeds in seedling alfalfa in the high desert valleys of Southern California. 2,4-DB ester is no longer available, leaving only the amine formulation. Three trials were established to compare the efficacy of these 2,4-DB formulations. Rates used were 0.5, 0.75, 1.0, and 1.5 lb/A of the amine formulation compared to 0.5, 0.75, and 1.0 lb/A of the ester formulation. All plots were applied in late November using a constant pressure CO_2 backpack sprayer at a spray volume of 30 gal/A. Alfalfa was in the three to five trifoliate leaf stage at the time of application. Weeds were actively growing and ranged from two to five inches in diameter. Weed control evaluations were made over a period of one to four months after application.

London rocket and shepherd's purse were completely controlled by the lowest rate (0.5 lb/A) of the ester formulation. However, the highest rate (1.5 lb/A) of the amine formulation controlled only 80 to 90% of these weeds. Tansy mustard was also controlled with the 0.5 lb/A rate of the ester formulation, but in this case the 1.5 lb/A rate of the amine provided only 70 to 80% control. Filaree and fiddleneck were more difficult to control with either formulation. However, at the same application rate, the ester was twice as effective. Although the ester was more effective, neither formulation provided acceptable control of malva or common groundsel. Overall at the same application rate, the amine formulation was less than half as effective as the ester. Thus, higher application rates will be necessary and poor control of the more difficult weeds may result from the use of the amine formulation.

Additional trials were conducted to determine if the efficacy of 2,4-DB amine could be enhanced through treatment timing or with the use of an adjuvant. Three treatment timings were studied: unifoliate, third trifoliate, and seven trifoliate alfalfa growth stages. In a third study four adjuvants, crop oil concentrate, a non-ionic surfactant, and two commercial formulations known as "Surphtac" and Dash, were added at two rates to 2,4-DB amine (0.75 lb/A) and compared to 2,4-DB ester.

Alfalfa phytotoxicity decreased with increasing alfalfa growth stage. However, weed control was best at early application times. Application timing was more critical for the amine formulation than the ester, as the amine formulation did not control weeds at the late application stage. Adding a surfactant to the amine formulation of 2,4-DB increased weed control significantly. The non-ionic surfactant, COC, and Dash improved weed control to a level comparable to the ester formulation. 2,4-DB amine at 0.75 lb/A with any of these three adjuvants controlled weeds better than 2,4-DB amine at 1.5 lb/A without an adjuvant. These results suggest that through proper application timing and the use of an adjuvant, acceptable weed control can be achieved with the amine formulation of 2,4-DB.

THE EFFECT OF IMAZETHAPYR UPON CROPS GROWN IN ROTATION WITH ALFALFA. Barry R. Tickes and Kai Umeda, Extension Agent, University of Arizona Cooperative Extension, Yuma, AZ 85364 and Agriculturalist, American Cyanamide Company, Chandler, AZ 85226.

Abstract. Imazethapyr has produced excellent control of many winter annual broadleaf weeds in tests conducted in Arizona alfalfa. Alfalfa is rotated in Arizona with a variety of crops including vegetables, melons, wheat, sorghum and cotton. This test was conducted from December 1986 to December 1989 to evaluate the effect of imazethapyr on these crops when grown in rotation with treated alfalfa. Imazethapyr was applied at 0.125 and 0.25 lb/A on December 30, 1986 to a two month old stand of alfalfa (CUP101) located at the University of Arizona Yuma Valley Agricultural Center in Yuma, Arizona. The plots were split and a second application was made on November 6, 1987. The alfalfa was removed at 4 and 12 months after the single applications and at 1, 12, and 16 months after two applications. Lettuce, cauliflower, broccoli and wheat were planted in December at 12 and 24 months after the single application and 1 and 12 months after two applications. Cotton, sorghum and cantaloupe were planted in April, 4 and 16 months after the single application and 4 months after 2 applications. Phytotoxicity was evaluated by harvesting, drying and weighing 25 seedling plants from each plot 3 to 5 weeks after stand establishment, by seedling counts per 3 ft of row and by visual estimates. Soil type at this location was a silty clay loam. Treated plot size was 95 by 180 ft and these plots were split into 30 by 95 ft subplots. Planted plot size was 25 ft by one 40 inch bed replicated four times on a randomized complete block.

The single applications of imazethapyr caused severe damage at both rates to the summer crops planted 4 months after treatment and removal of the alfalfa. Cantaloupe was stunted by 93% at the high rate and 61% at the low rate; sorghum was stunted by 83% at the high rate and 64% at the low rate; and cotton was stunted by 60% at the high rate and 32% at the low rate. Severe weed competition in the untreated checks made it difficult to accurately evaluate phytotoxicity to these crops when planted 16 months after treatment. Phytotoxicity to cauliflower, broccoli and lettuce was moderate to severe 12 months following the application of both rates of imazethapyr. Phytotoxicity to cauliflower was 53% at the high rate and 31% at the low rate; broccoli: 33% at the high rate and 16% at the low rate; lettuce: 19% at the high rate and 18% at the low rate. No damage was measured to any of these crops, however, when a summer crop had been grown in the same plots 8 months earlier. No phytotoxicity was measured to any of these crops from either rate, 24 months after a single application. Two applications of imazethapyr caused severe damage to all three of these crops when planted 1 and 24 months after the second application. Phytotoxicity to cauliflower was 100% at the high rate and 90% at the low rate, 1 month after the second application. Twelve months later phytotoxicity was 83% from the high rate and 40% at the low rate. Phytotoxicity to broccoli was 100% at the high rate and 81% at the low rate, 1 month after the second application. Twelve months later, phytotoxicity was 70% at the high rate and 18% at the low rate. Phytotoxicity to lettuce was 79% at the high rate and 45% at the low rate, 1 month after the second application. Twelve months later this had dropped to 75% at the high rate and 25% at the low rate. Phytotoxicity to wheat was found only as the result of two applications of imazethapyr. Phytotoxicity of 69% at the high rate was measured 12 months after the second application although only 38% phytotoxicity had been measured 12 months earlier.

WEED CONTROL IN SEEDLING ALFALFA WITH IMAZETHAPYR. David Zamora and Ted Alby, Technical Services Representative and Agriculturalist, American Cyanamid Company, 4525 Cochees Way, Boise, ID 83709.

Abstract. Field trials with imazethapyr alone and in tank mixes were conducted in Washington to determine crop safety and weed control efficacy in seedling alfalfa. The applications were made at Touchet to alfalfa with 2 to 3 trifoliate leaves. Weeds had 2 to 6 leaves at application. Crop injury and weed control were visually

evaluated 7 weeks after application. The applications were made at Warden to alfalfa with 5 trifoliate leaves. Weeds had 2 to 7 leaves at application. Crop injury and weed control were visually evaluated 8 weeks after application. Seedling alfalfa was not injured at Touchet by any treatment (Table 1). Imazethapyr at 0.094 lb/A initially stunted the alfalfa at Warden (Table 2) but by July, no stunting was observed. Bentazon plus imazethapyr caused chlorosis and stunting of the alfalfa at Warden. Imazethapyr alone or in tank mix controlled green foxtail, mustard species, pigweed, and lambsquarters. Imazethapyr alone or in a tank mix also controlled 58 to 72% of wild oats and 58 to 79% of field bindweed.

Table 1. Weed control in seedling alfalfa at Touchet, WA.

Treatment[a]	Rate	Injury	AVEFA	SETVI	SINAR	THLAR	DESSO	CHEAL	CONAR
	(lb/A)	(%)	(% of check)						
Imazethapyr	0.047	1.2	58	86	79	60	62	62	58
Imazethapyr	0.063	0	68	86	82	65	54	66	71
Imazethapyr	0.094	2.5	72	90	94	84	86	82	79
Imazethapyr	0.063								
+ bromoxynil	0.25	1.2	69	89	94	91	89	92	75
Imazethapyr	0.063								
+ 2,4-DB ester	0.5	5.0	62	88	92	79	74	80	72
Imazethapyr	0.063								
+ bentazon	0.5	1.2	62	91	90	92	81	89	78
LSD (0.05)		NS	14	NS	NS	20	NS	16	10

[a]All treatments included a nonionic surfactant, at 0.25% v/v.

Table 2. Weed control in seedling alfalfa at Warden, WA.

Treatment[a]	Rate	Injury	TRIAX	ECHCG	AMARE	CHEAL	CIRAR
	(lb/A)	(%)	(% of check)				
Imazethapyr	0.047	0	6	79	90	75	5
Imazethapyr	0.063	0	21	81	96	74	14
Imazethapyr	0.094	5.8	25	91	100	94	22
Imazethapyr	0.063						
+ bromoxynil	0.25	0	24	90	98	90	16
Imazethapyr	0.063						
+ 2,4-DB ester	0.5	1.2	17	86	95	85	10
Imazethapyr	0.063						
+ bentazon	0.5	17.5	21	85	90	85	22
Imazethapyr	0.063						
+ pendimethalin	0.5	0	24	85	96	82	14
LSD (0.05)		3.8	11	NS	NS	14	10

[a]All treatments included a nonionic surfactant, at 0.25% v/v.

IMAZETHAPYR: REGISTRATION STATUS, CROP TOLERANCE, AND WEED CONTROL IN ALFALFA.
R. L. Johnston, D. Colbert, and K. Umeda Field Research Agriculturists, American Cyanamid Company, Princeton, NJ 08543-0400.

Abstract. Registration of imazethapyr for use in alfalfa is expected in 1992. The proposed use rate will be 53 to 105 g/ha applied early postemergence in a tank-mix with a nonionic surfactant. Major alfalfa weeds, including *Setaria* spp., *Echinochloa crus-gali*, *Amaranthus* spp., *Kochia scoparia*, *Sinapis arvensis*, *Capsella bursa-pastoris*, *Stellaria media*, *Taraxacum officinale* and *Chenopodium album* are controlled at 70 g/ha.

Alfalfa exhibits excellent tolerance to postemergence applications of imazethapyr. Forage yields and alfalfa quality are consistently better in plots treated with imazethapyr, compared to untreated plots.

MODIFYING FENOXAPROP FOR USE IN CEREALS. M. D. Anderson, Hoechst Roussel Agri-Vet Co., Spokane, WA 99204.

Abstract. Applications of fenoxaprop were injurious to wheat and barley. The addition of phenoxy herbicides improved the tolerance to acceptable levels in wheat but only to marginal levels in barley. A non-herbicidal modifer, HOE 70542, provided excellent wheat tolerance in combination with fenoxaprop. Tolerance in barley was inadequate with HOE 70542 and fenoxaprop. Wild oat control was slightly reduced from phenoxy herbicides in combination with fenoxaprop. HOE 70542 in combination with fenoxaprop did not affect wild oat efficacy. A fenoxaprop premix with 2,4-D and MCPA esters has been commercially available via Section 18's (Emergency Exemptions) in certain states since 1988 for the control of green and yellow foxtail.

SEQUENTIAL DECISION CARD FOR WILD OAT MANAGEMENT IN SPRING BARLEY. E.J. Bechinski, D.C. Thill, R.M. Evans and D.L. Barton; Assistant Professor, Professor, former Graduate Research Assistant and Graduate Research Assistant; Department of Plant, Soil & Entomological Sciences; University of Idaho, Moscow, ID 83843.

Abstract. We used the Sequential Probability Ratio Test (SPRT) (6) to design a "Decision Card" that allows farmers to determine if post-emergence herbicides are justified for wild oat control in spring barley. Formally, the card sequentially tests the null hypothesis (H_o) that wild oat density is less than the economic injury level (EIL), the break-even infestation level at which the cost of control equals the value of yield loss prevented (4, 5). Acceptance or rejection of H_o respectively gives "Do Not Spray" and "Spray" recommendations. The special advantages of sequential decision-making are speed and accuracy. When pest density is far above or far below the EIL, relatively few samples are needed to confidently determine if pesticide use is warranted. Additionally, sequential sampling allows Type I and Type II error rates (i.e., the probability of mistakenly recommending control when density is less than the EIL and the probability of failing to recommend control for infestations ≥ EIL) to be specified in advance. Sequential sampling has seen wide use in pest management programs because it can minimize field scouting costs while maximizing reliability (3).

Two types of data are required to develop sequential decision plans: knowledge of pest population dispersion and economic injury levels. Spatial pattern determines the amount of sampling effort required to make accurate control decisions; EILs provide the basis for differentiating between economic and non-economic infestations. We quantified wild oat population dispersion by inspecting 216 randomly located 1-ft^2 quadrats in a commercial barley field during the soft dough stage. Count data were reorganized as a frequency distribution (i.e., the number of 1-ft^2 sample-units with 0, 1, 2,...x plants) and were compared to frequencies expected according to Poisson and negative binomial models (1). The former model tests the hypothesis that population dispersion is random whereas the latter tests the hypothesis that spatial pattern is aggregated. The probability of finding x individuals in a sample-unit is given by

(1a) $P(x) = (e^{-\bar{x}}\bar{x}^x)/x!$

(1b) $P(x) = [1 + (\bar{x}/k)^{-k} \{(k + x - 1)!/[x!(k - 1)!]\} [\bar{x}/(\bar{x} + k)^x$

for the Poisson (Equa. 1a) and negative binomial (Equa. 1b) models, where e is the base of the natural logarithms, x is observed mean wild oat density per 1-ft^2 and k is a parameter related to the degree of population aggregation. As expected, goodness-of-fit tests rejected the Poisson series as an inadequate model for the observed frequency distribution ($\chi^2_{11\ d.f.} = 566.78$, $P < 0.001$). In contrast, differences between observed frequencies and those expected according to the negative binomial distribution (with k = 1.63) were insignificant ($\chi^2_{25\ d.f.} = 30.57$, $P = 0.10$).

Economic injury levels were derived from data generated by addition series field experiments conducted during 1987 and 1988 (2). Here barley grain yield (Y, cwt/acre) best was described as a function of wild oat density (X, no. plants/ft^2) with a segmented quadratic equation:

(2a) $Y = 45.90663 - 1.65936X + 0.00183X^2$ [for $X \leq 41.9/ft^2$]

(2b) $Y = 11.19$ cwt/acre [for $X > 41.9/ft^2$]

($n = 10$, $P > F = 0.00001$, $r^2 = 0.979$)

Economic injury levels then were computed by deriving an equation that equates costs of wild oat control with the value of preventable crop yield loss:

(3) $EIL = \{-b - [(b^2 - 4\ c\ C_s)/KV]^{0.5}\ \}/2c$

where EIL is wild oat density/ft^2, Cs is control cost ($/acre), V is barley market value ($/cwt), K is proportional weed kill following herbicide application, and b and c are the linear and quadratic regression terms from Equation 2a. Control efficacy was assigned K = 0.9 (i.e., 90% control) and a range of control costs and market values were substituted for Cs and V, generating the EIL values in Table 1. Given current barley prices of $4 to $5 per cwt and control costs of $15 to $30 per acre, use of a post-emergence herbicide for wild oat control is not justified unless density exceeds 2 to 5.3 wild oat/ft^2.

Decision card classification boundaries were calculated with the formulas of Waters (7) for the negative binomial distribution with k = 1.63. The upper limit of a non-economic infestation (Waters' m_1 value) was designated 2.0 wild oat/ft^2 and the lower limit of an economic infestation (Waters' m_2 value) was designated 5.3 wild oat/ft^2. Type I and II errors rates were assigned 0.10 and 0.01, respectively. Expressed in tabular format (Figure 1), these classification boundaries comprise two columns ("Do not spray" and "Spray") against which is tallied the cumulative number of wild oat observed during random field scouting. If the observed field tally is between or equal to these limits, then another randomly selected 1-ft^2 unit is inspected. However, whenever the cumulative number falls outside these classification limits, scouting stops and a management decision can be made. Because Type I and II errors were specified as 0.01 and 0.01, it follows that one can be 90% and 99% confident that infestations are less than 2.0 and greater than 5.3 wild oat/ft^2 when the cards give a "Do not spray" and "Spray" decision, respectively.

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Table. Economic injury levels (no. plants/ft^2) for management of wild oat with post-emergence herbicides in spring barley.

Barley value	Herbicide cost + application expense ($/A)				
	$15	$20	$25	$30	$35
$/cwt					
3	3.4	4.7	6.0	7.2	8.6
4	2.6	3.4	4.4	5.3	6.2
5	2.0	2.8	3.4	4.3	5.0
6	1.7	2.3	2.9	3.4	4.1
7	1.4	2.0	2.5	3.0	3.4

SEQUENTIAL DECISION CARD
Wild oat control in spring barley

Sample number	DO NOT SPRAY if tally is less than	RUNNING TALLY: total no. of wild oat	SPRAY if tally exceeds
1	▒	______	8
2	▒	______	10
3	▒	______	12
4	▒	______	14
5	▒	______	16
6	▒	______	18
7	1	______	20
8	3	______	22
9	5	______	24
10	6	______	26
11	8	______	28
12	10	______	30
13	12	______	32
14	14	______	34
15	16	______	36
16	18	______	38
17	20	______	40
18	22	______	42
19	24	______	44
20	26	______	46
21	28	______	48
22	30	______	50
23	32	______	52
24	34	______	54
25	36	______	56

▒ designates that a decision cannot be made; continue sampling

Figure. Sequential decision card for determining if post-emergence herbicides are warranted for wild oat control in spring barley.

ALFALFA CONTROL OR SUPPRESSION IN IRRIGATED BARLEY. J. M. Krall and S. D. Miller, Associate Professor and Professor, Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. When alfalfa is converted to spring barley, soil erosion can occur when conventional plow-based seed bed preparation is used. The purpose of this research was to examine a minimum till approach to field preparation, using herbicides to suppress or control the alfalfa in the barley crop. Plots were established under sprinkler irrigation at the Research and Extension Center, Torrington, Wyoming in 1988, 1989 and 1990. The plot areas were chiseled and/or disc to 2 to 3 inches then roller packed prior to barley seeding the first week of April. Then postemergence herbicides were applied when the barley had 3 to 4 leaves and the alfalfa was 4 to 6 inches tall. No treatment reduced barley stand; slight injury was observed but this was not consistent for treatments across years. Alfalfa stands were reduced from 12 to 92% due to herbicide treatment, along with biomass which declined from 32 to 98% averaged over years (Table 1). Barley yields were related to alfalfa control and were 6 to 16 bu/A lower in untreated than in herbicide-treated plots.

Table 1. Alfalfa response to selected herbicide treatments in irrigated barley.

		Barley		Alfalfa		
Treatment	Rate	Inj	Yield	Ctr	Std	Yield
	lb/A	%	bu/A	%	plt/A	lb/A
Clopyralid	0.032	0	74	40	15680	580
Clopyralid	0.063	0	75	56	11550	270
Clopyralid	0.125	1	77	79	3580	100
Clopyralid+2,4-D	0.22	0	76	66	8800	250
Clopyralid+2,4-D	0.44	0	72	83	3300	130
Clopyralid+2,4-D	0.88	4	74	90	1620	40
Metsulfuron+2,4-D	0.008+0.5	4	75	86	2750	150
Bromoxynil	0.38	0	67	6	18700	1160
Bromoxynil+MCPA	0.75	0	72	68	8530	460
Picloram+2,4-D	0.012+0.38	3	75	69	8250	220
Picloram+2,4-D	0.023+0.38	7	75	82	6050	100
2,4-D	0.5	0	75	58	9530	310
MCPA	0.5	0	75	54	9530	310
Minimum till check		0	61	0	21180	1710
LSD 0.05		2		5	2770	270
LSD 0.10			9			

WILD OAT AND SPRING WHEAT DENSITY AND WHEAT ROW SPACING EFFECTS ON WHEAT COMPETITION. Saleem Khan and Donald C. Thill, Graduate Assistant and Professor, Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83843.

Abstract. Wild oat is the most serious weed problem in spring wheat in Idaho. An addition series experiment was conducted in 1989 near Moscow, Idaho, to determine the effects of four wild oat and spring wheat densities and three wheat row spacings on wheat growth and yield. The four densities used for both species were 0, 100, 200 and 300 plants m^{-2} with 9, 18 and 36 cm row spacings for wheat. The experimental design was a randomized complete block, split block with four replications. Plant number and above ground biomass of wheat were determined at the tillering, boot, and physiological maturity stages of wheat development. At physiological maturity stage, wheat density ranged from 87 to 172 plants m^{-2} and wild oat density ranged from

62 to 86 plants m^{-2}. Wheat plant number was less at the 36 cm row spacing than with narrower spaced rows, likely due to increased intraspecific competition within the row. Wild oat had little effect on wheat density at narrower row spacings. At wider row spacings, increasing wild oat density adversely impacted wheat density. Wheat biomass increased with increasing wheat density to 135 plants m^{-2} then plateaued. Wheat biomass decreased with increasing wild oat density, however, wild oat interference was less at higher wheat densities. Wheat grain yield also decreased with increasing wild oat density and the competitive ability of wild oat was less at higher spring wheat densities.

"RELAY-PLANTING" FROM ALFALFA TO COTTON, BLACKEYES OR SILAGE CORN. Harold M. Kempen, Douglas Munier and Martha P. Gonzalez, Farm Advisor, Farm Advisor and Staff Research Associate, University of California Cooperative Extension, 1031 S. Mt. Vernon Avenue, Bakersfield, CA 93307.

INTRODUCTION

Studies were conducted during a three year period to evaluate the potential of planting summer crops into established alfalfa after the stand diminishes, usually the third or fourth year of production. This would permit taking one or two alfalfa cuttings off in the spring before planting into the relay crop. Planting directly into established alfalfa would reduce the turn-around time and reduce land preparation inputs. Replicated experiments were conducted for weed control and alfalfa suppression components of the system within demonstration plots. Three relay crops were evaluated: cotton, blackeye dry beans and silage corn.

MATERIALS AND METHODS

Because the methods changed as we developed experience with this practice they are described in each of the crops planted into established alfalfa. However, in all cases the planter utilized was a two row John Deere # 71 flex-planter, which uses reversed disk openers and has a system to control the vertical depth of planted seed. All cultivations which followed were also done with our two row equipment, equipment that was not as good as a grower would normally utilize.

All weed plots were done using randomized complete block design, and data were subjected to analyses of variance. These plots were within an alfalfa check about 50 feet wide and 1300 feet long which were used as the demonstration block for the tests. These demonstration blocks were treated with glyphosate at 3 lb/A in each case, avoiding the weed plots except on the blackeye test. All applications were calculated as isopropyl amine salt of glyphosate in demonstration blocks and included 0.25% non-ionic surfactant.

RESULTS AND DISCUSSION

1. Relay planting Test # 1: Cotton 1988. In this initial test, we applied glyphosate, glyphosate plus oxyfluorfen or quinclorac to alfalfa after the first spring cutting. Glyphosate was applied at three dates to evaluate relative effectiveness. Cotton was planted directly into the alfalfa sod, using a fluted coulter in advance of the planter. Table 1a provides field and application data and Table 1b provides results.

Table 1a. Relay planting of alfalfa to cotton - field and application data.

CROP:	Cotton	APPLICATION DATES:	3/23, 3/31, 4/4
LOCATION:	Bakersfield, CA	APPLICATION METHOD:	CO_2 backpack (8002)
PLANTING DATE:	3/31/88	VOLUME:	20 gpa, 18 psi
ROW SPACING:	40 inch	SOIL TYPE:	sandy clay loam
PLOT SIZE:	8.3 ft x 15 ft	O.M.:	~1.0%
PLOT DESIGN:	RCB, 3 replications	WEED SPECIES:alfalfa, foxtail barley	
CONDITIONS:	75 F, moderate NW wind, dry soil		

SEQUENCE: 3/17: mowed and removed hay; 3/21: hay removed; 3/23: alfalfa 3 to 6 inches; 3/28: flood (border) irrigated; 3/31: cotton planted into sod; 4/4: alfalfa 13 inches; 4/18: alfalfa at cotyledonary stage; 5/1: abandoned.

Table 1b. Summary of weed control on 4/18/88, 19 days after treatment.

Treatment	Application	Rate	Alfalfa Stage	Alfalfa Control[a]	Alfalfa Height	Foxtail barley
	DATE	(lb/a)	inches		inches	control[a]
Untreated[b]	-	-	-	0.0	17.0	0.0
Glyphosate	3/23	0.75	3-6	5.3	9.7	9.7
Glyphosate	3/31	0.75	8	4.7	9.7	8.3
Glyphosate	4/4	0.75	13	4.3	12.0	9.3
Glyphosate	3/23	1.5	3-6	6.8	6.0	9.0
Glyphosate	3/31	1.5	8	6.7	9.0	9.7
Glyphosate	4/4	1.5	13	7.7	9.8	9.7
Glyphosate+oxyfluorfen	3/31	0.38+0.06	8	7.0	10.0	1.3
Glyphosate+oxyfluorfen	3/31	0.75+0.12	8	7.0	8.7	4.0
Quinclorac	3/31	0.1	8	1.7	16.0	0.0
Quinclorac	3/31	0.2	8	2.7	11.0	0.0
LSD (0.05)				1.0	2.5	4.1

[a]0-10 Rating: 0=no injury, 10=kill. All treatments included 0.25% non-ionic surfactant.
[b]Cotton was not injured by any of the treatments.

Table 1c. Results from the demonstration block treatment rated 4/22/88, 23 days after planting.

TREATMENT - glyphosate at 3 lb/A + prometryn at 1.6 lb/A + pendimethalin at 0.75 lb/A
WEED CONTROL (0-10 Rating: 0=no injury, 10=kill)

Purple nutsedge	0	Horseweed	9
Alfalfa	7	Prickly lettuce	10
Volunteer barley	10	Knotweed	10
Cheeseweed	8	Annual bluegrass	10
London rocket	10	Sowthistle	10
Cotton	0 (damaged by hail: 25% leaf loss)		

In this initial test, we planted directly into the alfalfa sod. Alfalfa suppression in the demonstration block from a treatment of glyphosate was obtained (rated 7.0 23 days after planting), but we were unable to control its regrowth in the drill row area and had to abandon the block by May 1. Individual alfalfa plant control varied from 2 to 9.5 (rated 0-10) which seemed due to the degree of regrowth after the mowing. This is probably because alfalfa is a mix of different plant lines.

The results of the glyphosate timing and rate studies above suggested, however, that not too much difference occurred whether alfalfa was treated when 3 to 6 inches, or if larger. Results from the demonstration block showed that glyphosate controlled emerged weeds very well at the 3 lb/A rate, including perennial purple nutsedge.

2. Relay planting Test # 2: Blackeye dry beans 1988. In this test the alfalfa was under sprinkler irrigation and a block was used for a demonstration of this technique. Because of the adverse effects of the previous test, we tried various planting techniques here to assist in crop establishment. Comparisons included a vertical ripper shank, a 20-inch flat sweep, or just the fluted coulter, each placed ahead of the flex-planter. The herbicides were applied after planting to evaluate the need for residual control of spring-emerging weeds under this sprinkled system, following the previous glyphosate application on the demonstration block. Table 2a below shows field and application data and Table 2b provides tabular results.

Table 2a. Relay-planting of alfalfa to blackeyes - field and application data.

CROP:	Blackeyes, #5	APPLICATION DATE:	4/13/88
LOCATION:	Bakersfield, CA	APPLICATION METHOD:	CO_2 backpack (8002)
PLANTING DATE:	4/12/88	VOLUME:	20 gpa, 18 psi
ROW SPACING:	38 inch	SOIL TYPE:	sandy loam
PLOT SIZE:	8.3 ft x 19 ft	O.M.:	~0.5%
PLOT DESIGN:	RCB, 3 replications	IRRIGATION METHOD:sprinkler	
CONDITIONS:	78 F, no wind, cloudy, moist soil		

SEQUENCE: 4/1 to 4/7: mowed and removed alfalfa; 4/8: demonstration block treatment with glyphosate at 3 lb ai/a; 4/10: sprinkler irrigated with 0.5 inches; also received 1 inch of rainfall; 4/12: blackeyes planted; 4/13: residual plots applied; 4/14 sprinkler irrigated with 0.5 inches.

Table 2b. Summary of weed control on 5/13/88, 30 days after treatment.

Treatment	Rate	0-10 Rating (0-no injury, 10=kill)					
		Begr[a]	Stne	Colq	Tupw	Bygr[b]	Yeft
	(lb/a)						
Control[d]	-	6.0	4.0	0.0	0.0	0.0	0.7
Metolachlor	1.5	10.0	8.0	3.7	2.0	6.7	7.7
Metolachlor	3.0	10.0	7.3	5.7	6.7	9.7	10.0
Metolachlor + pendimethalin	1.5 + 0.75	9.3	8.3	8.7	7.3	6.7	8.0
Metolachlor + pendimethalin	3.0 + 1.5	10.0	10.0	9.7	9.0	10.0	7.0
Metolachlor + glyphosate	1.5 + 1.5	10.0	7.7	4.0	6.7	8.3	7.3
Metolachlor + glyphosate	3.0 + 3.0	10.0	10.0	10.0	8.0	10.0	10.0
	LSD (0.05)	NS	NS	1.8	3.2	3.5	3.7

[a]Begr=bermudagrass; Stne=stinging nettle; Colq=common lambsquarter; Tupw=tumble pigweed;
[b]Bygr=barnyardgrass;Yeft=yellow foxtail
[d]Alfalfa control was rated 8.7-9.3 in the demonstration block. NS = No Significance

This demonstration block was carried to harvest with a normal yield for this region. The evaluation of different equipment demonstrated that the use of a flat sweep was very valuable for cutting off alfalfa crowns in the drill row area. It functioned well in conjunction with the two-row planter used. After taking our data on the weed control component, the field was hand weeded. Overall control of weeds in this block was judged good (rated 7.5), 5 days after treatment. All winter annual weeds were controlled, but were not visible when we made our control ratings in Table 2b.

The weed control experiment showed that, under sprinklers, residual control was needed for control of summer annual species. This is because several of these weeds germinate after the glyphosate application, when sprinkled after some soil disturbance has occurred. The higher rate of metolachlor provided better control, but some advantage of combining it with pendimethalin or glyphosate was shown on some species. Again, results suggested substantial control of the perennial, bermudagrass, even though it was not very large when treated. No injury to corn occurred from herbicides used.

3. Relay planting Test # 3: Silage corn 1989. After a previous silage corn trial demonstrated equipment principles, this test was done using only a 20-inch sweep ahead of the planter. The trial was conducted immediately after the second cutting of alfalfa was removed as hay, border irrigated and then treated with glyphosate. The planting was successful, was cultivated to remove alfalfa and weeds from the middles and taken to harvest.

Our weed control plots were treated as described below in Table 3a, which includes field and application data, and in Table 3b, which includes salient data taken.

Table 3a. Reduced tillage planting of silage corn into alfalfa - field and application data.

CROP:	Corn, silage	APPLICATION DATE:	5/31/89
LOCATION:	Bakersfield, CA	APPLICATION METHOD:	CO_2 backpack
PLANTING DATE:	6/1/89	VOLUME / PSI:	20 gpa, 15 psi
ROW SPACING:	38 in.	SOIL TYPE:	silt loam
PLOT SIZE:	8.3 ft by 15 ft	O.M.:	0.5%
PLOT DESIGN:	RCB, 3 replications	IRRIGATION METHOD:	Border
CONDITIONS:	75 F, light NW wind, dry surface, moist root zone		
SEQUENCE:	5/15: mowed second cutting and removed; 5/30: border irrigated; 5/31: herbicides applied, including demonstration treatment; 6/1 corn planted; 6/8: border irrigated;		

Table 3b. Alfalfa control and percent grassy weeds[a] in relay corn plantings, after establishment on 5/31/89.

		Alfalfa control[b]		Percent grass	
		June 14, 1989		June 23, 1989	
Treatment	1X Rate	1X Rate	2X Rate[c]	1X Rate	2X Rate[c]
	(lb/A)				
Control	- -	0.0	0.0	56.7%	40.0%
Glyphosate[d]	0.75	8.0	8.0	3.7%	3.0%
Glyphosate[d]	3.00	8.3	8.3	1.7%	0.3%
Glyphosate (applied June 5)[d]	0.75	6.3	7.0	1.0%	0.0%
Glyphosate + metolachlor[d]	0.75+2.00	7.3	7.5	0.7%	2.7%
Dicamba[d]	0.25	8.2	9.0	63.3%	50.0%
LSD 0.05		1.2		15.9%	

[a]Grassy weeds include bermudagrass and crabgrass.
[b]0=no injury to 10=kill.
[c]All 2X treatments were double-sprayed, like an overlap [K2X].
[d]All herbicides were mixed with non-ionic surfactant at 0.25%. No injury to corn except for drought due to lack of control in the check and dicamba treatments.

Results from this experiment again demonstrated severe suppression of bermudagrass and purple nutsedge, thereby allowing a fast growing crop such as corn to gain enough height to permit cultivations which move dirt over the suppressed weeds. Again no crop injury resulted from the herbicides used. A dry soil mulch occurred after planting with this 20-inch flat sweep system and the addition of metolachlor showed no benefit in weed control. Control with the glyphosate rate of 0.75 lb/A was equal to control with 6.0. The single application of glyphosate just before corn emergence on June 5, 1989 suggested a trend for poorer alfalfa control. No corn injury was evident. Dicamba controlled alfalfa very well at the 0.25 lb/A rate but did not control existing crabgrass or bermudagrass, which then caused the corn to be stressed for moisture on June 14, 1989 prior to the second irrigation.

4. Relay planting Test # 4: cotton 1990. Here we attempted cotton again and planted it as was done in the silage corn test above. Cotton is slower to gain stature and we needed to assure ourselves that we could suppress alfalfa long enough to permit field entry after cotton emergence so that the middles could be sweep-cultivated to remove the alfalfa.

Table 4a. Relay planting of cotton into alfalfa - field and application data.

CROP:	Cotton, Prema	APPLICATION DATE:	4/4/90
LOCATION:	Bakersfield, CA	APPLICATION METHOD:	CO_2 backpack
PLANTING DATE:	4/16/90	VOLUME:	20 gpa, 22psi(8002)
PLOT SIZE:	8.3 ft X 15 ft	SOIL TYPE:	heavy sandy loam
PLOT DESIGN:	RCB, 3 replications	O.M.:	~1.0 %
IRRIGATION METHOD:	Border to furrow	CULTIVATION:	4/27, 5/4, 5/11, 6/1
CONDITIONS:	80 F, variable wind; none to light SE, moist soil		
WEED SPECIES:	Alfalfa, London rocket		

SEQUENCE: 3/15: Alfalfa sheeped off; 3/29: border irrigated; 4/4: herbicide plots established; 4/9: irrigated again; 4/16: planted; 4/27: first middles cultivation; 5/4: second cultivation; 5/9: spot-treated bermudagrass with fluazifop-P; 5/14: cotton in 4th leaf, 1 to 2 inches tall; 5/25 fertilized with 100 lb of nitrogen side-dressed and irrigated; 5/29: counts of weeds in the drill row taken; 5/31: hand weeded; 6/1: cultivated making beds.

Table 4b. Summary of alfalfa injury and London rocket control prior to cultivation (0-10 Rating: 0=no control,10=kill).

		Alfalfa injury						London rocket injury	
		Apr 6		Apr 12		Apr 25[b]		Apr 12	
Treatment	1X Rate[a]	1X	2X	1X	2X	1X	2X	1X	2X
	(lb/A)								
Control	-	0.0		0.0		2.3		4.3	
Flamed w/propane	-	6.3		9.0		0.0		10.0	
Glyphosate+pendimethalin+prometryn[c]	0.75+0.75+1.0	1.3	2.0	5.0	7.0	4.7	6.3	10.0	10.0
Glyphosate[c]	0.75	1.7	3.0	3.7	5.7	4.3	6.7	8.0	9.7
Glyphosate[c]	2.0	3.3	3.7	7.3	9.0	8.2	10.0	10.0	10.0
Glyphosate+prometryn[c]	0.75+1.0	0.3	0.7	5.0	6.3	6.3	8.0	10.0	10.0
Sulfosate[c]	1.12	2.0	3.7	5.0	7.0	7.0	8.7	10.0	10.0
Glufosinate	0.67	3.3	4.3	8.7	10.0	4.0	6.3	10.0	10.0
Paraquat[c]	0.5	4.7	6.0	5.3	6 7	3.0	1.3	10.0	10.0
Monocarbamide dihydrogen sulfide[c]	20 gpa	5.7	6.7	4.7	6.0	2.3	1.7	9.7	10.0
LSD (0.05)	1.2	0.6	2.3	1.6					

[a]All 2X treatments were double-sprayed, like an overlap (K2X).
[b]Cotton is emerging.
[c]Surfactant at 0.25%.

Results of this demonstrational trial were very favorable and yields were over 2 bales/A, normal for the grower. Again, glyphosate applied prior to planting provided good suppression of the alfalfa at the 3 lb/A rate and also provided suppression of bermudagrass and yellow nutsedge. As with the silage corn, the soil disturbance during planting induced a dry soil mulch which, typically for this area on sandy loam soils, prevented emergence of small seeded annual weeds. Winter annual weeds such as annual bluegrass and London rocket were killed by glyphosate while summer weeds such as lambsquarters, barnyardgrass, and crabgrass did not emerge and populations were low enough to permit handweeding. Cotton emergence on May 25, 1990 permitted middle cultivation to remove suppressed alfalfa and later soil was moved to the cotton drill row, which is required to permit efficient cotton picking.

Results from the weed control trials showed that glyphosate at 0.75 lb/A was not adequate here. Other herbicides such as glufosinate, paraquat, monocarbamide dihydrogen sulfide and propane provided much more rapid desiccation of alfalfa foliage but rapid recovery and did not seem suitable for suppression. Adding residual herbicides such as pendimethalin or prometryn were not necessary here because of the dry soil mulch.

CONCLUSIONS

The results of these studies strongly suggest that relay planting under the irrigated conditions of the San Joaquin Valley, from alfalfa to cotton, corn or blackeye beans are feasible. Their use could permit harvest of one cutting of alfalfa valued at about $150/A before planting cotton, or two cuttings worth about $250 before planting silage corn or beans. Also about $50/A could be saved on land preparation costs. Reduced tillage would reduce particulate air pollution, a problem in the San Joaquin Valley.

Without rainfall, a dry mulch can be achieved which greatly reduces weed emergence. However, if rains occur after planting (which happens about 50% of the seasons in the San Joaquin Valley), then a residual herbicide may be needed if no post-emergence controls are available. On loam soils, more weeds might be expected.

Glyphosate seems to work well on recently mowed alfalfa, which enhances the feasibility since sprays can be made immediately after the forage is removed. Irrigating just before glyphosate application appears to improve control. Combinations with residual herbicide did not affect its performance.

Further studies need to be done to evaluate blading off all alfalfa before planting these relay crops. That might eliminate the need for glyphosate, or if it is needed for weeds present, then lower rates might be satisfactory. Evaluation during colder and rainy periods after planting is needed to verify risk under such conditions.

BERMUDAGRASS CONTROL IN LIMA BEANS. W. E. Bendixen and D. W. Cudney, Farm Advisor and Weed Science Specialist, University of California Cooperative Extension, 5266 Hollister Ave., Bldg B, Santa Barbara, CA 93111 and University of California, Riverside, CA 92521.

Abstract. Lima beans are an important crop in the central coastal region of California. Preemergence weed control treatments have done much to ease the burden of annual weed control, but as a secondary problem perennial weeds such as bermudagrass have become an increasing production problem. Bermudagrass was shown to decrease yields by more than 50%. Three postemergence grass herbicides were evaluated over a 3 yr period in the Santa Ynez Valley of Santa Barbara county. These herbicides included: sethoxydim, clethodim, and fluazifop-P. Sequential treatments consisting of two applications spaced 2 weeks apart were necessary for best control. All herbicide treatments provided effective bermudagrass control. There was a slight difference in years with slightly less control in 1989 than in 1988 and 1990. In 1990 a bean yield increase of 1540 lb/A was noted for herbicide treatment.

LACTOFEN AND ACIFLUORFEN FOR WEED CONTROL IN SNAP BEANS. Dan Curtis and Ray William, Research Assistant and Professor, Department of Horticulture, Oregon State University, Corvallis OR 97331.

Abstract. Previous research indicated that lactofen applied preemergence and acifluorfen applied postemergence were potential replacements for dinoseb for broadleaf weed control in mechanically harvested snap beans in western Oregon. Three trials were established in grower-cooperator plantings in 1990 to evaluate weed control efficacy, particularly with nightshade species, and also to observe crop tolerance (Tables 1 to 3). Lactofen at 0.25 lb/A provided excellent hairy and black nightshade control (>95%). Directed acifluorfen treatments were slightly superior to broadcast treatments for nightshade control. Initial crop injury with acifluorfen was severe, but plants were quick to recover. Application timing on postemergence treatments was critical to avoid yield losses. Applications must be made before the visual emergence of any flower primordia.

Treatments were applied with CO_2 propelled unicycle sprayers at 30 psi. Preemergence (PRE) and postemergence (POST) treatments were broadcast on 8 by 30 foot plots. Directed postemergence (POSTD) treatments were applied between rows, up one row side and down the other side, overlapping a center row in the plot. Plot size in these treatments was 5 by 30 feet. Bean row spacing was 30 inches. Trial design was a randomized complete block with four replications. Carrier volume per acre was 23 GPA for the broadcast treatments and 36.3 GPA for the directed treatments.

Preemergence treatments were applied on the day of planting; Postemergence treatments were applied at Trial One 37 days after planting when the first trifoliate was fully expanded, no flower primordia visible; Trial Two, 43 days after planting when the third trifoliate was one half expanded and the first flower primordia were visible; Trial Three, 31 days after planting, as the second trifoliate was fully expanded and the third trifoliate was just emerging and no flower primordia were visible.

Table 1. Lactofen and acifluorfen for weed control in snap beans 1990, Irish Bend, Oregon.

Treat-ment		Rate/type		Crop injury	Weed control: Night-shade	Weed control: Redroot-pigweed	Yield	Sizes 1-4
		lb/A		----	-------%-------	----	T/A	%
01	C			0	0	0	4.61	59
02	L	0.125	P	4	98	100	9.02	50
03	L	0.25	P	0	99	100	9.20	50
04	L	0.50	P	5	100	100	9.13	41
05	L	0.25	P	3	100	100	9.38	54
	M	2.00	P					
06	A	0.25	PS	6	95	100	9.01	56
07	A	0.375	PS	10	100	100	8.35	49
08	A	0.25	PD	4	99	100	8.38	51
09	A	0.50	PD	6	100	100	8.29	56
10	A	0.25	PD	6	99	100	9.06	61
	B	0.50	PD					
11	A	0.50	PD	14	100	100	6.60	54
	B	0.50	PD					
12	A	0.25	PD	4	98	100	8.58	52
	B	1.00	PD					

Planted: May 5, 1990 Harvested: July 19, 1990 Variety: OSU 91-G
Surfactant added to all ps and pd treatments at 0.25% (v/v).
Nightshade rating is for a mixed stand of black and hairy 10%/90%.
C = Control L = Lactofen M = Metolachlor A = Acifluorfen B = Bentazon
P = Preemergence PS = Postemergence PD = Postemergence-directed

Table 2. Lactofen and acifluorfen for weed control in snap beans 1990, Hopmere, Oregon.

Treat-ment		Rate/type	Crop injury	Weed control Night-shade	Ground-sel	Shepards-purse	Dog fennel	Yield	Sizes 1-4
		lb/A	------	------	%	------	------	T/A	%
01	C		0	0	0	0	0	5.29	70
02	L	0.125 P	3	91	100	100	100	9.72	53
03	L	0.25 P	0	99	100	100	100	10.32	60
04	L	0.50 P	0	100	100	100	100	9.91	53
05	L	0.25 P	0	100	100	100	100	9.16	58
	M	2.00 P							
06	A	0.25 PS	23	93	91	86	83	6.26	66
07	A	0.375 PS	24	94	99	88	92	6.39	64
08	A	0.25 PD	15	90	95	88	85	5.35	73
09	A	0.50 PD	20	100	100	95	96	6.33	60
10	A	0.25 PD	16	93	94	86	94	8.05	59
	B	0.50 PD							
11	A	0.50 PD	40	97	100	95	98	5.77	59
	B	0.50 PD							
12	A	0.25 PD	14	97	96	91	96	6.42	56
	B	1.00 PD							

Planted: May 17, 1990 Harvested: July 26, 1990 Variety: OSU 91-G
Surfactant added to all ps and pd treatments at 0.25% (v/v).
Nightshade rating is for a mixed stand of black and hairy 75%/25%.
C = Control L = Lactofen M = Metolachlor A = Acifluorfen B = Bentazon
P = Preemergence PS = Postemergence PD = Postemergence-directed

Table 3. Lactofen and aciflurfen for weed control in snap beans 1990, Monroe, Oregon.

Treat-ment		Rate/type		Crop injury	Yield	Sizes 1-4
		lb/A		%	T/A	%
01	C			10	8.69	47.0
02	L	0.125	P	0	8.95	55.3
03	L	0.25	P	3	11.27	39.1
04	L	0.50	P	13	8.66	46.0
05	L	0.25	P	8	11.79	44.4
	M	2.00	P			
06	A	0.25	PS	14	9.04	41.2
07	A	0.375	PS	21	8.67	47.0
08	A	0.25	PD	14	9.98	50.1
09	A	0.50	PD	39	6.50	59.6
10	A	0.25	PD	24	8.80	46.5
	B	0.50	PD			
11	A	0.50	PD	23	8.16	44.8
	B	0.50	PD			
12	A	0.25	PD	11	9.69	49.9
	B	1.00	PD			

Planted: June 12, 1990 Harvested: August 8, 1990 Variety: OSU 91-G
Surfactant added to all ps and pd treatments at 0.25% (v/v).
C = Control L = Lactofen M = Metolachlor A = Acifluorfen B = Bentazon
P = Preemergence PS = Postemergence PD = Postemergence-directed

RESIDUAL EFFECTS OF IMAZETHAPYR AND IMAZETHAPYR COMBINATIONS ON YIELD OF CENTENNIAL AND ATLANTIC POTATOES. E. J. Gregory, R. N. Arnold, and M. W. Murray, Professor of Agronomy, Pest Management Specialist, and Research Assistant, Agricultural Science Center, New Mexico State University, Farmington, NM 87499.

Abstract. Imazethapyr is a member of a new herbicide family called imidazolinones. Imazethapyr is used to control a wide range of broadleaf and grassy weeds in edible beans, pinto beans, snap beans, lima beans, peas, southern peas, and lentils throughout the United States. Rotational crops such as wheat can be planted 4 months after application, field corn 9 months after application, and potatoes 26 months after application. In 1989, at the New Mexico State University Agricultural Science Center at Farmington, NM, imazethapyr was applied alone or in combination with other herbicides preplant incorporated, preemergence, and postemergence for annual grass and broadleaf weed control in pinto beans. Broadleaf weed control was good to excellent with imazethapyr applied either preplant incorporated, preemergence or postemergence. Annual grass control with imazethapyr was fair to poor at all three spraying applications. Imazethapyr combinations with metolachlor, pendimethalin, or trifluralin provided excellent control of annual grasses and broadleaf weeds. In 1990, these research plots were planted to Centennial and Atlantic potatoes to determine possible residual effects of imazethapyr. Total yield of centennial and Atlantic potatoes including #1 (1.8 to 3 inches) and jumbo (3 inches and bigger) yielded between 510 and 403 cwt/A and 455 and 355 cwt/A, respectively. There were no malformed tubers including cracking, folding or knobbiness in any of the treatments.

ROTATIONAL CROP RESPONSE TO IMAZETHAPYR. Stephen D. Miller, Professor, Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY 82071 and Paul J. Ogg, Field Development Specialist, American Cyanamid Co., Longmont, CO 80501.

Abstract. Imazethapyr has shown promise for broad spectrum weed control in alfalfa and dry beans; however, herbicide carryover from one crop season to the next is possible. Plots were established at the Research and Extension Centers, Torrington and Powell, WY to evaluate the sensitivity of seven crops to soil residual levels of imazethapyr under sprinkler and furrow irrigation. Plots were 10 by 60 ft with three replications arranged in a split block. Herbicide treatments were applied broadcast with a CO_2 pressurized six-nozzle knapsack sprayer as preplant incorporated, preemergence or postemergence treatments in dry beans and rotational crops seeded the following season. The study was conducted twice at Torrington under sprinkler irrigation in a sandy loam soil (78% sand, 13% silt and 9% clay) with 1.3% organic matter and pH 7.6 and once at Powell under furrow irrigation in a clay loam soil (40% sand, 29% silt and 31% clay) with 1.5% organic matter and pH 7.7.

Barley, alfalfa, corn and sorghum tolerance to soil residual levels of imazethapyr was excellent. Plants were not injured nor yields reduced when seeded into areas that had been treated with 0.063 and 0.094 lb/A imazethapyr the previous year. Oats were injured slightly by imazethapyr at both rates one of two years at Torrington; however, only the 0.094 lb/A rate applied postemergence resulted in a significant yield reduction. Sugarbeets were injured by all methods and rates of imazethapyr application at both locations. Sugarbeet injury ranged from 10 to 42% and yield reductions from 0 to 57% and were generally greatest when seeded into areas treated with 0.094 lb/A imazethapyr the previous year. Sugarbeets were not injured by residual levels of imazethapyr when seeded two years following application at Torrington. Canola was seeded only at Powell with injury ranging from 13 to 23% and yield reductions form 0 to 41% 1 yr after application.

WEED CONTROL IN POTATOES WITH DPX-E9636. C. V. Eberlein and C. W. Kral, Associate Professor, Department of Plant, Soil and Entomological Sciences, University of Idaho, Aberdeen, ID 83210, and Developmental Representative, E. I. Du Pont de Nemours and Company, Twin Falls, ID 83301.

Abstract. DPX-E9636 is a new sulfonylurea herbicide that shows potential for broadleaf and grass weed control in potatoes. The objectives of this research were to evaluate weed control with DPX-E9636 applied

preemergence or postemergence, and to determine potato tolerance to DPX-E9636 applied postemergence under weed-free conditions. Field trials conducted at Aberdeen and American Falls, ID showed that DPX-E9636 gave good to excellent control of hairy nightshade and kochia when applied preemergence at 17 to 35 g/ha in combination with linuron at 0.84 kg/ha. Field trials at Aberdeen, American Falls, and Tetonia, ID showed that DPX-E9636 applied postemergence at 17 to 35 g/ha gave fair to good control of hairy nightshade, kochia, redroot pigweed, shepherdspurse, and volunteer oats, and poor control of common lambsquarters. DPX-E9636 applied in combination with metribuzin at 0.28 kg/ha gave good to excellent control of all of these species except volunteer oats. Volunteer oats control by DPX-E9636 at 17 and 26 g/ha was antagonized by metribuzin at 0.28 kg/ha. Potatoes ('Russet Burbank') showed good tolerance to DPX-E9636 plus linuron preemergence and DPX-E9636 alone or in combination with metribuzin postemergence. In weed free trials at Aberdeen, ID, yield of US #1 potatoes was reduced 49.6 kg/ha per g/ha of DPX-E9636 applied. In weed free trials at Tetonia, ID yield of seed potatoes was not reduced by DPX-E9636 at rates of 17 to 70 g/ha.

EFFECTS OF THIFENSULFURON METHYL PLUS TRIBENURON METHYL AND IMAZAMETHABENZ DRIFT ON FOUR POTATO VARIETIES TREATED AT THREE DIFFERENT GROWTH STAGES. P. Westra, and B. Cranmer, Weed Science Laboratory, Colorado State University, Ft. Collins, CO, 80523.

Abstract. Russett nugget, sangre, centennial russett, and russett burbank potatoes were planted on the CSU San Luis Valley research farm on May 22, 1990. Plots were 12 feet wide by 25 feet long, and all 4 varieties were present in each plot. The study consisted of three replications where herbicides were applied with a carbon dioxide powered backpack sprayer. Thifensulfuron methyl plus tribenuron at 0.185 and 0.375 oz/A and imazamethabenz at 0.235 and 0.47 lb/A were applied on June 25, 1990 as an early postemergence treatment, on July 12, 1990 as a pre-bloom treatment, and on August 2, 1990 as a post-bloom treatment. Non-destructive canopy measurements were taken during the growing season, and potatoes were harvested on September 25, 1990.

The russett nugget variety was most tolerant of herbicide treatments, followed by centennial russett and sangre. Sangre sensitivity was expressed in deep epidermal cracks, most often from the assert treatments. Russett burbank was most sensitive to all herbicide treatments, and readily developed cracked, knobby, or folded tubers which would not be marketable. The potatoes were most sensitive to damage when treatment occurred at the pre-bloom stage. Most obvious effects included a reduction in normal tuber number, a reduction in potato yield, and a reduction in average tuber weight. Imazamethabenz applied at 0.47 lb/A at the early postemergence stage caused appreciable tuber damage to both the sangre and russett burbank varieties. This research re-emphasizes the importance of exercising caution when applying these herbicides near growing potatoes, and the importance of proper spray tank cleaning procedures following use of these herbicides.

DISTRIBUTION, CHARACTERISTICS, AND CONTROL OF TRIAZINE RESISTANT POWELL AMARANTH IN IDAHO. C. V. Eberlein, K. Al-Khatib, and E. P. Fuerst, Associate Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Aberdeen, ID 83210, Postdoctoral Research Associate and Assistant Professor, Department of Agronomy and Soils, Pullman, WA 99164.

Abstract. Triazine resistant Powell amaranth was discovered near Jerome, ID in 1989 in a potato field treated with metribuzin. A 1990 survey of all agricultural counties in Idaho showed that the infestation of resistant Powell amaranth was localized in the southeastern corner of Gooding county in southern Idaho. To determine the mechanism of resistance, I_{50} values for inhibition of photosystem II were determined for metribuzin, atrazine, and diuron using thylakoids isolated from triazine resistant and susceptible biotypes. For the resistant biotype, I_{50} values were 5.5×10^{-5} M, 1.8×10^{-5} M, and 2.4×10^{-7} M for atrazine, metribuzin, and diuron, respectively. For the susceptible biotype, I_{50} values were 4.1×10^{-7} M, 2.9×10^{-7} M, and 1.3×10^{-7} M for atrazine, metribuzin, and diuron, respectively. R/S ratios based on I_{50} values were 134 for atrazine, 62 for metribuzin, and 1.9 for diuron. Results of herbicide binding studies were consistent with the I_{50} studies,

indicating that resistance was due to reduced binding of triazines to the thylakoid membrane D1 protein. Greenhouse studies showed that control of the triazine resistant biotype was similar to the susceptible biotype for EPTC and trifluralin applied PPI; linuron, metolachlor, and pendimethalin applied preemergence; and bentazon, bromoxynil, DPX-E9636, and 2,4-D applied postemergence.

A RESEARCH TEAM APPROACH TO BIOLOGICAL CONTROL OF ANNUAL GRASSES IN WINTER WHEAT. A. G. Ogg, Jr., A. C. Kennedy, F. L. Young, D. R. Gealy, B. N. Johnson, ARS-USDA, S. Gurusiddaiah, Washington State University, Pullman, WA 99164, and H. D. Skipper, Clemson University, Clemson, SC 29634.

Abstract. The discovery of *Pseudomonas* spp. isolates that reduce the germination and early root growth of downy brome has provided an exciting new method to manage this and perhaps other troublesome weeds in winter wheat. These bacteria produce plant suppressive compounds (PSC) that selectively inhibit the germination and early root growth of downy brome and thus shift the competitive advantage to wheat. The Agricultural Research Service, U.S. Dept. of Agriculture at Pullman, WA in cooperation with Washington State University has organized a team of scientists to research this new weed management discovery and to develop fully this biological weed control practice. The importance of having a multidisciplinary team is critical to understanding the basic processes involved and in solving technological problems that are invariably associated with new practices.

The following is a list of the scientists involved and the objectives of their specific research.

I. A. G. Ogg, Jr. - ARS Research Leader/Weed Scientist and F. L. Young - ARS Research Agronomist/Weed Scientist.

Objectives:

1. Determine the weed-suppressive activity of the bacteria at different geographical sites.
2. Determine the relationship between timing of bacteria applications and suppression of weeds.
3. Integrate the biological control method with currently available herbicides and cultural practices.
4. Develop new application technologies to enhance survivability and activity of the bacteria.
5. Coordinate field tests in a 5-state pilot-test project.
6. Field screen new bacterial isolates from laboratory and greenhouse screening tests.
7. Prepare patents.

II. A. A. C. Kennedy - ARS Soil Microbiologist and Tami Stubbs - WSU Technician.

Objectives:

1. Survey for new active isolates and bioassay selected isolates in the laboratory and greenhouse.
2. Determine bacterial survival and root colonization under field conditions.
3. Determine the response of downy brome ecotypes and other *Bromus* spp. to the bacteria.
4. Determine the effect of long-term storage on selected isolates.
5. Determine the movement of bacteria through the soil.
6. Identify isolates by nucleic and fatty acid fingerprinting.
7. Determine the activity of bacteria on broadleaf weeds and crops.
8. Prepare patents.

II. B. Jean Doty - WSU Ph.D Graduate Student Major Professor - A. C. Kennedy

Objectives:
1. Define the role of downy brome seed colonization on establishment of D-7 bacteria.
2. Determine the influence of seed exudates on seed colonization by bacteria.
3. Determine the chemotaxis and motility of the bacteria.

II. C. Tom Vaughn - WSU M.S. Graduate Student Major Professor - A. C. Kennedy

Objectives:
1. Determine carbohydrate uptake and utilization by bacteria in the rhizosphere.
2. Evaluate and isolate potential competitive genes in rhizosphere bacteria.
3. Amplify straw degrading ability of bacteria.

III. D. R. Gealy - ARS Plant Physiologist and Steve Seefeldt - ARS Technician.

Objectives:
1. Determine the site and mechanism of action for bacterial PSC.
2. Determine the physiological effects of the bacterial PSC on plants.

III. B. Pat Tranel - WSU M.S. Graduate Student.
Major Professor - D. R. Gealy.

Objectives:
1. Determine the effects of the bacterial PSC on cell division and cell elongation in roots.
2. Determine the effects of the bacterial PSC on cell membranes.
3. Evaluate the effects of PSC on whole-plant growth.

IV. B. N. Johnson - ARS Post-doctorate Microbiologist.

Objectives:
1. Determine the environmental factors affecting survival, colonization, and PSC production of the bacteria.
2. Determine the effects on non-target species.
3. Develop toxin minus mutants and evaluate them against the wild-type.
4. Determine the effects of herbicides in solution on the survival and growth of bacterial colonies.

V. S. Gurusiddaiah - Assistant Director WSU Bio-Analytical Center/Chemist.

Objectives:
1. Isolate, purify, and identify PSC from bacteria that suppress downy brome.
2. Prepare patents.

VI. H. D. Skipper - Soil Microbiologist/Weed Scientist, Clemson University, on sabbatical leave at Pullman, WA.

Objectives:
1. Determine the survival of bacteria in soil from the Pilot-test sites.
2. Determine soil factors affecting survival of the bacteria.
3. Ascertain if wheat roots can serve as carriers of the bacteria to roots of near-by downy brome.
4. Isolate weed-suppressive bacteria from perennial range grasses.

Each team member plays an important role in the overall team effort. Weekly group discussions help coordinate research and advance this new technology.

CONTROL OF WINTER ANNUAL GRASS WEEDS IN WINTER WHEAT WITH INDIGENOUS SOIL BACTERIA. Pamela A. Harris and Phillip W. Stahlman, Research Associate and Associate Professor, Fort Hays Branch, Kansas Agricultural Experiment Station, Hays, KS 67601.

Abstract. Few chemical herbicides are currently available for adequate and cost-effective control of winter annual *Bromus* spp., and no effective herbicides are now available for selective control of jointed goatgrass, an increasing weed problem in winter wheat fields in Kansas. The development of a biological herbicide which can selectively control one or more of these problem weeds without affecting winter wheat production would increase the available weed control options, possibly reduce weed control costs, and may help protect water quality and the environment. Indigenous bacteria are being isolated from Kansas soils and the rhizosphere of several crop and weed species and evaluated for selective inhibition of several of these problem weeds. Initial screenings of over 500 isolates in laboratory bioassays have identified 105 isolates which inhibit downy brome root elongation at least 30% without significantly affecting wheat. Almost 40 of these isolates reduce brome root growth over 70%. Sixty-five isolates have reduced Japanese brome root growth by at least 30%, whereas 42 of these isolates inhibit both downy brome and Japanese brome root elongation without affecting winter wheat. Bioassays are currently being run to assess the effects of these bacteria on jointed goatgrass. Also, promising isolates are being evaluated in growth chamber and field studies. If bacterial isolates are discovered which control economically important weeds in major cropping systems, these new biological control mechanisms may become a powerful alternative or addition to a traditional weed control program.

WEED MANAGEMENT DECISIONS IN CORN BASED ON BIOECONOMIC MODELING. Edward E. Schweizer, Philip Westra, and Donald W. Lybecker, USDA- ARS, Crops Research Laboratory and Colorado State University, Fort Collins CO 80523.

Abstract. A 3-yr pilot test was initiated in 1989 to determine the feasibility of a computer bioeconomic model for weed management decisions in irrigated corn in eastern Colorado. For the 1989 and 1990 seasons a total of 26 farmer sites differing in soil type, irrigation method, and weed species were selected by county extension agents. Each fall soil samples were collected to a depth of 30 cm from each cooperator's field to determine the weed seed bank. The weed seed bank averaged over 7,900 seed m^2 in 1988 and 18,700 seed m^2 in 1989, with 85% of the seed being annual dicots. Analysis of the model's recommendations and the weed management strategies employed by the pilot test corn producers indicate: (1) 66% of the farms had higher gross margins, (2) 60% of the farms had lower soil surface herbicide loads, and (3) 71% of the farms had lower herbicide costs when the bioeconomic weed management model was used over the 2-year period. The model managed plots averaged $12.25 and $5.90 more than the farmer managed plots in 1989 and 1990, respectively.

WEEDS OF CANAL AND LATERAL DITCH BANKS. Tom Shrader, Supervisory Natural Resource Specialist, Rio Grande Project, United States Bureau of Reclamation, El Paso, Texas 79901.

Abstract. A considerable amount of money is spent annually on controlling weeds on 941 km of canal and lateral ditch banks in south central New Mexico and El Paso County, Texas. The canals and laterals of the Bureau of Reclamation's Rio Grande Project are constructed of earthen berms, although 112 km of lateral ditches have been concrete-lined.

Ditch bank vegetation is helpful in stabilizing ditch berms but weedy species present several management problems by reducing the water-carrying capacity of ditches through biomass and the collateral encouragement of sedimentation, serving as a source of weeds in crops and turf, restricting visibility required for safe and efficient performance of operation and maintenance functions, effecting water loss via transpiration, serving as alternate habitat for plant diseases and insects, attracting burrowing animals, and being a nuisance (e.g., allergies).

Knowledge of the composition of ditch bank flora would be helpful in understanding the synecology of ditch plants and in developing a program of vegetation management. An understanding of the spatial distribution of plant species over a moisture gradient has been obtained over the past 15 yr, and composition, frequency, and cover of warm-season species were quantified via the line-intercept method using 320 randomized line-transect plots on unlined ditches in 1975.

Based on field observations and line-intercept data, 152 species of plants have been identified and classified as to zones of common occurrence along a moisture gradient, which ranged from the wettable prism of the ditch channel, through a narrow mesic zone on the inside shoulder of ditch berms, to xeric bank tops and outside berm slopes (Table).

The line transects intercepted 70 plant species at ground level and 79 plant species as overstory. The most frequently intercepted plant species are sum-- marized in the accompanying table along with cover values at ground level and as overstory. The cumulative cover for all species at ground level and as over- story was 351 m and 354 m, respectively. Johnsongrass was the most commonly intercepted (70%) species. Bermudagrass was the second most frequently (54%) intercepted species, and it had the greatest relative cover at ground level of 73%. The cover of bermudagrass on several ditch sections was such that it nearly excluded many species common to unsodded sites. Bare ground accounted for 84% of the cumulative line transect lengths. Aquatic plant species were very rare due to the high turbidity of ditch waters.

Ditch bank flora may be economically managed by controlling problem weeds (e.g., field bindweed and johnsongrass) while trying to maintain and encourage the spread of soil-binding and site-competitive species such as saltgrass and bermudagrass, although the latter can be a troublesome weed in crops.

Table. Summary of plant species with highest line-transect frequency and cover for 320 line-transect plots conducted on canal and lateral ditch banks in 1975.

Plant species/bare ground	Line-transect frequency	Cover: Ground level	Cover: Over-story
	(%)	(%)	(%)
Johnsongrass	70.00	0.54	5.15
Bermudagrass	53.75	11.83	1.44
Seashore paspalum	31.87	1.32	0.47
Russian thistle	29.38	0.26	1.66
Rumex spp. (mostly curly dock)	23.13	0.09	0.64
Conyza spp.	23.13	0.06	0.10
Spiny aster	19.06	0.07	0.68
Polygonum spp.	17.50	0.05	0.33
Silverleaf nightshade	16.25	0.01	0.38
Aster hesperius Gray & *A. subulantus* Michx.	15.31	0.02	0.30
Saltgrass	11.25	0.57	0.21
Rabbitfoot polypogon	11.25	0.09	0.09
Sphaeralcea spp.	9.38	0.03	0.22
Suaeda suffrutescens Wats.	8.75	0.05	0.62
White sweetclover	7.81	0.01	0.15
Texas blueweed	7.50	0.01	0.12
Atriplex wrightii S. Wats.	7.19	0.08	0.30
Echinochloa spp.	7.19	0.07	0.23
Amaranthus spp.	7.19	0.01	0.23
Pyrrhopappus multicaulis DC.	7.19	0.01	0.13
Helenium spp.	6.56	0.01	0.05
Bare ground	98.40	84.01	--

SETHOXYDIM CONTROL OF GRASSY WEEDS IN CALIFORNIA RICE. D. C. Wiley, C. L. Regusci, J. O. Pearson, BASF Corporation, Field Development, P.O. Box 13528, Research Triangle Park, NC 27709.

INTRODUCTION

The control of grass weeds is a critical factor in California rice production. Most chemical control measures for barnyardgrass or sprangletop depend on preemergence or very early postemergence applications. Sethoxydim has been tested for 4 years as a postemergence herbicide in CA and other areas of rice production in the United States. The use of sethoxydim is intended to be a rescue treatment and not a primary one.

Research objectives have included the effects of rate, time, and method of application for weed control and rice tolerance. Results have been very encouraging and it appears that sethoxydim can provide a new tool to the rice grower for safe and effective control of grassy weeds. This report is intended as a progress report. Research is continuing to confirm previous results and to further define conditions for optimum control.

METHODS AND MATERIALS

Sethoxydim has been evaluated in California rice since 1986 at 22 locations mainly in the Sacramento Valley. Most work has been done in small plots with randomized complete block designs with three to five replications. Two trials were conducted by fixed wing aircraft. Spray volumes and pressures have been in the range of typical ground and air applications. The water depth at application has been 3 to 4 inches. Unless a timing trial was conducted, the grass has usually been 2 to 4 inches above the rice at the time of application. Rice ranged from the 6 to 12 leaf stage.

Weed control and injury ratings were based on visuals observations using percent scale. Yields were taken using a small plot combine and were corrected for moisture to 13%. Germination tests were conducted using the standard cold temperature method.

SUMMARY

The effects of sethoxydim on rice, weed control, and yields are shown in Tables 1, 2, and 3. Sethoxydim has the potential of being injurious to rice. It is felt that by delaying application until the grassy weeds are above the rice that some shielding is provided. The highest rice injury recorded over a 4 year period at 14 DAT (0 days after treatment) was 19%. Generally after about 3 weeks DAT the injury was substantially reduced.

The 0.75 lb/A rate was not adequate for barnyardgrass control and on the average resulted in 69% control. Barnyardgrass control with sethoxydim at 0.1 lb/A averaged 81%, and at 0.125 to 0.15 lb/A control ranged from 85 to 88%. Bearded sprangletop control was excellent (Table 3) and ranged from 80 to 98% when sethoxydim was applied at 0.1 to 0.15 lb/A at 44 to 51 DAS (days after seeding). Control declined as applications were delayed to 58 DAS. Rice yields increased with sethoxydim treatments compared to untreated plots (Table 2 and 3). Differences among treatments did not vary significantly. The effects of sethoxydim on rice seed germination were evaluated in two trials (Table 4). Both the 0.1 and 0.15 lb/A rates did not affect germination. Two variety-phytotoxicity screening trials were conducted in 1989 and 1990. Ten varieties were evaluated and there were no interactions among the varieties and sethoxydim treatments. The varieties tested are listed in Table 5.

In summary, sethoxydim is a promising herbicide for late postemergence control of barnyardgrass and sprangletop in rice. Effective rates range between 0.1 to 0.15 lb/A. Treatments should be made when grasses are 4 to 6 inches above the rice. Spray applications were made into standing water 2 to 4 inches deep.

Table 1. Effects of three rates of sethoxydim on barnyardgrass control and rice injury. 3 trials 1986-87.

Rate	Injury		Maximum control
	14 DAT	22-40 DAT	
lb/A	----------%---------		%
0.75	8	0	69
0.1	14	0	81
0.125	19	0	85

Table 2. Effects of two rates of sethoxydim on barnyardgrass control and rice injury. 5 trials, 1989, 1990

	Injury			
Rate	10-20 DAT	21-31 DAT	Control	Yield
lb/A	----------%---------		%	lb/A
Check				5407
0.1	9	1	81	6561
0.15	11	3	88	6372

Table 3. Effects of time of application and rate of sethoxydim on bearded sprangletop control, rice injury and yields.

		Injury			
Rate	DAS	14	22-30 DAT	Control	Yield
lb/A		------%---------		%	lb/A
Check					3987
0.1	44	8	0	87	6471
0.15		12	0	98	6904
0.1	51	4	5	80	5948
0.15		8	11	89	6713
0.1	58	7	0	65	6389
0.15		13	11	82	6808

Table 4. Effects of sethoxydim on rice seed gemination (%).

Rate	1987	1988
lb/A		
Check	85	89
0.1	92	94
0.15	96	91

Table 5. Rice varieties evaluated in sethoxydim phytotoxicity screening.

Calmochi-101	L-202	M-203
KRM-2	M-103	M-401
KR-4	M-201	S-201
	M-202	

BASIC SCIENCES

RESEARCH ON THE PHYSIOLOGY AND MOLECULAR REGULATION OF SEED DORMANCY IN THE GRASS WEEDS OF WINTER WHEAT. Peter J. Goldmark, Project Director, Double J. Ranch, Star Route, Okanogan, WA 98840.

Abstract. Seed dormancy is an important survival trait of grass weeds that greatly complicates weed control methods in winter cereal crops. Breaking of weed seed dormancy is a potential control method, yet little is known about the variability and regulation of seed dormancy among grass weeds. To initiate a molecular study on the mechanism of seed dormancy in grass weeds of winter cereals, defined conditions for the transition of dormant to nondormant seeds were developed. In addition, the influence of seed coat and seed endosperm was studied to clearly define the factors affecting seed dormancy. Plant hormones were evaluated for their ability to alter levels of dormancy in imbibed seeds and compared with the results from other plant systems.

To focus the project on weeds of agricultural importance, five of the most troublesome weeds (cheat, downy brome, jointed goatgrass, common rye and wild oats) were selected and grown under controlled greenhouse conditions. Weed seeds were harvested at the hard dough stage, dried to 12% moisture, and stored at -20 C to prevent loss of dormancy. A portion of each seed lot was after-ripened at 20 C, and a seed lot was scored as nondormant when 100% of the tested seeds germinated in 48 hr. Wild oat seeds were most dormant, requiring over 300 days of after-ripening at 20 C to completely lose seed dormancy, followed by common rye, downy brome, jointed goatgrass and cheat in that order. Cheat seeds required only 20 days at 20 C to lose dormancy. Removal of the seed coat in all species did not release the seed from dormancy, but puncture of the aleurone layer did promote germination in wild oat, common rye and jointed goatgrass. Cheat and downy brome seed embryos retained dormancy even after removal of the endosperm.

These initial studies served as background for a molecular analysis of the differences between dormant and nondormant seeds that could lead to an understanding of the molecular events responsible for the suppression of germination in dormant seeds. Cheat was selected as the source of material since excised mature seed embryos remained dormant and the after-ripening time at 20 C was short. The first molecular studies compared mRNA synthesis in imbibed dormant and nondormant embryos, and found that after 10 hr at 20 C, dormant embryos synthesize mRNA at 30% of the rate found in nondormant (germinating) embryos. To understand the role of these transcribed messages in dormant embryos, a cDNA library was constructed from mRNA isolated from dormant cheat embryos imbibed in water for 10 hr. This library was differentially probed with cDNA derived from dormant and nondormant embryos imbibed in water for 10 hr, and clones unique to dormant embryos purified. Northern analysis has shown that the mRNAs represented by these clones are differentially expressed in dormant imbibed embryos and are ABA responsive. These cloned mRNAs are present in dormant and after-ripened mature dry seeds but are degraded and absent 6 hr post-imbibition in germinating embryos. Further characterization of the regulation and products of these cloned mRNAs may contribute to an understanding of the molecular events in dormant embryos that maintain the dormant state.

EVALUATION OF PARAQUAT RESISTANCE MECHANISMS IN HAIRY FLEABANE (*Conyza bonariensis* (L.) Cronq.). M. A. Norman and E. P. Fuerst, Washington State University, Pullman, WA, 99164 and R. J. Smeda, and K. C Vaughn, USDA-ARS Southern Weed Science Lab, Stoneville, MS, 38776.

Abstract. Experiments were conducted to determine the mechanism of paraquat resistance in the R biotype of hairy fleabane. A previous report and a preliminary study have indicated, respectively, that either an altered site of action (Photosystem I) or metabolic conversion of paraquat to a non-toxic form does not account for resistance. The activity of various protective enzymes (superoxide dismutase, catalase, ascorbate peroxidase, and glutathione reductase) isolated from the R and paraquat-susceptible (S) biotypes were determined using native polyacrylamide activity gels. Ascorbate peroxidase activity was slightly elevated in the R biotype, but no discernable differences were observed for the other protective enzymes. Consequently, the enzymatic detoxication of paraquat-generated oxygen radicals does not appear to be a mechanism of resistance. Paraquat

absorption/adsorption by intact leaf, transverse leaf section (2 mm), palisade/mesophyll cell, and protoplast preparations was similar in both biotypes. Thus, reduced uptake of paraquat by the R biotype is not the mechanism of resistance. The results of these uptake studies are also inconsistent with a sequestration mechanism of resistance. The sequestration hypothesis predicts that paraquat is compartmentalized in leaves of the R biotype in a manner that prevents paraquat from interacting with Photosystem I. Microautoradiographic analysis to determine the distribution of [^{14}C]paraquat indicate that at 4 hr after treatment, 35 and 10 times more paraquat was found in trichomes of the R and S biotypes, respectively, than in the epidermal, palisade, and mesophyll cells combined. Additional studies are being conducted to determine the role of trichomes and other potential mechanisms of paraquat resistance in hairy fleabane.

INTERPRETING GERMINATION RESULTS BASED ON DIFFERENT GERMINATION CRITERIA. F.E. Northam and R.H. Callihan, Research Associate and Associate Professor, Department of Plant, Soils and Entomological Sciences, University of Idaho, Moscow, ID 83843.

Abstract. One purpose of a germination test is to assess the capability of a seedlot to establish autotrophic seedlings. Yet, substantial disagreement exists regarding the criteria by which a seed is declared germinated. The endpoint most commonly used to designate a germinated seed is the initial appearance of any embryo structure (usually the radicle). Another view requires the presence of sufficient root and shoot tissue to ensure seedling independence from seed resources before germination is considered complete.

This study evaluated four germination categories that may be used to quantify visible embryo activity of laboratory germinated weed seeds. The categories were: root germination (seeds with radicles emerged); shoot germination (seeds with plumules or cotyledons emerged); complete germination (seeds with both roots and plumules emerged); and total germination (all seeds with any emergence, roots or shoots or both). These categories were derived from the germination opinions described in the above paragraph. Medusahead and yellow starthistle germination data were used to illustrate how different conclusions would arise when the germination endpoint based on early embryo emergence was compared to endpoints requiring radicle and shoot emergence.

The results from both medusahead and yellow starthistle experiments showed that counts in the root and total germination categories were nearly identical (Tables 1, 2 and 3). Counts from the shoot and complete germination categories were nearly equal during all experiments, but the counts in both the total and the root categories were often significantly different from counts in either the complete or shoot categories.

Different germination times resulted when the counts from medusahead root germination versus complete germination were compared at 8 C (Table 1). After seven days at 18 C, the difference between the four germination categories never exceeded 2%, and this trend continued through day 16, but root emergence at 8 C on day seven was 3 to 39 times greater than shoot emergence. Medusahead root emergence at 8 C was accomplished 3 to 6 days before shoots emerged. The root germination endpoint under-estimated the time needed for medusahead embryos to establish both a root and shoot (complete germination).

Yellow starthistle germination in 200 ppb picloram resulted in diverse conclusions depending on which definition was used (Table 2). Radicle emergence (root germination) was not affected by picloram, but cotyledon emergence (shoot germination) averaged only 13% in picloram compared to 63% in distilled water after ten days. Since root germination did not ascertain the inhibitory effect of picloram on yellow starthistle embryos, complete germination was the best criterion for quantifying yellow starthistle embryo response to picloram.

Shoot germination was retarded in 74 and 90-month-old yellow starthistle seeds germinated at 28 C (Table 3). The 74-month-old seeds had 77% root emergence and 53% shoot emergence at 28 days. The 90-month-old root germination category had 63% emergence at 28 days, but the complete germination category had only 9% emergence. Based on these data, the germination definition requiring the presence of both roots and shoots (complete germination) best described the capability of seeds to establish self-sustaining plants.

Table 1. Comparison of four categories for assessing embryo emergence during germination of medusahead.

Germin. Category	8 C Seedlot year 1985	1986	1987	18 C Seedlot year 1985	1986	1987
	(% emerged)					
			DAY 4			
Total	0...	0...	3...	55	88	93
Root	0...	0...	3...	55	88	93
Shoot	0...	0...	0...	51	82	91
Complete	0...	0...	0...	51	82	91
			DAY 7			
Total	0...	39 *	79 *	83	95	97
Root	0...	39 *	79 *	83	95	97
Shoot	0...	0	25	81	94	95
Complete	0...	0	25	81	94	95
			DAY 10			
Total	51 *	88 *	86	89	97	97
Root	51 *	88 *	86	89	97	97
Shoot	0	12	83	89	96	96
Complete	0	12	83	89	96	96
			DAY 13			
Total	82 *	93 *	86	93	97	97
Root	82 *	91	86	93	97	97
Shoot	61	73	84	92	96	96
Complete	61	71	84	92	96	96
			DAY 16			
Total	85	93	89	93	97	97
Root	83	91	89	93	97	97
Shoot	79	91	88	92	96	96
Complete	77	89	88	92	96	96

...These data were not analyzed.

*Comparisons were between the complete category and the total root and shoot categories within days and years (P=0.05).

Table 2. Comparison of four categories for assessing the effects of picloram on yellow starthistle embryos during germination.

Germin. category	Experiment 1 0 PPB	Experiment 1 200 PPB	Experiment 2 0 PPB	Experiment 2 200 PPB
	------------(% emerged)------------			
		DAY 4		
Total	59	63 *	63	63 *
Root	57	62 *	63	59 *
Shoot	56	1	61	3
Complete	55	0	60	0
		DAY 7		
Total	61	64 *	65	64 *
Root	59	64 *	64	61 *
Shoot	59	15	63	4
Complete	57	15	63	0
		DAY 10		
Total	61	64 *	65	64 *
Root	59	64 *	65	61 *
Shoot	61	21	65	5
Complete	59	21	65	1

*Comparisons were between the complete category and the total root and shoot categories within days and picloram concentrations (P=0.05).

Table 3. Comparison of four germination categories for assessing yellow starthistle embryo response to aging for 74 and 90 months.

Germin. category	Time in germinator	Seed age (months) 74	Seed age (months) 90
	(days)	-----(% emerged)-----	
Total	4	69 *	63 *
Root		69 *	63 *
Shoot		0	4
Complete		0	4
Total	7	76 *	63 *
Root		76 *	63 *
Shoot		46	7
Complete		46	7
Total	13	77 *	63 *
Root		77 *	63 *
Shoot		51	9
Complete		51	9
Total	28	77 *	63 *
Root		77 *	63 *
Shoot		53	9
Complete		53	9

*Comparisons were between the complete category and the total root and shoot categories within days and seed ages (P=0.05).

MECHANISMS OF RESISTANCE TO ACETOLACTATE SYNTHASE/ACETOHYDROXYACID SYNTHASE INHIBITORS. Dale L. Shaner, American Cyanamid Co., Princeton, ND 08540.

INTRODUCTION

In the last few years new classes of highly potent herbicides have been discovered and introduced into the weed control market. These are the imidazolinones (13), sulfonylureas (2), and triazolopyrimidine sulfonanilides (8). These herbicides represent a new generation of herbicides which are used at low rates, and have extremely low mammaliantoxicity. They control a broad spectrum of monocots and dicots and are registered or being developed for use in most of the major agronomic crops including cereals, rice, legumes, cotton, and maize (2, 8, 13).

Another unique property of these new classes of chemistry is that they kill plants by inhibiting the enzyme that catalyzes the first step in branched chain amino acid biosynthesis, acetolactate synthase (ALS; also known as acetohydroxyacid synthase) (5, 20, 22).

Attempts to select for resistance to these ALS inhibitors through various selection protocols have been successful in a wide range of species including maize (1), tobacco (6), *Arabidopsis* (9), canola (25), flax (11), *Datura innoxia* (17), carrot (27), cotton (23), and soybeans (19). Resistant populations of *Lactuca serriola*, *Kochia scoparia*, *Salsola iberica* and *Stellaria media* have also been selected in the field after continuous use of sulfonylureas (14).

All of these populations that are resistant to ALS inhibitors have been shown to contain an altered ALS. The primary objectives of this paper are to discuss the types of changes in ALS that have occurred in resistant plant populations, and to consider the phenomenon of cross resistance in plant populations to different ALS inhibitors.

MECHANISM OF RESISTANCE TO ALS INHIBITORS

There are at least four different classes of herbicides that are ALS inhibitors. These include imidazolinones (20), sulfonylureas (18), triazolopyrimidine sulfonanilides (22), and pyrimidyl-oxy-benzoates (23).

Many different labs have successfully selected for either imidazolinone, sulfonylurea, or triazolopyrimidine sulfonanilide resistant plants lines via various selection protocols. In all cases where the mechanism of resistance was determined, the resistant plant populations had an altered ALS that was no longer sensitive to the inhibitors (19, 11, 16, 23, 24, 26, 27, 28).

ALS inhibitor resistance is inherited as a single, semidominant trait in maize (16), tobacco (4), canola (25), *Arabidopsis*, (10), *Lactuca serriola* (14) and *Chlamydomonas reinhardtii* (28).

In vitro characterization of ALS from resistant plants has shown that the enzyme is generally expressed at the same level as in sensitive plants (4, 16, 23). Furthermore, the resistant enzyme in most cases is feedback regulated by the branched chain amino acids. These results indicate that these ALS inhibitors are not interacting with the enzyme at the site of feedback regulation of valine and leucine. Furthermore, the enzyme appears to function normally within the plant.

Lee et al. (12) have reported on the isolation and characterization of the ALS gene from two different sulfonylurea resistant tobacco lines. They were able to show that one of the lines, C3, had one mutation in position 196 of the enzyme from a Pro to a Gln which was responsible for the resistance. In a highly resistant line, S4-Hra, there were two mutations, one at position 196 with a Pro to Ala change and the other at position 574 with a Trp to Leu substitution.

CROSS RESISTANCE BETWEEN ALS INHIBITORS

The imidazolinones, triazolopyrimidine sulfonanalides, and sulfonylureas inhibited the same enzyme and there is data to suggest that they may bind to the same site on ALS (18, 21). Thus, it is logical to hypothesize that any change in binding of one of these chemicals to ALS will also affect the binding of the other. However, the data on the different ALS inhibitor resistant plant populations show that cross resistance is not predictable.

When selection for resistance to an ALS inhibitor in various species was done in the lab, all combinations of cross resistance were found. Newhouse *et al.* (16) reported that imidazolinone resistant maize lines showed not only differences in resistance between imidazolinones and sulfonylureas, but also differences among imidazolinones. Line XA17 was highly resistant to all imidazolinones and sulfonylureas tested, while line XI12 was only highly resistant to imazethapyr with lesser resistance to imazaquin and no resistance to sulfometuron methyl.

Winder and Spalding (28) reported that among *Chlamydomonas reinhardtii* mutants selected on imazaquin cross tolerance to chlorsulfuron was rare. But among chlorsulfuron-selected mutants low levels of cross tolerance to imazaquin were common. However, the ALS from these chlorsulfuron resistant lines was not highly resistant to imazaquin *in vitro*. They also found one line that was highly resistant to imazaquin and hypersensitive to chlorsulfuron.

Just the opposite case was reported by Saxena and King (17) in *Datura innoxia* where they selected for a sulfonylurea resistant line which was hypersensitive to imazaquin. Other *Datura* lines selected on either chlorsulfuron or sulfometuron methyl were either not cross resistant to imazaquin or imazapyr or showed intermediate resistance. One line, SMR1, was only moderately tolerant to chlorsulfuron, sulfometuron methyl and imazaquin, but was highly tolerant to imazapyr.

Thill *et al*. (26) reported that ALS from sulfonylurea resistant weed populations of *Lactuca serriola* and *Kochia scoparia* are also resistant to the imidazolinones. The degree of this cross resistance, however, varied with the plant population. DeCastro and Youmans (7) found that the cross resistance of 4 different chlorsulfuron-resistant populations of *Kochia scoparia* to use rates of 4 sulfonylureas and 3 imidazolinones was quite variable. One population was resistant to all sulfonylureas and to imazethapyr and imazaquin, while all of the populations were still controlled by a use rate of imazapyr. All of the populations were resistant to chlorsulfuron, which was the selective agent.

Subramanian et al (23) characterized the pattern of resistance to one tobacco and two cotton mutants to different ALS inhibitors. The tobacco mutant and one of the cotton mutants showed cross resistance to all the ALS inhibitors, while the other cotton mutant was not resistant to imazethapyr or the pyrimidyl-oxy-benzoate, but was highly resistant to triazolopyrmidine sulfonanilide and chlorsulfuron.

These results clearly show that one cannot *a priori* assume that a plant population that is resistant to one class of ALS inhibitors will also be resistant to another class of inhibitors. The reason for this lies in the type of mutation that occurs in the ALS gene. Bedbrook *et al*. (13) have identified at least 6 different mutation sites within the ALS gene that can confer resistance to ALS inhibitors. At least one of the mutations at position 197 of a Pro to Ser substitution results in an ALS that is resistant to chlorsulfuron and sulfometuron methyl but not to imazapyr. Presumably the other types of mutations selected in other species are the result of different substitutions. These results also show that although these inhibitors share some common binding sites on ALS, there also must be enough differences in their binding to allow this type of discrimination among mutated ALS enzymes.

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PROJECT 1: WEEDS OF RANGE AND FORESTS
Co-Chairpersons: John Brock and Diane White

Subject: Holistic Resource Management Model for Vegetation Management

John Brock gave overview of "Holistic Resource Management" patterned after Allan Savory's HRM model. Some progressive ranchers have made it work. Several have had severe wrecks trying to double the stocking rate. Most people now acknowledge that stocking rate cannot be substantially increased.

Celestine Lacy commented that there were very few examples of success of HRM in weed management. It hasn't worked on knapweeds or leafy spurge. Noxious weeds keep the site in a low seral stage. HRM can't break the hold these weeds have on the site. Grazing can impact plant species livestock will graze, but they will generally not graze noxious weeds.

Ted Nelson presented his experiences with "Forestry management by Consensus". Consensus building has not been completely successful. It is a better approach than legislation or initiatives that mandate management. It did bring opposing groups together. They were able to sit down in the field and try and resolve the issues. They were able to identify the real issues that were important to all interested groups. However, agreements made by the representatives of environmental groups were not ratified by their parent organizations, thus consensus could not be attained and a unified management plan could not be implemented.

John Brock related experiences of failure of other planning groups that had reached consensus on the ground only to have the parent environmental organizations refuse to go along with the agreed upon plans. He suggested that some of the more radical environmental groups had hidden agendas to eliminate productive uses of natural resources (forest products, grazing, and mining). The threatened and endangered species act is often being used as a club to drive off productive uses. Research has found that some animals are not threatened and there is no adverse influence of the productive uses. Users of resources must pursue legislation and the courts to counter the attack of the environmentalists.

Mike Ralphs asked if consensus building will ever be successful in light of the hidden agendas. Extreme groups will never come to consensus. The general public must be educated on these issues in order to attain a rational approach to management of resources.

1992 Officers of Project 1:

Chairperson:	Mike Ralphs USDA/ARS 1150 E. Ircon Logan, Utah 84321 (801)752-2942	Chairperson-elect:	Paul Figueroa Weyerhauser Co. 505 N. Pearl St. Centralia, WA 98531 (206)736-8241

PROJECT 2: WEEDS OF HORTICULTURAL CROPS
Chairperson: David Zamora

Subject: The EPA and Herbicide Registration

Dr. Karl Arne, a registration specialist from the Environmental Protection Agency (EPA) at Seattle, led a discussion on herbicide registration. The basic process and requirements for registration were explained. FIFRA was described as a risk/benefit statue that licenses the release of chemicals into the environment. FFDCA provided the authority for establishing tolerances.

The various registrations under FIFRA are a Section 3 (a full registration), a Section 18 (an exemption from the normal registration process), a Section 24(c) (a special local need), and a Section 2ee (a definition of use inconsistent with the label). Four types of Section 18's were mentioned. A specific exemption is allowed if a significant economic loss will occur without a product use; it requires good economic and/or environmental benefits data. A quarantine exemption is allowed to control introduced pests. A crisis exemption can be issued by a state, but the EPA must be promptly notified of the action. Exemptions are also allowed for pests that are a threat to public health. A Section 24(c) is issued for a product to meet a special local need; the product must have a tolerance (for food use); registration for the same use must not have been previously denied, disapproved, or canceled; and the product must be registered in accordance with FIFRA.

Requirements for registration include the submission of data on product chemistry, re-entry protection, product performance, residue chemistry, spray drift studies, the effect on non-target insects, environmental fate, plant protection, microbial factors, toxicology, biochemical characteristics, and on the effect on wildlife and aquatic organisms.

FIFRA was amended in 1988. The amended FIFRA included sections on disposal and storage, maintenance and re-registration fees, expedited registration, and re-registration requirements. The various phases of re-registration were discussed. EPA is no longer affected by indemnification under the new FIFRA.

The effects of private and public sectors on pesticide registration were also discussed. According to Dr. Arne, most groups don't have much direct effect on the EPA; however, they can have an indirect impact through Congress. An example of a significant effect that pro-active groups can have on product registration or the registrant is the Alar-apple scare scenario.

Re-registration is forcing the issue of minor pesticide uses. These uses are not economically attractive to registrants; this raises liability concerns; the registrants may support major but not minor uses of a chemical product; if a chemical product has no major uses, it may be lost for lack of registration. There are also possibilities for "crop grouping tolerances" for minor use registrations. Contacts for minor use issues are:

1. EPA - Hoyt Jamerson, Minor Use Officer (703)557-2310
2. IR4 - Dick Guest, National Director (201)932-9575
3. NACA
4. Northwest Food Processor's Association - Craig Smith (503)226-2848

Future changes for pesticide registration include regulations on worker protection standards, groundwater strategy, and endangered species protection. Legislation has been proposed for a Food Safety Plan and increased funding for IR4.

1992 Officers of Project 2:

Chairperson:	Bob Mullen UC Cooperative Extension 420 South Wilson Way Stockton, CA 95205 (209)468-2085	Chairperson-elect:	Jill Schroeder New Mexico State University Box 30003, Dept. 3BE Las Cruces, NM 88003-0003 (505)646-2328

PROJECT 3: WEEDS OF AGRONOMIC CROPS
Chairperson: Pat Fuerst

Subject: Management to Prevent the Development of Herbicide Resistant Weeds. Establishing a Herbicide Resistance Working Group in WSWS.

Project 3 meeting was conducted from 9:30 a.m. on Thursday, March 14, with approximately 100 professionals attending. Chris Boerboom was nominated as chairperson-elect for 1992.

Two subjects were presented during the meeting:
1. Management to Prevent the Development of herbicide resistant Weeds.
2. Establishing a Herbicide Resistance Working Group in the WSWS.

Donn Thill and Carol A. Mallory-Smith presented a talk entitled, "Anticipating and preventing the occurrence of sulfonylurea herbicide resistance". Professionals during the discussion had mixed views of how to prevent or manage weed resistance. Sulfonylurea resistance (kochia, and possibly Russian thistle) is becoming a major production problem in many grain producing areas of the northwest. Sulfonylurea herbicides inhibit the ALS enzyme in susceptible plants causing death. Kochia and possibly Russian thistle populations are increasing in their ability to produce resistant bio-types when a sulfonylurea herbicide has been used extensively year after year. These resistant bio-types can cause yield reductions and create harvest problems. Possible suggestions to this dilemma of sulfonylurea resistance were:

1. Management (Cultural or by Herbicides)
2. Plant Ecology (Initial frequencies, Inheritance)
3. Strategy based on ALS Resistance

Furthermore research is needed in ALS resistant plants to aid growers in grain production.

Lyle Friesen presented a talk entitled, "A Western Canadian Perspective". He indicated that green foxtail became resistant to repeated use of treflan in the southern provinces. Growers have replaced treflan with fenoxaprop and sethoxydim to rid fields of treflan resistant green foxtail. It was also noted that wild oats seem to be becoming resistant to the applications of triallate. Growers are combating resistant weeds by not allowing those areas to pollinate and set seed.

Steven R. Radosevich and Mary Lynn Roush presented a talk entitled "Managing for susceptibility". This talk stressed that possibly weed scientists need to manage threshold levels of weeds as opposed to achieving 100% control. It was noted that why use a herbicide if you do not have susceptible weeds. A herbicide resistance working group was tentatively selected in the WSWS.

1992 Officers of Project 3:

Chairperson:	Rick Arnold New Mexico State University Agricultural Science Center P. O. Box 1018 Farmington, NM 87499 (505)327-7757	Chairperson-elect:	Chris Boerboom Washington State University Dept. Agronomy and Soils Pullman, WA 99164-6420 (509)335-2961

PROJECT 4: EXTENSION, EDUCATION, AND REGULATORY
Chairperson: Bob Parker

Subject: Systemic Process of Resolving Conflicts.
How to Conduct Day to Day Research Activities.

Systematic Process of Resolving Conflicts. This portion of the discussion session differed from the more traditional discussion session normally organized at the Western Society of Weed Science meetings. It was more of a workshop. The workshop and introduction was led by Dr. Ray William, Oregon State University. To demonstrate the method of working with people, he divided the participants into three groups (Extension, Education, and Regulatory). Each participant was given a worksheet to determine how each of the participants learns and how that individual may relate to others with different learning styles. Each group was then given a real or hypothetical problem that is confronting them and were asked to get all their concerns out on the table, boil all the concerns down to one, and then develop action statements on how the problem could be solved. The purpose of showing the group how this type of approach might used would be by having diverse groups buy into a program and feel part of the solution instead of part of the problem.

How to Conduct Day to Day Research Activities within Legal Guidelines. The discussion was led by Mark Sybouts, BASF Corporation. Each state has different guidelines and regulations on how research is to be conducted that can be quite frustrating to those who conduct research in several states. Although research may be conducted by some across several states by those in the private industry, individuals conducting research from the public sector also picked up ideas on how they can do their research and meet the regulatory requirements. Several manufacturer's apparently have guidelines on how things are to be conducted within their organization and this information was shared with the group. Some of the concerns presented and ideas on how others have handled the situatio were: storage requirements, total amount of test herbicides sent by manufacturers, disposal of rinsate and left over non-labeled materials, transportation and shipping requirements of pesticide samples, spills, and so forth.

Other Items. A display area for extension publications, videos, and slide/tape series was available for the 1991 meeting but was not utilized to a great extent. Two papers were submitted for inclusion into the 1991 Research Progress Reports.

1992 Officers of Project 4:

Chairperson: Tom Whitson
University of Wyoming
P.O. Box 3354, Ag. Bldg.
Laramie, WY 82071
(307)766-3113

PROJECT 5: WEEDS OF AGUATIC, INDUSTRIAL, AND NONCROP AREAS
Chairperson: David Spencer

Subject: Biology and Control of Purple Loosestrife.

At the recent Western Society of Weed Science Annual Meeting, the discussion in Project 5 focused on purple loosestrife. Diane Dahlstad (206/586-5306) discussed purple loosestrife's general biology and invasiveness. She noted that the plant first appeared in Washington in 1933. It now occurs in 25 of 39 counties. It displaces native species, increases siltation, impedes water flow, and is not readily used by wildlife for food or habitat. Seeds may be viable for up to 10 years. So-called "sterile" varieties do not appear to be. Barbra Mullin (406/444-2944) reviewed available control options using herbicides. They are glyphosate, 2,4-D, and dicamba. Triclopyr and imazapyr are being evaluated experimentally. It would be helpful to use materials that are selective and can be applied aerially. She also discussed problems caused by label restrictions for use around water. Gary Piper (509/335-1947) discussed five species of insects which snow promise and biological control agents. The insects, 4 types of beetle and 1 species of fly, consume flowers, buds, and roots. Field tests should begin in the U.S. within a year. Chuck Perry (509/765-6236) discussed his experiences with alternative control methods, primarily, hand harvesting of flowers combined with wick applications of glyphosate, burning, and solarization. Solarization with several layers of black plastic appears to be promising. For more information, contact the speakers. Their telephone numbers are listed in parenthesis above.

Forty-eight people signed the attendance sheet. The room was full most of the time. There were several good periods of questions and answers involving both the presenters and members of the audience.

1992 Officers of Project 5:

Chairperson: Vanelle Carrithers
Agricultural Products Dept
28884 So. Marshall
Mulino, Oregon 97042
(503)829-4933

Chairperson-elect: Ron P. Crockett
17004 NE 37th Circle
Vancouver, WA 98682
(206)892-9884

PROJECT 6: BASIC SCIENCES: ECOLOGY, BIOLOGY, PHYSIOLOGY, GENETICS, AND CHEMISTRY
Chairperson: Charlotte Eberlein,

Subject: Weed Science and Molecular Biology: A Natural Partnership

The Project 6 meeting was conducted from 10:15 to 11:45 on Wednesday, March 13, with 50 people in attendance. Bill Dyer was nominated and unanimously confirmed as chairperson-elect for 1992.

The topic of the 1991 project was the use of molecular biology techniques in weed science studies. Bill Dyer, Dept. of Plant and Soil Science, Montana State University, Bozeman, led the discussion. Molecular biology techniques could prove useful in studies on herbicide mode of action, safener mode of action, herbicide resistance, weed biology, weed systematics, and biological weed control.

With currently available techniques it is possible to mix and match promoters and genes. Stimuli such as light, temperature, flowering, and stress could be used to trigger genes for herbicide resistance, insect resistance, disease resistance, stress tolerance, ripening, etc. For example, a gene that encodes a specific nitrilase that rapidly metabolizes bromoxynil has been incorporated into tomatoes. The gene was placed under control of the ribulose bisphosphate carboxylase small subunit promoter, which is a light-regulated tissue-specific promoter. The rational for using this promoter was that the primary target of bromoxynil is photosynthesis. Since bromoxynil is not translocated, detoxification in green tissue would give whole-plant resistance.

Molecular biology techniques could be used in mechanism of action studies. For example, subtractive hybridization could be used to study safener mechanism of action. In this procedure, mRNA from safener-treated and untreated plants is extracted and mRNA that is common to both is eliminated. The remaining mRNA is presumably unique to safener-treated plants and could be studied further.

Weed biology studies could also benefit from the use of molecular biology techniques. In the weed systematics area, information on the interrelatedness of populations, taxonomic classifications, and centers of origin could be gleaned from use of techniques such as restriction fragment length polymorphism (RFLP). In this technique, DNA extracted from accessions of a given species is digested with restriction enzymes, and then the DNA fragments are separated by electrophoresis. Fragment banding patterns (as detected by Southern blot hybridizations) among accessions are compared, and relationships among accessions can be determined. RFLP mapping of leafy spurge accessions is currently underway to determine if North American leafy spurge accessions represent a number of unique species with distinct genetic origins or if they are interspecific hybrids derived from European sources. A better understanding of the origins of North American leafy spurge accessions could lead to improved biological control efforts.

Biological control methods could be enhanced through molecular biology techniques. For example, spotted knapweed produces cnicin in root exudates. A cnicin-sensitive promoter could be linked to a growth gene for a fungus that would attack and control knapweed. By linking the promoter and the growth gene, the fungus would grow only in the presence of knapweed, and would not be a threat to other species.

Molecular biology techniques may be useful in studies on the mechanisms of weed seed and bud dormancy. In wild oats, for example, changes in embryonic protein and mRNA populations during imbibition of dormant and nondormant wild oat seeds are being monitored. Soluble embryonic proteins were isolated at several times from imbibed dormant and nondormant caryopses. Two-dimensional gels showed that by 6 hours, dormant embryos contained two distinct polypeptides not visible in extracts from nondormant embryos. Poly $(A)^{+}$ RNA was isolated from embryos and translated in vitro. Two-dimensional gels showed that dormant embryos contained low levels of a message encoding a 38 kD protein not detectable in nondormant embryos. Thus, gene products of differentially expressed genes may be responsible for the maintenance of seed dormancy.

1992 Officers of Project 6:

Chairperson: Tracy Sterling
Dept. of Entomol.,
Plant Path., and Weed Sci.
New Mexico State University
Box 30003, Dept. 3BE
Las Cruces, New Mexico 88003-0003
(505)646-6177

Chairperson-elect: Bill Dyer
Dept. Plant and Soil Science
Montana State University
Bozeman, Montana 59717
(406)994-5063

PROJECT 7: ALTERNATIVE METHODS OF WEED CONTROL
Chairperson: Barbra Mullin

Subject: <u>100 Years. of Biological Weed Control.</u>
<u>Use of Grazing Animals for Controlling Weeds.</u>
<u>Integrated Weed Management. How do we tie it all together?</u>

The project opened with a discussion by Chairman Barbra Mullin regarding the importance of this new project. It was noted that this forum will provide an excellent opportunity for members of WSWS to discuss information and coordinate planning on future needs on alternative methods of weed management. There were several topics of discussion.

The Classical Approach to Biological Control: 100 Years of Biological Weed Control - Dr. Phil Motooka, University of Hawaii.
Use of Grazing Animals for Controlling Weeds - Carl E. Bell, University of California.
Organic Weed Control in Corn - Phil Westra, Colorado State University.
Integrated Weed Management: How do we tie it all together? - Dr. P. C. Quimbey, Jr., USDA-ARS, Rangeland Weeds Lab, Bozeman, Montana.

After a presentation by each of the invited participants, the following topics were discussed as important considerations in the field of alternative methods of weed management. They can be used as potential discussion items at future meetings.

1. Biocontrol and concerns regarding endangered species.
2. Cost-benefit analysis of alternative control methods.
3. Use of microbials, especially fungal mycotoxins:
   - potential of persistence and reproduction
   - toxicity
   - annual applications
   - regulation of mycotoxins
4. Agronomic uses of biological control organisms
   - "Tank mix" of several to cover a weed spectrum
5. Use of vegetation to out compete noxious weeds.
6. Economics and long-term effects of grazing animals.
7. A systems approach to cropping, including weeds.
8. Do regulations of biologicals (insects, fungi, etc.) need to be excessive like we see for Ag chemicals?
   - what is a reasonable vs. an unreasonable approach
   - can WSWS help to develop policy for regulation?

1992 Officers of Project 7:

Chairperson: Bob Callihan
University of Idaho
Plant and Soil Sciences Dept.
Moscow, Idaho 83843
(208)885-6617

Chairperson-elect: Ed Schweitzer
Crops Research Lab
USDA-ARS
1701 Center Avenue
Ft. Collins, Colorado 80526
(303)482-7717

MINUTES OF THE BUSINESS MEETING
WESTERN SOCIETY OF WEED SCIENCE
STOUFFER MADISON HOTEL - SEATTLE, WASHINGTON
MARCH 14, 1991

The meeting was called to order by President Peter Fay at 7:40 a.m. Minutes of the 1990 business meeting were approved as published on pages 120-123 in the Proceedings of the 1990 annual meeting in Reno, Nevada.

Financial Report. Steve Wright reported that the financial records have been reviewed and found to be in good order. The Society is in excellent financial standing.

Wanda Graves summarized the Society's financial situation, reporting a previous balance of $58,228.11, income of $144,018.97, expenses of $120,625.03, earnings of $23,393.94, and a current balance of $81,622.05. Capital is distributed as $13,800.00 and $33,800.00 in certificates of deposit in Logan and Newark, respectively; $28,060.52 in money market savings; and $5,961.53 in checking. Most of the increase in earnings this year was the result of Weeds of the West book sales.

Wanda reported receiving 250 pre-registrations, with a total conference registration of 350. All members were encouraged to pre-register next year. There were 32 graduate students registered and 17 spouses. Members were encouraged to leave their plastic name-tag holders at the registration desk after the conference for use again next year.

Local Arrangements Committee. Jim McKinley reported that arrangements for the meeting went smoothly, and the hotel management and staff had been very cooperative and efficient. The pre-conference harbor tour on Monday was a success. However, due to events in the Middle East, the Boeing tour had to be canceled. Twelve meeting rooms were needed to accommodate the various Society functions, which included an awards luncheon, a business meeting breakfast, two graduate student breakfast meetings, a spouse breakfast, two coffee breaks, and two apple breaks.

Program Committee. Paul Ogg named members of the program committee and thanked them for their help in organizing a successful conference. The number of oral and poster presentations increased from 59 last year in Reno to 77 this year. The number of poster presentations was up from 18 to 24; graduate student contest papers increased from 6 to 15; and oral papers increased from 35 to 38.

Research Section. Frank Young reported that realignment of the 7 projects was successful, with very few complaints. He thanked the project chairpersons, reminded them to prepare minutes of their respective discussion sections, and asked them to make sure that chairpersons-elect were chosen for each project. Project chairs for 1992 will be:

Project 1 - Michael Ralphs
Project 2 - Bob Mullen
Project 3 - Rick Arnold
Project 4 - Tom Whitson
Project 5 - Vanelle Carrithers
Project 6 - Tracy Sterling
Project 7 - Robert Callihan.

Education and Regulatory Section. Robert Parker reported that only two papers were published in the newly created Project 4 (Extension, Education, and Regulatory) of the 1991 Research Progress Report, and encouraged greater participation in the future. Bob also reported that topics for tomorrow's Extension, Education, and Regulatory discussion section were selected as a result of a survey of persons attending the 1990 session. This year for the first time an area was designated in the Poster Session room to display Extension bulletins and other educational publications.

Poster Committee. Dave Zamora reported that 24 poster papers were submitted this year, with 23 actually displayed at the meeting. Two books were presented as part of the new Extension/Education/Regulatory publications display section.

Editorial Committee (Ad hoc) Rodney Lym reported that an index was included for the first time in the 1990 Proceedings. Last year was the first time authors were required to submit papers on computer disk. The change to disks has saved secretarial time and increased reproduction accuracy. Rod proposed modification in the procedure for submitting papers, suggesting that authors send 2 copies of each abstract directly to the program chairperson, rather than 1 to the chairperson and one to the editor. The program chairperson would then send the editor one copy of each abstract by December 10. This would save mailing costs and lessen confusion.

Member-At-Large. Steven Miller reported that his assignment during the past year was to investigate ways to 1) increase graduate student participation, and 2) obtain nominations from the private sector for the WSWS Outstanding Weed Scientist Award. Suggestions were solicited in a survey of selected members. This year participation in the graduate student paper contest more than doubled, and four nominations were received for Outstanding Weed Scientist from industry.

Nominations Committee. George Beck reported that 150 ballots were cast by the deadline in this year's election. Several additional ballots arrived late and could not be included. All members were encouraged to vote next year and to return ballots before the February 1 deadline.

George announced that President-elect for the coming year will be Steve Miller. Jack Schlesselman was elected secretary; Charlotte Eberlein will be Chair-elect of the Research Section; and Don Morishita will be Chair-elect of the Extension, Education, and Regulatory Section. George thanked members of the committee for their service and announced that LaMar Anderson will chair the Nominations Committee next year.

Fellows & Honorary Members Committee, Harvey Triple reported that two nominations for WSWS Fellow were submitted to the Executive Committee and both were approved. Larry Mitich and Ed Schweizer were honored as new WSWS Fellows at the awards luncheon yesterday. Harvey reported that his committee submitted one nomination for Honorary Member, and expressed disappointment that their nomination was rejected by the Executive Committee. Harvey named members of this year's committee and thanked them for their effort. Donn Thill will serve as chairperson for the coming year.

Student Paper Judging Committee. Kurt Volker thanked members of the committee for their work and congratulated all participating students for the excellent quality of papers. Winners of the Student Paper Contest were announced:

1st Place ($150) - Mostapha A. Haidar, Colorado State University
2nd Place ($100) - Rose Wallander, Montana State University
3rd Place ($ 75) - M. Ying, Montana State University
4th Place ($ 50) - Pedro J. Christoffoleti, Colorado State University
5th Place ($ 25) - Keith D. Miller, Washington State University
5th Place ($ 25) - Claudio Dunan, Colorado State University

Winners were asked to remain after the business meeting for photographs. Award plaques will be mailed to each winner.

Resolutions Committee. Shafeek Ali presented one resolution which was passed by the membership:
WHEREAS, the local arrangements for the 1991 annual meeting of the Western Society of Weed Science were of satisfactory quality and well organized; and
WHEREAS, the organization and content of the Program have been of good quality; and
WHEREAS, meeting and sleeping accommodations were excellent; and
WHEREAS, personnel and services provided were outstanding.
THEREFORE, BE IT RESOLVED that the Western Society of Weed Science expresses its appreciation to the members of the 1991 Local Arrangements Committee, to the members of the 1991 WSWS Program Committee and to the management and staff of the Stouffer Madison Hotel.

Site Selection Committee. Steven Kimball announced that the 1995 WSWS annual meeting will be held in Sacramento at the Red Lion Inn. Steve reminded the membership that the annual meeting will be in Salt Lake City in 1992, Tucson in 1993, and Cour D'Alene in 1994.

Awards Committee. Stott Howard reported that the awards committee received four nominations for Outstanding Weed Scientist from the private sector, and Harvey Triple was selected. The committee received two nominations for Outstanding Weed Scientist from the public sector, and Steven Miller was selected. Stott thanked the committee members for their efforts, and announced that Alex Ogg will chair the committee next year. WSWS members were asked to submit more nominations next year.

CAST Representative. Gary Lee reported that the CAST Board of Directors met in Washington D.C. on February 25-27, 1991. Lowell Jordan was installed as President and Gale Buchanan as President-elect. Stan Wilson was hired as Executive Vice-president. Twenty-nine societies are now represented in CAST. All WSWS members are encouraged to become members. CAST has an operating budget of approximately $500,000. Fifteen project reports are currently underway. More reports are planned, including a report for the USDA on global warming.

Placement Committee. Steve Orloff reported that a placement service was provided. Listings of 'positions wanted' and 'positions available' from the national WSWS meeting were available, but few additional forms were filled out by WSWS members. It was believed that this might be due to the sluggish economy, and the fact that the placement services room was located on the 4th floor -- a considerable distance from the meeting rooms.

The placement committee met and received suggestions on ways the service might be improved in the future. Committee chair for next year will be Mike King.

Legislative Committee. George Beck reported that Public Lands bill 93-629, section 15, (The Management of Undesirable Plants on Federal Lands) was passed into law. This is the law that INWAC (Intermountain Noxious Weed Ad-hoc Committee) had been working on for the past 3 1/2 years. The law was passed as an amendment to the Federal Noxious Weed Act and attached to the Farm bill. The law requires all federal agencies to manage weeds on federal lands, in cooperation with states. Barbra Mullin chairs a new committee called the Western Weed Coordination Committee (WWCC), formed to encourage implementation of the law in western states. INWAC will remain intact, but its name has been changed to the Inter-regional Noxious Weed Advisory Council. Its primary function will be to promote favorable weed legislative actions and policies.

Necrology Committee. Larry Mitich reported that 25 state and industry members of WSWS were contacted for names of present or past WSWS members that had died since the 1990 Reno meeting. Two names were submitted.

Marcus E. Cravens passed away August 3. He was President of the California Weed Conference in 1954, and Deputy Agricultural Commissioner of Santa Barbara county from 1939 until his retirement in 1972. Marcus was an active member of WSWS and WSSA for many years.

Conrad Schilling passed away in California. He was President of the California Weed Conference in 1980.

The membership observed a moment of silence in memory of these two men.

Publication Committee (Ad hoc). Tom Whitson reported that Weeds of the West has been published. Tom thanked members of the committee for their effort, announcing that the book required approximately 1.5 man-years to complete. No charges were made to the Society for the time, film, or travel required by individual committee members. There are no personal profits being made by any of the committee members. Cost to the Society is $9.00 per book. Potential income to the Society is at least $1.50 per book for pre-publication sales and at least $4.00 per book for post-publication sales. Current net profit to the Society is $22,243, with total profits for the first printing expected to exceed $30,000. The committee recommended that all profits from publication be set aside to partially offset the cost of reprinting. Color posters are available for promotional purposes. Photos used in the publication are part of the book copyright. Use of these photographs will be considered by the committee if written proposals are submitted.

1990 & 1991 Legislative Trip. Paul Ogg reported that he and Pete Fay participated in the 1990 WSSA legislative trip to Washington D.C. in May. Five position papers were presented to legislators on topics of sustainable agriculture, water quality, food safety, changes in the federal noxious weed act, and support of IR-4 projects. These position statements are printed in Weed Technology, Vol. 4, October-December, 1990. The group met with individuals from USDA, EPA, the Wildlife Federation, Environmental Defense Fund, and Natural Resources Defense Fund. Paul noted that weed science is represented by a half-time Congressional Science Fellow in Washington D.C., compared to over 30 lobbyists representing environmental groups. The 1991 WSSA legislative trip has been postponed until September.

Past President's Report. Sheldon Blank reported that through the efforts of Wanda Graves and Ken Dunster the WSWS is incorporated with official Articles of Incorporation and Tax Exempt Status in the state of California. Stamped Articles of Incorporation were obtained July 5, 1990.

Sustaining Membership Committee (Ad hoc). Donn Thill reported that a proposal to allow WSWS sustaining membership was recently voted on by the WSWS membership. The proposal passed by a majority of 82%, with 157 voting for and 34 voting against sustaining memberships. A ballot will be included in the Summer Newsletter for members to vote on proposed changes in the Constitution and By-Laws which would make the Sustaining Membership Committee a standing committee. A copy of the proposed committee operating guide will also be included in the newsletter.

Currently, the WSWS has 14 sustaining members. These are R&D Sprayers, Agrolinz Inc., Western Farm Service, Kincaid Equipment, American Cyanamid, Sandoz Crop Protection, Hoechst-Roussel, Rhom & Haas Co., Ciby-Geigy, DuPont, BASF, Rhone-Poulenc, Wilbur Ellis, and Mobay Corp.

WSSA Representative. The WSSA met in Louisville, Kentucky, February 4-7, 1991. New officers elected in the 1991 balloting were Harold Coble, Vice-President; Michael Chandler, Treasurer; and Richard Oliver, Member-at-large (Southern region). WSSA will partially support two Congressional Science Fellows, beginning in September 1991. Interested individuals should apply. Weed Science and Weed Technology journals will be published quarterly. A witchweed monograph is almost ready for publication, a wheat monograph is being printed, and the 5th volume of Reviews of Weed Science is nearly ready for publication.

Committee Appointments. Terms of numerous individuals serving committees will expire at the end of this meeting, and positions will need to be filled. Members wishing to serve on WSWS committees should contact Paul Ogg.

Other Business. Paul Ogg, the new WSWS President, presented a plaque and gavel to Peter Fay, expressing appreciation on behalf of the Society for his dedicated service as 1990/91 President.

There being no further business, the meeting was adjourned at 8:35 a.m. by President Paul Ogg.

Respectfully submitted,

Steven Dewey
Secretary, WSWS

WESTERN SOCIETY OF WEED SCIENCE FINANCIAL STATEMENT

March 1, 1990 through February 28, 1991

Income

Weeds of the West Book	$108,545.00	
Registration Fees(1990 Conference)	5,180.00	
Registration Fees (1991 Conference)	10,660.00	
Spouse Registration(1990 Conference)	100.00	
Spouse Registration (1991 Conference)	390.00	
Tours	934.00	
Membership Dues	715.00	
1990 Research Progress Reports	2,701.11	
1990 Proceedings	2,662.00	
1991 Proceedings	2,229.00	
1991 Research Progress Reports	1,970.00	
Past Research Progress Reports	76.00	
Past Proceedings	84.50	
Interest on Bank Accounts	5,822.36	
Sustaining Memberships	1,950.00	
NET INCOME YTD		$144,018.97

Expenses

1990 Meeting		
Audio Visual Rental	$ 673.94	
Easel Rental & Poster Board	376.40	
Spouse Breakfast	215.98	
Luncheon	3,617.11	
Guest Speakers	717.72	
Grad Student Room Subsidy	360.00	
Grad Student Paper Awards	175.00	
Registration Desk Clerical Help	56.25	
Plaques	61.76	
Miscellaneous	39.23	
Printing		
1990 Research Progress Reports	4,375.00	
1990 Proceedings	3,952.16	
Newsletters, Stationary	1,469.94	
1991 Programs	548.27	
Office Supplies	347.75	
Phone	131.68	
Postage & Box Rental	802.10	
Annual Bulk Mailing Permit Fee	60.00	
Refund of Reg Fees	467.50	
Business Mgr/Treasurer	2,720.00	
Articles of Incorporation Filing Fee	30.00	
Tax Exemption Filing Fee	25.00	
Annual State Non Profit Filing Fee	5.00	
Typist - 1990 Proceedings	499.50	
1991 Conference Planning Meetings	390.39	
Weeds of The West Book	97,260.00	
CAST	580.00	
1991 Meeting		
Refund Boeing Tour Fees	444.00	
Plaques	112.35	
Poster Session Supplies	111.00	
EXPENSES YTD		$120,625.03

CAPITAL

1989-90 Balance Forward	$ 58,228.11	
Current Earnings	23,393.94	
		$ 81,622.05

DISTRIBUTION OF CAPITAL

Certificates of Deposit-Newark	$ 33,800.00	
Certificates of Deposit-Logan	13,800.00	
Money Market Savings	28,060.52	
Checking Account Balance	5,961.53	
		$ 81,622.05

1991 FELLOW AWARD
WESTERN SOCIETY OF WEED SCIENCE

Larry W. Mitich

Dr. Larry Mitich is an Extension Weed Scientist at the University of California, Davis, with responsibility for weed control in dry beans, wheat, corn and alfalfa. Larry was raised on a farm and ranch in Wyoming, and received his M.S. and Ph.D. degrees at the University of Wyoming. He served over 4 years as Assistant Professor of Agronomy at the University of Kabul in Afghanistan in the 1950's. He joined the Cooperative Extension Service at North Dakota State University at Fargo as Extension Agronomist in 1963 and served in that capacity for over 17 years. In 1980, he moved to Davis, California and accepted his current position as Extension Weed Scientist. In his professional career, Dr. Mitich has published over 200 popular, extension, semi-technical, and technical articles on weeds and their control.

Dr. Mitich is active in the Western Society of Weed Science. Larry was President-elect and Program Chairman in 1987 and served as President in 1988. Also, he has served on several committees, made a number of presentations at annual meetings, and published over 70 reports of research in the Research Progress Report.

While at North Dakota State University, Larry was active in the North Central Weed Science Society and served on numerous committees, the board of Directors, and as editor of the Research Report and the Proceedings. For his service he received the NCWCC Distinguished Service Award in 1978 and was made an Honorary Member of the NCWCC in 1981.

In 1981, Larry was elected Vice-president of the Weed Science Society of America, progressing to President-elect and Program Chairman in 1989, and served WSSA as its President in 1990. In 1978, he received the WSSA Outstanding Extension Worker Award and in 1983 was elected Fellow of WSSA. He was editor of the WSSA Newsletter for 3 years and Weeds Today for 3 years. As present he is an associate Editor of Weed Technology and contributes regularly to the feature "The Intriguing World of Weeds."

1991 FELLOW AWARD
WESTERN SOCIETY OF WEED SCIENCE

Edward E. Schweizer

Dr. Edward E. Schweizer is a Plant Physiologist with the USDA/ARS Crops Research laboratory, Ft. Collins, CO. He received his B.S. and M.S. in Agronomy at the University of Illinois and a Ph.D. in Plant Physiology from Purdue University. He has spent the last 28 years with ARS conducting weed research on cotton, soybean, and sugarbeet. His most recent efforts have centered upon IPM, weed and crop modeling, and pilot testing. DR. Schweizer has authored or coauthored over 130 scientific publications.

Dr. Schweizer's research on crop production has had a significant impact on agriculture in U.S., particularly on sugarbeet production and irrigated cropping systems. His original ideas, generated from his sustained involvement in research for 28 years, continue to influence agriculture in the semi-arid West and Mid-west. These efforts have been instrumental in increasing yields of several crops, in minimizing herbicide use, and in providing direction in research related to groundwater quality in the corn belt.

Dr. Schweizer has made a number of significant discoveries that have been widely adapted in crop production. His economic weed threshold equations for sugarbeet culture revealed that low densities of broadleaf weeds reduce root yields 5 to 30%. He developed the first simulation bioeconomic weed/sugarbeet model which identified alternative weed management strategies that are more cost effective than traditional practices; reduced the reliance on broad-spectrum herbicide usage, hence, minimized the potential pollution of the atmosphere and groundwater; and provided growers with flexible weed management strategies that increase their crop production efficiency.

Dr. Schweizer's research leadership and expertise in his field have been recognized by ARS administrators, as evidenced by special ARS funding of over $280,000 between 1975-1980, $1.5 million between 1980-1984, and $180,000 between 1988-1992 for cooperative research projects that he conceived and proposed on IPM and weed management expert systems. He served/serves as Lead Scientist and Project Coordinator on these special projects.

Ed Schweizer received the American Society of SugarBeet Technologists Meritorious Service Award, the USDA Certificate of Merit Award, and was elected Fellow, WSSA in 1985. He was given the Outstanding Article in Weed Science Award in 1985. He has served the WSWS in numerous capacities over the past 24 years.

1991 OUTSTANDING WEED SCIENTIST AWARD
PUBLIC SECTOR

STEPHEN D. MILLER

Stephen Miller is currently a professor of Weed Science at the University of Wyoming where he holds a research/teaching appointment in the Department of Plant, Soil and Insect Sciences. His educational background includes an undergraduate degree from Colorado State University and an M.S. and Ph.D. from North Dakota State University. Upon receiving his Ph.D. in 1973, Stephen began a career in agronomy at North Dakota State University where his responsibilities were research and teaching. In 1984 he moved to his current position at the University of Wyoming.

Stephen has done an excellent job of conducting research in Weed Science for over 19 years. During that period, he has written 30 refereed journal articles, over 630 research progress reports, and presented over 158 scientific papers at Weed Science meetings. Emphasis areas of research have included annual and perennial weed control in agronomic crops, weed control in reduced tillage systems, and biology and control of wild oats.

Stephen has served as major advisor for 45 undergraduate, 13 masters and five doctoral students. He has served on six committees with the Weed Science Society of America. In the North Central Weed Control Conference he: served as editorial assistant for the research report from 1976 to 1983; was on the board of directors; was a member of the publications committee; and served as chairman of the cereal and oilseeds committee.

In the Western Society of Weed Science, Stephen has served with distinction. He has been chairman of the research and the agronomic crops sections. He has been on the student paper and WSWS Executive committees. Currently Stephen is serving the WSWS as Member-at-Large.

Stephen is well respected by University of Wyoming faculty, the agricultural community in Wyoming, and his colleagues in the WSWS and WSSA. He is always busy and constantly thinking of new or innovative projects in Weed Science.

1991 OUTSTANDING WEED SCIENTIST AWARD
PRIVATE SECTOR

HARVEY TRIPPLE

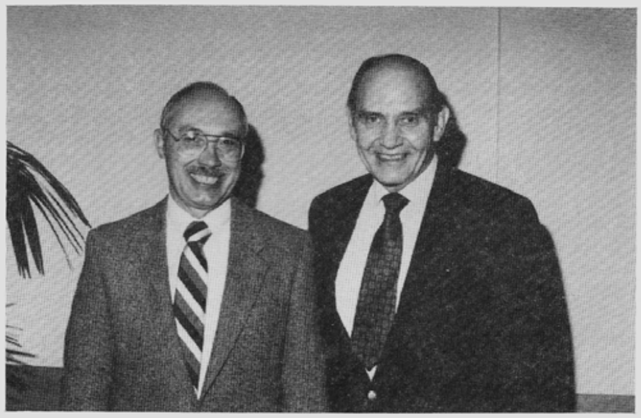
Harvey Tripple is a native of Nebraska where he received his undergraduate and graduate degrees at the University of Nebraska. He began his involvement with Weed Science while working in sugarcane production in Hawaii, where, as Harvey likes to put it, "he raised cane 24 hours a day".

Harvey has been with Monsanto since 1968, starting his career in St. Louis, before moving to Ohio, where as a field representative he was involved with the development of Lasso. He was also involved with the early development of Roundup. In 1975 Harvey moved to St. Louis and served as Regional Product Development

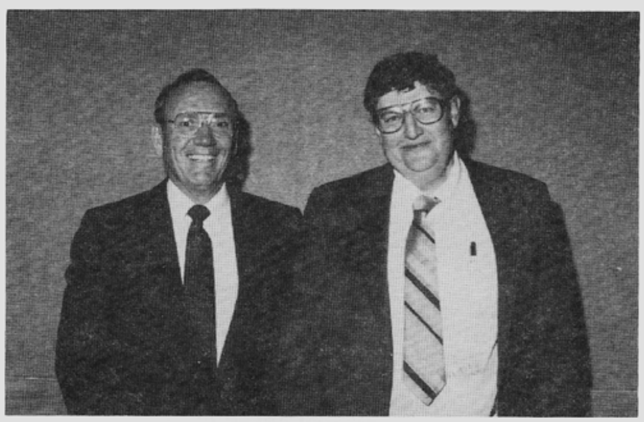
Manager for the west and southwest and eventually as International Product Development Manager. In 1978 Harvey moved to Denver to become Regional Product Development Manager for the western United States. He served in this capacity until his recent retirement after 22 years with Monsanto.

Harvey has made major contributions to the WSWS. He served as chairman of the Finance Committee, chairman of the Site Selection Committee, chairman of the Local Arrangements Committee, and Chairman of the Research Section. He served as President-Elect and Program Chairman, President, and Past-President. Harvey has also shown a more-than-average interest in graduate student training. He generally knows all of the Weed Science graduate students in his area and keeps track of their progress.

Harvey Tripple has had a distinguished career in Weed Science and has been a major contributor to the activities of the WSWS.



1991 WESTERN SOCIETY OF WEED SCIENCE FELLOWS (L to R): Edward E. Schweizer and Larry Mitich.



1991 WESTERN SOCIETY OF WEED SCIENCE OUTSTANDING WEED SCIENTISTS (L to R): Harvey Tripple (Private sector) and Steve Miller (Public sector).

WHAT HAS THE WSWS MEANT TO ME

RICHARD D. COMES

Thank you for inviting me to visit with you today about some of my feelings and experiences in the society.

As I get older, it seems to me that the history of an organization and the people involved in making that history, plays a larger and larger role in shaping my assessment of the organization. As I look back, I can see that my respect for, and loyalty to, certain individuals in WSWS contributed deeply to my interest, involvement and dedication to the society. I am not going to mention the names of these individuals for fear that I may forget someone. Besides, I am sure my list would be somewaht different than yours. The important thing is that I am certain all of us can recall someone in WSWS who made a significant impact on our lives and professional development.

Let me regress for a moment and recall a bit of the history of WSWS (formerly the Western Weed Control Conference). Back in the early to mid 1930s several perennial weeds were becoming an increasingly severe and spreading problem. Incidentally, most of these weeds are considered noxious and very difficult to control even today, 55 to 60 yr later. State officials charged with preventing the spread of these weeds into agricultural lands of their states were very concerned about the uncontrolled growth and reproduction on all lands, but especially on federal lands where little or nothing was being done to control them. During a meeting of the Plant Quarantine Board in Boise, Idaho in 1936, members of that board discussed the need for getting people together that had a broad range of interests in and responsibilities for, controlling weeds. It was at this meeting in Boise that the Western Weed Control Conference was conceived. Two yr later, (1938) the first meeting of our society was held in Denver, Colorado. This was the first weed control conference ever held in the United States and predated other regional weed conferences by 6 to 10 yr and the WSA (now WSSA) by 18 yr. The foresight, enthusiasm, and actions of the people who formed and got this organization off the ground should be an inspiration and challenge to all of us.

I personally did not know many of the founders of our society but several of those who became active in the mid-to-late 1940s later became my professors, co-workers and friends. It is these and later developed personal and professional relationships that have meant the most to me. I feel a bond with members of this society that is not common to other professional groups to which I belong. That is the principal reason that I came to this meeting and what will draw me to several of our future meetings.

I believe one reason for this bonding and commaraderia is the open, friendly, cooperative nature of our membership. This is not to say that we do not occasionally have some disagreements within our ranks concerning certain matters. However, in my 32 year membership, I do not recall a single instance where such disagreement led to any significant or permanent division within the society. This I believe, attests to the cooperative and positive nature of our members.

In my opinion another reason for the cohesiveness of our membership is the size and makeup of our society. We have a relatively small and stable membership compared to some of the other regional weed science societies and WSSA. This affords members repetitive contacts with nearly everyone if they actively participate in all of the events sponsored by the society plus the usual night life associated with these meetings. One event sponsored by the society in recent yr that increases our contact with one another and with the spouses that attend these meetings is the pre-conference tour or tours. These tours have meant much to me because I have gotten to know many of you and your spouses much better than I would have through our formal meetings and workshops.

The Society not only provides a wide array of opportunities to develop personal and professional relationships with one another, it also provides an excellent forum for each of us to discuss our work in a formal as well as an informal manner. Over the yr there have been many changes in the way that our annual meetings are conducted and it seems to me they just keep getting better and better. Many of you remember the days when all members of the conference (society) would meet every other yr and then just those conducting research would meet in alternate yr in what was known as the Research Committee Meeting. I believe the last meeting of this type was in Reno, Nevada, in 1966. I'll never forget my first meeting with this group in Salt Lake City in 1961. I had begun working for ARS the year before and had never presented a paper at any meeting in my whole life. In those yr graduate students, at least from Wyoming, never went anywhere except to research plots scattered throughout the state. When I presented my paper, I know my knees must have been knocking so hard everyone in the front rows could tell that I was scared to death. Later in the session, a young man from Oregon presented a paper having something to do with weed control in winter wheat. As he went to the podium, I thought to myself - I didn't know high school students got to come to these meetings and give papers. We didn't even get to come as graduate students. The young man looked all of 16 but he gave an excellent report and was very composed. I'll give you three guesses as to whom I'm referring to and the first two don't count. His initials are A. P. A. Little did I know at that time that within 4 yr this young man would be a very important member of my Ph.D. graduate committee.

Graduate students are now an integral part of the society and are major participants in these annual meetings. They are presenting nearly 30% of the papers delivered orally at this meeting. I am grateful that the society has organized a forum for these students to compete and for us to recognize them at our business meeting. These are the leaders of Weed Science in the future and are the ones who will be responsible for maintaining a dynamic society that is relevant to the needs of society in general and to our members in particular.

Active participation in the society for more than 30 yr has been extremely rewarding to me. I would like to take this opportunity to thank all of you who have given of your time and talent to serve and lead the society during this time. I encourage all of you younger members or any others who have not been actively involved to get your feet wet and volunteer to serve on committees or task groups. You will be rewarded for your service by an increased appreciation for, and pride in, the society. In turn, the Society will become even stronger because of the increased participation of its members in directing and operating its business. Every one becomes a winner.

Thank you again for inviting me to share some of my feelings and thoughts with you today.

1991-92 WESTERN SOCIETY OF WEED SCIENCE OFFICERS AND EXECUTIVE COMMITTEE. Seated (L to R): Peter K. Fay, Immediate Past President; Wanda Graves, Treasurer-Business Manager; Paul J. Ogg, President; Steve Miller, President-elect; John O. Evans, WSSA Representative. Standing (L to R): Don Colbert, Member-At-Large; Thomas Whitson, Chairman, Education and Regulatory; Gary Lee, CAST Representative; Edward E. Schweizer, Chairman, Research Section; Jack Schlesselman, Secretary.

WSWS NECROLOGY COMMITTEE REPORT
11 MARCH 1991

Twenty five state and industry members of WSWS were contacted requesting names of present or past WSWS members who have died since the Reno meeting in 1990.

Marcus E. Cravens passed away August 3, 1990 in California. Marcus was born August 6, 1912 and spent his entire career working with California growers. He was president of the California Weed Conference in 1954 and Deputy Agricultural Commissioner of Santa Barbara County from 1939 until his retirement in 1972. Marcus was an active member of WSWS for many years and a member of WSSA until his death.

Conrad Schilling also passed away in California. Conrad was the 1980 president of the California Weed Conference, but we have no record of him bing a member of WSWS.

Respectfully submitted in behalf of the WSWS Necrology Committee
J. LaMar Anderson, Chr.

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E. I. du Pont de Nemours Co.

Hoechst–Roussel Agri–Vet Co.

Kincaid Equipment Co.

Mobay Co.

R & D Sprayers

Rhone–Poulenc Agriculture Co.

Rohm and Haas Co.

Sandoz Crop Protection Co.

Western Farm Service

Wilbur–Ellis Co.