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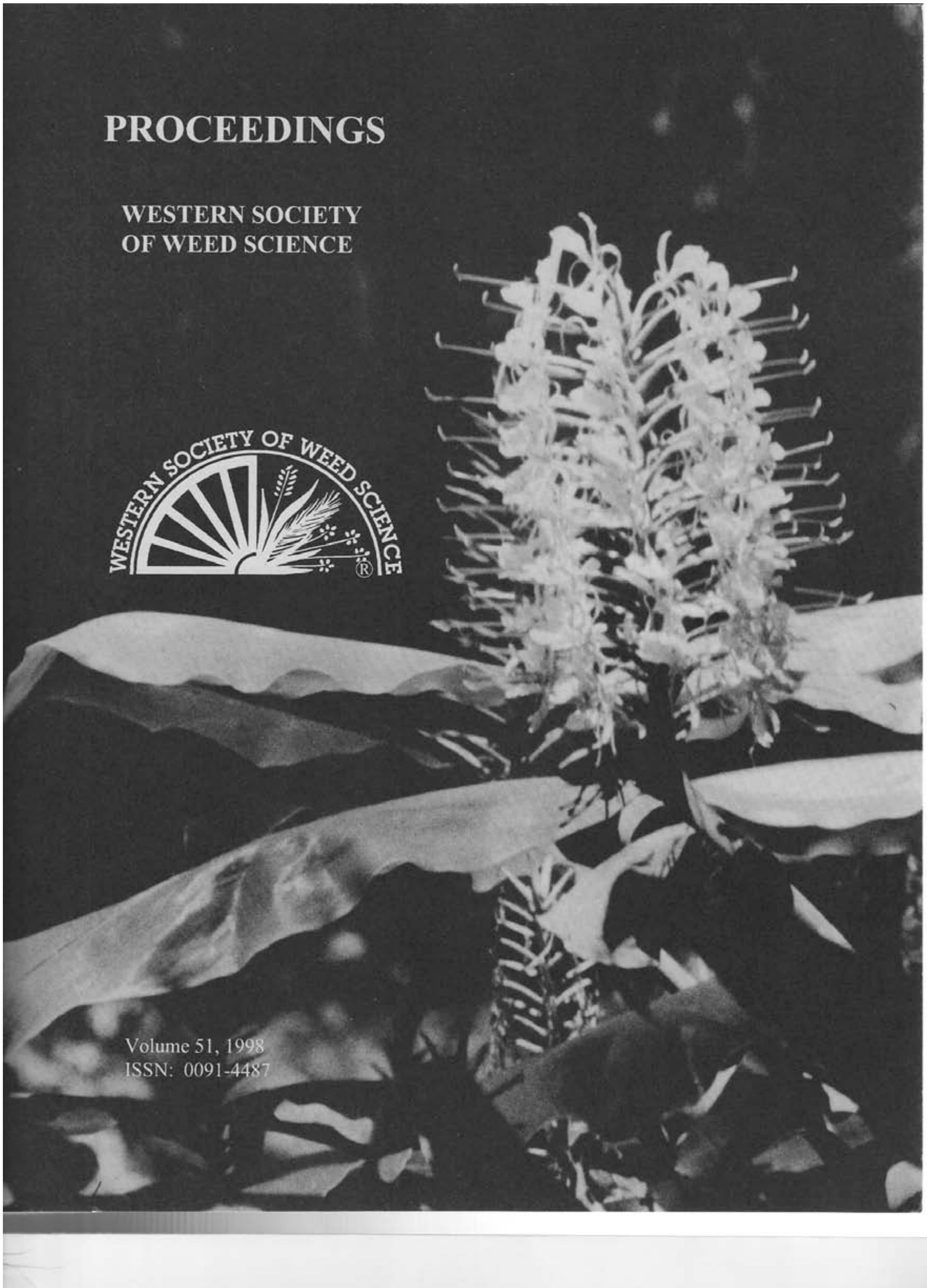
WESTERN SOCIETY OF WEED SCIENCE



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WESTERN SOCIETY OF WEED SCIENCE

1998 - 1999

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1998

PROCEEDINGS

OF

THE WESTERN SOCIETY OF WEED SCIENCE

VOLUME 51

PAPERS PRESENTED AT THE ANNUAL MEETING

MARCH 10 TO 12, 1998

THE ROYAL WAIKOLOAN

WAIKOLOA, HAWAII

PREFACE

The Proceedings contain the written summary of the papers presented at the 1998 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 botanical 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.

Cover: Kahili ginger (*Hedychium gardnerianum* Ker-Gawl). Cover photograph by Phil Motooka, University of Hawaii. All other photographs are courtesy of Jack Schlesselman.

Proceedings Editor: Kathy Christianson

TABLE OF CONTENTS

GENERAL SESSION

POSTER SESSION

RESEARCH SECTION IV (Teaching and Technology Transfer)

RESEARCH SECTION V (Wetland and Wildlands)

RESEARCH SECTION VI (Basic Sciences)

GENERAL SESSION

PRESIDENTIAL ADDRESS

Barbra Mullin, Weed Specialist
Montana Department of Agriculture
Helena, Montana

Last September Rod Lym reminded me I would need to get him the title of my presidential address by the first part of December. Well, I give a lot of talks during the course of a year, I don't write any of them six months in advance and I rarely come up with a title three months early. But, Rod was wise in starting me thinking about comments to make to the membership of the Western Society of Weed Science. I started by wondering what really is a Presidential Address.

The first thing I thought of was that this President's address is 920 North Benton. Any of you who have mailed me things may be surprised to see that I have my Society mail come to my house. That's because of what my other address is - 109 Agriculture Livestock Building, Capitol Station. I think sometimes that I spend more time here than I do at 920 North Benton. But more than that, I spend even more time in the field and at meetings, working with ag producers and weed managers in the state of Montana.

Which leads me to the point I'm trying to make - I have a little bit different background and job responsibilities from many of the past WSWS presidents. I don't get heavily involved in basic or applied research on weeds and weed management. My job is to use the research results from many of you in this room.

I work with farmers and ranchers in the field and turn to the *WSWS Proceedings* regularly to see what recent work has been done on crops and weeds that I'm not familiar with. I look to the *WSWS Research Progress Reports* when the Montana Department of Agriculture get requests for special herbicide registrations - emergency exemption (Section 18) or special local need (24c). I look at past discussions from meetings and find great information when I need to update Montana pesticide training applicator manuals. I can call on colleagues from WSWS when I'm organizing pesticide applicator training and need a real expert on a subject as a speaker. And *Weeds of West* makes a great prize for weed id contests at tours and training that I'm involved in.

The smartest thing I've ever done was convince the Montana Department of Agriculture administration that I needed to go to the WSWS meeting in Denver in 1982. The smartest thing the Department has done is let me continue to attend and be active in WSWS.

To those of you who are just coming to WSWS for the first time - first, good timing, Hawaii as a first meeting is a great idea. But more importantly, take the time to talk to people, introduce yourself to those around you, attend papers and discussions of interest and get to know others with similar interests. To those of you who have been coming to WSWS for lots of years, pick a new discussion group to participate in. Introduce yourself to someone you don't know. Keep active!! All of you can help make this Society grow and use it to help you grow. My membership in the Western Society of Weed Science has been my most valuable professional activity.

In the early 90's, when we needed someone to sponsor the Western Noxious Weed Management Short Course, the Executive Board of WSWS gave it serious consideration and has fully supported this effort. Wanda Graves provides valuable help in tracking the financial end and Society members provide much of the staff for the training. This extremely popular course offers training to federal land managers who have the responsibility of weed control on lands under their jurisdiction. Often they have no specific training in weeds and weed management and this course helps them with the practical aspects of their jobs.

When a group of us had funding to put together a book on biological control of weeds, we came once again to the Society and the Publications Committee. We received valuable advice on how to proceed with the book, we used many Society members as a review team to help put a "weedy" twist on a book mostly devoted to bugs, and we got support to publish the book through the Society. WSWS support for this project resulted in the publication of *Biological Control of Weeds in the West.* It also provided an excellent opportunity for cooperation and collaboration between many states, federal agencies, and this Society. We printed 3000 copies of the book in April of 1995 and we are currently working on an update and reprint of the book. It's been a big hit, but I don't think we'll ever rival the WSWS best seller - *Weeds of the West.*

Since 1982, I've gained great experience participating in and leading project discussions. I've enjoyed all of the committees I've served on, with the possible exception of the Necrology Committee. I've enjoyed running for office, even when I didn't win and even the time Sheldon beat me by the toss of a coin. I've enjoyed serving as an officer of this Society and I've especially appreciated the opportunity to serve as President, in spite of the mammoth increase in my e-mail since last March.

To those of you willing to serve the Society as discussion leaders, committee members, editors, organizers, and nominees for office, even when you lose, thanks from the entire membership for making this Society functional. At this time I would like to introduce the full Executive Board of the Western Society of Weed Science: Rod Lym, President-Elect; Neal Hageman, Secretary; Wanda Graves, Treasurer-Business Manager; Don Morishita, Research Section Chair and Carol Mallory-Smith, Chair-Elect; Rick Arnold, Education and Regulatory Section Chair and Dan Ball, Chair-Elect; Paul Ogg, Immediate Past WSSA Representative and Donn Thill, who has accepted the challenge to fill his shoes; Jack Evans, Immediate Past CAST Representative and Steve Miller who will take Jack's place for a three year term; Charlotte Eberlein, Immediate Past-President; and Shaffeek Ali, Member-at-Large who has put up with innumerable e-mails from me to help with special projects.

My thanks to all of the committee chairs as well. You'll meet then at breakfast on Thursday when they fill you in on committee activities at the Business Meeting. At this time I would like to invite Tracy Sterling, Chair of the Nominations Committee, to introduce you to the newest members of the Executive Board, your newly elected officers: President-Elect, Jeff Tichota; Secretary, Jill Schroeder; Research Section Chair-Elect, Jesse Richardson; and Education and Regulatory Section Chair-Elect, Gil Cook.

Which leads me back to my original ruminations. I've heard a lot of Presidential Addresses in the years that I have been attending WSWS. Alex Ogg gave the first address I heard and Charlotte Eberlein gave the last one I heard and our 50th. In thinking about some of these, I decided maybe we needed a "State of the Society" address. Then I decided that, while that sounds presidential, it may be a little too pompous. I hope I'm not pompous, so I'll just try to report key activities from this year.

Thanks to Rod Lym's hard work, we have both a copyright and trademark for the WSWS logo. The copyright protects the original artwork of the logo without the words "Western Society of Weed Science" with the copyright symbol [©] and is good for the life of the author plus fifty years. So we wish long life and great prosperity to Rod Lym, Tom Whitson, and Steve Dewey as the listed authors of our logo artwork.

The trademark identifies and distinguishes the source of our goods and services from those of others and includes the logo artwork and the words Western Society of Weed Science. Any goods for sale through the Society should be marked with the trademark logo [®]. This also protects our logo from being misused. We will need to show the trademark office in five years that we are still using our trademark and it will need to be renewed in ten years. All publications of the Western Society of Weed Science will now have the logo with the trademark designation.

The Executive Board voted to made changes in two of the project discussion groups at the summer meeting. Project 5 was changed from "Weeds of Aquatic, Industrial, and Non-Crop Areas" to "Weeds of Wetlands and Wildlands" to better fit interests of the current membership. Also, since all projects tie to a commodity or site of weed control, "Project 7: Alternative Methods of Weed Control" was discontinued. All project section chairs are encouraged to include alternative methods in their discussion and paper sections.

Thanks to Dave Cudney, from the Publications Committee, and Shaffeek Ali, Member-at-Large, for their work on developing a new society brochure. It should be available for use soon. Thanks to Joan Campbell and her two ad hoc committees. The Guidelines Ad Hoc group has worked hard to get committee input so we can print updated guidelines. The Guidelines will go out after this meeting to all new chairs and chairs are encouraged to use these as a work in progress to help run committees. Joan also headed up the fledgling webpage. The Operating Guidelines, WSWS Constitution and By-Laws, and WSWS Newsletter will be added to the webpage this year. Feel free to use it as a calendar for western weed events. Any other information that members can provide to Joan for the page will help make it that much more useful.

The Western Society of Weed Science is a great organization because it is made up of great people. To my colleagues in the Western Society of Weed Science, thank you for the opportunity to serve as President and for all of your help over the years. We're not done yet, so I will continue to call on you.

WEED CONTROL ON THE NATURE CONSERVANCY'S MAUI PRESERVES. Patrick A. Bily, Alien Plant Control Specialist, The Nature Conservancy of Hawaii, P.O. Box 1716, Makawao, HI 96768.

Abstract. Alien plants pose a substantial threat to island ecosystems. In the interest of preserving the native biological diversity on the Preserves, The Nature Conservancy of Hawaii, Maui Field Office, ranks control of highly invasive weeds as a priority of the resource management activities. The species targeted and the control measures taken are chosen carefully, according to available resources and practical long range goals.

The significance of weed invasions in the Hawaiian Islands is relative to the uniqueness of Hawaiian flora and the sequence of contributing impacts on the original natural landscape. Ninety-one percent of the native plants are endemic only to Hawaii. Adaptive radiation and other evolutionary patterns left the native flora especially vulnerable to disruptions.

Although impacts from early Polynesian settlers changed lowland habitat through agricultural practices, the arrival of Westerners accelerated ecosystem decline, notably through the introduction of ungulates (Hawaii has no native land mammals). Likewise, very few Polynesian introduced plants became invasive, but many of the plant species that came with the Europeans and their animals spread rapidly in the Hawaiian environment. Wild cattle roamed much of Hawaii's wildlands uncontrolled for over 40 years, causing considerable destruction in their wake. Other introduced ungulates (pigs, goats, and deer) were released, and to this day, the impact caused by feral animals continues to open Hawaii's landscape to weed invasions.

The advent of commercial sugarcane and other large scale agriculture stimulated more land clearing, but also prompted an awareness of watershed degradation. To control erosion, Territorial foresters began widespread planting of fast growing trees from Asia, Australia, and Tropical America. These botanical immigrants adapted well and began pushing further into the native habitat. In some cases, more native forest was cleared to allow space for these new trees to expand, with hopes of a subsequent timber industry. In some instances, Hawaii's diverse ethnic groups brought plants from their homelands that escaped cultivation. Finally, as the state's population and a higher standard of living increased, the horticultural industry expanded to supply a plethora of ornamental plants from all over the world to the backyard gardener or landscaper. Fortunately, only a small percentage of these ornamentals became invasive. Yet some species may act as time-bombs, perched to explode into larger populations when influenced by various factors.

The actual strategies for controlling weeds that invade Hawaii's natural areas may vary with the particular resource and agency responsible for management. The Nature Conservancy's Maui Preserves focuses on preventing new introductions and containing localized populations; eradication is unrealistic on a Preserve-wide basis, but we work with other agencies towards that goal at a state or island level for certain species.

The spread of new weeds not localized to certain areas has been documented. To avoid complicating our current weed control problems, with ourselves becoming the culprits, Maui Preserves field staff strictly adhere to a protocol that outlines preventative measures. This includes cleaning all field gear (i.e.,supplies, equipment, vehicles) of weed seeds or mud as it gets transferred to different work sites. Personal gear (rubber boots, raingear, packs) for the two preserves are assigned to individual field staff.

Much of our control work aims at stopping the spread of highly invasive weeds into pristine or semi-pristine habitat. The severity of the weed's ability to alter habitat, along with the importance and rarity of native elements contained in that habitat, delegate how we prioritize these invaders. Critical to any management is the mapping of these alien plant populations and their densities, through transect monitoring, on the ground scouting, and aerial reconnaissance by helicopter. Usually, many of these plants are being dispersed from highly disturbed lands below, up into mountainous, native-dominant areas. After we locate the edge of the invasion, control boundaries are established into management units. Satellite populations are attacked first, proceeding down into moderate densities. Treatment cycles vary with the maturity cycles of the individual target species.

As most of our applications are spot treatments, herbicide amounts used on a per acre basis are a fraction of the label rate. Triclopyr amine and ester are mostly used, as aspects of their fate and toxicity seem to favor applications in watershed or environmentally sensitive areas. For stubborn weeds such as gorse or cane tibouchina (*Tibouchina herbacea*), we have success with foliar applications using light dilutions of triclopyr amine with silicone based surfactants. This same herbicide in higher concentrations, applied to a complete frill cut at the trunk base, has helped us in controlling hard to kill trees such as Mexican ash. Other trees, such as invasive pines, eucalyptus, and silk oak, seem to be easily controlled with this method. Basal applications, using different concentrations of triclopyr ester in a diesel or vegetable oil carrier, provide very high treatment efficacy for trees like strawberry guava, miconia (*Miconia calvescens*), and blackwood acacia (some of the latter having greater than 20 cm. DBH). We've also been able to control blackberry canes with no non-target impact in dense native vegetation, using basal stem treatments. When successful on the particular target, basal treatment is the least labor intensive method we have available for treating pest trees without non-target impacts. We tested another very target specific method, using a lance manufactured for injecting glyphosate caps, but the inconsistent kill on various trees has led to too much retreatment. Glyphosate works well in controlling our grassy pests, as long as we apply it carefully to avoid non-targets. At this time on Maui Preserves, invasive grasses are of lower priority and do not merit a new program testing grass selective herbicides. Neither are pre-emergents used in our Preserve work, as we usually welcome native plant recruitment, even in monospecific weed stands. However, they may be of use in the multi-agency battle against miconia, as a single mature tree can produce millions of seed annually.

The Nature Conservancy on Maui is working outside the Preserves to assist with that island's miconia control through mapping and removal of smaller populations outside the core infestation in the Hana area. These 'satellite' groups actually stem from separate cultivations that began naturalizing rapidly. Presently, the general dispersal range is limited to approximately a quarter mile from the originally planted trees; but the exception to this deceiving trend is nightmarish! Helicopter reconnaissance has found miconia up to 2 miles away from the nearest known seed sources. During ground sweeps, our crew intensely surveys the extremely rough terrain in dense jungle to seek out any miconia outlyers from the areas we have already controlled. Fortunately, the large majority of our satellite miconia work can be performed manually, as carrying spray equipment in this setting would be impractical. For the rare instance of discovering a tree too large to pull, we carry a small squirt bottle with a mix of triclopyr ester and oil, and apply it basally or to a cut stump.

The prognosis for eventual eradication of miconia in the Hawaiian Islands is still uncertain, but the efforts for containment on Maui have proven successful, as the known fruit bearing trees were the first targeted. The future of this program depends on continued funding for crews to remove miconia recruitment until the current seed bank expires. A strong public outreach campaign has been active, not just to garnish support for ongoing miconia control, but to encourage the public to report miconia sightings to a 'hotline' number. Aerial spectral imaging, using infra-red photography, seems promising as a means of detecting the strong signal given off by remote miconia outlyers. After their location is mapped onto GIS, these trees can be spot treated with a long line helicopter rig. One biological control agent (*Collectotrichium gloesporoides* f. *miconiae)*, a fungus specific to miconia, has been released and is being monitored for efficacy on seedlings.

Back on The Nature Conservancy's Maui Preserves, our alien plant control strategies can eventually lead to population decline of priority weeds in critical areas. If disturbance factors are limited in tandem (control of feral pigs is normally the first step in Preserve weed control strategies), recovery and competition from native plants help to minimize weed recruitment. Meanwhile, species spreading by short range dispersal are kept at bay as new seed sources are driven further downhill. Although this approach borders on maintenance rather than elimination, it may help delay these alien plant invasions until better technology (including effective biological controls) catches up with natural resources management. Again, the preservation of native habitat is our primary goal, and we are relying on advancing weed science to help us accomplish this. Future vegetation management will need improved methods for target specificity and low labor application techniques in order to practically contribute to the protection of natural resources.

DIVERSIFIED WEED MANAGEMENT - KEY TO IPM IMPLEMENTATION. Harold D. Coble, IPM Coordinator, USDA/CSREES, Washington, DC 20250.

INTRODUCTION

In joint testimony before Congress on September 21, 1993, USDA, EPA and FDA established the goal of having Integrated Pest Management (IPM) implemented on 75% of US cropland acres by the year 2000. National Agricultural Statistics Service (NASS) figures for 1996 show approximately 335 million acres of planted cropland in the US. Of those acres, 79.5 million are in field corn, 75.6 million in wheat, 64.2 million in soybean, and 14.6 million in cotton for a total of 234 million acres, or 70% of the total planted cropland acres. These figures indicate that unless a majority of the acreage of these four crops is included under IPM, reaching the implementation goal will be impossible. Weed Scientists must play a major role if the 75% goal is to be reached since the most widely distributed and intensively managed pests on these planted acres are weeds.

SITUATION

There is growing public debate over the potential health and environmental risks resulting from the use of pesticides in American agriculture. At the center of the debate is a concern that pesticides may cause food quality deterioration, degrade the natural resource base, and endanger the health of farm workers. Recently, calls for a concerted effort to provide the knowledge base, new technology, and financial incentives needed to reduce the use of synthetic pesticides in agricultural and urban landscapes have become more urgent. At the same time, pests remain a major constraint to agricultural production and profitability. It is estimated that in some instances up to 50% of farm variable input costs are attributable to the management of pests.

Federal agricultural agencies now operate under the premise that new strategies for managing pests with less reliance on pesticides must be found and adopted. Inherent in this premise is the realization that pesticide registrations are being curtailed or withdrawn, that pesticide residues are present in groundwater and in food, that public pressure to reduce pesticide drift and contamination will increase, that growing numbers of pests have developed resistance to chemicals, and that conflicts between agricultural producers and communities over environmental and health-related issues continue to grow.

APPROACH

One approach to providing economically, ecologically, and socially acceptable pest management solutions is IPM. IPM is a multiple-strategy approach using pest prevention and avoidance strategies as a first line of defense. Detection strategies are utilized to determine the need for pest suppression when prevention or avoidance strategies fail to keep populations below economically damaging levels. Appropriate pest population suppression strategies utilize suitable combinations of non-chemical pest control techniques such as biological control agents, pest resistant plants, and cultural management along with pesticides. While pesticides should be applied as a last resort in suppression systems, some use will remain necessary. IPM is an information-driven management approach that relies on an understanding of pest population biology (biologically intensive) and educational programs to disseminate pest management techniques to agricultural producers, private consultants, pesticide applicators, and other persons making pest management decisions.

Adoption of IPM systems normally occurs along a continuum from largely reliant on prophylactic control measures and pesticides to multiple-strategy biologically intensive approaches. IPM is site-specific in nature, but certain general criteria must be met at each site for control methods to qualify as IPM practices. The more biologically intensive the approach, the further along the continuum the grower is likely to be. The use of IPM approaches makes it possible to maintain a financially competitive agricultural industry while ensuring a safe food supply and a healthy environment. When practiced widely by farmers, food processors, homeowners and gardeners, IPM has more potential than any other currently available set of practices or technologies to simultaneously reduce human health risks associated with pesticide use; increase the profitability of farming; protect our natural resources; and ensure consumers a supply of safe, high-quality foods and other agricultural products at reasonable cost.

In September 1993 EPA, FDA and USDA announced a national policy to develop and deliver IPM methods on 75% of U.S. crop acreage by the year 2000. USDA and EPA signed a memorandum of understanding in August 1994 in which the two agencies agreed to cooperate in supporting 1) the development and implementation of the most environmentally-sound pest management strategies possible that reduce risk to human health and the environment, reduce the incidence of pest resistance to pesticides, and ensure economical agricultural production and 2) research, technology transfer, and registration activities to ensure the availability of pest management alternatives when regulatory action would result in pest management problems.

On December 14, 1994 the Department of Agriculture announced an initiative to provide agricultural producers with the tools they need to deal with the environmental and economic problems of pest control and help them implement IPM on 75% of the crop acreage in the U.S. by the year 2000. The IPM Initiative addresses pest management needs identified by farmers and others through a comprehensive needs identification and priority setting process involving every state.

National Agricultural Statistics Service figures for 1996 show approximately 335 million A of planted cropland in the US. Of those acres, 79.5 million are in field corn, 75.6 million in wheat, 64.2 million in soybean, and 14.6 million in cotton for a total of 234 million A, or 70% of the total planted cropland acres. These figures indicate that unless a majority of the acreage of these four crops is included under IPM, reaching the implementation goal will be impossible.

Data on pesticide use in the aforementioned four major acreage crops offer a telling view of the relative importance of the different pest types in each crop. Total herbicide use on the four crops is 345.7 million pounds on 200.7 million A, while insecticide use totals 37.1 million pounds on 43.6 million A and fungicide use totals 0.9 million pounds on 1.7 million A. Just over 90% of all pesticides used in these four crops are herbicides (Table). Clearly, weeds are the most widely distributed and intensely managed pest type in all of these major acreage crops.

Table. Pesticide use on field corn, wheat, soybean and cotton in the US in 1996 (NASS).

		Acres treated			Pounds used (millions)		
Crop	Acres (millions)	Herbicide	Insecticide	Fungicide	Herbicide	Insecticide	Fungicide
Corn	79.5	97%	30%	<1%	212.5	16.1	0.1
Wheat	75.6	63%	10%	1%	28.3	2.3	0.2
Soybean	64.2	97%	1%	<1%	77.7	0.4	0.1
Cotton	14.6	92%	79%	6%	27.2	18.3	0.5
Totals	233.9	200.7	43.6	1.7	345.7	37.1	0.9

SOLUTIONS

Weed management is obviously the means to implementation of IPM on large acreages of cropland. The only question remaining is "how do we go about fitting weed management into the IPM context"? IPM is based on a multiple-strategy approach aimed at providing economically feasible, environmentally sound, and socially acceptable management of pest populations. IPM is site-specific in nature, but certain general criteria must be met at each site for control methods to qualify as IPM practices. At a minimum, each site should have in place a management strategy which includes Prevention, Avoidance, Detection, and Suppression of pest populations (the PADS approach). Weed management fits very well under this approach.

Prevention is the first line of defense, and includes such tactics as using weed-free seeds and transplants, preventing weeds from reproducing, cleaning tillage, harvesting and transportation equipment between fields or operations, using irrigation water free of weed seeds, and eliminating alternate hosts or sites for insect pests and disease organisms.

Avoidance may be practiced when pest populations exist in a field or site but the impact of the pest on the crop can be avoided through some cultural practice. Examples of weed avoidance include crop rotation such that the crop of choice is not grown when the weed is present, choosing cultivars with maturity dates that may allow harvest before weed populations develop, and simply not planting certain areas of fields where weed populations are likely to cause crop failure and control is not feasible.

Detection and proper identification of weeds through surveys, scouting programs, or monitoring, including weather monitoring and soil testing, should be performed as the basis for any suppression activities. Records should be kept of weed incidence on a temporal and spatial basis for each field. Such records form the basis for crop rotation selection, economic thresholds, and suppressive actions.

Suppression of weed populations may become necessary to avoid economic loss if prevention and avoidance tactics are not successful. Suppressive tactics may include cultural practices such as narrow row spacings or optimized in-row plant populations designed to give crops a competitive advantage over weeds. Physical suppression tactics such as cultivation for weed control may be beneficial where soils are not prone to erosion. Biological controls, where available, should be considered as alternatives to conventional pesticides, especially where long-term control of an especially troublesome weed species can be obtained. Chemical herbicides are the most widely-used suppression tactic, particularly on large-acreage or high-value crops. Herbicides are important in IPM programs, but sound management of herbicide use involves the following: 1) The cost:benefit should be confirmed prior to use (economic thresholds); 2) Sprayers or other application devices should be calibrated prior to use and occasionally during the use season; 3) When available and where economically feasible, precision agriculture technology should be utilized to limit herbicide use to areas in fields where weeds actually exist; 4) Herbicides should be selected based on least negative effects on environment and human health in addition to efficacy and economics; and 5) Chemicals with the same mode of action should not be used continuously on the same field in order to avoid resistance development.

WHAT IS THE FUTURE OF PROFESSIONAL SCIENTIFIC SOCIETIES? Calvin G. Messersmith, Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105-5051.

To communicate: This is the biggest challenge in any organization. Communication is even more important in weed science, because we have several regional societies and the Weed Science Society of America (WSSA). To communicate more effectively during this past year, we emphasized several activities including: a) a weed science society retreat was held in Chicago; b) the regional weed society presidents were invited to meet with the WSSA board of directors where we addressed several key issues of mutual interest; c) e-mail newsletter messages were sent periodically to the key officers and WSSA board; and d) increase external communications with related societies such as the Tri-Societies (American Society of Agronomy, Crop Science Society of America, Soil Science Society of America) and to a lesser extent the American Society for Horticultural Science (ASHS), the American Phytopathological Society (APS), and the Entomological Society of America (ESA). Also, WSSA and the four U.S. regional weed science societies all are active in the Council for Agricultural Science and Technology (CAST) Conversations for Change program.

Communication within weed science is challenging because we have many independent societies. WSSA typically is called the national organization but it really is international for North America, because Canada is part of the official structure. The other major international societies with liaisons with WSSA are Latin American Weed Association (ALAM), Asian Pacific Weed Science Society, European Weed Research Society, and the International Weed Science Society (IWSS).

The weed science societies at the regional levels are the Aquatic Plant Management Society (APMS), the Expert Committee on Weeds (Canada) (ECW), North Central Weed Science Society (NCWSS), Northeastern Weed Science Society (NEWSS), Southern Weed Science Society (SWSS), and the Western Society for Weed Science (WSWS). Each organization originated independent of the WSSA but does appoint a member to serve on the WSSA board of directors. As separate organizations, they behave mostly independently, whereas in most scientific societies, the regional or state organizations are groups chartered by the national organization. Also, there are several state weed control or agricultural chemical organizations, which have not been closely linked to either the regional or national organization. However, these people provide an opportunity for future activities and perhaps some associate memberships.

Weed science society priorities: I mentioned the weed science retreat held July 10 to 11, 1997, in Chicago. The outcomes of this retreat is a way to focus on key activities where we have tried to communicate better among our societies and plan for the future. There were 24 representatives from eight societies, i.e., the WSSA, the six regional societies with a member on the WSSA board, and the IWSS. We went through a series of group activities, lead by an external facilitator, to consolidate a brainstorming list to about 20 activities. Then each participant was given about 10 votes to distribute on their priority items. This forced each of us individually to identify our top priorities, and every individual had equal input. The final list of concepts in priority order were:

1. Provide continuity and influence of weed science representation on the national level. Additional comments of progress will be presented later.

2. Rework the format of the annual meeting. Several changes were made at the 1998 annual meeting, including moving the presidential address and presidents' reception to Monday afternoon, providing extra discussion in two sections, and adding a professional development workshop on statistics where participants paid an extra fee.

3. Conduct surveys and focus groups with members, clients, prospective members and ex-members on many issues. So often, if we are uncertain of where an organization should go, we survey our members, which is appropriate. But probably more importantly, we need to survey people who could be members or were members, i.e., who can we serve effectively.

4. Stronger links from national to regional to state organizations. What is the potential for increasing the number of clients we serve, especially as we increase our activity in Washington, DC? Our effectiveness and message will increase as we represent more people and varieties of interests related to weed prevention and control.

5. Serve/cater to practitioners. This will be discussed later.

6. Initiate/expand use of electronic communication tools. Changes in use of e-mail, web sites, and electronic publication demand that we respond to the change around us. The challenge is determining the best mechanism.

7. Upgrade efforts to maintain a timely list of research priorities and ensure that such a list receives regular, deep public debate. This is particularly important as we determine priorities related to Washington liaison.

8. Solidify and grow links to CAST and other societies for insight, help on common issues, and leverage of dollars. To date, our closest linkages have been with CAST and the Tri-Societies. As we look to the future, we need to increase linkages with the APS, ESA, ASHS, the range science society, and many other organizations.

9. Evaluate common management of pooled financial resources. Even though several of our organizations have $200,000 to $400,000 invested, the WSSA financial manager indicates that this isn't a large enough pool to substantially influence total income from joint management.

Membership trends. The WSSA membership has slowly declined from a peak in 1986 of 2143 full members to 1986 members in 1997. The student membership has been stable for several years with 219 in 1997, although this is a decline from 325 student members in 1986. However, few of us are able to recruit enough graduate students to fill vacant assistantships. However, the change that is having the most impact on WSSA is the decline in institutional memberships, which primarily represent university libraries, from a peak of 1292 in 1986 to 830 in 1997. Libraries are under very tight budgets while publication costs have increased dramatically. Thus, with the increase of electronic communication and interlibrary loan services, libraries are eliminating subscriptions for titles that are not heavily used.

The WSWS has maintained a strong membership and actually has about a 25% increase in membership in the past 10 years from 414 members in 1986 to 517 in 1997 and a stable graduate student membership. Why has the WSWS continued to grow and is there something that we can carry over to other regional societies or the WSSA? Among regional societies, the NCWSS and WSWS have had a significant increase in members in the past 5 yr and the APMS is virtually stable, while the SWSS has decreased significantly and the NEWSS decreased modestly.

Another factor is that the membership distribution of weed science societies tend to differ from most scientific societies. The "traditional" scientific society often has 70% or more of their membership from university and government scientists and a small portion from allied industry, with very few members in technical service or practitioners. The WSSA has 49% membership from industry and 46% from universities and government, and 14% from technical service, practitioner, and retired. The regional societies likely have close to an equal distribution of university/government, industry, and technical service members and a small number of practitioners. The state societies would have a high proportion of practitioners, with a small proportion of technical service, industry and university scientists.

One big questions is what kind of membership do we want? Do we want our organizations to reflect a more traditional scientific society or do we want to embrace a broader audience than most societies?

Our challenge is similar to that faced by other scientific societies. Diana Slade in Chemical and Engineering News (July 28, 1997) stated that "Chemists once joined (the American Chemical Society) because 'they were joiners'--they joined organizations from a civic sense. Now...active participation often centers around career development and growth. The past buzzword was 'service'; the new buzzword is 'network'." I believe our whole society reflects this general philosophy. The public is not joining the Eagles, Elks, American Legion, ...as they did in the past, but rather they join groups that provide the best personal growth and development.

Professional society services. The present trend is for people to be less concerned about service than their parents. However, our scientific societies still are structured primarily related to service. Some of the service areas provided by scientific societies include organizational structure, annual meetings, publications, legislative impact, and professional development education. Following is an examination of each area in more detail.

Services: Organizational. These include our membership records and regular newsletter. Annual meeting preparation including preregistration, ordering of award plaques, printing of programs and abstracts, ... The national organization provides the structure for intersociety interaction, such as what the WSSA has done with the Tri-Societies and CAST. A development in the last decade has been professional certification. This area has been small in weed science and most agronomic and horticultural areas, although the affiliated Certified Crop Adviser program for practitioners has grown dramatically in recent years.

Services: Annual meeting. This is where we interact with our colleagues and many people say this is the most important benefit of the annual meeting, i.e., "networking". Of course, we are interested in several scientific papers and the networking to authors who are conducting research similar to our areas of interest. We expect the annual meetings to have informative symposia and/or discussion groups to stimulate thinking. We recognize our colleagues through awards and take care of official society business through the board of directors and business meetings. Also, we have programs to enhance graduate studies, particularly through the paper and poster contests in the NCWSS, NEWSS, SWSS, and WSWS. These contests when started in the early 1970s greatly increased graduate student participation in regional meetings and increased the quality of presentations by everyone.

Services: Publications. The national and international societies typically have provided the refereed journals. Now we are struggling with how to present the information electronically. Do people want them on CD disks? Do they want them accessible via the Web? How do we get paid for those services when we can no longer rely on traditional paper subscriptions?

There is a great interest in non-refereed information. Our regional societies publish research reports and proceedings of the annual meeting, which provide up-to-date information on what people observed that year. The national and regional societies have published various books and reviews, such as the WSWS "Weeds of the West".

There is a lot of interest in publications for practitioners. This is a priority issue from the weed science retreat. Some people feel that we should publish a magazine, although I'm not convinced this is the best choice. I do believe there is an opportunity for extension-like publications. A good example is the APS which in 1996 was projecting about $1 million in publication sales, with 80% to non-members. They have many specialized publications, such as diseases of peanut, tomato, turf, ... This may be an area for growth by our societies?

Services: Legislative impact. I believe that weed science was ahead of many plant science disciplines in this area. Beginning in the 1970s, the top two or three WSSA officers visited key offices in Washington, DC. Later, participation was expanded to include the presidents of the regional societies. Because this effort did not provide much continuity, WSSA joined with the Tri-Societies to fund two Congressional Science Fellows (CSF) to work directly in the office of a U.S. congressman. The CSF becomes an employee of the legislator, even though we provide their salary, so the feeling is that we weren't getting as much impact as expected.

The next step was to employ the services of a Washington, DC, representative, which was done through AESOP Enterprises. From 1995 through 1998, we have shared funding for one person with the Tri-Societies. For our one-half share, WSSA has provided 25% of the funding and the regional societies have divided the other 25%. At the recent 1998 WSSA board meeting, when we met with the presidents of the regional societies, we concurred that we will discontinue CSF funding at the end of 1998 and transfer those monies to a full-time Washington liaison. We expect to draft a job description by mid summer and have a person employed by early 1999.

What is the future? Are we going to end up with an Executive Vice President; a professional weed scientist located in the Washington, DC, area who can be a full-time spokesperson for weed science rather than a liaison who is more the "eyes and ears" for our interests? Perhaps we can grow into the Executive Vice President position and perhaps that should be considered a goal for the future.

Services: Professional education. I feel societies have not done enough for the professional education of our members, beyond the traditional annual meeting. And we haven't tried very strongly to reach out to new members. We could be conducting workshops, and these could be directed at member and/or non-member education. At the recent WSSA meeting, 62 people signed up for a fee-based statistics workshop. Many other scientific societies, not so much in agricultural and biological sciences but in areas like chemistry and physics, have extensive workshops with fairly high tuition. Concerning non-member education, at the 1997 WSSA meeting in Orlando, the WSSA and ASHS co-sponsored a post-meeting workshop focused on horticultural weed control with around 80 attendees.

Are there other opportunities? The WSWS has their Noxious Weed Management Workshop, with interest more than they are able to handle. Are there opportunities for special publications? Some groups have products such as the "Weeds of the West" by the WSWS and the CD-ROM on Weeds of the United States by the SWSS. Maybe we should be doing a series on weeds of turf, with different publications for the west, south, ...? Maybe there is a market for visual aids such as computer programs, videotapes, slides, ...?

To explore these opportunities, the WSSA board has agreed to appoint a Director of Education for 1 yr, with a directive to interact with the regional societies. The charge is to determine the services that we can provide that have a market. The first charge is to help our own members but to consider outreach to non-members.

What are our challenges for the future? There are fewer companies and the state and federal government, including universities, are getting smaller. Thus, our traditional base of scientists is decreasing. What services can we provide to the practitioner? Do they become members of our societies? If yes, how do we change our meeting structure and the things we offer to attract them? Or do they become a buyer of services, such as publications or workshops? Are there efficiencies of scale by forming a federation with other scientific societies and/or including a broader membership base? Would all of the weed science societies benefit by having the same headquarters? Or do we federate with the Tri-Societies, the APS, ... Can we establish a structure to maintain enough independence and still become more efficient for delivering electronic publications, marketing of books and other publications, setting up educational meetings, ...?

If we evaluate the dues structure, we are conservative groups. For WSSA, we provide dues and two journals for $75 per year, whereas most other societies consider dues to be around $60 to $65 per member plus $30 to $40 for each journal subscription. Probably WSSA charges about $15 under comparable societies for similar services.

The weed science societies have several shared activities, but managing them becomes a challenge. When voting, each organization wants one vote regardless of size; but for money, they want one person equals $1 based on membership. This is like a sibling rivalry, that scrapes internally but they are united when someone tries to break up the family.

And how do we charge for services? Does the user pay? Several scientific societies have separated dues from journals. Can we afford to do that, and should we do that? How are we going to deliver electronic publications, and how will we make the information accessible to more people, such as through the Web, and how will be get paid for those services? Are we going to conduct workshops, and will we provide our members with the option of taking a workshop instead of the journals? Or will there be a fee for all the extra workshops?

Are we able to serve our member and potential member desires? One goal from the 1997 retreat is to have a good survey of our current members, and also potential members. That may mean that we hire some professional assistance, and maybe do some telephone interviews or focus groups with current and potential members.

And finally, what will be the impact of herbicide-resistant crops on our professional societies? Will there be just two or three or four herbicides for which herbicide-resistance is transferred to virtually every crop, and consequently our membership will decline because there isn't near the current need for the kinds of research we have traditionally conducted?

There are many challenges! We are a comparatively small professional group. What will we do to survive?

VOLATILITY LOSSES OF DIMETHENAMID, METOLACHLOR, AND EPTC DURING CHEMIGATION. Scott J. Nissen, Galen R. Brunk, and Gus Foster, Associate Professor and Research Associate, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523 and Field Biologist, BASF, Fort Collins, CO 80524.

Abstract. A small plot chemigation unit was constructed using a field scale Agri-Inject (Yuma, Colorado) metering system and greenhouse sprinkler heads connected to 1 m by 5 m frame made of PVC tubing. The sprinkler heads were held at a height of 2 m during the course of the experiment and herbicides were applied at concentrations equal to an application rate of 1 kg/ha applied in 1.3 cm of water. Water samples were collected from the sprinkler head and ground during applications made at 0630, 1030 and 1430 hours on 3 consecutive days in early September, 1997. Temperatures at the time of application ranged from 14 to 32 C. Water samples were extracted with water saturated toluene, transferred to 2 ml volumetric flasks containing 10 μg of butylate internal standard and 1 μl samples were injected for analysis by GC-MS (SIM).

There was no detectable loss of dimethenamid or metolachlor during chemigation at temperatures ranging from 14 to 32 C; however, EPTC losses were highly correlated with temperature. Comparing the concentration of EPTC from ground samples as a percent of initial concentrations, EPTC losses ranged from 15% at 14 C to 45% at 32 C. Temperature alone accounted for 78% of the variability in EPTC concentrations. EPTC losses as high as 30% could occur even at very moderate air temperatures and could result in reduced herbicide performance because actual application rates would be reduced by 33%. Nightshade and pigweed control is highly dependent on EPTC rate, requiring 3.5 kg/ha or more, so growers need to understand that application rates should be increased as air temperature increases to compensate for volatility losses.

INFLUENCE OF 1,3-DICHLOROPROPENE FUMIGATION ON YELLOW AND PURPLE NUTSEDGE ASSOCIATION WITH ROOT-KNOT NEMATODES. Jill Schroeder, Stephen H. Thomas, and Leigh W. Murray, Associate Professor and Associate Professor, Department of Entomology, Plant Pathology and Weed Science, and Associate Professor, University Statistics Center, New Mexico State University, Las Cruces, NM 88003.

Abstract. Yellow and purple nutsedge host the plant parasitic root-knot nematode, *Meloidogyne incognita*. A field survey was conducted in 1996 to determine the extent of this association. Yellow and purple nutsedge were sampled from root-knot nematode infested chile pepper fields at 40 locations in the three New Mexico counties that grow the largest hectarage of chile peppers. Root systems of these plants were extracted to determine the level of root-knot nematode infection. Root-knot nematodes were found on 85% of the nutsedges sampled indicating that the association between these pests is widespread. Greenhouse and field research at NMSU has also shown that yellow and purple nutsedge tubers serve as a source of root-knot nematode inoculum at levels high enough to infect chile. One,3-dichloropropene (Telone II) is the only fumigant nematicide with broad registration in vegetable crops and compatibility with low spring soil temperatures in the region. However, this nematicide has limited activity on nutsedge tubers. A field and greenhouse study was conducted in 1997 to determine the response of root-knot nematode infested and noninfested yellow and purple nutsedge tubers to 1,3-dichloropropene applied at a commercial rate. A nontreated control was included. Two weeks after fumigant application to soil planted with yellow and purple nutsedge tubers, half of the tubers were planted in pots containing growing chile plants to bioassay for root-knot nematode presence in the tubers. The remaining tubers were placed in pots in the greenhouse for 14 days to determine percent tuber germination. Results confirmed that 1,3-dichloropropene had no effect on yellow or purple nutsedge tubers; however, root-knot nematode increased percent yellow nutsedge tuber germination, number of shoots per tuber, and number of daughter tubers. Root-knot infection of chile was observed in bioassays planted with root-knot infested purple nutsedge that had been treated with 1,3-dichloropropene indicating that purple nutsedge may protect some of the root-knot nematodes from this fumigant nematicide.

EVALUATION OF COVER CROP SYSTEMS FOR WEED CONTROL ON SUMMER FALLOW. J. R. Moyer, E. G. Smith, and R. E. Blackshaw, Research Scientists, Lethbridge Research Centre, Agriculture and Agri-Food Canada, Lethbridge, Alberta.

Abstract. Annual crop-summer fallow cropping sequences are often more profitable than continuous cropping sequences on Brown (Aridic Boroll) and Dark Brown (Typic Boroll) soils of western Canada. Weed control in the fallow year requires three to seven cultivations or three to five applications of herbicide. Experiments were conducted at Lethbridge with short-term cover crops from 1992 to 1996 in an attempt to suppress weed growth, increase plant residue cover on the soil surface and decrease herbicide use. Growing fall rye from September to June, and leaving the residue on the soil surface, reduced weed biomass produced during the fallow year by 50% compared to untreated fallow. In experiments conducted from 1992 to 1996, soil moisture content at the end of the fallow period and wheat yield were similar after a fallow period with a fall rye cover crop plus minimum tillage, minimum tillage alone, and zero tillage. Plant residue cover after a fall rye cover crop was enough to permit up to four tillage operations without exposing the soil to erosion. Net returns from a fallow wheat sequence under minimum tillage, zero tillage and a fall rye cover crop were $43, $20, and $28/ha, respectively. The rye cover crop system should permit sufficient tillage to control perennial weeds such as foxtail barley and dandelion which require more expensive herbicide treatments than those included in the costs for minimum- and zero-tillage fallow. If control of these weeds is required net returns could be the largest from the fall rye plus tillage system. Spring seeded cover crops were included in the experiment but net returns were less than with fall seeded cover crops.

EVALUATION OF PREEMERGENCE AND POSTEMERGENCE HERBICIDE APPLICATIONS ON SUGARBEETS IN CENTRAL OREGON. Marvin D. Butler, Extension Crop Scientist, Central Oregon Agricultural Research Center, Madras, OR 97741.

Abstract. Evaluation of preemergence and postemergence herbicide applications on sugar beets was conducted in commercial fields near Prineville, Oregon in 1996 and 1997. Herbicides applied preemergence included ethofumesate and pyrazon, alone and in combination. Herbicides applied postemergence were phenmedipham plus desmedipham, phenmedipham plus desmedipham plus ethofumesate, triflusulfuron, and clopyralid.

During 1996, weeds evaluated included common lambsquarters, redroot pigweed, hairy nightshade, redstem filaree, common mallow, and mustard species. One hundred percent weed control was provided by preemergence application of pyrazon alone and in combination with ethofumesate, followed by postemergence application of phenmedipham plus desmedipham plus ethofumesate and triflusulfuron. Preemergence application of ethofumesate alone, followed by phenmedipham plus desmedipham plus ethofumesate and triflusulfuron provided 99% weed control. Plots treated with a combination of preemergence and postemergence applications had less weeds than those receiving postemergence applications alone. Phenmedipham plus desmedipham and triflusulfuron performed better than phenmedipham plus desmedipham plus ethofumesate and triflusulfuron. Yields were not affected by slight stunting by ethofumesate or moderate stunting from pyrazon applied preemergence. Percent sugar and parts per million nitrate in sugar beets was unaffected by treatments.

During 1997, weeds evaluated included common lambsquarters, redroot pigweed, hairy nightshade, and prostrate knotweed. Greater than 99% weed control was provided by ethofumesate or pyrazon alone or in combination, followed by phenmedipham plus desmedipham and triflusulfuron. Similar control was provided by preemergence applications of ethofumesate at the 1 or 1.5 lb/A rate, pyrazon at the 2 or 3.1 lb/A rate, or a combination of ethofumesate at 0.75 lb/A and pyrazon at 1 lb/A, followed by two postemergence applications of phenmedipham plus desmedipham and triflusulfuron. Paraquat applied preemergence followed by postemergence application of phenmedipham plus desmedipham and triflusulfuron provided less control of prostrate knotweed than other preemergence applications. A preemergence application of ethofumesate and pyrazon without postemergence herbicides provided inadequate weed control. When the rate of phenmedipham plus desmedipham was reduced by 50% and crop oil concentrate was added at 1.5% v/v in combination with triflusulfuron, there was an increase in control of prostrate knotweed from 43 to 89% while maintaining similar control of the other weed species.

BROADLEAF WEED CONTROL IN FIELD CORN WITH POSTEMERGENCE HERBICIDES. E. J. Gregory, R. N. Arnold, and C. K. Owen, Professor, Pest Management Specialist and Research Assistant, New Mexico State University Agricultural Science Center at Farmington, Farmington, NM 87499.

Abstract. Weeds compete vigorously with corn for light, nutrients, and moisture. Redroot and prostrate pigweed and black nightshade are three common weeds found in field corn in northwestern New Mexico. A field experiment was conducted in 1997 at Farmington, New Mexico to evaluate the response of field corn (Dekalb 561SR) and broadleaf weeds to postemergence herbicides. Treatments were applied with a compressed air backpack sprayer calibrated to deliver 30 gpa at 30 psi. Nine treatments were applied June 2 when corn was in the 5-leaf stage (less than 8 inches tall) and weeds were small. Five treatments were applied when corn was in the 7-leaf stage (greater than 8 inches tall) with annual broadleaf weeds greater than 2 inches. Black nightshade infestations were heavy and redroot and prostrate pigweed infestations were moderate throughout the experimental area. Treatments were rated visually on July 2 and July 14. BASF 1269 applied to corn less than 8 inches was the only treatment that injured corn. Redroot pigweed control was good to excellent with all treatments except a low rate of flumetsulam plus clopyralid applied to corn greater than 8 inches tall and the check. All three rates of flumetsulam plus clopyralid applied to corn greater than 8 inches tall gave poor control of prostrate pigweed. Flumetsulam plus clopyralid and flumetsulam plus clopyralid plus 2,4-D applied to corn less than 8 inches tall gave poor control of black nightshade.

WILD PROSO MILLET (*PANICUM MILLIACEUM* L.) GROWTH ANALYSIS. Decio Karam, Philip Westra, and Scott J. Nissen, Graduate Research Assistant, Professor, and Associate Professor, Bioagricultural Science and Pest Management, Colorado State University, Ft. Collins, CO 80523.

Abstract. Wild proso millet, a potential weed in corn producing areas, was studied under greenhouse conditions at Colorado State University. Twelve biotypes were grown in 3 L pots. Five destructive harvests were taken to compare growth among biotypes. At each harvest height, number of tillers, leaf area, leaf area dry weight, stem dry weight, panicle dry matter, and root dry weight were analyzed. Absolute growth rate and relative growth rate were derived from Richard's function. Biotypes that did not fit the Richard's function were fitted with a third degree polynomial. Panicle dry matter was separated using Tukey's test. Significant differences were observed in the number of tillers among biotypes. Root dry matter showed significant difference only at 70 days. The highest accumulation of root dry matter was obtained by a Nebraska-Panhandle biotype. Minnesota-Cambridge and Wyoming-Plate County obtained the lowest height. Leaf area and total dry weight showed significant differences among biotypes as well as their derivation to absolute growth rate and relative growth rate. The Colorado-commercial biotype showed the highest panicle dry matter but there was no significant difference between this biotype and Colorado-Weld county biotype (wild) and South Dakota-commercial. These results suggest that biotypes with different growth characteristics may show different competitive ability. Experiments with interaction between wild proso millet biotypes and corn varieties will be conducted.

TRIAZINE SPECIAL REVIEW STATUS: NEW STUDIES CONTINUE TO CONFIRM SAFETY AND BENEFITS. Janis E. McFarland, Carroll M. Moseley, Eugene R. Hill, Ronald L. Brooks, Thomas R. Dill, and Randy L. Ratliff, Novartis Crop Protection, Inc., Greensboro, NC 27419.

Abstract. The Triazine Special Review was initiated by the Environmental Protection Agency (EPA) in November of 1994. The EPA has since been evaluating the extensive data submissions and the record 88,000+ supportive responses submitted to the public docket. From March, 1995 to June, 1997, Novartis Crop Protection, Inc. completed more than 100 new studies on the safety and benefits of atrazine and simazine. Published data, computer

model simulations and field studies continue to confirm the agricultural importance of triazines, especially in conservation tillage systems. Corn and sorghum yield increases range up to greater than 10 bu/A with atrazine versus alternative products. Triazines are also critical for the management of the seven economically important broadleaf weed species that have recently developed resistance to the acetolactate synthase (ALS) inhibitor herbicides. The new toxicology and exposure data continue to show wide safety margins for the triazines even when analyzed using the guidelines of the 1996 Food Quality Protection Act and new EPA health guidelines. Water stewardship programs initiated throughout the US are showing that site-specific best management practices are effective in improving water quality by reducing run-off of triazines and other pesticides as well as nutrients and soil into water. Recent scientific reviews conducted in the United Kingdom for the EU and in Australia concluded that atrazine used properly, is safe and poses no harmful effects to humans, animals, or the environment. EPA expects to make a preliminary proposed regulatory decision on atrazine and simazine in 1998 and establish their final recommendations in 1999. Novartis is committed to continue the scientific support of atrazine and simazine to ensure a successful resolution of the Triazine Special Review for agriculture. Novartis will continue to support the use and availability of atrazine and simazine in order to promote safe and effective weed control for the American farmer.

CHEMICAL WEED CONTROL IN PROSO MILLET. Robert K. Higgins, Drew J. Lyon, and Stephen D. Miller, Research Technician and Associate Professor, Panhandle Research and Extension Center, Scottsbluff, NE 69361 and Professor, Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Proso millet is a warm season grass that is well adapted to the semi-arid regions of the Central Great Plains. As growers in this region have diversified their winter wheat-fallow systems in response to new Federal farm policy, proso millet acreage has significantly increased. Very few herbicides are labeled for use in proso millet. Currently, only one brand of 2,4-D amine and prosulfuron have full Federal labels. Additionally, dicamba has 24(c) labels in several states in the Great Plains. Only postemergence uses are currently labeled. Field studies were conducted in 1996 and 1997 at Sidney, NE and Archer, WY to investigate the efficacy of several PRE and POST herbicide options in proso millet. Pigweed (tumble and redroot) control was evaluated at Sidney in both years and at Archer in 1996. Pigweed control was excellent with all PRE herbicide treatments, but at Sidney, POST herbicide treatments were not as effective as PRE treatments (Table). Control of kochia, Russian thistle, common lambsquarters, wild buckwheat, and common purslane was also evaluated, but data for these weeds were limited to a single site and a single year. Atrazine at 0.5 lb/A and propazine at 1 lb/A applied PRE provided excellent control of all weeds. Dicamba plus 2,4-D amine provided excellent control of all broadleaf weeds at Archer, but was less effective at Sidney. Crop injury was observed with POST treatments, but not with PRE treatments. Treatments containing pyridate caused the most injury at Archer in 1996 and 1997, while treatments containing 2,4-D caused the most crop injury at Sidney in 1997. Grain yields were highest at both locations for PRE treatments containing atrazine or propazine. Several excellent PRE herbicide options exist for proso millet if labels can be obtained.

Table. Weed control, crop injury and grain yield in proso millet with PRE and POST herbicides at Sidney, NE and Archer, WY in 1996 and 1997.

				Weed control						
Herbicide treatment	Rate	Timing	Crop injury	AMARE & AMAAL	KCHSC	SASKR	CHEAL	POLCO	POROL	Grain yield
	lb/A		%							lb/A
Atrazine	0.5	PRE	1	97	100	100	100	95	98	1420
Propazine	0.5	PRE	0	96	97	90	98	83	97	1450
Propazine	1	PRE	0	98	100	97	100	87	100	1530
Prosulfuron	0.018	PRE	0	99	87	97	90	60	100	1320
Prosulfuron + 2,4-D amine + NIS	0.018 + 0.375 + 0.25% v/v	POST	5	83	100	100	98	72	77	1310
2,4-D amine + dicamba	0.375 + 0.125	POST	6	84	100	100	100	95	77	1250
Pyridate + COC	0.47 + 1 qt/A	POST	15	76	100	90	90	53	67	1140
Pyridate + dicamba + NIS	0.023 +0.125 + 0.25% v/v	POST	5	78	100	97	90	93	80	1200
Check			0	0	0	0	0	0	0	1030
LSD (0.05)			2	8	2	4	7	9	14	130

THE EFFECT OF THIAZOPYR ON PREEMERGENCE WEED CONTROL IN COTTON FALLOW BEDS AND IN TREES AND VINES. Bill Weir, University of California Cooperative Extension, Merced, CA 95340 and Jack Schlesselman, Rohm and Haas Company, Fresno, CA 93654.

Abstract. Thiazopyr was applied to dry soil during the fall months to fallow cotton beds, mature orchards, and grapes. Thiazopyr was applied alone and in tank mixes with oxyfluorfen and with oryzalin, and compared to an untreated control. Materials were sprayed on the soils using a plot tractor sprayer and rain incorporated. Treatments were evaluated for control of seven broadleaf weeds and three grasses in the fallow beds; and 24 broadleaf weeds and nine annual grasses in trees and vines. Ratings were made on approximately 3-month intervals to determine residual activity.

All materials and tank mixes gave 90 to 100% control of broadleaf weeds through the first 6 months, but lost some activity after 9 months. Similar results were found for annual grassy weed control. Thiazopyr provided excellent residual activity up to 9 months at medium to high rates (0.5 to 1 lb/A), but low rates (0.1 to 0.2 lb/A) lasted only up to 6 months. Thiazopyr and oxyfluorfen, and thiazopyr and oryzalin tank mixes, gave excellent control for more than 9 months and had no adverse effect on cotton planted the following spring or on permanent crops tested

PYRITHIOBAC INFLUENCE ON POSTEMERGENCE GRASS HERBICIDE EFFICACY IN DONA ANA COUNTY, NM. C. Fiore, J. Schroeder, and G. Hoxworth, Graduate Student, Associate Professor, and Research Assistant, Department of Entomology, Plant Pathology, and Weed Science, New Mexico State University, Las Cruces, NM 88003.

Abstract. Weed control studies in cotton have been conducted under distinctly different environmental and management conditions than are present in New Mexico cotton growing regions. These studies have shown that tank mixing pyrithiobac with ACCase inhibiting grass herbicides results in reduced grass control. Field experiments were conducted from 1995 through 1997 at the Weed Science Research Center in Las Cruces, New Mexico to evaluate the interactions of pyrithiobac with ACCase inhibiting grass herbicides in Acala cotton. Sethoxydim (210 g ha^{-1}), fluazifop-P (210 g ha^{-1}), clethodim (140 g ha^{-1}), and quizalofop-P (70 g ha^{-1}) were evaluated alone and in a tank mix with pyrithiobac (70 g ha^{-1}). Johnsongrass (1995 to 1997) and barnyardgrass (1996 only) were visually rated for percent control monthly after treatment application. The sethoxydim-pyrithiobac tank mix reduced johnsongrass control each year of the study. Barnyardgrass control was not affected by the sethoxydim-pyrithiobac tank mix. Fluazifop-P-pyrithiobac mix reduced johnsongrass control in 1995 and

1996 and barnyardgrass control in 1996. Clethodim-pyrithiobac tank mix showed a significant reduction in control of johnsongrass in 1995. Quizalofop-P-pyrithiobac tank mix significantly reduced barnyardgrass control, but showed no significant difference in johnsongrass control compared to quizalofop-P alone.

PYRITHIOBAC, GRASS HERBICIDE ANTAGONISM STUDY IN COTTON. Steven D. Wright[1], R. N. Vargas[2], T. Martin-Duvall[2], and M. R. Jimenez, Jr.[2], UC Cooperative Extension[1], Visalia, CA 93291-4584 and UC Cooperative Extension[2], Madera, CA 93639.

Abstract. The objective of this study was to examine whether pyrithiobac herbicide had an antagonistic effect on sethoxydim, fluazifop, or clethodim herbicides for control of johnsongrass and barnyardgrass. The first application was made on April 24 to a uniform population of johnsongrass that was 3- to 8-leaf stage and 1 to 10 inches tall. Maxxa cotton was in the 2-true leaf stage. Treatments were applied with a CO_2 backpack sprayer using 8002 EVS nozzles at 38 psi delivering 20 gpa. Walking speed was 2 mph. Wind speed was 0 to 5 mph and air temperature 70 F. Treatments received a second application on May 1. Air temperature was 80 F and wind speed 0 to 3 mph. Some of the treatments received a third application on May 15. Air temperature was 80 F and wind speed 0 to 4 mph. Plots were arranged in a randomized complete block design with four, 38 inch rows by 40 feet with four replications.

A uniform stand of Acala Maxxa cotton, infested with barnyardgrass was divided into plots four, 40 foot rows by 20 feet and replicated four times in a randomized complete block design. Treatments were applied with a $C0_2$ backpack sprayer with 8002VS nozzles at 30 psi delivering 20 gpa of spray solution. On day one pyrithiobac, clethodim, sethoxydim, and fluazifop were applied alone and in combination over the top of 3-leaf cotton with barnyardgrass being 4 to 8 inches tall and just beginning to tiller. Seven days later, the 1 oz rate of pyrithiobac was followed by applications of clethodim, sethoxydim and fluazifop.

The johnsongrass study showed that there were no antagonistic effects with combinations of pyrithiobac and fluazifop or with pyrithiobac and clethodim herbicides. However, we did observe a clear antagonistic effect when pyrithiobac was tank mixed with sethoxydim. The 21, 28, and 35 day evaluations showed that the tank mix of pyrithiobac and sethoxydim herbicides, exhibited significantly lower control of johnsongrass than the sequential application of pyrithiobac and sethoxydim.

Johnsongrass control results were as follows. At the 7 DAT evaluation all treatments with fluazifop, sethoxydim, and clethodim exhibited higher control than those treatments that only had pyrithiobac in the first application. At the 15 DAT evaluation, pyrithiobac plus fluazifop, pyrithiobac plus clethodim, clethodim, and sethoxydim treatments exhibited the highest level of control ranging from 26 to 30%. At the 21 DAT evaluation, pyrithiobac followed by clethodim, pyrithiobac plus clethodim, clethodim, and pyrithiobac followed by sethoxydim treatments exhibited the highest level of control ranging from 58 to 60%. At the 28 DAT evaluation, pyrithiobac followed by clethodim, pyrithiobac plus clethodim, pyrithiobac followed by fluazifop, clethodim, pyrithiobac plus fluazifop treatments exhibited the highest level of control ranging from 77 to 88%. At the 35 DAT evaluation, pyrithiobac followed by clethodim, pyrithiobac plus clethodim, clethodim, pyrithiobac followed by fluazifop, fluazifop, and pyrithiobac plus fluazifop treatments exhibited the highest level of control ranging from 85 to 91%.

At the barnyardgrass study, evaluation of cotton phytotoxicity indicated no injury from any of the grass herbicides when applied alone at both 7 and 14 DAT. Pyrithiobac applied alone or in combination with the grass herbicides exhibited up to 12% cotton injury at 7 DAT, but little to no injury at 14 DAT. Evaluations of barnyardgrass control indicate less control at 14 DAT when the grass herbicides were applied in combination with pyrithiobac and 7 d later than when applied alone. Control ranged from 85 to 95% when the grass herbicides were applied alone compared to 23 to 80% when either applied with or following a pyrithiobac application. Pyrithiobac

provided no barnyardgrass control at any evaluation date. The trend for less control with clethodim, sethoxydim, and fluazifop applied either in combination or following a pyrithiobac treatment was evident at 21 and 28 DAT. One hundred percent barnyardgrass control was achieved with all grass herbicides when applied alone. The greatest antagonism occurred when fluazifop was applied in combination with pyrithiobac, resulting in only 14% control. Control improved to 86% when a fluazifop treatment followed the pyrithiobac treatment, which was still significantly lower than fluazifop applied alone.

Table. Johnsongrass control 1997.

Treatment	Rate	7 DAT * 1 May	15 DAT ** 9 May	21 DAT ** 15 May	28 DAT *** 22 May	35 DAT *** 29 May
	oz/A	%				
Pyrithiobac[a]	1	0	1	3	13	33
Clethodim[a]	2	18	20	34	64	83
Sethoxydim[b]	8	20	26	36	67	72
Fluazifop[c]	4	20	24	48	66	84
Pyrithiobac + clethodim[a]	1 + 1	10	10	9	24	48
Pyrithiobac + sethoxydim[b]	1 + 8	18	25	38	39	45
Pyrithiobac + fluazifop[c]	1 + 4	18	30	49	77	85
Pyrithiobac	1	0	20	60	88	91
B. clethodim[a]	2					
Pyrithiobac	1	0	24	58	74	79
B. sethoxydim[b]	5					
Pyrithiobac	1	0	21	48	79	89
B. fluazifop[c]	1					
Pyrithiobac + clethodim[a]	1 + 2	15	30	59	84	93
Clethodim[a]	2	20	26	58	78	91
Untreated[a]	-	0	0	0	14	23
LSD (0.05)	-	3.7	4.9	12.5	8.8	8.6
% CV	-	24.5	17.3	22.8	10.5	8.6

Note: All treatments had Agridex. Those with sethoxydim had Agridex at 1 qt/A, all others had 1% v/v.

[a]Treated with clethodim 2 oz/A + Agridex 1 % v/v following the 21 day evaluation.
[b]Treated with sethoxydim at 4 oz/A + Agridex 1 qt/A following the 21 day evaluation.
[c]Treated with fluazifop 4 oz/A + Agridex 1% v/v following the 21 day evaluation.

* Evaluated following the 1st application
** Evaluated following the 2nd application
*** Evaluated following the 3rd application

TOLERANCE OF GLYPHOSATE READY COTTON TO GLYPHOSATE ULTRA APPLIED TO VARIOUS GROWTH STAGES AND ITS EFFECT ON MORNINGGLORY. Ron Vargas[1], Steve Wright[2] and Tomé Martin-Duvall[1], Farm Advisor, Farm Advisor and Staff Research Associate, University of California Cooperative Extension, [1]Madera, CA 93637-5465 and [2]Visalia, CA 93291-4584.

Abstract. Cotton variety development and testing has entered into a new phase with the advent of biotechnology and transgenic varieties. Herbicide tolerant cotton (Roundup Ready and BXN) are becoming a reality across the US cotton belt, but are limited in California. Because of the One Quality Law regulated by CDFA through the San Joaquin Valley Cotton Board, transgenic herbicide tolerant cotton will not be available to San Joaquin Valley growers any sooner than the year 2000. Glyphosate tolerant cotton varieties will provide growers a weed management alternative to address problem weeds, but as this new technology becomes more available many questions and concerns are raised. Can existing herbicides be reduced or eliminated? Can cultivation be reduced? Can hand hoeing be eliminated and what impacts will this have on soil, water and air quality? And, will weed resistance or weed species shifts become an issue?

Field experiments were conducted in 1996 and 1997 to evaluate the tolerance of glyphosate tolerant cotton to Roundup Ultra when applied at various growth stages and to evaluate the efficacy of a glyphosate tolerant system for the control of ivyleaf morningglory. Effective season long ivyleaf morningglory was achieved when glyphosate was applied over the top of 2-node cotton at 1 lb/A, when ivyleaf morningglory was in the cotyledon to 4- to 6-leaf stages, followed by a 1 lb/A post directed glyphosate treatment (Table 1). A second 1 lb/A post directed treatment did not enhance control beyond one post directed treatment. Control was 86% at harvest, compared to the one early over the top glyphosate treatment at 63% control.

Early evaluations of cotton tolerance indicated no visual injury symptoms when glyphosate was applied over the top at all rates and growth stages (Table 2). Final plant mapping data did show a significant reduction of percent boll retention in the bottom five fruiting branches and in the 95% zone. Glyphosate applications at all rates (0.5, 0.75 and 1 lb/A) significantly reduced retention levels at the 6-, 9-, and 12-node stage when compared to treatments made at the 2-node stage. Seed cotton yields were significantly lower at all glyphosate rates applied at the 12-node stage, when compared to the single over the top applications at the 2-node stage. All other treatments produced numerically lower yields when compared to the 2-node stage application.

Table 1. Ivyleaf morningglory control and seed cotton yields.

Herbicide treatment	Control 28 DAT	35 DAT	54 DAT	94 DAT	At harvest	Yield
	%					lb/A
Glyphosate 1 lb (OT)	90	92	88	67	19	2988
Glyphosate 1 lb (OT) + 1 lb (PD)	100	100	100	96	80	3302
Glyphosate 1 lb (OT) + 1 lb (PD) + 1 lb (PD)	100	100	100	96	80	3407
Pyrithiobac sodium 1.2 oz (OT) + 1 lb (PD)	96	100	95	93	76	3106
Mean	-	-	-	-	-	3201
LSD 0.05	6	3	6	3	-	NS

OT - Over the top
PD - Post directed

Table 2. Glyphosate[a] tolerant seed yield.

Treatment	Rate	Growth stage	Yield
	lb/A		lb/A
1. UTC	-	-	3607 bc
2. Glyphosate	1	2 Node	4352 a
3. Glyphosate	1	2 Node	4032 ab
B. Glyphosate	0.5	6 Node	
4. Glyphosate	1	2 Node	4055 ab
B. Glyphosate	0.75	6 Node	
5. Glyphosate	1	2 Node	3745 ab
B. Glyphosate	1	6 Node	
6. Glyphosate	1	2 Node	4002 ab
B. Glyphosate	0.5	9 Node	
7. Glyphosate	1	2 Node	4153 ab
B. Glyphosate	0.75	9 Node	
8. Glyphosate	1	2 Node	3685 ab
B. Glyphosate	1	9 Node	
9. Glyphosate	1	2 Node	3555 bc
B. Glyphosate	0.5	12 Node	
10. Glyphosate	1	2 Node	3517 bc
B. Glyphosate	0.75	12 Node	
11. Glyphosate	1	2 Node	2912 c
B. Glyphosate	1	12 Node	
LSD 0.05			720.65

[a]Roundup Ultra.

TOLERANCE OF SIX COMMERCIAL MEDIC VARIETIES TO SELECTED HERBICIDES. Jerry J. Nachtman, Craig M. Alford, James M. Krall, and Steven D. Miller, Research Associate, Graduate Research Assistant, and Professors, Department of Plant Sciences, University of Wyoming, Laramie, WY 82070.

Abstract. Hard red winter wheat (HRWW) is the most commonly grown non-irrigated crop in eastern Wyoming. Approximately 80,940 ha of HRWW are grown annually in a wheat fallow system. The predominance of HRWW is due largely to climatic patterns of eastern Wyoming. The latitude (41 to 43 N) and altitude (1220 to 1830 m) combine to give a mean frost-free period of 128 days. Mean annual precipitation is 390 mm with 66% occurring between the months of April and August. The addition of annual medics to this system could increase soil fertility if used as a green manure or provide valuable livestock grazing. If the medics were allowed to remain until seed set it could become a self regenerating system. Previous studies indicate that several summer annual medics varieties: Sava (*M. scutellata*), Paraponto (*M. rugosa*), Black (*M. lupulina*), Orion (*M. schaerocarpos*), Santiago (*M. polymorpha*) and Caliph (*M. truncatula*) will produce forage and set seed in this climate. Weeds often became a problem. If the medics are going to be adapted to this system herbicides may be necessary. Greenhouse studies were undertaken to evaluate the tolerance of these medic species to fourteen herbicide treatments. The treatments were imazethapyr and bentazon, both alone and in combinations at various rates, and the sodium salt of MCPA at two rates plus a check. Based on statistical analysis Caliph and Paraponto exhibited more tolerance for all herbicide treatments than the other varieties. Imazethapyr at the three rates applied (36, 53 and 72 g/ha) showed the least injury to all medics in general.

FORAGE QUALITY AND PRODUCTION OF ANNUAL LEGUMES INTER-CROPPED WITH IRRIGATED CORN. C. M. Alford, W. Cecil, J. M. Krall, and S. D. Miller, Graduate student, Student, and Professors, Department of Plant Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Annual medics (*Medicago spp.*) have been used with good success in inter-cropping/fallow farming systems in Australia. We reported in previous studies that several medic species might be suited to an inter-cropping system with corn. However, no data is available on the forage yield and quality of these medics in this inter-cropped situation. Experiments were conducted at Torrington, and Huntley, WY, under sprinkler irrigation in 1996, to determine medic forage yield and quality when inter-cropped with irrigated corn. Plots were 3.05 by 6.10 m with four replications in a RCB design. Eight legume species were evaluated with corn. Forage samples were taken at mid-season and again just after corn harvest, using a 0.3 by1 m quadrant. After drying, the samples were tested for forage quality by determining neutral detergent fiber (NDF), acid detergent fiber (ADF), and crude protein (CP). The relative feed value (RFV) was calculated using the University of Wisconsin equation. There were significant differences in medic production between locations, species, and harvest time. At mid-season *Medicago truncatula* yielded 2.05 Mg/ha which was 81% better than *Medicago lupulina*. After corn harvest *Medicago sphacrocarpus* produced 0.92 Mg/ha, 60% better than *Medicago sativa*. There were differences in CP and RFV between mid-season and harvest. CP was 41% higher at midseason, while RFV was 45% higher. *Medicago lupulina* had the highest CP content at 19.1% while *Medicago scutallata* was lowest at 14.7%. RFV for *Medicago lupulina* and *Medicago scutallata* was 121.8 and 77.1, respectively.

ANNUAL GRASS AND BROADLEAF WEED CONTROL IN DRY BEANS WITH DIMETHENAMID ALONE OR IN COMBINATION. C. K. Owen, R. N. Arnold, and E. J. Gregory, Research Assistant, Pest Management Specialist, and Professor, New Mexico State University Agricultural Science Center at Farmington, Farmington, NM 87499.

Abstract. Approximately 97% of New Mexico's pinto bean production occurs in northwestern New Mexico. Most of this production occurs under sprinkler irrigation. Pinto bean growers usually preplant incorporate one or two herbicides in combination and then follow with one mechanical cultivation for annual weed control. Weeds

compete vigorously with dry beans and yield reductions exceeding 70% have been recorded. A field experiment was conducted in 1997 at Farmington, NM to evaluate the response of pinto beans (var. Bill Z), annual grass and broadleaf weeds to dimethenamid applied alone or in combination. Individual treatments were applied with a compressed air backpack sprayer calibrated to deliver 30 gpa at 30 psi. Preplant incorporated treatments were applied May 19 and immediately incorporated to a depth of 2 to 4 inches using a tractor driven rototiller. Preemergence treatments were applied May 20 and immediately incorporated with 0.75 inch of sprinkler applied water. Postemergence treatments were applied June 23 when the bean plants were in the third trifoliolate leaf stage and weeds were small. Black nightshade infestations were heavy and redroot and prostrate pigweed, barnyardgrass and green foxtail infestations were moderate throughout the experimental area. Preplant incorporated and preemergence treatments were evaluated visually on June 19. Postemergence treatments were evaluated visually on July 23. Beans were harvested on September 4. No crop injury was observed in any of the treatments. Annual grass control was excellent with all treatments except postemergence treatments of dimethenamid plus imazethapyr plus bentazon and imazethapyr plus bentazon and the check. Sethoxydim plus dimethenamid plus bentazon applied postemergence gave poor control of broadleaf weeds. A trend was noticed that all postemergence treatments did not control broadleaf weeds was well as treatments applied preplant incorporated, preplant incorporated followed by preemergence or preemergence followed by postemergence. Yields were 3229 lb/A higher in the herbicide treated plots as compared to the check.

EDIBLE DRY BEAN RESPONSE TO CHLOROACETAMIDE HERBICIDES AND INCORPORATION METHOD. Thomas McDaniel[1], Gus Foster[2], Jill Schroeder[1], Patrick Miller[3], Kirk Howatt[3], and Casey McDaniel[2]. Undergraduate Student, BASF Field Biologist, Associate Professor, Graduate Research Assistant, Graduate Research Assistant, BASF AgSales, [1]New Mexico State University, Las Cruces NM 88003; [2]BASF Corporation, Fort Collins, CO 80524; and [3]Colorado State University, Fort Collins, CO 80523.

Abstract. Success in producing dry edible beans depends on effective weed control. Chloroacetamide herbicides, dimethenamid and metolachlor, are used to control broadleaf and grass weeds in this system. Successful weed control with minimal crop damage from these herbicides depends on timing of application and depth of herbicide placement. Therefore, two studies were conducted in 1996 and 1997 to evaluate dry bean tolerance to dimethenamid and metolachlor applied at 1X and 2X rates both preplant incorporated and pre-emergence at different incorporation depths. Treatments included two application timings, PPI or PRE, in relation to planting and three depths of incorporation; no incorporation ('surface'), incorporation to a 0.5 or 0.25 inch depth (PPI or PRE, respectively, 'surface scratch') with a rotary hoe in 1996 and a dragtooth harrow (PPI) or rolling basket (PRE) in 1997, and incorporation to a 1.5 or 0.5 inch depth with Triple K or a drag-toothed harrow for the PPI or PRE treatment, respectively ('aggressive'). Weed control and crop safety were expected to be greatest with shallow incorporation (surface scratch) of these herbicides if the dry beans were planted under conditions of adequate soil moisture and delayed irrigation.

The pinto beans (Bill Z variety) were planted at a depth of 1.5 inches on July 8, 1996 and June 25, 1997. On July 8 and 9, 1996, the experimental area received 0.5 inch of rainfall after treatments were applied. In 1997, the first rainfall occurred 10 days after application. At the unifoliate stage of growth, the number of bean plants per meter of row were counted in three sections of each of the two middle rows. Weed control was evaluated 4 and 6 weeks after planting. Plants were harvested after an early frost in September 1996 and October 1997 and pod yields obtained. Yields for the PPI experiment in 1996 and PRE experiment in 1997 were not obtained due to a heavy bindweed infestation and planting error, respectively. The results in 1996 were contrary to what was expected. The rainfall immediately after treatment in 1996 may have moved the herbicides into the soil profile decreasing the differences among incorporation treatments and increasing crop injury from surface and surface scratch treatments.

Control of barnyardgrass, green foxtail and redroot pigweed was very good to excellent for all herbicide and tillage treatments in the PPI experiment for both 1996 and 1997. In 1997, early rainfall did not affect the experiment. In the PPI experiment the aggressive herbicide incorporation reduced dry bean yields compared to the other two incorporation methods. In the PRE experiment, dry beans were not injured by either herbicide regardless of incorporation method. Herbicides incorporated by the surface scratch method provided the most consistent weed control through the season.

SOLID-SEEDED VERSUS ROW-PLANTED GLYPHOSATE-RESISTANT SOYBEANS. Phillip W. Stahlman[1], Mark M. Claassen[2], Larry D. Maddux[2], Barney Gordon[2], Dallas E. Peterson[3], and Gerald W. Warmann[4], [1]Research Weed Scientist, KSU Agricultural Research Center-Hays, Hays, KS 67601; [2]Research Agronomists and [3]Extension Weed Specialist, Department of Agronomy, Kansas State University, Manhattan, KS 66506; and [4]Extension Agricultural Economist, South Central Area Research and Extension, Hutchinson, KS 67501.

Abstract. Field experiments were conducted at five locations in Kansas in 1997 to evaluate timings and rates of glyphosate application in solid-seeded versus row-planted soybeans compared with conventional soybean production. Results varied by location and weed species. Sequential applications of glyphosate resulted in better late-season control of most weed species than single glyphosate applications, especially in row-planted soybeans. The optimum glyphosate rate in most experiments was 0.75 lb/A; control of velvetleaf especially was marginal at 0.5 lb/A. Weed control by single applications of glyphosate at 0.75 lb/A or more in row-planted soybeans, when weeds were either 2 to 3 or 5 to 6 inches tall, was satisfactory only when no weeds emerged following herbicide application. Weed control and crop yields for sequential glyphosate treatments were equal to or better than for competitive standard herbicide treatments.

COMBINE DISPERSAL OF JOINTED GOATGRASS. Kim Hemmesch, Steven S. Seefeldt, and Joseph P. Yenish, Graduate Research Assistant, Department of Crop and Soil Sciences, Washington State University, Agronomist, USDA/ARS, and Extension Weed Scientist, Department of Crop and Soil Sciences, Washington State University, Pullman, WA 99164-6420.

Abstract. Jointed goatgrass has greatly increased its area of infestation within winter wheat production regions of the Pacific Northwest and Great Plains. Once a jointed goatgrass plant has established in a field, it only takes a few years for a patch of jointed goatgrass to develop. The patch of jointed goatgrass will have come from shattering and other dispersal mechanisms. One mechanism of dispersal which may provide for a rapid increase in the distribution of jointed goatgrass is the combine. An investigation of the distribution of jointed goatgrass spikelets by a combine was conducted at the Palouse Conservation Farm Station near Pullman, WA using fluorescent paint and an ultraviolet light. Nine to 45% of painted jointed goatgrass spikelets were recovered in an area 10 to 30 times larger than the original jointed goatgrass infestation. These results suggest that combines have an impact in the distribution and development of jointed goatgrass patches.

JOINTED GOATGRASS CROSSES WITH A HERBICIDE-RESISTANT WHEAT TO PRODUCE HERBICIDE-RESISTANT HYBRIDS. Steven S. Seefeldt[1], Kim Hemmesch[2], Frank Young[1], Stephen S. Jones[2], and Xiwen Cai[2], Agronomist, Graduate Research Assistant, Agronomist, Assistant Professor, and Graduate Research Assistant, [1]UDSA/ARS, Land Management and Water Quality Unit, Pullman, WA, 99164 and [2]Department of Crop and Soil Sciences, Washington State University, Pullman, WA 99164.

Abstract. Jointed goatgrass, is a serious winter annual grass weed problem in winter wheat in the western United States. Because jointed goatgrass is genetically related to wheat (sharing the D genome), there are no selective herbicides to control jointed goatgrass in winter wheat. Recently, a soft red winter wheat was mutagenized and resistance to imazamox, an imidazolinone graminicide, selected from the population (cv. Fidel). During the 1995 to 1996 growing season, jointed goatgrass pollen fertilized some Fidel wheat plants in herbicide evaluation trials. The next year seed from the 1995 to 1996 experiment was replanted and two hybrid plants were discovered in plots where the two highest rates (0.048 and 0.063 lb/A) of imazamox was applied. These rates killed all jointed goatgrass in the plots where they were applied, but had no effect on the Fidel wheat. About 2% of the florets from these hybrids had viable seed (4 from one plant and 3 from the other); resulting seedlings were resistant to 0.064 lb/A imazamox in a greenhouse spray trial. Hybrids contained 37 to 53 chromosomes (wheat = 42 and

jointed goatgrass = 28). This rapid transfer of a resistance trait from wheat to jointed goatgrass necessitates the development of a resistance management strategy before this technology becomes widely used. More seed from the 1995 to 1996 experiment has been planted and will be sprayed with 0.063 lb/A imazamox to determine the incidence of outcrossing and to provide more seed to conduct further studies.

INFLUENCE OF FERTILIZER PLACEMENT ON JOINTED GOATGRASS COMPETITION IN WINTER WHEAT. Abdel O. Mesbah and Stephen D. Miller, Post Doctoral Research Associate and Professor, Department of Plant Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. A 3-year study was conducted in 1995, 1996, and 1997 under dryland conditions at the Research and Extension Center, Archer, Wyoming to evaluate the effect of fertilizer placement on jointed goatgrass competitiveness with winter wheat. Jointed goatgrass joints were seeded at the rate of 70 viable seed/m^2 one week prior to planting winter wheat. Fertilizer placement treatments consisted of applying 40 lb/A of nitrogen (50% as urea and 50% as ammonium nitrate) in a deep band 2 inches below and 1 inch to the side of the wheat row, broadcasting on the soil surface or spoke wheel injecting fertilizer 4 inches deep and 2 inches to the side of the wheat row. Jointed goatgrass populations were generally not influenced by fertilizer placement; however, spikes/plant, joints/spike, height, biomass production and dockage were highest in the broadcast fertilizer treatment. The presence of jointed goatgrass decreased winter wheat spikes/plant, seed/spike, 200 seed weight, yield, plant height and biomass with all fertilizer placement treatments. Compared to the spoke wheel or deep band treatments, winter wheat was less competitive with jointed goatgrass in the broadcast treatment.

EFFECTS OF FALL POST-PLANT, SPRING, AND FLOWER-STAGE TREATMENTS OF SULFOSULFURON ON JOINTED GOATGRASS. Caleb D. Dalley, John O. Evans, and R. William Mace, Graduate Research Assistant, Professor, and Research Technician, Department of Plant, Soils, and Biometerology, Utah State University, Logan, UT 84322-4820.

INTRODUCTION

Jointed goatgrass, one of the worst weeds to infest dryland winter wheat fields in the West, is estimated to infest nearly 5 million acres of farmland, and costs producers over $145 million annually in lost crop yield, decreased crop value, increased control costs, and reduced farm value (Ogg 1993). While most jointed goatgrass seeds will germinate within 3 years, a residual amount remains in the soil 5 years or more (Donald 1991). Genetic similarities between jointed goatgrass and wheat make selective herbicide control difficult. Sulfosulfuron, currently registered under the trade name Maverick®, has been tested for selective weed control in winter wheat. Unlike most sulfonylurea herbicides, sulfosulfuron controls grass weeds better than broadleaf weeds (Geier, and Stahlman 1996). This study was designed to measure sulfosulfuron's effects on jointed goatgrass control and its seed development when applied at various plant growth stages.

MATERIALS AND METHODS

A wheat field severely infested with jointed goatgrass was selected in Box Elder County, Utah. Treatments were applied in a randomized block design with three replications. In the 1995 to 1996 season, MON 37532 (a formulation of sulfosulfuron) was applied at three rates (18, 26, and 35 g ha^{-1}), at three stages (two fall application--PRE and POST, and a spring application). Spraybooster surfactant at 0.5% v/v was used in the spring application. In 1996 to 1997, MON 37536 (another sulfosulfuron formulation) was applied at two rates (9 and 18 g ha-1), at three stages (one fall, one spring, and one at flowering). A non-ionic surfactant at 0.25% v/v was used in all POST applications. Plots were harvested with a combine with a 1.5 m header. Jointed goatgrass samples were collected randomly from plots. Spikelets were germinated in Parafilm® sealed petri-dishes. Seeds were removed from spikelets for counting, visual inspection, and weight measurements. Spikelets were separated and analyzed separately according to position on the spike for seed weight and germination. Apical spikelets refer to the uppermost two spikelets on the spike. Basal spiklets refers to the bottom two spikelets. Medial spikelets are a grouping of all spikelets not apical or basal. These comparisons show differences in both germination and seed weight, and were necessary in showing differences in degree of injury due to position on the spike.

RESULTS

MON 37532 caused no visual damage to wheat or jointed goatgrass in 1996. However, jointed goatgrass germination, seed weights, and number of seeds per spikelet in spring applications were somewhat decreased (Table 1). Although these results were not conclusive, the revealed that MON 37532 had some herbicidal effects of jointed goatgrass seed dynamics.

Table 1. Comparisons of percent germination, seed weight, and seeds per spikelet for different treatment rates of MON 37532 during spring of the1996 to 1997 growing season.

Treatments	Germination	Spikelet weight	Seeds per spikelet
	— % —	— mg —	— No. seeds —
Control	93.3a	2.90a	1.39a
18 g ha^{-1}	57.3b	2.69a	1.17a
26 g ha^{-1}	58.7b	2.36ab	0.78b
35 g ha^{-1}	40b	1.69b	0.74b

All treatments were analyzed using ANOVAand Tukey's Test for statistical differences.

In 1997, jointed goatgrass treated with MON 37536 during flowering showed visual signs of herbicide damage. At harvest, jointed goatgrass in these treatments were brown, while all other treatments were straw-colored. Flower-stage treated plants had stiff, non-disarticulating spikes requiring considerable force to break into individual spikelets. Germination of spikelets showed no significant decreases from controls in fall, or spring herbicide treatments. However, sulfosulfuron dramatically reduced germination when applied at flower-stage (Figure 1).

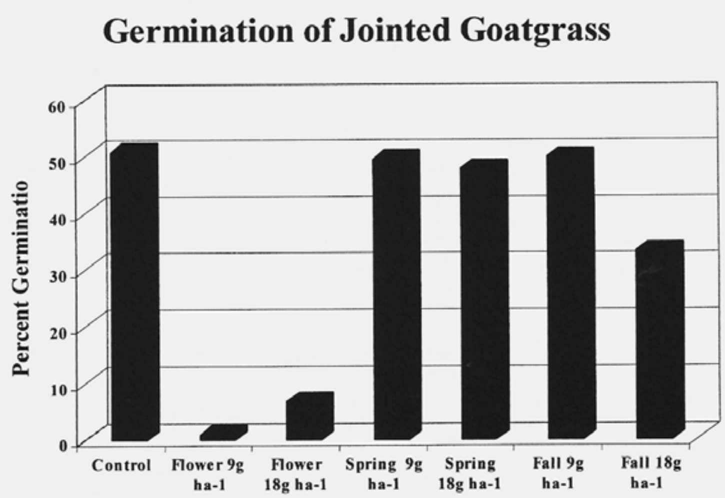

Figure 1. Germination rates for jointed goatgrass spikelets when MON 37536 was applied at fall, spring, and during flower-stage. Germination rate was reduced from 50.7% in controls to 0.86 and 6.67% for flower stage treatments of 9 and 18 g ha^{-1} respectively.

Inspection of seeds also showed a dramatic decrease in size, and weight of flower-stage treated jointed goatgrass (Figure 2 and Table 2) plants that was not evident when the weed was treated in the fall or early spring. Germination reduction and seed weight loss were independent of herbicide application dosage. There was no increased herbicidal effect at higher application rates during flower-stage.

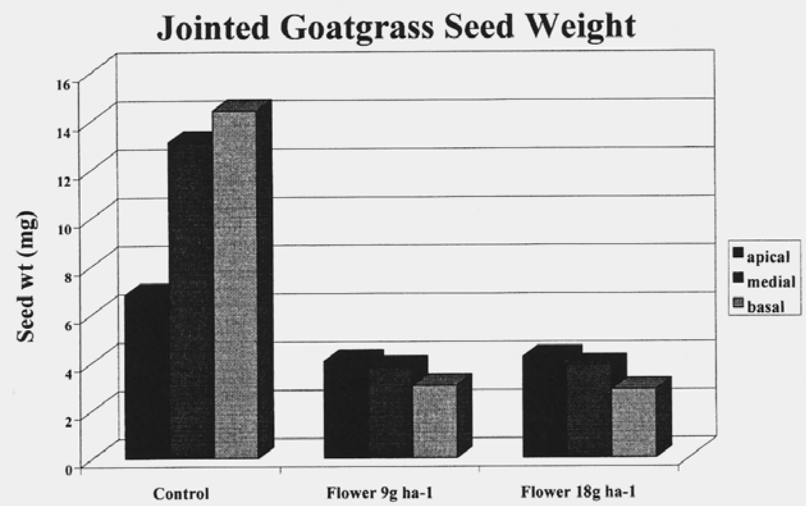

Figure 2. Caryopsis weights were dramatically reduced when MON 37536 was applied to flowering jointed goatgrass. Weights were most reduced for medial and basal seeds.

Table 2. Jointed goatgrass seed weight, germination, and wheat yield at different rates and timings for application of MON 37536.

	Jointed goatgrass seed wt			Jointed goatgrass spikelet germination						Wheat yield
	Apical	Medial	Basal	Apical	Sub-apical	Medial	Pro-basal	Basal	Average	
	mg			%						Bu/acre
Control	6.79a	13.1a	14.4a	40a	41.7a	72.5a	25b	30a	50.7a	32.2a
Flower 9g ha^{-1}	4.02a	3.83b	3.01b	18.3a	8.3a	0b	0a	1.67b	0.86b	30.6a
Flower 18 g ha^{-1}	4.19a	3.83b	2.83b	25a	13.3a	0b	0a	1.67b	6.67b	28.8a
Spring 9g ha^{-1}	--	--	--	45a	26.7a	70a	46.7b	38.3a	49.4a	15.4a
Spring 18 g ha^{-1}	--	--	--	28.3a	13.3a	52.5a	65b	58.3a	47.8a	29.1a
Fall 9 g ha^{-1}	--	--	--	31.7a	26.7a	65a	50b	51.7a	49.7a	24.3a
Fall 18 g ha^{-1}	--	--	--	31.7a	16.7a	43.3a	43.3b	28.3a	33.1a	52.8a

All treatments were analyzed using ANOVA and Tukeys Multiple Comparison Test for statistical differences.

CONCLUSIONS

Although jointed goatgrass plants were not satisfactorily controlled in winter wheat by any of the sulfosulfuron applications, the decreased levels of seed development, and lowered germination resulting from flower-stage applications of sulfosulfuron could result in lowered weed pressures in following years. Soil seedbank levels were not measured as part of this experiment, but the results imply that the use of sulfosulfuron on flowering jointed goatgrass plants would reduce levels of viable seed in the soil. Lowering viable seed production would be important in reducing future infestations of jointed goatgrass. Application of herbicides to flowering jointed goatgrass would likely be useful only in areas of extreme infestation, such as field borders due to physical impact of application to the growing wheat, and the cost of application. More research into the long-term effects of flower-stage applied sulfosulfuron on the soil seedbank should be pursued.

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PREHARVEST GLYPHOSATE TREATMENTS AND SEED QUALITY OF WHEAT. Joseph P. Yenish and Nichole A. Eaton, Assistant Professor and Agricultural Research Technologist, Department of Crop and Soil Sciences, Washington State University, Pullman, WA 99164.

Abstract. In 1996, several growers in eastern Washington reported poor stand establishment of soft white spring wheat, particularly with the variety Alpowa. Interviews with seed producers lead to suspicions that some fields of seed wheat had received a preharvest application of glyphosate to desiccate late maturing tillers even though this use is off-label. Glyphosate is labeled for use as a harvest aid treatment in winter and spring wheat, but not wheat to be used for seed. Typically, seed from late maturing tillers are not fully developed at harvest and lessen the quality of seed lots. Glyphosate residues, within tolerance levels for food use, have been reported in wheat grain following preharvest applications. However, it is not clear if residues of glyphosate interfere with wheat seed germination and plant development.

In 1996, glyphosate rates of 0.625 and 0.841 kg ha^{-1} were applied to Alpowa and Pennewawa varieties of soft white spring wheat at the milk, soft dough, and hard dough stages of maturity. Additional treatments at the same rates were applied 7 d following the application at the hard dough stage and 1 d prior to mechanical harvest of the wheat. Grain yield, thousand-kernel weights, germination percentage, and coleoptile length 7 d following germination were evaluated. In the spring of 1997, seed harvested from the plots treated in 1996 were planted in the field. Seedling establishment and height were measured approximately 3 wk after planting. Grain yield was measured from these plots in August of 1997.

Glyphosate applied during the milk stage of wheat development was the only treatment timing which affected any of the parameters measured. Milk stage applications of glyphosate resulted in reduced yield, kernel weight, and seed harvest in the year of treatment. When these seed were planted in the field the following year, seedling establishment was reduced for seed originating from plots treated at the milk stage during the previous growing season. Grain yield was also less for these treatments due to the severely reduced stand. Reduction in seed quality and seedling establishment of the planted seed were more likely due to killing the wheat prior to maturity rather than glyphosate residues in the seed. There is no evidence in this study to indicate glyphosate residues from preharvest applications, either on the surface of the seed or incorporated into the seed, had any effect on seed or subsequent seedling quality.

WINTER WHEAT VARIETY RESPONSE TO HERBICIDE TREATMENTS AT THREE APPLICATION TIMINGS. Tim D'Amato, J. Johnson, and P. Westra, Graduate Student and Professor, Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523.

Abstract. Field studies were undertaken from 1993 to 1996 at the USDA-ARS Central Great Plains Research Station near Akron, Colorado to assess tolerance of five winter wheat varieties to herbicide treatments applied at three different spring timings. Dicamba was applied at 0.14, 2,4-D at 0.42, and metsulfuron at 0.004 kg/ha in 121 L/ha of spray solution. All herbicides were applied alone and in combination for seven treatments. The seven herbicide treatments were applied at three timings: dormancy break, full tiller, and jointing, totaling 21 treatments. Wheat varieties were evaluated for visual injury symptoms and wheat yield was measured each of the three years the study was conducted. Visual injury in the form of spraddling, or matting, occurred from treatments containing dicamba. Visual injury symptoms did not translate directly to yield loss. Application timing was not a factor in yield reduction. No wheat variety stood out as more sensitive to treatment than another. All herbicide treatments affected wheat yield regardless of application timing or wheat variety.

SMALL GRAIN CULTIVAR RESPONSE TO TRIFLURALIN GRANULES. Gregory J. Endres, Michael D. Peel, and Todd C. Geselius, Area Extension Specialist/Cropping Systems, Extension Agronomist, and Herbicide Development Specialist, Carrington Research Extension Center, Carrington, ND 58421; Department of Plant Sciences, North Dakota State University, Fargo, ND 58105; and Herbicide Development Specialist, Dow AgroSciences, Fargo, ND 58104.

Abstract. Numerous hard red spring (HRS) and durum wheat, and barley cultivars have been recently released in the Northern Great Plains. Tolerance of PPI trifluralin granules has not been documented with many of these new small grain cultivars. A trial was established at Carrington and Prosper, ND in 1997 to determine tolerance of small grain cultivars to spring-applied PPI trifluralin granules. PPI trifluralin granules were applied at 0.4 and 0.8 lb/A on May 15 and 16 and the small grain planted May 22. Cultivars tested were 2375, AC Barrie, AC Cora, Butte 86, Gunner, Hamer, Keene, Kulm, Lars, Oxen, Russ, Trenton, and Verde HRS wheat; Belzer, Ben, Munich, and Renville durum; and Foster, Robust, and Stander barley. At Carrington, Butte 86 had the highest injury (6%) among cultivars with trifluralin at 0.4 lb/A. Butte 86 and Verde had 19% injury with trifluralin at 0.8 lb/A. Other cultivars with 10% or more injury with trifluralin applied at the high rate include 2375, Hamer, Keene, Kulm, Lars, and Stander. However, cultivars did not differ in their response to the trifluralin treatments as measured by plant and head density, plant height, grain yield, and test weight. A combination of dry topsoil at granule application time and lack of substantial rainfall after trifluralin application may have slowed herbicide release and likely reduced injury during crop germination and emergence. At Prosper, generally all cultivars were injured with trifluralin when evaluated at the 1.5- to 2-leaf stage. Stand density was reduced 29 to 53% except with Foster, and visual injury indicated 14 to 44% stand reduction with trifluralin at 0.4 lb/A compared to the untreated check. Cultivars with > 50% stand reduction included Butte 86 and Munich. While substantial injury from trifluralin was evident at Prosper, grain yield was reduced 20 to 34% only with the HRS wheat varieties 2375, AC Barrie, Butte 86, and Kulm. AC Barrie and Kulm yield was reduced 20 to 27% at 0.4 lb/A trifluralin.

THE INFLUENCE OF F-8426 AND ADDITIVES ON WEED CONTROL IN WINTER WHEAT. Stephen M. Van Vleet, Stephen D. Miller, and David E. Legg, Research Associate and Professor, Department of Plant Sciences, and Professor, Department of Natural Resources, University of Wyoming, Laramie, WY 82071.

Abstract. Weed control response in hard red winter wheat to F-8426, (proposed common name=carfentrazone-ethyl) and several additives in a dryland system was studied. The dryland experiment was located at the Research and Extension Center, Archer, WY. Wheat was analyzed based on weed control, number tillers, number leaves,

height, heads/meter, 200 seed weight, test weight, protein and yield. Treatments were applied during the early spring or at mid-spring. Additives to F-8426 included 2,4-D ester, 28-0-0 nitrogen, surfactant (NIS), and a safener (ACA). Differences were not observed in number tillers, number leaves, height, heads/meter, 200 seed weight, test weight, protein or yield. Differences were observed in the amount of visual injury and weed control. Mid-spring treatments had significantly more injury than early spring treatments. Additives of nitrogen or surfactant significantly increased injury in some mid-spring treatments. F-8426 alone provided better control than F-8426 with nitrogen or surfactant for the early spring treatments. Mid-spring treatments of F-8426 with nitrogen and F-8426 with surfactant provided more control when compared to the early spring treatments. Application of F-8426 with additives in mid-spring was shown to cause slightly more injury but also provided better weed control.

EFFECT OF APPLICATION TIME, CARRIER pH, CARRIER VOLUME AND RATE ON TRALKOXYDIM ACTIVITY ON WILD OAT (*AVENA FATUA* L.). K. J. Kirkland[1], F. A. Holm[2], and E. N. Johnson[1], Weed Scientist, Professor, and Soil and Crop Specialist, [1]Agriculture and Agri-Food Canada, Scott, Sakatchewan, Canada, S0K 4A0 and [2]Crop Science Department, University of Saskatchewan, Saskatoon, Saskatchewan, Canada, S7N 5A8.

Abstract. Field studies were conducted from 1994 to 1997 at the Agriculture and Agri-Food Canada Research Farm, Scott, Saskatchewan and Crop Science Dept., University of Saskatchewan, Saskatoon, Saskatchewan. Tralkoxydim was applied to wild oat in hard red spring wheat (*Triticum aestivum*) at two application times, 11:00 a.m. and 9:00 p.m.; two carrier pH levels, 8 and 4; three water volumes; 100, 50 and 30 L/ha and four rates; 100, 75, 50 and 25% of recommended (200 g/ha). Wild oat populations were heavy at Saskatoon in 1994 and 1995 and light to moderate in 1996 and 1997 and light to moderate at Scott in all years. At Scott, 9:00 p.m. application compared to 11:00 a.m. reduced wild oat biomass significantly in all years with reductions ranging from 26 to 80%. This suggests that the high intensity of UV light present at midday may reduce the effectiveness of tralkoxydim. Reducing carrier pH from 8 to 4 produced reductions in wild oat biomass in 3 of 4 years with reductions ranging from 40 to 76%. The interaction, time X carrier pH was significant for wild oat biomass in all years and wheat yields in one year. Late evening application combined with reduced carrier pH was the most effective. At Saskatoon, time of application and carrier pH had no influence on wild oat biomass or wheat yields although trends toward a reduction in total biomass with reduced carrier pH were noted in all years. Reduced carrier volume decreased efficacy in 7 of 8 site years and was particularly evident when carrier volume was reduced to 30 L/ha. Wheat yields declined 9 and 14% at Scott and Saskatoon, respectively when tralkoxydim carrier volume was reduced from 100 to 30 L/ha. Reducing the tralkoxydim rate to 75% of recommended had no effect on wild oat biomass in 7 of 8 site years. Further reductions to 50 or 25% of recommended resulted in significant increases in wild oat biomass and reductions in wheat yields.

SOLUTION VOLUME EFFECT ON WILD OAT CONTROL WITH IMAZAMETHABENZ AND DIFENZOQUAT. Joan M. Campbell and Donald C. Thill, Research Associate and Professor, Plant Science Division, University of Idaho, Moscow, ID 83844-2339.

Abstract. The effect of imazamethabenz and difenzoquat applied at four spray solution volumes for wild oat control and spring barley yield was examined in an experiment in Idaho in 1996 and 1997. The experimental design was a split-block with four replications. Main plots were two densities of wild oat (100 and 300 plants/m^2) and sub-plots were a factorial arrangement of herbicide treatment and spray solution volume. Herbicide treatments were imazamethabenz at 0.41 kg/ha, imazamethabenz at 0.53 kg/ha, and imazamethabenz at 0.235 kg/ha + difenzoquat at 0.56 kg/ha. An untreated control was included for comparison. Wild oat and spring barley were seeded perpendicular to each other with a 2.4 m wide double-disk drill. Herbicide treatments were applied with a CO_2 pressurized backpack sprayer calibrated to deliver 47, 94, 140, and 187 L/ha. Wild oat control was evaluated visually and barley grain was harvested at maturity.

In 1996, all herbicide treatments at all spray solution volumes, except imazamethabenz at 0.41 kg/ha at 47 L/ha, controlled wild oat 66 to 81%. Wild oat control averaged over herbicide treatments was better with all spray solution volumes higher than 47 L/ha. Imazamethabenz at 0.41 kg/ha did not control wild oat as well as the other two treatments, especially at low spray solution volume. Barley grain yield was best when herbicides were applied at 187 L/ha spray solution volume. Barley grain yield was 3333 kg/ha for 100 wild oat plants/m^2 and 3688 kg/ha for 300 wild oat plants/m^2 when averaged over herbicide treatment and spray solution volume.

In 1997, all herbicide treatments at all spray solution volumes controlled wild oat 71 to 95% regardless of wild oat density. Wild oat control averaged over herbicide treatments tended to be higher with 140 and 187 L/ha compared to 47 and 94 L/ha. Wild oat control averaged over spray solution volume was 83, 89, and 93% with imazamethabenz at 0.41 kg/ha, imazamethabenz at 0.53 kg/ha, and imazamethabenz plus difenzoquat, respectively. Barley grain yield was 5321 kg/ha for 100 wild oat plants/m^2 and 4679 kg/ha for 300 wild oat plants/m^2 when averaged over herbicide treatment and spray solution volume. This corresponded to 85 and 91% control for 100 and 300 wild oat plants/m^2, respectively, however, wild oat control was not significantly different. Herbicide treatment and spray solution volume did not affect barley grain yield.

DOSE RESPONSE AND CROSS RESISTANCE STUDIES OF DICAMBA-RESISTANT KOCHIA.
Harwood J. Cranston, Anthony J. Kern, Erica K. Miller, Josette L. Hackett, and William E. Dyer, Graduate Research Assistants and Associate Professor, Department of Plant, Soil and Environmental Sciences, Montana State University, Bozeman, MT 59717-0312.

Abstract. Extensive use of the herbicide dicamba in small grain crops has selected for populations of dicamba-resistant kochia. Dose response studies indicate that resistant (R) plants are 5- to 10-fold more tolerant to dicamba treatment than susceptible (S) plants. Because dicamba is thought to be a growth-regulator (auxinic) type herbicide, cross resistance patterns to other auxinic herbicides were investigated. Five-cm tall greenhouse-grown R and S kochia seedlings were treated with 2,4-D, 2,4-DP, 2,4-DB, clopyralid, fluroxypyr, MCPA, picloram, and quinclorac at a range of treatment rates. R kochia were cross resistant to low and medium rates of picloram, 2,4-DB, and MCPA, but not to any other auxinic herbicide tested.

AUXIN-BINDING PROTEINS FROM SUSCEPTIBLE AND DICAMBA-RESISTANT KOCHIA ACCESSIONS.
Tracy M. Sterling[1], William E. Dyer[2], Marta E. Chaverra[2], John K. Pepelnjak[2], and Robert P. Sabba[3], [1]Associate Professor, New Mexico State University, Las Cruces, NM 88003; [2]Associate Professor, Research Technician, and Undergraduate, Montana State University, Bozeman, MT 59717; and [3]Research Associate, USDA-ARS, Stoneville, MS 38776.

Abstract. Kochia is an invasive broadleaf weed that infests millions of hectares of cropland and rangeland in the Great Plains and intermountain western U.S. and Canada. In 1995, populations of kochia *(Kochia scoparia* L. Schrad) resistant (R) to the auxinic herbicide dicamba were discovered in a corn field in Nebraska and around the Fort Benton area in Montana. Our previous research showed that dicamba resistance in Montana accessions could not be attributed to altered herbicide absorption, translocation, or metabolism. Therefore, a purification procedure was optimized to isolate and assay auxin binding proteins (ABPs) from kochia, receptors which may play a role in herbicide binding and therefore resistance. Meristematic regions of dicamba-resistant and susceptible (S) kochia plants were collected and proteins extracted in buffer containing PVPP and DTT in a 6:1 buffer:tissue ratio. Following an initial centrifugation, the resulting supernatant was ultracentrifuged at 113,400 g to obtain microsomal fractions which were incubated with 0.2% Triton X-100 to release membrane proteins. The microsomal fraction was ultracentrifuged as before and the resulting solubilized membrane proteins loaded onto a picloram-Sepharose affinity column. This type of purification procedure represents the first affinity column of this type in which the

amino group of picloram is covalently attached to NHS-Sepharose, allowing the proposed active site of the herbicide (carboxylic acid group and pyridine nitrogen) to be exposed for protein binding. In contrast, many putative ABPs have been obtained using affinity chromatography in which indole-3-acetic acid (IAA) is covalently bound at its carboxylic acid group, a proposed critical site for physiologic activity. Bound proteins were eluted with 3.5M NaCl, concentrated using reverse dialysis (PEG concentration) and desalted using Sephadex G25 chromatography. The resulting affinity-purified samples contained two proteins of ca. 57 and 70 kDa as detected in silver-stained SDS-PAGE gels with protein recoveries of about 3 g protein per 180 g tissue fresh weight. Soluble and membrane-bound fractions were assayed for ^{3}H-IAA binding using an ultrafiltration procedure. Specific ligand binding to affinity-purified kochia fractions was obtained, thus providing a necessary prerequisite for comparison of high-affinity herbicide binding patterns in R and S kochia.

MULTIPLE AND CROSS-RESISTANCE OF DICLOFOP-RESISTANT *LOLIUM MULTIFLORUM* LAM. TO ACETOLACTATE SYNTHASE AND ACETYL-COA CARBOXYLASE-INHIBITING HERBICIDES.
Matthew D. Schuster, Carol A. Mallory-Smith, and Bill D. Brewster, Graduate Research Assistant, Assistant Professor, and Senior Instructor, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331-3002.

Abstract. Diclofop-resistant *Lolium multiflorum* Lam. populations were identified from Willamette Valley, Oregon wheat fields in 1987. Since then, some growers have used a pre-emergence treatment of chlorsulfuron-metsulfuron plus metribuzin. Inconsistent control of *L. multiflorum* with these herbicides was reported in 1996 winter wheat fields with confirmed diclofop-resistant *L. multiflorum*. In addition, similar observations were noted with sulfosulfuron. Greenhouse studies were conducted to determine whether known diclofop-resistant biotypes of *L. multiflorum* (Fast and DeJong) were cross-resistant to other acetyl-CoA carboxylase-inhibiting herbicides and if they were also resistant to the acetolactate synthase-inhibiting herbicides. The Fast biotype was 10 times more resistant to chlorsulfuron-metsulfuron than to sulfosulfuron. However, the DeJong biotype showed little resistance to the two sulfonylureas. Cross-resistance to fenoxaprop occurred for both resistant biotypes similar to that of diclofop. However, none of the biotypes were resistant to the cyclohexanediones, clethodim, and sethoxydim at any dose. Additional studies are now being conducted to determine if the biotypes are resistant to other sulfonylurea, aryloxyphenoxy propionate, and cyclohexanedione herbicides.

A NEW APPROACH FOR MODELING LONG TERM MULTI-SPECIES WEED POPULATION DYNAMICS. Stephen R. Canner[1], Lori J. Wiles[2], Claudio R. Dunan[3], and Robert H. Erskine[1], Research Associate, Plant Physiologist, Professor, and Biological Science Technician, [1]USDA-ARS, Great Plains Systems Research Unit, Fort Collins, CO 80522; [2]USDA-ARS, Water Management Unit, AERC, Colorado State University, Fort Collins, CO 80521; and [3]University of Lomas de Zamora, Buenos Aires, Argentina.

Abstract. GPFARM (Great Plains Framework for Agricultural Resource Management) is a computerized decision support system for whole-farm long-term strategic planning. In response to the requests of potential system users, a weed module was developed which simulates weed population variation over several years in response to crop rotation, tillage system, and specific weed management tactics. The model uses an innovative weed population dynamics structure which summarizes major weed demographic processes, including seed mortality, seedling emergence, herbicide and tillage based weed control, and density-dependent weed seed production. The model uses a small number of parameters, all of which can be readily derived from literature sources and regional surveys of weed experts. The model has been parameterized for 15 weeds and four crops. Validations of long-term weed population predictions have been successful for several weeds and crops, although complete testing is limited by the availability of long-term weed population data sets.

EFFECTS OF MOISTURE AND NUTRIENT STRESS ON PROTOCHLOROPHYLLIDE BIOSYNTHESIS IN CORN. W. Mack Thompson, Scott J. Nissen, and Claude G. Ross, Graduate Research Assistant, Assistant Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523 and Sr. Research Biologist, FMC Corp., Loveland, CO 80537.

Abstract. Protoporphyrinogen oxidase (PPO) inhibiting herbicides, such as carfentrazone-ethyl, inhibit chlorophyll biosynthesis and cause accumulation of protoporphyrin IX (ProtoIX). In the presence of light, ProtoIX produces oxygen free-radicals resulting in membrane disruption and plant death. Environmental stresses that affect rates of herbicide metabolism, chlorophyll biosynthesis, protoporphyrin degradation, or oxygen radical detoxification could alter the selectivity and activity of PPO inhibiting herbicides. The objective of this study was to determine the effects of moisture and nutrient stress on the chlorophyll biosynthesis pathway via measuring the rate of protochlorophyllide (Pchlide, precursor to chlorophyll) production.

Corn plants were grown in washed silica sand in 4 cm diameter by 21 cm tall cone-tainers. High nutrient treatments were watered with Hoagland's nutrient solution; low nutrient treatments received tap water. Moisture status was controlled by weighing cone-tainers then adding water or nutrient solution to achieve field capacity (FC) or 40% of FC. Plants (4-leaf stage) were placed in darkness and harvested at 0, 30, 60, and 120 minutes. At harvest the two youngest leaves from each plant were dipped in liquid nitrogen and stored at –20 C in the dark until extraction. Samples were homogenized and extracted in 9:1, methanol:10% 0.1N NH_4OH, followed by centrifugation. Pchlide was analyzed by HPLC coupled with fluorescence and diode array detection.

The majority of Pchlide was produced within 20 min after the plants were placed in darkness (Table). Nutrient status was a major influence on the production of Pchlide. Plants treated with nutrient solution produced 6 to 8 times the Pchlide of plants treated with tap water. Moisture stress did not affect Pchlide production in nutrient deficient plants, but was a significant factor in fertilized plants. High nutrient plants at 40% of FC produced more Pchlide per g fresh wt than high nutrient plants at FC. This could be an artifact due to fresh wt. The FC plants were heavier and may have been more hydrated, in effect reducing the amount of Pchlide on a per fresh weight basis. Nutrient stress was the major factor affecting Pchlide production and is probably due to lack of magnesium (for chlorophyllides) or lack of nitrogen for growth.

Table. The effects of nutrient and moisture stress on protochlorophyllide production in corn. High nutrient treatments were watered with Hoagland's nutrient solution; low nutrient treatments received tap water. Moisture status was controlled at field capacity (FC) and 40% of FC by weight.

Treatment	Fresh weight	Time (min) 0	20	60	120
	(g)	(nmol protochlorophyllide / g fresh wt)			
High nutr. / FC	1.86	1.21 (0.18)	3.70 (0.81)	4.03 (1.14)	6.29 (1.58)
High nutr. / 40% FC	0.71	0.99 (0.15)	5.89 (1.16)	6.15 (0.53)	7.90 (1.43)
Low nutr. / FC	1.02	0.16 (0.09)	0.39 (0.14)	0.63 (0.20)	1.22 (0.36)
Low nutr. / 40% FC	0.46	0.76 (0.10)	0.64 (0.45)	0.50 (0.20)	0.90 (0.31)

ABSORPTION AND TRANSLOCATION OF MON 37500 IN GRASS SPECIES AS AFFECTED BY TEMPERATURE AND SOIL MOISTURE. Brian L. S. Olson, Kassim Al-Khatib, and Phillip Stahlman, Graduate Student, Assistant Professor, and Professor, Kansas State University, Manhattan, KS 66506 and Shay Sunderland, Neal Hageman, Sharon Moran, and Scott Parish, Monsanto Co., St. Louis, MO 63198.

INTRODUCTION

Grass weed management in wheat fields across the country and around the world has been difficult due to the similarities of these weeds to wheat. Current herbicides are ineffective in controlling these weeds, while integrated weed management strategies have only had moderate success. Some of these species are downy brome, wild oat, and jointed goatgrass along with other Bromus species. A new herbicide, MON 37500, has shown great promise in controlling a majority of these weeds; however, unusual environmental conditions can cause the control of these weeds to vary. Therefore, research is needed to evaluate the effect of temperature and moisture on absorption and translocation MON 37500. The objective of this study was to evaluate the effect of temperature and moisture on the absorption and translocation of MON 37500 in wheat, jointed goatgrass, wild oat, and downy brome.

MATERIALS AND METHODS

Spring wheat, downy brome, wild oat, and jointed goatgrass, were grown at three temperatures with three different soil moistures. The study was conducted as a split-plot design with the temperatures of 25/23, 15/13, and 5/3 C applied to growth chambers as the whole plot factor. The subplot factor was soil moisture with rates of 1/3, 2/3, or full field capacity. The study was sequentially replicated five times. Plants were germinated in the greenhouse and moved into the growth chambers except for the 5 C plants. Due to the lack of growth at 5 C, these plants were kept in the greenhouse until 1 week before herbicide application. Herbicide application occurred when the plants were at the 3-leaf stage. Ten one microliter drops of herbicide were applied to the second leaf of wheat, jointed goatgrass, and wild oat. Five one microliter drops of herbicide were applied to downy brome because of its small and narrow second leaf. Plants were harvested at 6, 24, and 96 hours after application by sectioning the plant into treated leaf, above treated leaf, below treated leaf, and roots. These sections were then air dried for 48 hours. The treated leaf was placed into a vial at harvest with 10 to 15 ml of double distilled water and shaken for 30 seconds. This procedure washed off the unabsorbed MON 37500. A sand bath was then used to evaporate the rinseate to 1 ml. The dried plant parts were combusted in a biological oxidizer, and all radioactivity was measured with a liquid scintillation counter.

RESULTS

Absorption. MON 37500 absorption by species was affected by cutting time (Figure 1), by temperature (Figure 2), but not by moisture (Figure 3). MON 37500 absorption was similar in wheat and jointed goatgrass which was higher than downy brome and wild oat (Figure1). The greatest temperature effect on absorption was in wheat and wild oat with a high of 47 and 24%, respectively, at 15 C and a low of 23 and 10%, respectively, at 5 C (Figure 2). This represented a 51 and 58% reduction in herbicide absorption as temperature decreases 10 C. Jointed goatgrass absorption decreased as the temperature decreased with a high of 37% at 25 C to a low of 28% at 5 C. Downy brome tended to remain constant at approximately 20% absorption which could be due to its pubescent leaf surface (Figure 2). The moisture effect was non significant as shown in Figure 3.

Translocation. Wheat, downy brome, and jointed goatgrass had approximately 0.5 to 1.0%, 94 to 97%, 1.5 to 2.5%, and 1.5 to 3.0% of the absorbed MON 37500 in the above, treated, below, and root sections, respectively (Figures 4 and 5). Wild oat had 1 to 2%, 90 to 94%, 2.5 to 6%, 1 to 2% of the absorbed MON 37500 in the above, treated, below, and root sections, respectively (Figures 4 and 5). MON 37500 translocation was influenced by temperature and moisture (Figures 4 and 5), but the MON 37500 translocation from the treated leaf only occurred in minor amounts with 90 to 97% of the absorbed MON 37500 remaining in the treated leaf.

CONCLUSIONS

Absorption occurs at a high rate for the first 24 hours, and decreases in rate over the next 72 hours with the highest absorption in wheat and lowest absorption in wild oat. Temperature has a large effect on absorption while moisture has no effect. The majority of the MON 37500 remains in the treated leaf.

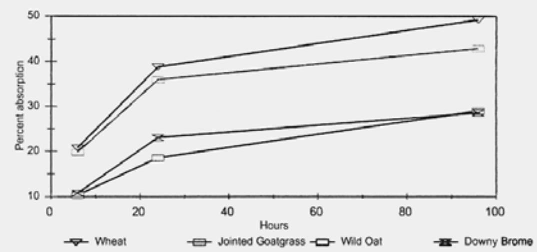

Figure 1. MON 37500 absorption in wheat, jointed goatgrass, wild oat and downy brome at three time intervals. LSD (0.05) = 9.0.

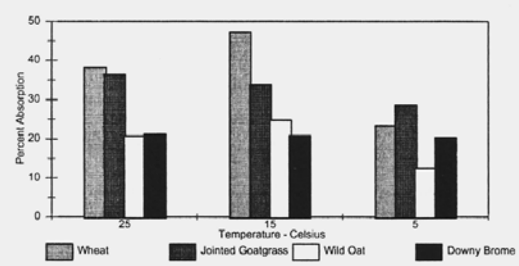

Figure 2. MON 37500 absorption for each species as effected by temperature. LSD (0.05) = 9.1.

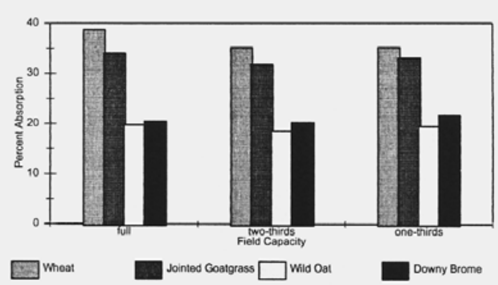

Figure 3. MON 37500 absorption for wheat, jointed goatgrass, wild oat, and downy brome as effected by soil moisture. LSD (0.05) = 9.4.

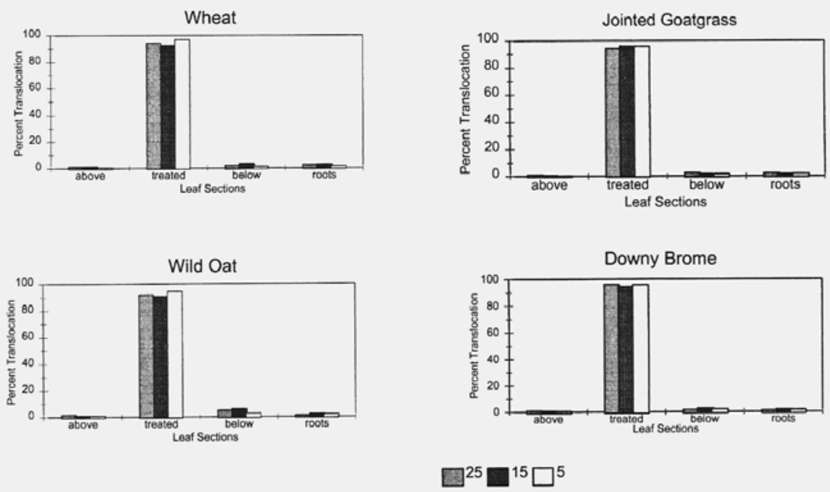

Figure 4. MON 37500 translocation in wheat, jointed goatgrass, wild oat and downy brome as affected by temperature. LSD (0.05) = 0.65.

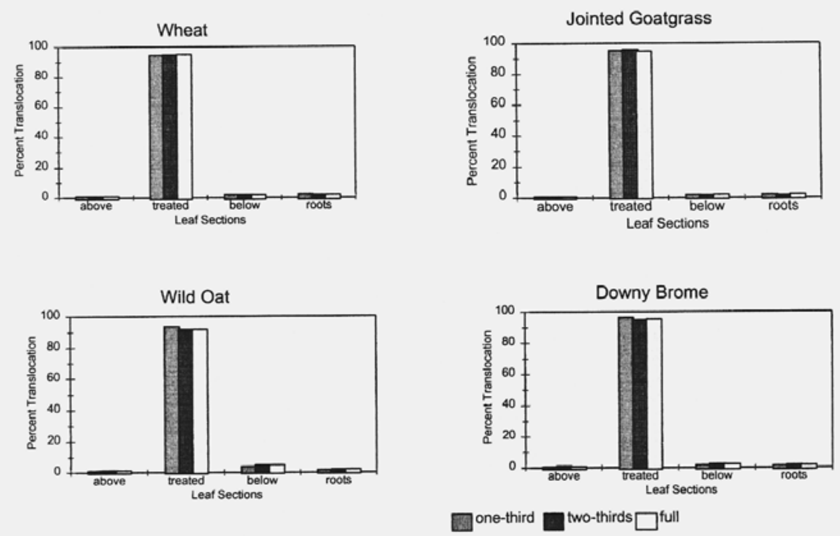

Figure 5. MON 37500 translocation in wheat, jointed goatgrass, wild oat, and downy brome as affected by soil moisture. LSD (0.05) = 0.63.

BENSULFURON RESISTANT WEEDS INCREASE QUICKLY IN CALIFORNIA RICE. James E. Hill[1], Michael D. Carriere[1], and Timothy D. Butler[2], Agronomist and Chair, Graduate Research Assistant and Development Representative, [1]Department of Agronomy and Range Science, University of California, Davis, CA 95616 and [2]DuPont Agricultural Products, Sacramento, CA 95864.

Abstract. Bensulfuron was introduced commercially in California rice in 1989 to control aquatic broadleaf and sedge weeds. Ninety-three percent of the acreage was treated with bensulfuron in the first year and nearly 100% in each of the next 3 years. This herbicide was rapidly adopted because of its high level of efficacy, its compatibility with rice water management, and because the registration of bentazon was canceled quite suddenly in 1989 due to trace residues in well water. Only 3 years following the introduction of bensulfuron, two annual aquatic broadleaf and sedge weed species were discovered to be resistant, and the following year two more were confirmed. In 1993, resistance to bensulfuron was monitored in suspect fields using twice normal rate oversprays (0.13 lb/A) in small plots; and through survey instruments in 1994 and 1995 with California Pest Control Advisors. From 1992 to 1995 the number of fields with resistant weeds increased to 18% for ricefield bulrush, 33% for redstem, 35% for smallflower umbrella sedge and 60% for California arrowhead. The rapid and simultaneous development of resistance from the northern Sacramento Valley to the central San Joaquin Valley in only 3 years suggested that genes conferring resistance were widely present prior to the introduction of the herbicide. Based on previously conducted efficacy studies, the number of fields with resistance to any one of the four species was directly related to susceptibility of that species to bensulfuron and hence to selection pressure. The heavy reliance of growers on bensulfuron coupled with few alternative broadleaf and sedge herbicides is now a serious threat to good weed control and continued high yields in California rice.

WEED SUPPRESSION IN ALMOND ORCHARDS USING SUB-SURFACE DRIP IRRIGATION. John P. Edstrom and Larry Schwankl, University of California Cooperative Extension Farm Advisor-Colusa, CA 95932 and Irrigation Specialist Department of Land, Air and Water Resources, University of California, Davis, CA 95616.

Abstract. Preemergence herbicides (oxyfluorfen, simazine, trifluralin, oryzalin, napropamide, norflurazon, dichlobenil) are typically applied in tree rows for weed suppression in almonds. Herbicide contamination of ground water has stimulated the development of alternatives such as use of sub-surface drip irrigation (SSDI) systems, where water is applied below the soil surface. Subsurface application of water could decrease the germination of weed seeds in the tree row where weeds are most troublesome.

Eight years of evaluating low volume irrigation systems on almonds in a replicated field trial has shown a marked reduction in weed pressure without the use of preemergence herbicides in the SSDI areas when compared to surface drip and microsprinkler irrigation systems (Table). Use of SSDI resulted in reductions in mowing, harvest costs and foliar applied herbicides (glyphosate plus oxyfluorfen) when compared to surface drip and microsprinklers. Areas irrigated with drip or microsprinklers required 6 to 7 mowing operations yearly verses three mowings for SSDI. Hand raking of harvested nuts from around irrigation tubing was totally eliminated with SSDI. Without the use of preemergence herbicides, Microsprinklers required six foliar herbicide applications in the tree rows per season compared to four on drip and two for SSDI areas. Drip and micro plots also required a preharvest foliar herbicide application in the orchard drive rows while SSDI did not.

Four years of almond yield data show no difference between standard drip irrigation and SSDI. Initial evidence from this field trial suggests that SSDI lowers weed pressure and could reduce the reliance upon preemergence herbicides while maintaining almond production.

Table. Almond yields.

Irrigation method	1994	1995	1996	1997
	lb/A			
Drip	1047 b	833	2142 b	2229
Microsprinkler	1543 a	855	2454 a	2346
Sub-surface drip	1235 b	811	1962 b	2017
LSD (0.10)				

Average yields of Nonpareil and Butte ctv. Nickels Soil Lab, Arbuckle, CA
Fishers LSD P = .10

CUCUMBER PHYTOTOXICITY AND YIELD RESPONSE RESULTING FROM RIMSULFURON APPLICATIONS. Mike Murray, Farm Advisor and County Director, University of California Cooperative Extension, Colusa County, CA 95932.

Abstract. Rimsulfuron is currently being widely tested in California, in anticipation of a registration for use on processing tomatoes. As part of this testing procedure, off-site drift studies on other crops produced in processing tomato production areas are being conducted. A field test was conducted on the male parent line in a hybrid cucumber-seed field to evaluate potential drift problems. Rimsulfuron rates of 0 (untreated control), 0.032, 0.063, 0.125, 0.25, and 0.5 oz/A were sprayed directly over the cucumber rows at the pre-bloom growth stage (11 to 17 days after plant emergence).

Phytotoxicity symptoms were obvious in all rimsulfuron plots 9 d after treating, but could not be observed in the two lowest rates 16 d after treatments were applied. Cucumber plants in the two highest rates were stunted and displayed abnormal growth 21d after applying treatments. However, at harvest there were no significant differences between treatments for the number of fruit, average fruit weight or total fruit yield per plot.

Table 1. Cucumber phytotoxicity ratings and fruit yield data.

	Crop Phytotoxicity[a]			Ave. fruit	Fruit
Rimsulfuron rate	9 Days	16 Days	Fruit	weight	yield
(oz/A)			-No.-	-oz-	-lb-
0	0.0	0.0	112	9.2	64.2
0.032	1.1	0.0	117	9.9	71.6
0.063	2.0	0.0	109	9.4	64.1
0.125	3.3	1.5	113	8.6	60.7
0.25	3.9	3.1	114	8.3	59.3
0.5	5.1	4.4	118	8.6	63.5
LSD (0.05)	0.9	0.9	N.S.	N.S.	N.S.
C.V.(%)	22.1	38.6	10.2	11.5	13.2

[a]0= no phytotoxicity, 10= total death.

SEPARATING COMPETITION FROM CROP INJURY IN GRASS SEED PRODUCTION.
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Abstract. Weed control in seed production of forage and turf-type perennial grasses faces several unique constraints. One serious problem is the genetic similarity between these crops and many of their weeds, including volunteer crop seedlings from previous harvests, other crop species such as tall fescue, and weedy annual grasses such as Italian ryegrass, downy brome, and annual bluegrass. Many treatments relying on growth stage differences between seedling weeds and older, more well established crop plants possess only marginal selectivity. A major research challenge has been to separate the effects of crop injury from herbicides from those of competition with surviving weeds. Measuring crop injury in "weed-free" environments is often impractical because such conditions seldom exist in established grass seed fields. Kentucky bluegrass yield loss to downy brome competition reached 70% at weed populations of 100 plants/m^2, and a model was developed to estimate the competitiveness of lower populations of downy brome. Adjusting Kentucky bluegrass seed yield per plot for these competitive effects then provided an estimate of the impact of herbicide treatments on crop yield at equivalent post-treatment weed populations. Annual bluegrass reduced perennial ryegrass seed yield by 222 kg ha^{-1} as weed density increased from 13 to 42% ground cover in early spring. However, yields were decreased by all treatments capable of reducing annual bluegrass ground cover below 13%. Information on the relative contributions of herbicide damage and weed competition to seed yield will help growers adjust treatments to maximize yield or income at specific weed densities.

HOARY CRESS MANAGEMENT IN ALFALFA WITH IMAZETHAPYR.
R. N. Stougaard[1], J. I. Stivers[2], and D. L. Holen[1], Associate Professor, Extension Agent, and Research Associate, Montana State University, [1]Northwestern Agricultural Research Center, Kalispell, MT 59901 and [2]Lake County Extension Office, Ronan, MT 59864.

Abstract. Hoary cress is a deep-rooted perennial of the Mustard family which was originally introduced as a contaminate in Turkestan alfalfa seed. Hoary cress in now widely distributed throughout much of Canada and the western United States with the level of infestation in Montana estimated at 55,000 acres. Hoary cress is most prevalent in alfalfa and perennial grass settings and can also be a problem in small grains. While control options exist for the latter two situations, no management strategies are available for alfalfa. Due to this lack of information, research was initiated to evaluate imazethapyr for hoary cress control in alfalfa and to assess the impact of hoary cress interference on alfalfa yield.

Field trials were established near St. Ignatius, MT in 1995 and again in 1997. The treatment design was a three by two by two factorial with imazethapyr rate, adjuvant, and 28% urea ammonium nitrate (UAN) as the main effects. Imazethapyr was applied at 0.03, 0.06, and 0.09 lb/A in combination with either a nonionic surfactant (NIS) or methylated seed oil (MSO) as adjuvants at 0.25% v/v and 1 qt/A respectively. Herbicide-adjuvant combinations were applied alone or with 28% UAN at 1 qt/A. A nontreated control outside the factorial was included for comparison. Herbicide treatments were applied in early April of each year to 10 by 15 foot plots with a backpack sprayer when hoary cress was in the rosette stage. Treatments were rated visually for percent hoary cress control 1 month after application. The studies were harvested twice each year and total fresh weight recorded. A subsample was taken from each harvested plot to determine species composition.

Imazethapyr applied at 0.06 and 0.09 lb/A provided greater than 90% control at all sites regardless of adjuvant or UAN additions. Hoary cress control was less complete when imazethapyr was applied at 0.03 lb/A, providing a minimum of 75% control. Differences among adjuvants and UAN additions were minor, suggesting that root uptake may be an important route in controlling hoary cress. Although differences in percent control ratings were observed, hoary cress biomass reduction was similar among imazethapyr treatments, regardless of rate, adjuvant and UAN considerations. Alfalfa yield did not differ among any of the treatments, suggesting that hoary cress is either noncompetitive or that weed densities were not high enough to result in significant yield reductions.

ARE BROOM SNAKEWEED POPULATIONS REALLY CYCLIC? Kirk C. McDaniel, Professor, Department of Animal and Range Sciences, New Mexico State University, Las Cruces, NM 88003.

Abstract. Broom snakeweed populations have often been described in the literature as cyclic through time. That is, propagation occurs under favorable environmental conditions and plants survive until conditions become unfavorable, then they die. The term cyclic implies a regular and repeated life history pattern that occurs through time. Environmental events that influence snakeweed cycles are becoming better understood. Major increases in snakeweed seedlings have been noted after above-average winter and spring precipitation. Die-offs from weather usually result from summer drought conditions, but insects and old age are also responsible for plant losses. Because some studies and observations describe snakeweed as short-lived, it seems logical to assume fecundity and mortality rates through time give the appearance of being cyclic.

This study, beginning in May 1979 to present, traces the life history of broom snakeweed growing at nine permanent locations in New Mexico. At each location two 20 by 40 m plots were established that allowed long-term changes in the snakeweed cycle to be examined. This was done by counting snakeweed density each spring and fall, and harvesting plants for yield (in fall) annually. Snakeweed density was determined by counting seedlings and mature snakeweed in 20 sample frames (0.2 by 1.5 m) per plot. Snakeweed yield was determined by clipping plants in 10 sample frames (every-other frame previously counted) to a 3-cm stubble height. Placement of sample lines (two lines per plot, 38 m in length) was changed each year to prevent repeated harvesting.

Monthly precipitation averages, from permanent meteorological stations near each site, were obtained to compare with snakeweed densities and yield data collected between 1979 to 1997. Under New Mexico conditions above average rainfall received in April and May was most critical for germination. The most critical period for seedling and mature plant survival was during June and July. During this period, air temperatures are normally highest and soils become parched under limited rainfall. Seedlings are unlikely to survive the first year if monthly rainfall is not at least normal or above, and if rainfall does not occur at close (weekly) intervals to provide sufficient soil moisture.

Examination of data from each location which show the trend in snakeweed numbers and yield over the 19-year study indicate that plant numbers and yield increase and decrease at individual locations through time. However, the pattern is not repeatable from one location to another. Lack of repeatability suggest local environmental conditions act more directly towards influencing the life of snakeweed than do regional conditions. Implications from this research suggest that snakeweed populations act independent of each other and are not uniformly, nor predictably cyclic over time.

CHLOROPHYLL AND WATER POTENTIAL VARIATION AMONG BROOM AND THREADLEAF SNAKEWEED POPULATIONS. M. C. Campanella, T. M. Sterling, and Leigh Murray, Research Assistant and Associate Professor, Department of Entomology, Plant Pathology and Weed Science, Associate Professor, University Statistics Center, New Mexico State University, Las Cruces, NM 88003.

Abstract. Threadleaf and broom snakeweed are highly variable perennials which grow in a wide range of environments throughout the western United States. Snakeweed is toxic to cattle and increases abortion rates. Snakeweed is also very competitive on rangelands and can decrease the availability of desirable forage for livestock. An understanding of physiological differences among snakeweed populations is crucial in determining the impact variability may have on biological control agents. Therefore, variability in chlorophyll content and water potential among nine broom and two threadleaf grown in the same environment were compared. A common garden was established in Las Cruces, NM during 1992 consisting of snakeweed originally collected from nine locations in NM, one location in AZ, and one in TX. Cuttings from original plants were transplanted into five plots containing 240 plants each. For chlorophyll determination, stem tissue (5 to 8 cm long) was collected from the upper canopy of ten individual plants from each population each month from July to October in 1996 and May to

October in 1997. Samples were placed in test tubes and kept on ice in the dark before being weighed. Five ml of dimethylformamide (DMF) was added to each sample in a test tube on ice and placed in a dark at 4 C. After 48 h, the absorbance was determined at 647 and 665 nm and chlorophyll a and b content estimated. Stem tissue (8 to 10 cm long) was collected from six plants from each of the 11 populations for water potential determination each month from July to October 1996 and May to October 1997. Samples were collected at pre-dawn and solar noon and water potential was measured using a pressure bomb. Both pre-dawn and solar noon readings had significant population by date interactions. Water potential difference between the two sample times differed among populations and dates. Broom snakeweed showed greater stress compared to threadleaf snakeweed under increasing water deficit. Neither total chlorophyll or the ratio of chlorophyll a:b showed a population by date interaction. Both varied throughout the year; thus, a comparison of photosynthetic rates among snakeweed species and populations may better explain phenotypic difference among snakeweed.

COMPARING MECHANICAL, CHEMICAL, AND MECHANICAL PLUS CHEMICAL METHODS TO CONTROL CANADA THISTLE IN NON-CROP SITUATIONS. James R. Sebastian and K. George Beck, Research Associate and Associate Professor, Department of Bioag Science and Pest Management, Colorado State University, Ft. Collins, CO 80523.

Abstract. Canada thistle is a creeping, perennial noxious weed that is difficult to control. A recent survey conducted in Colorado identified Canada thistle as the most significant noxious weed problem in the state. Canada thistle grows in numerous environmental settings in Colorado but is most troublesome in pastures and non-crop situations along the Front Range because landowners at these sites are primarily non-agricultural and somewhat reluctant to invoke effective control methods. Two similar experiments were initiated in 1996 at Estes Park and Ft. Collins to compare the effects of multiple handpullings, multiple mowings, multiple mowings plus herbicides, and herbicides applied alone on Canada thistle and the surrounding plant communities. The experimental design was a randomized complete block with four replications and each site was analyzed separately. Canada thistle was handpulled twice per year, the first at flowering and the second 1 month later. Three mowings were done per year, the first when Canada thistle was bolting and the two successive mowing at 1 month intervals. Two mowings were done on a similar schedule then these plots were sprayed in September with picloram at 0.19 lb/A or clopyralid plus 2,4-D at 0.19 + 1 lb/A or triclopyr at 1 lb/A. Herbicides applied alone included dicamba plus 2,4-D at 1 + 2 lb/A at the rosette growth stage or picloram, triclopyr, or clopyralid plus 2,4-D at 0.38, 1.5, and 0.19 + 1 lb/A all applied at the early bolting growth stage when Canada thistle was 5 to 17 inches tall and all shoots were emerged. Canada thistle density and cover and cover of perennial grasses were used to evaluate the effects of the various treatments.

Data gathered before the first treatments were invoked showed that Canada thistle density and cover and cover of perennial grasses did not vary among treatments at either site but there was more Canada thistle at Estes Park than Ft. Collins. Data were collected in June 1997 about 1 year after the initial treatments were invoked and 9 months after the fall treatments were made. Canada thistle density at Estes Park was decreased 41, 83, and 58% from clopyralid plus 2,4-D, picloram, or mowing plus picloram, respectively. There was no difference between picloram applied alone and mowing plus picloram. At Ft. Collins, picloram alone decreased Canada thistle density to zero whereas mowing three times in 1996 increased density by 50%. Handpulling, clopyralid plus 2,4-D, triclopyr, dicamba plus 2,4-D, and mowing plus picloram decreased Canada thistle density by 75, 80, 75, 90, and 78%, respectively. Canada thistle cover in the non-treated control plots at Estes Park was 1.7, 6, 2.4, 1.7, and 1.6 times greater than in plots where clopyralid plus 2,4-D, picloram, mowing plus picloram, mowing plus clopyralid plus 2,4-D, or mowing plus triclopyr were used. Mowing three times at Ft. Collins increased Canada thistle cover 1.5-fold but picloram applied alone decreased cover to zero. Canada thistle cover in non-treated control plots at Ft. Collins was 5.5, 7.3, 7.3, 3.7, and 1.7 times greater than in plots where Canada thistle was handpulled twice, sprayed with clopyralid plus 2,4-D or dicamba plus 2,4-D, or mowed twice then sprayed with picloram or clopyralid plus 2,4-D. Perennial grass cover was not influenced by treatment at Estes Park in June 1997 and ranged

from 68 to 82%. However at Ft. Collins, plots treated with triclopyr, picloram, dicamba plus 2,4-D, or mowed twice then sprayed with picloram or clopyralid plus 2,4-D had about 1.4 times more perennial grass cover than in non-treated control plots. Final data collections will be made in 1998.

RUSSIAN KNAPWEED BIOLOGICAL CONTROL PROJECT PROGRESS REPORT. John L. Baker[1], David Kazmer[2], Kiana Zimmerman[2], Lloyd Wendel[3], Paul Parker[3], Don Vacek[3], Raul Ruis[3], Robert D. Richard[4], Urs Schaffner[5], and Rouhollah Sobhian[6], Chairman, Assistant Professor, CAPS Technician, Director, Plant Pathologist, Geneticist, Research Assistant, Director/Entomologist, Supervising Entomologist, and Entomologist, [1]Wyoming Biological Control Steering Committee, Fremont County Weed & Pest, Lander, WY 82520; [2] Entomology Section, University of Wyoming, Laramie, WY 82701; [3] USDA/APHIS/PPQ, Mission Plant Protection Center, Mission, TX 78572-2140; [4] USDA/APHIS/PPQ, FSL-MSU, Bozeman, MT 59717-0278; [5] International Institute of Biological Control, Delémont, Switzerland; and [6] USDA/ARS European Biological Control Lab, Montpellier, France.

Abstract. Russian knapweed is a native of Eurasia. It is found across the western United States with over 100,000 acres in Wyoming alone. Its bitter taste limits its use as forage and it is poisonous to horses. It forms dense monoculture on irrigated cropland and sub-irrigated riparian sites. In 1996, six Wyoming Weed and Pest Control Districts and the Bureau of Indian Affairs pooled funds to initiate a cooperative biological control project. On the strength of funding raised, USDA/APHIS/PPQ Western Region and the Bureau of Land Management joined the effort.

A 5 year plan was developed for the project which includes an economic analysis, a new North American inventory, a literature search, the host plant test list development and collection of native test plants, and DNA analysis of Russian knapweed across its range. Contracts have been developed with the International Institute of Biological Control in Delémont, Switzerland, for foreign exploration, life history studies and screening of potential insect agents. The USDA/ARS European Biological Control Laboratory has expanded exploration into the former USSR states and will screen mites and pathogens. Petitions for introduction will be submitted jointly by the participants and agents will be processed through quarantine at APHIS/ PPQ/MPPC at Mission, TX. A budget of $409,000 has been developed for the first 3 years.

Accomplishments during the first year include the host plant test list, collection of native plants for testing, establishment of North American Russian Knapweed in gardens in Switzerland, life history study and preliminary screening of two agents, and preliminary DNA analysis of Russian Knapweed from Wyoming and Turkey. Approval is pending on proposals for the economic study and the North American inventory.

A SURVEY OF WEED SPECIES FOUND IN IRRIGATED PASTURES IN THE INTERMOUNTAIN WEST. Steven Dewey, Holli Murdock, and Stewart Lamb, Professor and Research Assistants, Department of Plants, Soils, and Biometeorology, Utah State University, Logan, UT 84322-4820.

Abstract. A survey was conducted in 32 counties of southeastern Idaho, northern Utah, central Utah, and western Wyoming to identify and quantify the principle weed species found in 150 irrigated pastures. Five pastures were surveyed in each county, with individual pastures chosen to represent typical local practices and conditions. Plants were identified and counted at 1-foot internals along a 100-foot transect established in a representative area of each pasture. Specimens of all plant species were collected from each pasture and later verified at the USU Intermountain Herbarium. Plants were classified into the four general categories of forages, broadleaf weeds, weedy grasses, and other weeds (rush, sedge, and scouringrush species). Percent surface cover was based on the frequency of species occurrence along the transect.

A total of 105 broadleaf weeds, 23 weedy grasses, 20 forages and 3 "other" species or genera were identified in the surveyed pastures. The most common forage was perennial bluegrass, found in 84.7% of pastures and making up an average of 16.1% of the surface cover at those sites. Clover and fescue species were the next most common forages, present in 68 and 66% of pastures, respectively. The most common broadleaf weed was dandelion, present in 80.7% of pastures and making up 8.6% of the surface cover. Curly dock was the second most common weed (50.7% of pastures), followed by Canada thistle (43.3%), field bindweed (37.3%), aster species (32.7%), black medic (30.7%), and salsify (30%). Quackgrass was the most common weedy grass, found in 70% of the pastures and making up an average of 17.3% of the surface cover. Foxtail barley and downy brome were the next most prevalent weedy grasses, present in 38 and 12.7% of pastures, respectively. Sedge and rush species were common in sub-irrigated and flood irrigated pastures. Rush species were present in 19.3% of pastures. Sedges were found at 23 locations (15.3%), and constituted an average of 11% of the plant cover at those sites.

A SYSTEMS APPROACH FOR THE MANAGEMENT OF RUSSIAN KNAPWEED. Rick M. Bottoms and Tom D. Whitson, Extension Agronomist, University of Missouri, Columbia, MO 65211 and Extension Weed Specialist, University of Wyoming, Laramie, WY 82071.

Abstract. Studies were initiated in Wyoming to determine the potential of grass competition as an alternative to repetitive herbicide treatment or other cultural practices for control of Russian knapweed. An experiment was established to evaluate the effects of five grass species including Russian wildrye. Applications of clopyralid (0.32 kg/ha) plus 2,4-D (1.65 kg/ha) and picloram (0.28 kg/ha), applied to Russian knapweed during the first frost, reduced Russian knapweed from an average of 80.1% live canopy cover which equates to 0% control. Untreated unseeded checks resulted in 83.9% and 81.1% control in tilled and non-tilled treated plots respectively. Grass cover increased in untreated seeded plots from an average of 11.3% and 8.2% in tilled and non-tilled plots, respectively, to 65% in tilled and 66% in non-tilled plots treated with clopyralid plus 2,4-D. Grass cover also increased 69.7% in tilled and 66% in non-tilled plots treated with picloram. There was no significant difference between grass varieties when compared to percent Russian knapweed cover. Reductions to 0% live canopy cover of Russian knapweed were obtained with a single application of picloram. Except for thickspike wheatgrass, economic feasibility thresholds were obtained from four out of five varieties including a significant difference provided by non-tilled Russian wildrye treated with picloram.

Table 1. Control of Russian knapweed at Arapaho (AR) and Fort Washakie (FW).

Grass[c]	Control of Russian knapweed–tilled[a,d]				Untreated/seed[d]	
	Clopyralid[b]		Picloram[b]			
	AR	FW	AR	FW	AR	FW
	%				%	
Russian wildrye	93	69	100	85	20	27
Crested wheatgrass	*	*	91	52	25	18
Thickspike wheatgrass	87	79	100	88	24	27
Western wheatgrass	97	68	95	78	16	22
Streambank wheatgrass	94	51	97	82	24	24
LSD (0.05)	11.1	37.2	11.8	20		
Mean	80		87		23	

[a]Percent knapweed control reflects untreated unseeded checks as 0% control.
[b]Herbicides were applied Oct 91, Aug 92, and Aug 94.
[c]Grasses were seeded Apr 92.
[d]Control was based on 100 point-frame counts/plot.
*Evaluations below 70% control in 1995 and did not occur.

Table 2. Control of Russian knapweed at Arapaho (AR) and Fort Washakie (FW).

	Control of Russian knapweed–no-till[a,d]					
	Clopyralid[b]		Picloram[b]		Untreated/seed[d]	
Grass[c]	AR	FW	AR	FW	AR	FW
	%				%	
Russian wildrye	95	77	100	72	21	25
Crested wheatgrass	*	*	96	59	23	29
Thickspike wheatgrass	*	*	*	*	22	32
Western wheatgrass	*	*	95	55	22	22
Streambank wheatgrass	*	*	93	64	24	34
LSD (0.05)			7.1	29.9		
Mean	84		79		25	

[a]Percent knapweed control reflects untreated unseeded checks as 0% control.
[b]Herbicides were applied Oct 91, Aug 92, and Aug 94.
[c]Grasses were seeded Apr 92.
[d]Control was based on 100 point-frame counts/plot.
*Evaluations below 70% control in 1995 and did not occur.

Table 3. Grass cover at Arapaho (AR) and Fort Washakie (FW).

	Grass cover–tilled[a]					
	Clopyralid[b]		Picloram[b]		Untreated/seed[d]	
Grass[c]	AR	FW	AR	FW	AR	FW
	%				%	
Russian wildrye	81	49	90	55	8	6
Crested wheatgrass	*	*	70	34	18	3
Thickspike wheatgrass	69	65	83	70	14	17
Western wheatgrass	80	49	82	60	5	6
Streambank wheatgrass	88	41	85	68	16	20
LSD (0.05)	20.9	32.6	21	16.4		
Mean	65		70		11	

[a]Percent grass cover reflects untreated unseeded check with 1% grass.
[b]Herbicides were applied Oct 91, Aug 92, and Aug 94.
[c]Grasses were seeded Apr 92.
[d]Control was based on 100 point-frame counts/plot.
*Evaluations below 70% control in 1995 did not occur.

Table 4. Grass cover at Arapaho (AR) and Fort Washakie (FW).

	Grass cover–no-till[a]					
	Clopyralid[b]		Picloram[b]		Untreated/seed[d]	
Grass[c]	AR	FW	AR	FW	AR	FW
	%				%	
Russian wildrye	83	49	92	65	8	4
Crested wheatgrass	*	*	78	43	10	5
Thickspike wheatgrass	*	*	*	*	10	9
Western wheatgrass	*	*	86	45	9	6
Streambank wheatgrass	*	*	70	47	9	12
LSD (0.05)			24.1	23.5		
Mean	66		66		8	

[a]Percent grass cover reflects untreated unseeded check with 1% grass.
[b]Herbicides were applied Oct 91, Aug 92, and Aug 94.
[c]Grasses were seeded Apr 92.
*Evaluations below 70% control in 1995 did not occur.

Table 5. Grass yield at Arapaho (AR) and Fort Washakie (FW).

	Tilled				No-till					
	Clopyralid[a]		Picloram[a]		Clopyralid[a]		Picloram[a]		Unt/unsd	
Grass[b]	AR	FW	AR	FW	AR	FW	AR	FW	AR	FW
	%				%				%	
Russian wildrye	1229	228	1227	492	770	378	1792	576	74	27
Crested wheatgrass	*	*	904	296	*	*	682	257	41	13
Thickspike wheatgrass	722	300	609	244	*	*	*	*	*	*
Western wheatgrass	715	146	530	302	*	*	673	218	48	16
Streambank wheatgrass	530	145	422	258	*	*	688	226	35	12
LSD (0.05)	294	154	695	245			447	301	308	270
Mean	502		528		574		639		33	

[a]Herbicides were applied Oct 91, Aug 92, and Aug 94.
[b]Grasses were seeded Apr 92.
*Evaluations did not occur as they were below 70% control in 1995.

INTEGRATED PEST MANAGEMENT SYSTEMS FOR WEED CONTROL. Tom D. Whitson, Professor of Weed Science and Extension IPM and Weed Specialist, Department of Plant Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Five steps are required to prevent and control noxious weeds. Step one requires prevention which includes legal steps, information for growers on new species that should be excluded and a planned approach to educate land users on methods they should use to prevent the spread of noxious weeds. The use of certified seed and hay are common requirements on public lands.

Early control is done by properly informed land managers who see noxious weeds as they first begin on a section of land. They commonly use hand control or herbicides to prevent these new infestations from producing seed. A follow-up approach is very important each year following initial control.

Strategies are necessary as weeds spread to large areas to prevent them from spreading to adjoining lands. Noxious weeds normally spread at the rate of 8 to 14% each year depending on the weed species and the type of new habitat that is occupied.

Planning is necessary as weed infestations occupy large areas. A budget must be prepared to keep project costs within reasonable limits. An accurate, detailed map is very useful for making step-by-step decisions. A long-term commitment and control procedure should be a part of a successful management plan.

Goal setting for noxious weed management should include a plan to establish competitive perennials to replace noxious weeds. If weeds are controlled with herbicides, insects or plant diseases and soil sites remain bare, weeds will return. When soil sites are filled with competitive perennial grasses and forbs which are properly managed a weed management system can be sustained.

MONITORING FIELD-GROWN RUSSIAN THISTLE ROOTS WITH A SCANNER-BASED RHIZOTRON. William L. Pan[1], Frank L. Young[2], and Ronald P. Bolton[1], Soil Scientist, Research Agronomist, and Agricultural Research Technologist, Department of Crop and Soil Sciences[1] and USDA-ARS[2], Washington State University, Pullman, WA 99164-6420.

Abstract. The study of root systems of weeds using destructive sampling and manual measurement is time-consuming, expensive and laborious. Rhizotrons allow the examination of spatial and temporal *in situ* root

development. Permanent rhizotron installations provide 2-D images of whole root profiles, but their immobility limits the number of soil-plant systems that can be studied.

Over the past 3 years, we have developed a portable rhizotron and scanning system to provide the capability to study the development of Russian thistle root systems with temporary rhizotron installations that can be inserted at the beginning of the growing season and removed at the end of the growing season. This system combines the full profile images afforded by conventional rhizotrons with the portability of cylinder-based mini-rhizotron systems, and at a fraction of the cost of either system. Covered, rectangular 11 by 33 by 130 cm hollow boxes with a transparent glass face are inserted into a field soil, and a seed or seed piece is planted in the soil adjacent to the glass. The glass face transverses the equivalent distance of one wheat row. Images of roots growing along the glass face are captured with two 120 cm long scans with a portable scanner.

The scanner is guided along the glass in a set track, and the images are directly stored as raster files in a field computer. Image thresholding discriminates roots from soil using combinations of red, green, blue (RGB) values, RGB differences, color proportionality values, and overall intensity. Scans were stitched together to compose a profile image from each rhizotron. Images are typically manually traced and tracings are analyzed for total root length with the customized software, ROOTLAW (c Washington State University). Root development of Russian thistle in early spring is rapid and extensive. Over a 14 day period, the tap root has been observed to extend over 60 cm while the shoot height increased 5 cm. This root observation method is a promising tool for monitoring root morphological development of Russian thistle and other weeds under field conditions.

INTEGRATED WEED MANAGEMENT IN DRY BEAN. Scott A. Fitterer, Richard K. Zollinger, and H. Art. Lamey, Research Specialist and Extension Weed Specialist, Plant Sciences and Extension Plant Pathologist, North Dakota State University, Fargo, ND 58105-5051.

Abstract. Dry bean grower surveys were conducted, in 1990 to 1992 and 1994 to 1996, for the Northarvest region. This area includes all of Minnesota and North Dakota. Respondents accounted for 225,000 of the 790,000 plus acres grown in this region or approximately a 30% survey response rate of the dry bean acreage. Production problems considered to be the worst by growers included disease and weeds, most commonly but also included were harvesting, insects, and planting delays. Problem weeds include redroot pigweed, wild mustard, Eastern black nightshade, green and yellow foxtail, common lambsquarters, Canada thistle, and volunteer grain. Herbicides most commonly used include spring applied ethalfluralin, bentazon, sethoxydim, and spring applied trifluralin. Non-chemical methods of weed control included row cultivation, typically 1 to 2 times, and use of a rotary hoe, usually once. Pesticide use has remained steady over the years, at around 60% of the acres. Corn and wheat were the most common crop preceding dry bean, in Minnesota, and wheat and barley, in North Dakota. Years to rotation back to dry bean has increased from 2 to 4 years in the past surveys to 4 to 5 years in the 1996 survey. IPM techniques used in dry bean pest control include pest monitoring, pest forecasting, timely application, resistant varieties, crop rotation, and tillage. Further research and training is needed in all these areas to aid growers in the best use of these techniques.

SPATIAL INFESTATION OF WEED SEEDLINGS IN TWO CENTER PIVOT IRRIGATED FIELDS.
Dawn Y. Wyse-Pester[1], Lori J. Wiles[2], and Philip Westra[1], Graduate Research Assistant, Professor, and Plant Physiologist, [1]Department of Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523 and [2]USDA-ARS-WMU, Ft. Collins, CO 80523.

Abstract. Controlling weeds only where necessary may be a method to reduce pesticide use, decrease costs, and prevent environmental damage. Knowing the infestation (spatial distribution and density) of a weed population

within a field will enhance site-specific management. With knowledge of the characteristic distribution of a weed population, cost-effective sampling plans and management units may be designed for site-specific management. In 1997, two center pivot irrigated corn fields in Eastern Colorado (175 and 130 acres) were sampled for weed seedling and seed bank populations. Three sampling strategies were used: regular, random-directed, and star. Among all grid types, there was 1349 observation sites. Within a field, weed seedlings tended to be spatially aggregated, but the amount of area that was infested and average density varied among species. Nightshade and pigweed species had a greater range of average seedling densities (0.01 to 5.06 seedling per 5 by 0.58 ft quadrat) than the other nine species that were detected. The spatial distribution of nightshade and pigweed populations (15 to 82% weed-free area) was greater than the other species (87 to 99% weed-free area). A management treatment could be reduced by 15 to 99% across the two fields by applying a treatment only to infested field locations. From this study there seems to be potential for implementing site-specific management to control weed populations.

USING GPS/GIS IN THE CONTINENTAL US GOATSRUE ERADICATION PROGRAM TO IMPROVE EFFICIENCY IN FIELD SCOUTING. Troy M. Price and John O. Evans, Research Technician and Professor, Plants, Soils, and Biometeorology Department, Utah State University, Logan, UT 84322-4820.

Abstract. Goatsrue (*Galega officinalis* L.) is a weed that has been under eradication since 1976 because of toxic levels of galegine and its lack of agronomic value. Goatsrue currently infests approximately 38,000 acres in Cache Valley in northern Utah at light and scattered infestations. The current eradication program began in 1980 with 38,000 acres moderately to densely infested fields. The intensive eradication program has been very successful in complying with goals originally set forth in 1980 of eliminating new seedlings, preventing seed production, eliminating perennial plants, and exhausting seed reserves. Some challenges remain towards total elimination of goatsrue including; 1) extended seed longevity in soils where seed scarification is incomplete, 2) crown regrowth from herbicide treated older perennial plants where new shoots emerge from a few quiescent crown buds many months after spraying, and 3) occasional new infestations result from soil movement on vehicle tires or new locations appear such as the three acre infestation at the Morris Arboretum in Philadelphia, PA. Global positioning technology provides much more accurate field monitoring and allows field positioning within 10 m. GPS continues to increase precision, accuracy, and ease of completing surveys. Combined with GIS to create maps of goatsrue infestation boundaries, GPS will hasten and improve present management decisions and eradication strategies.

COMPUTERIZED ANALYSIS OF SEED VIABILITY FOR WEED SEED BURIAL STUDIES. David W. Wilson, Stephen D. Miller, and Patrick S. Mees, Research Scientist/Instructor, Professor, and Programming Technician, Department of Plant Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Due to the inherently long chronologic scale required for seed burial studies, a tool to standardize viability analysis over several years was deemed necessary. Computerized analysis removes the human subjectivity and error associated with previously accepted visual measurement systems. Common human errors in viability assessment include miscounts, recounts and variable individual color interpretation. Software written for the Windows 3.11 platform was written with a C+ compiler and scanner interface toolkit. Using an color recognition program code, software was developed to use any flatbed color scanner connected to an IBM compatible computer to count and determine viability of seed embryos. A 24 h 1% tetrazolium chloride soak in petri dishes with Whatman 4, 90mm diameter filter paper was used for treating seeds. The embryos of three different seed studies were analyzed including corn/bean, a selection of stored weed seeds and a weed seed burial study. After the 24 h soak, seeds were analyzed by a professional seed test technician using visual analysis through a stereomicroscope. The seeds were then immediately placed on a black flannel cloth sandwiched between two clear acetate sheets and scanned using a single pass, 24-bit color, flatbed scanner connected to a 486DX80 computer

running Windows 3.11. Analysis using the computer viability software was done and compared with human analyzed samples. Samples with differences in human versus computer analysis were re-analyzed for error comparison of lot size and viability. Comparisons demonstrated the greater accuracy of the computerized system, associating errors to the human subjectives of analysis.

A RESEARCH PLOT HERBICIDE APPLICATION SYSTEM. Kevin D. Grams, Robert A. Masters, Kenneth L. Carlson, Joseph F. Schuh, Robert N. Klein, and Donald J. Thrailkill, Research Technician and Range Scientist, USDA-ARS, Department of Agronomy, University of Nebraska, Lincoln, NE 68583; Research Agriculturalist and Manager, American Cyanamid, Lincoln, NE 68506; Princeton, NJ 08543; and Professor and Research Technologist, West Central Research and Extension Center, University of Nebraska, North Platte, NE 69101.

Abstract. A tractor-mounted herbicide application system was designed and constructed for use during weed research activities on cropland, pastures, and rangeland. The spray system was designed to meet several requirements. A shield over the spray booms was needed to minimize wind distortion of the spray pattern. Multiple spray booms were to be mounted within the shield to expedite application of herbicide treatments. The spray system had to be durable enough to withstand the stresses of use on uneven and rough terrain. The sprayer had to be sufficiently portable to allow for easy loading and trailer transport. Current state-of-the-art, readily available spray system components had to be used. Finally, the spray system needed to be simple enough in design that any operational problems could be quickly diagnosed and corrected.

The spray system was constructed with a total shield frame length of 5.2 m. The shield frame was comprised of three segments. The two outside segments were 1.8 m long and the center segment was 1.6 m long. The outside segments were connected to the center segment by hinges that allowed the outside segments to be folded up over the center segment during loading and transport on a trailer. A total of four spray booms were mounted inside the shield with three clusters of four nozzle body assemblies and nozzle tips (XR11002) within each segment of the shield frame. The distance between nozzle clusters was 50 cm. The nozzle tips were located 20 cm from the top of the shield frame and 40 cm from the bottom edge of the shield frame. Nozzle assemblies were connected with 1.25 cm diameter reinforced clear vinyl tubing. Lexan™ panels, 20 cm wide, were installed in each of the three segments of the shield frame. These panels were mounted so that they could be rapidly removed to allow access to the nozzle clusters for purposes of calibrating the spray booms.

Herbicide spray solution containers were either 11 or 19 L stainless steel pressurized beverage containers that were 18 cm in diameter. A rack was mounted over the center segment of the spray shield to accommodate eight spray tanks. Four solenoid valves were mounted on the underside of the spray tank rack. Each of the solenoids was dedicated to one of the four spray booms. Switches to activate each solenoid were mounted on a panel placed adjacent to the seat of the tractor to which the sprayer was attached. An air tank was mounted in front of the spray tank rack over the center shield frame segment. A 12 volt DC 1/3 HP air compressor was mounted on the top of the air tank. The compressor and tank provide the pressurized air needed to charge and operate the spray booms.

This spray system has proven to be a durable and reliable tool that accurately and quickly applies herbicide treatments during research plot establishment. Herbicides are applied with the bottom of the shield placed 15 cm above the soil surface. This height provides 100% overlap of the spray pattern between adjacent nozzle tips. Herbicide treatments can be applied at ambient wind speeds of up to 40 km/hr without noticeable distortion of spray patterns.

IMPACT OF SOME EXOTIC WEEDS (SCOTCH BROOM AND GORSE) ON FOREST CROPS IN BRITISH COLUMBIA, CANADA. Raj Prasad, Research Scientist, Pacific Forestry Centre, Victoria, B.C. V8Z 1M5.

Abstract. Scotch broom (*Cystisus scoparius* (L) Link) and gorse (*Ulex europeus*, L.) are two exotic weeds invading the forested and other landscapes in southwestern British Columbia and posing a serious threat to conifer plantations. Both these exotic weeds were introduced in B.C. and possess several characteristics given below that promote their invasiveness and resultant suppression or displacement of native plant species: reduced leaves, active stem photosynthesis, nitrogen fixation, rapid vertical growth, profuse seed production, adaptation to various ecological niches and lack of natural enemies for control. There is little or no data on the impact of Scotch broom on conifers in British Columbia. Therefore, two field experiments were set up on southern Vancouver Island near Victoria to determine the nature and extent of its invasiveness and impact on Douglas-fir (*Pseudotsuga menziesii*) and other plant communities. A randomized block-layout type of experiment was laid out in August and the Scotch broom were either left intact (A) or removed from plots (B) where Douglas-fir seedlings were planted. Results from such a trial two years after indicated that Scotch broom reduces the growth (height and root collar diameter) of the Douglas-fir seedlings probably by reducing the infiltration of photosynthetically active radiation (PAR) measured at ground level, in the early establishment of the seedling crop (Table).

Table. Impact of Scotch broom on light infiltration and growth of Douglas-fir seedlings two years after cutting.

Treatment	PAR		Growth of Douglas-fir			
			Height		Root collar diameter	
	(μ E)	%	mm	%	mm	%
Scotch broom (not removed - uncut)	282.75	29	46.02	54	6.75	55
Scotch broom (removed - cut)	969.03	100	86.75	100	12.25	100

***APHTHONA* SPP. FLEA BEETLE MOVEMENT ALONG RAILROAD RIGHT-OF-WAYS.** K. M. Christianson, R. G. Lym, and C. G. Messersmith, Research Specialist and Professors, Plant Sciences Department, North Dakota State University, Fargo, ND 58105.

Abstract. Leafy spurge is often found in long narrow corridors such as railroad right-of-ways and is difficult to treat. Two experiments were conducted to determine the establishment, population increase, and movement of Aphthona species flea beetles in confined areas of leafy spurge.

A. nigriscutis was released in a dense stand of leafy spurge along a railroad corridor on June 28, 1993. There were five treatments consisting of 100, 200, 300, 400, and 500 adult insects released per treatment, plots were 260 feet apart, and replicated three times along a 2.5 mile stretch of the Burlington Northern railroad right-of-way near Buffalo, ND. Stem density and adult flea beetle population were monitored in the spring and summer, respectively, at the release point and at distances 10, 25, and 40 feet in a semi-circle pattern from the release point.

A. nigriscutis flea beetles were found in all treatment each year after release and leafy spurge stem density began to decline in 1995. The stem density decreased from an average of 18 stems/0.25 m^2 in 1993 to 5 stems/0.25 m^2 in 1997 (Table 1). The greatest stem density decrease was 72% when 500 beetles/plot were released. The maximum stem density decrease and highest beetle population occurred within 10 feet of the release point regardless of treatment. *A nigriscutis* populations in the 100 and 400 insects/release treatments averaged 7 beetles/m^2 compared to 2 beetles/m^2 for the 500 insects/release treatment.

A similar experiment was established on July 10, 1995 with a mixed population of *A. czwalinae/lacertosa* along the Red River Valley and Western railroad right-of-way near Lisbon, ND. The number of insects released was increased to 500, 1000, 15000, and 2000 adults per treatment. Release points were 150 feet apart with four replications along a 3.5 mile stretch of the right-of-way. Stem density and adult flea beetle population were monitored in the spring and summer, respectively, at the release point and at distances of 10, 30, 50, and 70 feet in a circular pattern around the release point.

A. czwalinae/lacertosa were found at all release sites in both 1996 and 1997. The average stem density in the 2000 insects/release treatment declined by 71% 2 years after release from 21 stems/m^2 to 6 stems/m^2 within 10 feet of the release point (Table 2). The average stem density declined 48, 60, and 23% within 10 feet of the release point for the 1500, 1000, and 500 insect treatments, respectively. *A czwalinae/lacertosa* were found up to 70 feet from the release point. Flea beetles will establish on industrial sites such as railroad right-of-ways. The larger the release number the more rapid the site stem density declines.

Table 1. *A. nigriscutis* establishment along the Burlington Northern Railroad near Buffalo, ND.

No. *A. nig.* released[a]	Stand count			Sweep count		
	1993	1996	1997	1995	1996	1997
	No./0.25m^2			No./m^2		
100	17	5	9	2	1	6
200	16	11	13	4	2	6
300	19	9	12	8	8	7
400	19	6	11	9	8	8
500	18	5	7	4	3	2
LSD (0.05)	NS	2	3	3	5	3

[a]Insects released June 1993, stand counts May each year.

Table 2. *A. czwalinae/lacertosa* establishment along the Red River Valley and Western Railroad near Lisbon, ND.

No. *A. nig.* released[a]	Stand count			Sweep count	
	1995	1996	1997	1996	1997
	No./0.25m^2			No./m^2	
500	26	26	21	2	19
1000	28	31	33	2	86
1500	27	23	20	3	14
2000	21	15	36	3	81
LSD (0.05)	NS	8	9	NS	NS

[a]Insects released June 1995, stand counts May each year.

CONTROL OF YELLOW STARTHISTLE WITH MOWING: EFFECTS OF TIMING, REPEATED CUTTINGS, AND GROWTH FORM. Carri B. Benefield, Joseph M. DiTomaso, Guy B. Kyser, Kenneth R. Churches, Daniel B. Marcum, Glenn A. Nader, and Steve Orloff, Extension Weed Ecologist, Graduate Student, and Staff Research Associate, Department of Vegetable Crops, University of California, Davis, CA 95616; Farm Advisor, University of California, Cooperative Extension, San Andeas, CA 95249; McArthur, CA 96056; Yuba City, CA 95991; and Yreka, CA 96097.

Abstract. Yellow starthistle is the most widespread non-crop weed in California. When used properly, mowing can offer an economical and effective option for control. However, successful implementation depends upon proper timing and plant growth form. We examined the effects of one or two cuttings at the bolting, spiny, or early flowering stage on plants with either a high (>10 cm) or low (<10 cm) branching pattern. Experiments were conducted in Calaveras, Shasta, Butte, and Siskiyou counties in northern California. Experiments were established in areas were yellow starthistle plants were in competition with grasses. Plants competing with grasses developed a more erect growth form with few basal branches. Low branching plants were produced when plots with yellow starthistle in the rosette stage were mowed, thinned, and treated with a postemergence graminicide. The efficacy of mowing was determined by measuring seedhead production per unit area at the end of the season. In all cases, mowing was most effective when conducted at the early flowering stage. Repeated mowing at the bolting stage was ineffective for the control of yellow starthistle. Mowing once at early flowering was just as effective as mowing twice at the spiny stage. Mowing erect plants with a high branching pattern provided better control than mowing low branching plants at all comparative stages of development. When plants developed a low branching pattern, mowing was not effective, regardless of the timing or number of cuttings.

MINIMIZING WEED SPREAD FOLLOWING WILDLAND FIRES. Jerry Asher, Steven Dewey, Jim Olivarez, and Curt Johnson, Natural Resources Specialist, Bureau of Land Management, Portland, OR 97208; Professor, Utah State University, Logan, UT 84322-4820; Regional Weed Specialist, USDA Forest Service, Missoula, MT 59807; and Regional Range Specialist, USDA Forest Service, Ogden, UT 84401.

Abstract. Every year we learn more about the challenge of reducing the spread of invasive wildland weeds. During the last few years more people have come to realize that small weed infestations often explode following the natural disturbance and release of nutrients associated with either wild or prescribed fire. Sometimes the increase in weeds following a fire is small, but sometimes the expansion is extensive. Recent examples of severe post-fire weed spread and impacts include new musk thistle infestations near Montrose and Glenwood Springs Colorado, leafy spurge near Idaho Falls and Burley Idaho, hoary cress near Worland Wyoming, dyer's woad at Perry Utah, yellow starthistle in the Ishi Wilderness Area of northern California, spotted knapweed in the Selway-Bitteroot Wilderness Area of Montana and Idaho, and rush skeletonweed in three wilderness study areas near Shoshone Idaho.

Potential weed problems must be addressed during pre-fire planning of prescribed burns, and careful post-fire vigilance following both unprescribed and prescribed fires. In planning any prescribed burn, the potential for increased weed populations must be evaluated. Existing weed maps must be reviewed and the entire proposed burn area should be surveyed for weeds. Adjacent areas should be included in the survey for an indication of what might be expected following the burn. These lands also may provide a source of weed seeds into the burn area via transport on wildlife, livestock, wind, water, vehicles, or other equipment. Ensure that equipment and personnel taking part in the burn operation do not introduce new weeds or redistribute existing weeds within the burn area. Ensure that the appropriate NEPA process and requirements are addressed during the planning stage in order to avoid any delays in timely post-fire herbicide applications in the event they are needed.

Post-fire growth of weeds often presents an excellent opportunity for effective control. They are often the first plants to begin regrowth, making them easier to find for mechanical or chemical controls. Spray coverage also is more thorough following a burn because weeds are no longer protected by non-target vegetation or debris. The cost of weed management should be included into fire rehabilitation plan budgets. Approximately one month following any fire, survey the entire area for signs of new or resprouting weeds. Repeated surveys will be needed, with the frequency and intensity guided by local conditions. When weeds are discovered, implement timely control measures with the vigor and dispatch commonly seen in emergency post-fire rehabilitation seedings.

PURPLE LOOSESTRIFE ERADICATION IN ALBERTA. Shaffeek Ali and Dennis Lee, Alberta Agriculture, Food and Rural Development, Edmonton, Alberta, T6H 5T6.

Abstract. Purple loosestrife is a herbaceous wetland perennial that was introduced into North America from Europe in the early 1800's. The plant's distribution has been expanding at the expense of native wetland. It invades wetland areas, competes with and replaces desirable native vegetation. Wildlife that depend on the native plants for food and shelter are forced to move to new areas.

In Canada, purple loosestrife is well established in the Maritimes, Quebec, and Southern Ontario. Pioneer communities are appearing in the Prairies and the Province of British Columbia. The first infestation of purple loosestrife in Alberta was reported in 1990. A program to eradicate all infestations and prevent the establishment of purple loosestrife was established in 1991. By 1997, a cumulative total of 80 infestations has been recorded and eradication measures have been undertaken at each site. No purple loosestrife have been observed for the past two or more years at 17 of these sites, suggesting that the weed has likely been eliminated at these sites.

TEN YEARS OF HERBICIDE TESTING IN PNW FOREST NURSERIES. Diane L. Haase and Robin Rose, Associate Director and Director, Nursery Technology Cooperative, Department of Forest Science, Oregon State University, Corvallis, OR 97331.

INTRODUCTION

Herbicide application is an important component of the integrated approach to producing quality conifer seedlings in a forest nursery. Herbicide products are subject to scrutiny based on environmental regulations and can therefore be removed from the market. Also, weed species may develop a tolerance for certain chemicals. As a result, it is crucial for the forest nursery industry to continually research and test new products for vegetation control. The Nursery Technology Cooperative (NTC) at Oregon State University has conducted herbicide screening trials for the past decade on bareroot seedling beds. The objective of the trials has been to evaluate phytotoxicity and weed control efficacy for products which show potential for the forest nursery industry.

MATERIALS AND METHODS

A standard protocol has been established for installing treatment plots and collecting data. The experimental design consisted of a randomized complete block with four replications. Treatments were assigned randomly to plots within each block. Each treatment plot was 6 feet long which includes a 1 foot buffer on each end resulting in a 4 foot area used to assess seedling damage and weed counts. Because of the relatively small test areas, herbicides were applied via a backpack sprayer. Herbicide test plots were commonly applied at 1X and 2X rates and were compared to a standard rate of an operational herbicide (oxyfluorfen and/or propionamide) known to have minimal phytotoxicity and effective weed control. In addition, comparisons were made to untreated control plots. Depending on the product, applications were made to both seedbeds and transplants. Douglas-fir seedlings were most commonly used in the trials and to a lesser extent ponderosa pine, western hemlock and a few other species. Up to eight bareroot forest nurseries in the PNW participated each year. Each herbicide was tested for 1 to 4 years (Table).

Data was collected from the treatment plots three to four times following herbicide application and again at the end of the seedlings' growing season. Phytotoxicity data was collected on three individual drill rows within the treatment plot. In each drill row, the total number of live trees was recorded as well as the number which were dead or damaged due to herbicide. Weed control efficacy data was collected on the entire four foot assessment area. The number of each species of forbs and grasses were recorded and the plots were handweeded at each data collection date. At least one weed tally was completed after pre-emergent herbicide application but before post-emergent herbicide application and at least once after post-emergent application.

Table. The rates and crops evaluated for each herbicide tested by the NTC during a 10-year period.

Herbicide	Years tested	Rates tested	Crops evaluated
		lb/A	
Lactofen	1987-88	0.25, 0.5	1-0, P-1, and 1-1 Douglas-fir, 1-0 noble fir, 1-0 lodgepole pine, 1-0 ponderosa pine, P-1 western hemlock
Clopyralid	1989-90	0.095, 0.190, 0.38, 0.76	1-0 and 1-1 Douglas-fir
Metolachlor	1989-90	3.9, 5.85	1-1 Douglas-fir
Isoxaben	1990	0.75, 1.5	1-0 and 1-1 Douglas-fir
Oxadiazon	1991-94	2, 4	1-0 and 1-1 Douglas-fir, 1-0 ponderosa pine
Clethodim	1992-94	0.25, 0.5	1-0 and 1-1 Douglas-fir, 1-0 grand fir, 1-0 ponderosa pine, 1-1 western hemlock, 1-1 Pacific yew, 1-0 red alder, 1-1 noble fir
Pendimethalin	1993-94	2, 4	1-1 Douglas-fir, 1-1 Pacific yew, 1-1 western hemlock
Prodiamine	1995-96	0.75, 1.5	1-0, P-0, and 1-1 Douglas-fir, 1-0 red alder, 1-1 western hemlock, 1-0 ponderosa pine, 1-0 bitterbrush
Thiazopyr	1995	0.5, 1	1-1 Douglas-fir, 1-1 western hemlock

RESULTS AND DISCUSSION

Six nurseries tested lactofen. It was applied as a pre-emergent application over seedbeds (1-0) and a pre-budbreak application over transplants (1-1 and P-1). Results indicate that damage to seedlings was not significantly different from the operational nursery herbicides. In addition, this herbicide provided good weed control. This herbicide has just recently been labeled for conifer nursery use and will be tested again in 1998 under the new label.

Five nurseries participated in the screening of clopyralid over seedbeds and transplants. Weed control was good but phytotoxicity levels were high. Rates were cut by half during the second year of testing, but phytotoxicity levels remained high and weed control efficacy was reduced. This herbicide was deemed unsuitable for forest nursery use. Metolachlor was tested at five nurseries on Douglas-fir transplant seedlings. There was minimal damage to seedlings and weed control efficacy was high. Metolachlor has been labeled for forest nurseries and is currently used in some nurseries depending on soil type.

Five nurseries evaluated isoxaben on both seedbeds and transplants. Minor damage (not statistically significant) was found at two of the nurseries. Weed control efficacy was comparable to that of the operational herbicide. Despite the favorable results, this product has not been registered for use in conifer nurseries in the U.S. The company which produces this product was held liable for crop damage from another herbicide and does not have an interest in pursuing the forest nursery market.

Oxadiazon herbicide was tested for four years by the NTC. Significant damage and mortality was found on 1-0 seedbeds during the first year of testing which resulted in fewer live seedlings in the treated plots. During the third year, a few nurseries tested oxadiazon on seedbeds at a lower rate and at different lengths of time after germination. Significant phytotoxicity was still found at all but one of the nurseries (Webster). The following year, the Webster nursery applied oxadiazon at two different rates to diverse seedlots of 1-0 Douglas-fir seedlings: early sown, late sown, low elevation, and high elevation. Again, phytotoxicity was minimal and did not differ significantly from the control plots and the number of weeds did not differ from those found in the operational treatment plots. There was very little phytotoxicity in transplant beds in all years tested. Weed control was very good with the exception of weeds in the Caryophyllaceae family. As a result of the NTC trials and other testing, this herbicide was labeled for forest nursery use in 1993.

Clethodim was tested on several conifer species and red alder over three years. Applications were made to both seedbeds and transplants. Phytotoxicity was minimal on treatment plots and control of grasses and forbs was good. The minimal damage to western hemlock was especially noteworthy since this species is particularly sensitive to chemical applications. Clethodim was also tested with and without a crop oil addition. There were no differences among treatments due to the presence or absence of crop oil. With the contribution of the NTC data, this herbicide was labeled in 1993 for use in forest nurseries. Three nurseries tested pendimethalin on transplant seedlings. This herbicide provided good weed control and minimal phytotoxicity on Douglas-fir and yew. However, western hemlock seedlings were significantly damaged. This product has not yet been labeled for forest nursery use.

A total of eight nurseries tested prodiamine over a 2 year period. During the first year, applications were made to transplant seedlings only. Weed control was good and no phytotoxicity was observed, even on bitterbrush seedlings which are sensitive to most herbicides. During the second year of testing, prodiamine was applied to transplants as well as 2 to 6 weeks following germination to determine if and when it could be applied to seedbeds. Weed control during the second year of testing was inconsistent and stem swelling at the groundline was observed in both Douglas-fir transplant and seedbed plots at most of the nurseries. This herbicide was deemed unsuitable for use with Douglas-fir seedlings.

Thiazopyr had no phytotoxic effect on Douglas-fir seedlings but did cause significant damage to western hemlock seedlings. Weed control efficacy was good. This herbicide was an experimental product. The manufacturer had no interest in additional screening for forest nursery use.

CONCLUSIONS

The results have led to product labeling for forest nursery use and have aided in the elimination of certain herbicides due to unacceptable levels of phytotoxicity or ineffective weed control. An added benefit is that the relationship established between the NTC and herbicide manufacturers has resulted in better wording on the labels specific to forest production nurseries. The NTC herbicide testing program will continue on an annual basis.

EFFECT OF SEVERAL SOIL ACTIVE HERBICIDES USED IN FORESTS OF THE PACIFIC NORTHWEST ON GERMINATION OF SEVERAL COMMON HARDWOOD SPECIES. J. Scott Ketchum and Robin Rose, Faculty Research Assistant and Associate Professor, Department of Forest Science, Oregon State University, Corvallis, OR 97331.

INTRODUCTION

There presently are several herbicides available for use in forest regeneration in the Pacific Northwest. These herbicides are mixed at different ratios and applied at differing rates as determined by the product label, perceived degree of vegetative competition, and the species composition on the site. Much of the research emphasis in the past has centered on how to control existing vegetation and on reducing the establishment of annual and perennial grasses and forbs. Currently soil and foliage active herbicides such as hexazinone, sulfometuron, metsulfuron and atrazine are widely used and are quite effective at preventing successful establishment of grass and forb species. These same herbicides have also been shown to have activity to differing degrees on established woody species.

There is a large bank of knowledge on the influence of the above herbicides on established shrub and tree species but little is known about how these same herbicides affect seed germination and establishment of woody species. Field observations suggest that the many soil active herbicides have greater action on germinating seedlings than on adult plants. There is a need to quantify the effect of these herbicides on germinating woody species. From a management perspective this could provide another tool in the control of such species, especially on sites where high germination rates are expected. For example, on sites adjacent to areas with large number of alders, or regions with historical populations of *Ceanothus*, etc.

MATERIALS AND METHODS

Four of the most common preemergent herbicides used in Pacific Northwest Reforestation (atrazine, hexazinone, sulfometuron, and metsulfuron) were selected to test over 12 common woody species. These species were picked because they readily reproduce via seed and are found across many forest sites west of the Cascades from Northern California to British Columbia. Prior to sowing, the seed were stratified (Table 1).

Treatments. Six rates of each herbicide were tested using seeds from 12 species. The rates ranged from a no herbicide control to nearly double normal operational rates. Operational rates typically fall within the treatment 4 and 5 range. The treatments were applied via a gas powered boom sprayer. All the pots for all species designated to receive a particular dose of each herbicide were placed within a 20 ft^2 area. The appropriate amount of herbicide based on this 20 ft^2 area was added to a 500 ml solution and the entire solution was sprayed evenly over the area. To spray the entire 500 ml of spray solution over the area required several passes with the boom sprayer insuring a continuous cover of herbicide over the entire area.

Eight replications of between 6 and 10 seeds for each species were placed on the surface of a sandy loam potting material in 2 by 3 by 2 inch pots for each herbicide rate treatment. The 2 by 3 inch pots are considered the treatment unit. A thin layer of fine gravel was placed over the seeds to hold them in place during watering. The number of seeds planted per pot was kept constant for each species. More seed of some species were used than others due to the size of the seed and their expected viability.

After planting and receiving herbicide treatments, the pots were placed in a greenhouse and kept watered to insure the best environment possible for the seeds to germinate and establish.

There was not enough seed available for some species to test germination success with all four herbicides. For these species tests were run for only as many herbicides as there was seed available. An outline of which seeds were tested against which herbicides and the number of seeds planted per pot (Table 2).

Measurements. The number of germinating seeds was recorded twice a week for eight weeks following the herbicide treatments. At the end of this time all the seedlings were harvested. Care was taken to keep the root systems of live germinants in tact. The final number of live germinants per pot and the dried weight of these germinants was recorded.

Analysis. An ANOVA procedure was used to test for significant differences in the percentage of successful germinants, the average dried weight of these germinants eight weeks following sowing and treatment with herbicides. The Waller Duncan test was used to determine mean separations among different rates of an individual herbicide for each species-herbicide combination tested.

Table 1.

Test species	Latin name	Common name	Stratification requirements
1	*Cytisus scoparius*	Scotch broom	nick seed coat and soak for 12 h
2	*Cytisus striatus*	Portuguese broom	nick seed coat and soak for 12 h
3	*Sambucus spp*	Elderberry	warm moist stratification for 90 d followed by cold moist stratification for 90 d
4	*Alnus rubra*	Alder	no stratification needed
5	*Rubus parviflorum*	Thimbleberry	warm moist stratification for 90 d followed by cold moist stratification for 90 d
6	*Rubus ursinus*	Trailing Blackberry	warm moist stratification for 90 d followed by cold moist stratification for 90 d
7	*Rubus spectabilis*	Salmonberry	warm moist stratification for 90 d followed by cold moist stratification for 90 d
8	*Prunus emarginata*	Bitter Cherry	warm moist stratification for 90 d followed by cold moist stratification for 90 d
9	*Ceanothus velutinus*	Snowbrush	place seed in 170 F allow to cool over night then cold moist conditions for 90 d
10	*Ceanothus integerrimus*	Deerbrush	place seed in 170 F allow to cool over night then cold moist conditions for 90 d
11	*Populus trichocarpa*	Cottonwood	no stratification needed
12	*Arctostaphylos patula*	Greenleaf Manzanita	place seed in 170 F allow to cool over night then cold moist conditions for 90 d

Table 2. Plant species tested against the four different herbicides and number of seed planted per pot.

Plant species	Sulfometuron	Hexazinone	Atrazine	Metsulfuron
	test/seeds	test/seeds	test/seeds	test/seeds
Cytisus scoparius	yes/6	yes/6	yes/6	yes/6
Cytisus striatus	yes/6	yes/6	no	yes/6
Sambucus spp	yes/10	yes/10	yes/10	yes/10
Alnus rubra	yes/10	yes/10	yes/10	yes/10
Rubus parviflorum	yes/6	yes/6	no	no
Rubus ursinus	yes/6	yes/6	no	no
Rubus spectabilis	yes/8	no	no	no
Prunus emarginata	yes/5	yes/5	yes/5	yes/5
Ceanothus velutinus	yes/10	yes/10	yes/10	yes/10
Ceanothus integerrimus	yes/10	yes/10	yes/10	yes/10
Populus trichocarpa	yes/10	yes/10	yes/10	yes/10
Arctostaphylos patula	yes/6	yes/6	yes/6	yes/6

RESULTS AND DISCUSSION

The number of seeds that successfully germinated (emerged from the seed and opened their cotyledons) varied widely with herbicide and species tested. In general, atrazine and hexazinone applications resulted in good to excellent control of all species tested. Sulfometuron effectiveness varied by species as did metsulfuron effectiveness.

Hexazinone and atrazine negatively influenced deerbrush germination success and average dry weight even at the lowest rates applied (Table 3). Neither metsulfuron or sulfometuron influenced germination success even at the highest rates. However, low rates of sulfometuron negatively influenced average germinant dry weight. Only at the highest rate of metsulfuron was a significant reduction of average dry weight observed relative to the control. All four herbicides strongly reduced germination success and average seedling dry weight of snowbrush (Table 3). Even the lowest rate of all four herbicides tested significantly reduced germination success and average seedling dry weight from the untreated controls.

Cottonwood germination success was low in the control treatments ranging from a low of 8% in the hexazinone trial to a high of 19% in the metsulfuron trial (Table 3). The lowest rates of hexazinone, sulfometuron and atrazine tested strongly reduced the germination success and average seedling dry weight of cottonwood germinants. Metsulfuron did not result in a significant reduction of germination success even at the highest rate applied. However, medium to high rates of metsulfuron significantly reduced the average dry weight of cottonwood seedlings.

Germination success and average seedling dry weight of scotch broom were significantly reduced at low rates of both hexazinone and atrazine (Table 3). Sulfometuron did not significantly influence germination success but moderate to high rates did reduce the average seedling dry weight. Differences in germination success for metsulfuron applications varied significantly by treatment. However, germination success did not differ significantly in any one treatment from the untreated check. Metsulfuron resulted in reduced average seedling weight but the magnitude of this was not as great as observed with either hexazinone or atrazine.

Portuguese broom germination success was poor (only 10% in the controls) for the metsulfuron trial and germination success did not vary significantly by rate for this herbicide (Table 3). Differences in average weight were observed but were generally not large and did not correspond well with increasing herbicide rate of metsulfuron. Germination success for both the sulfometuron and hexazinone trials was good. Sulfometuron did not result in significant reductions in germination success but low rates resulted in significant reductions in average seedling dry weight, although these reductions were not large. Hexazinone resulted in significant reductions in germination success and average seedling dry weight at moderate to high rates.

Both sulfometuron and hexazinone significantly reduced germination success and average seedling dry weight of thimbleberry even at low to moderate rates (Table 3). There was not enough available seed to test this species against metsulfuron or atrazine. At moderate to high rates of hexazinone trailing blackberry germination success and average seedling weight were significantly reduced. Sulfometuron had little influence on germination success but significantly reduced average seedling dry weight even at low rates. Trailing blackberry was not tested against metsulfuron or atrazine due to a shortage of available seed. Sulfometuron had little influence on Salmonberry germination success but even low rates strongly reduced the average seedling dry weight observed. Salmonberry was not tested against hexazinone, atrazine or metsulfuron due to a shortage of available seed.

Germination success in the untreated check treatment was good for most species. Unfortunately, three of the species tested failed to germinate in sufficient numbers to perform statistical tests. These three species were bitter cherry, greenleaf manzanita, and elderberry. The seed for these species remained viable throughout the experiment but apparently seed dormancy was not broken. Additionally, the seed used for red alder was of poor viability and only a limited number of seeds germinated.

CONCLUSION

Hexazinone and atrazine application resulted in the most consistent control of all the seed species examined. Sulfometuron resulted in good to excellent control of all species tested with the exception of both broom species. However, the highest rates of sulfometuron resulted in less dry weight of both broom species. Under less ideal conditions the combination of other environmental stresses along with herbicide stress may have resulted in greater scotch and Portuguese broom mortality. This is likely true for all the species examined and it is suspected that if the seeds in this trial had been subjected to even minor moisture stress many of those treated with herbicides would have perished. Growth of true leaves and of extensive root systems was dramatically reduced for most germinants exposed to any of the herbicides (with a few exceptions) which would have strongly limited their ability to successfully establish under field conditions.

Table 3. Mean percent germination and average seedling weight for each species and rate tested.[a]

		Deerbrush		Snowbrush		Black cottonwood		Scotch broom		Portuguese broom		Trailing blackberry		Thimbleberry		Salmonberry	
Treatment	Rate	germ.	wt	germ.	wt	germ.	wt	germ.	wt	germ.	wt	germ.	wt	germ.	wt	germ.	wt
	oz/A	%	mg	%	mg	%	mg	%	mg	%	mg	%	mg	%	mg	%	mg
Hexazinone	0	51 a	210 a	69 a	14 a	7.5 a	4 a	52 a	40 a	52 a	70 a	33 b	60 a	62.3 a	11 a	.	.
Hexazinone	8	26 b	9 b	10 b	3 b	0 b	0 b	30 b	30 ab	50 a	30 a	60 a	4 ab	29 b	2 b	.	.
Hexazinone	16	6 cd	3 cd	0 c	0 c	0 b	0 b	0 c	0 c	0 b	0 c	20 bc	4 ab	6.4 cd	1 b	.	.
Hexazinone	24	14 c	6 c	5 bc	1 c	0 b	0 b	10 c	10 bc	35 a	30 b	22 bc	2 bc	15 c	2 b	.	.
Hexazinone	32	4 cd	1 d	3 bc	1 c	0 b	0 b	5 c	6 c	7.5 b	10 c	8 cd	1 c	4 cd	1 b	.	.
Hexazinone	48	0 d	1d	0 c	0 c	0 b	0 b	3 c	2 c	2.5 b	0.1 c	2 d	1 c	0 d	0 b	.	.
Sulfometuron	0	40 a	24 a	46 a	16 a	13.7 a	14 a	42 a	40 a	60 a	70 a	31 a	7 a	41 a	11 a	57 a	13 a
Sulfometuron	0.75	45 a	11 b	10 b	2 b	5 b	1 b	50 a	30 ab	50 a	40 b	31 a	4 b	31 ab	1 b	39 ab	5 a
Sulfometuron	1.5	36 a	7 bc	8 b	2 b	7.5 ab	2 b	60 a	30 ab	58 a	30 b	15 ab	3 b	8 b	0.1 b	22 b	2 c
Sulfometuron	2.25	35 a	9 bc	5 b	1 b	5 b	1 b	58 a	30 ab	38 a	40 b	29 ab	3 b	19 ab	2 b	45 ab	3 c
Sulfometuron	3	29 a	7 bc	6 b	1 b	1.3 b	1 b	32 a	20 ab	45 a	30 b	13 b	1 b	19 ab	1 b	42 ab	3 c
Sulfometuron	4.5	20 a	6 c	4 b	1 b	1.3 b	1 b	45 a	10 b	55 a	30 b	27 ab	2 b	35 a	2 b	59 a	2 c
Metsulfuron	0	43 a	16 ab	46 a	14 a	18.8 a	6 a	37.5 abc	50 a	10 a	10 a	.	.	.	.	.	.
Metsulfuron	0.15	38 a	19 a	24 b	5 b	16.3 a	2 b	40 ab	40 a	12.5 a	40 a	.	.	.	.	.	.
Metsulfuron	0.3	51 a	12 b	33 ab	4 bc	11.3 a	1 b	52 a	20 b	0 a	0 b	.	.	.	.	.	.
Metsulfuron	0.45	45 a	15 ab	26 b	4 bc	10 a	2 b	25 bc	20 b	7.5 a	10 ab	.	.	.	.	.	.
Metsulfuron	0.6	39 a	13 ab	18 b	4 bc	6.3 a	1 b	32 bc	30 ab	7.5 a	4 b	.	.	.	.	.	.
Metsulfuron	1.2	48 a	11 b	14 b	2 c	5 a	1 b	20 c	20 b	12.5 a	23 ab	.	.	.	.	.	.
Atrazine	0	48 a	17 ac	51 a	17 a	18.8 a	5 a	22 a	21 a	.	.	.	.	.	.	.	.
Atrazine	16	12.5 bc	5 b	1.3 b	1 b	0 b	0 b	8 bc	5 b	.	.	.	.	.	.	.	.
Atrazine	32	0 c	0 c	0 b	0 b	0 b	0 b	0 c	0 b	.	.	.	.	.	.	.	.
Atrazine	48	17.5 b	3 bc	3 b	1 b	0 b	0 b	20 ab	6 b	.	.	.	.	.	.	.	.
Atrazine	64	0 c	0 c	0b	0 b	0 b	0 b	2.5 c	2 b	.	.	.	.	.	.	.	.
Atrazine	80	1.2 c	1 c	1.3 b	1 b	0 b	0 b	5 c	2 b	.	.	.	.	.	.	.	.

[a] Means within a column for each herbicide and species interaction associated with the same letter are not significantly different $p \leq 0.05$.

EARLY RESULTS OF THE 'HERB II' STUDY: EVALUATING THE INFLUENCE VEGETATION CONTROL HAS ON FERTILIZATION AT THE TIME OF PLANTING. Robin Rose and J. Scott Ketchum, Associate Professor and Faculty Research Assistant, Department of Forest Science, Oregon State University, Corvallis, OR 97331-7501.

INTRODUCTION

Fertilization in forest nurseries is a common practice to enhance growth rate and vigor of conifer seedlings. Fertilization has also been tried in the field at the time of planting as a means to enhance reforestation efforts. Early fertilization results have been mixed with positive responses in some trials (Woods et al. 1993, Powers and Ferrel 1996) and poor to negative responses in others (Sutton 1995, Roth and Newton 1996). The purpose of this study was to assess the interactive effects among increasing levels of vegetation control and fertilizer treatments over an array of conifer species on a variety of Pacific Northwest regional sites from northern California to eastern Washington.

MATERIALS AND METHODS

The basic study design was a completely randomized design with the plot being the treatment unit. The study design has been repeated five times with four species of crop trees: Douglas-fir, ponderosa pine, western hemlock, and coastal redwood (Table 1). Each of the five study sites consisted of four replications of six separate treatment plots. Treatments were: no vegetation control, no vegetation control and fertilization, 2 feet tree centered radius of vegetation control, 2 feet radius and fertilization, 3 feet tree centered radius of vegetation control, and 3 feet radius and fertilization Each plot consists of 36 conifer seedlings planted at a 10 by10 feet spacing.

Table 1. Study sites locations and crop trees used in the five repetitions of the Herb II study.

Study site	Established	Crop species	Location
Vernonia	spring 1995	Douglas-fir	Northwestern Oregon Coast Range
Klickitat	spring 1995	Ponderosa pine	East of Mt. Adams in WA
Drain	spring 1996	Douglas-fir	Oregon Coast Range a few miles N. of Roseburg
Seaside	spring 1996	Western hemlock	5 miles inland from the coastal town of Seaside OR
Korbel	spring 1996	Coastal redwood	10 miles inland from the N. CA coastal town of Arcata

The fertilization treatment consisted of two slow release (1 to 2 year) fertilizer briquettes with formulations of 14:3:3 (N:P:K) and 9:9:4. Both briquettes also contained micro-nutrients. The briquettes were added to the bottom of the hole at the time of planting. Either hexazinone or sulfometuron were used to create the vegetation control treatments and were applied in April the year of planting and again the following April using a backpack applicator. The herbicide used and rate varied with site. The goal of the herbicide treatments was not to test the activity of the herbicide or rate used but to achieve the desired radii of vegetation control and maintain it for a period of two growing seasons.

Seedlings were measured for stem diameter at 15 cm above the ground line and height each growing season in late fall after growth had ceased. Stem volume was calculated as the volume of a cone ((stem diameter)^2*height*p/12) and is used as the best measure of seedling response to the six treatments applied.

Analysis of variance was used to test for differences in stem volume by treatment for each site using initial stem caliper as a covariate. To meet the ANOVA assumptions means for stem volume were linear transformed and reported means have been backtransformed.

RESULTS AND DISCUSSION

Response to fertilization and vegetation management was surprisingly similar across the five study sites. At all but the Seaside site, the 3 feet radius of vegetation control with or without fertilization resulted in greater volume than both check treatments. At Seaside only the fertilized 3 feet radius treatment was significantly greater than the unfertilized check treatment. Fertilization did not result in a significant increase in volume at any site when compared between the same level of vegetation control treatments. Although not significantly different, means for the fertilized 3 feet radius treatments resulted in consistently greater volume than the unfertilized 3 feet treatments across all five sites. Similarly, the fertilized 2 feet treatments resulted in means that were larger than the unfertilized 2 feet treatments across all sites. There were no constant responses between the fertilized and unfertilized check treatments across the 5 study sites.

Prior to harvest the Seaside site was dominated by a dense mature stand of western hemlock (Figure 1a). After harvest vegetation invaded the site slowly taking more than two years to completely invade the site. Because of this, the vegetation control treatments had less influence on the competition faced by planted seedlings than on other sites. This explains in part the lack of a strong trend of increasing growth with increased radius of vegetation control. Means for the fertilized treatments although not significant were much larger than the unfertilized treatments.

Ponderosa pine stem volume responded nearly identical to the treatments as the Douglas-fir Vernonia site (Figure 1b). All radius control treatments resulted in significantly greater stem volume than the untreated check treatments. The fertilized 3 feet radius treatment resulted in the greatest stem volume, significantly greater than the 2 feet unfertilized treatment. A trend of increased response to fertilization with increased radius of control was observed although fertilization did not result in increased stem volume between any two similar radius treatments.

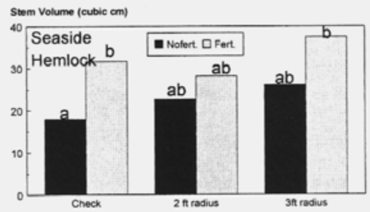
Douglas-fir stem volume increased with increased radius of vegetation control at the Vernonia site (Figure 1c). All the radius treatments of 2 feet or greater had significantly greater third year stem volume than the untreated check treatments. Only the 3 feet radius fertilized treatment had a significantly greater stem volume than the 2 feet radius unfertilized treatment. A trend of increasing response to fertilization with increased radius of control was observed Fertilization did not result in significantly larger stem volume among similar radius of control treatments.

No significant differences were observed among any of the six fertilizer and vegetation control treatments tested at the drain site (Figure 1d). However, the same trend of increasing stem volume with increased radius as seen at Vernonia and Klickitat was observed. This trend was not as pronounced as on the other two sites.

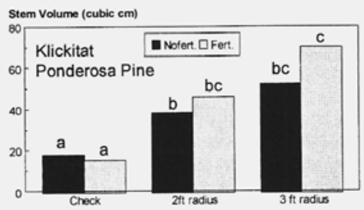
The fertilized 3 feet radius treatment resulted in second year coastal redwood stem volume significantly greater than all other treatments except the unfertilized 3 feet radius treatment at Korbel (Figure 1e). The fertilized check treatment was significantly smaller than both 2 feet treatments and both 3 feet treatments. Fertilization did not result in significantly greater stem volume between any two similar radius treatments.

CONCLUSION

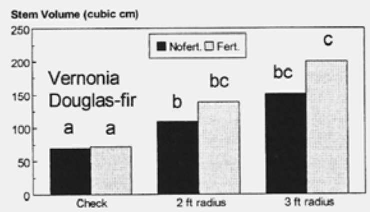
Without adequate vegetation control a positive response to fertilization is unlikely on most reforestation settings in the Pacific Northwest. Weed control results in increased levels of soil moisture and thus increased nutrient availability (Nambiar and Sands 1993). Plants require moisture to absorb soil nutrients. Although not directly measured, the increase in soil moisture resulting from the vegetation control treatments in our study is likely responsible for the growth responses observed in fertilized and control treatments. Similar findings have been reported by other investigators (Woods et al. 1993, Powers and Ferrel 1996). Placement of the fertilizer briquettes in the planting hole and the use of a complete fertilizer are also suspected of aiding in the positive fertilizer response measured. Fertilizer in the planting hole insures that the seedling targeted benefits from the added nutrients and not competing vegetation, which has been the case in other reported literature (Roth and Newton 1996). Variability was high at each site and, although there were differences in the overall plot means, many individual seedlings failed to respond to fertilization. More research is needed to find which combinations of application technique, weed control and fertilizer formulation will illicit the best response for different tree species on differing sites.



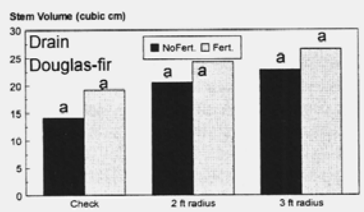
a. Seaside



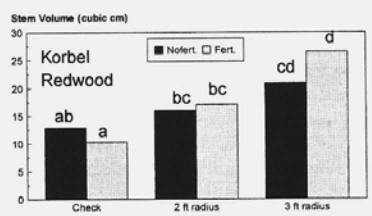
b. Klickitat



c. Vernonia



d. Drain



e. Korbel

Figure 1. Stem volume means for all five sites across all six treatments. Bars associated with similar letters within a graph are not significantly different ($p \leq .05$).

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DIFLUFENZOPYR INCREASES PERENNIAL WEED CONTROL WITH AUXIN HERBICIDES. Rodney G. Lym and Katheryn M. Christianson, Professor and Research Specialist, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

INTRODUCTION

BAS-662 (formally known as SAN-1269) is a combination of dicamba plus diflufenzopyr (SAN-836) in a ratio of 2.5:1 dicamba:diflufenzopyr. Diflufenzopyr is an auxin transport inhibitor (ATI), which suppresses the transport of naturally occurring IAA and synthetic auxin-like compounds in plants. In general, diflufenzopyr interferes with the auxin balance needed for plant growth. The purpose of this research was to evaluate diflufenzopyr alone and in combination with dicamba and other auxin herbicides for perennial weed control in a series of greenhouse and field studies.

MATERIALS AND METHODS

Greenhouse. Initially diflufenzopyr was only available for research as a tank-mix with dicamba (BAS-662) and was evaluated in two greenhouse studies. BAS-662 was applied to 12-week-old leafy spurge plants to achieve dicamba rates of 0.5 to 4 oz/A. The treatments were compared to dicamba applied alone. The plants were evaluated for top growth injury 1 and 2 WAT (weeks after treatment) Then all top growth was removed and the plants were allowed to regrow for 4 weeks (6 WAT), at which time the leafy spurge regrowth was harvested, oven dried, and weighed.

In a second greenhouse study, BAS-662 was applied in combination with other auxin and non-auxin herbicides. The ratio of the new auxin herbicide to ATI was 2.5:1. Since BAS-662 also contained dicamba, the treatments were in effect 3-way tankmixes.

Field. Diflufenzopyr in combination with auxin herbicides was evaluated in a series of field trials following the promising results observed in the greenhouse trials. Diflufenzopyr alone was available when these trials began. Auxin herbicides were applied with diflufenzopyr at a ratio of 2.5:1 to Canada thistle, leafy spurge, and spotted knapweed on June 12, 1997. The air temperature and dew point were in the mid-80s and mid-60s, respectively. Treatments were applied using a hand-held sprayer delivering 8.5 gpa. Each species was a separate trial. Treatments were visually evaluated for foliage injury 1.5 MAT (months after treatment) and control 3 MAT.

BAS-662 will likely be marketed for cropland use in 1998 and would be the first herbicide with diflufenzopyr available for pasture and rangeland use. Thus, a second leafy spurge experiment to compare dicamba alone and applied with the ATI was established near Fargo on July 22, 1997. The air temperature was 73 and the dew point was 66. The experimental area had been flooded in April 1997 which delayed the leafy spurge maturity. Leafy spurge was beginning seed-set (25%) but 50 to 75% were still flowering.

RESULTS AND DISCUSSION

Greenhouse. There were no visible differences in injury symptoms on plants where dicamba was applied alone or with diflufenzopyr. However, leafy spurge regrowth was much less when dicamba was applied with diflufenzopyr compared to dicamba applied alone at the same dicamba rate (Table 1). For example, leafy spurge regrowth 6 WAT averaged 385 mg/plant with dicamba at 4 oz/A and with BAS-662 that included dicamba at only 0.5 oz/A plus diflufenzopyr. Leafy spurge did not regrow when dicamba at 4 oz/A plus diflufenzopyr was applied.

Leafy spurge control also increased when BAS-662 was applied with picloram, 2,4-D, and picloram plus 2,4-D (Table 2). In general, leafy spurge regrowth was reduced nearly 50% more when picloram or 2,4-D was applied with BAS-662 compared to either herbicide alone and by 98% when picloram plus 2,4-D was applied with BAS-662 compared to the herbicide combination alone. No increase in control was observed when diflufenzopyr was applied with the non-auxin type herbicides glyphosate or AC 263,222 (data not shown). The combination of quinclorac plus BAS-662 resulted in precipitate formation, which probably reduced leafy spurge control. This problem was later overcome when quinclorac was applied with diflufenzopyr alone in the field studies. It is not known what amount, if any, the dicamba portion was contributing to the increase in control when BAS-662 was applied with these herbicides. However, dicamba at 4 oz/A caused less than 50% weight reduction (Table 1), so dicamba at 2 oz/A (as occurred with diflufenzopyr at 0.8 oz/A) probably had only a small additive effect on total control observed in this experiment.

Field. Diflufenzopyr applied with auxin herbicides increased both foliage injury and season-long control of Canada thistle, especially when applied with 2,4-D and quinclorac (Table 3). Foliage injury averaged 47% 1.5 MAT when the auxin herbicides were applied alone compared to 80% when applied with diflufenzopyr. Quinclorac has very little activity on Canada thistle; but when applied with diflufenzopyr, foliage injury increased from 19 to 76% and control 3 MAT increased from 6 to 67%. Control also dramatically increased when diflufenzopyr was applied with dicamba and 2,4-D, but control only tended to increase when applied with picloram or clopyralid. The increase in control was attributed to root kill to a lower depth and less bud regrowth on the remaining root tissue when the treatment contained diflufenzopyr compared to the corresponding herbicide applied alone.

Leafy spurge foliage injury and season-long control were also increased when diflufenzopyr was applied with auxin herbicides compared to the herbicides applied alone (Table 4). However, the increase in injury and control was less dramatic compared to the Canada thistle study. Foliage injury 1.5 MAT averaged 66% when auxin herbicides were applied alone compared to 97% when applied with diflufenzopyr. The largest increase in foliage injury occurred when diflufenzopyr was added to picloram, quinclorac, and fluroxypyr. Leafy spurge control 3 MAT was increased or tended to be increased when diflufenzopyr was applied with an auxin herbicide. The largest increase was from 28% with fluroxypyr alone to 76% when with diflufenzopyr, and from 10% with picloram alone to 47% when with diflufenzopyr. No grass injury was observed with any treatment.

Leafy spurge foliage injury 1 MAT was much higher when dicamba was applied with diflufenzopyr compared to dicamba alone (Table 5). Dicamba at 4 and 8 oz/A caused 10 and 66% foliage injury, respectively, compared to 36 and 80%, respectively, when applied with diflufenzopyr.

Spotted knapweed control was similar regardless of herbicide or whether the herbicide was applied alone or with diflufenzopyr (data not shown). The evaluations 12 MAT may provide a better indication of whether or not the addition of diflufenzopyr to an auxin herbicide treatment will improve spotted knapweed control.

In summary, foliage injury and season-long control of Canada thistle and leafy spurge increased when diflufenzopyr was applied with an auxin herbicide compared to the herbicide applied alone. The addition of diflufenzopyr to the herbicide treatments appeared to cause both root kill to a lower depth and less regrowth from the remaining root tissue than when the herbicide was applied alone. ATIs such as diflufenzopyr may be a very important addition for perennial broadleaf weed control by increasing long-term weed control and/or enabling the use of reduced herbicide rates.

Table 1. Leafy spurge regrowth 6 weeks after treatment with dicamba applied alone or with diflufenzopyr in the greenhouse.

Treatment	Rate	Dry weight
	— oz/A —	— mg —
Dicamba + diflufenzopyr[a]	0.5 + 0.2	385
Dicamba + diflufenzopyr[a]	1 + 0.4	73
Dicamba + diflufenzopyr[a]	2 + 0.8	43
Dicamba + diflufenzopyr[a]	4 + 1.6	0
Dicamba	4	385
Control		729
LSD (0.05)		210

[a]Commercial formulation, BAS-662.

Table 2. Leafy spurge regrowth 6 weeks after treatment with various auxin herbicides applied alone or with diflufenzopyr in the greenhouse.

Treatment	Rate	Dry weight
	— oz/A —	— mg —
Picloram	2	313
Picloram + diflufenzopyr[a]	2 + 0.8	137
2,4-D	2	1045
2,4-D + diflufenzopyr[a]	2 + 0.8	513
Picloram + 2,4-D	2 + 4	212
Picloram + 2,4-D + diflufenzopyr[a]	2 + 4 + 0.8	6
Control		595
LSD (0.05)		286

[a]Commercial formulation, BAS-662, which includes dicamba.

Table 3. Evaluation of diflufenzopyr applied with various auxin herbicides for Canada thistle control in the field.

Treatment[a]	Rate	Foliage inj. 1.5 MAT[b]	Control 3 MAT[b]
	— oz/A —	%	
Dicamba	4	54	37
Dicamba + diflufenzopyr[c]	5.6 + 2.2	76	70
Picloram	2	46	94
Picloram + diflufenzopyr[c]	2 + 0.8	89	88
2,4-D	4	36	44
2,4-D + diflufenzopyr[c]	4 + 1.6	65	83
Picloram + 2,4-D	2 + 4	63	93
Picloram + 2,4-D + diflufenzopyr[c]	2 + 4 + 0.8	84	94
Quinclorac	8	19	6
Quinclorac + diflufenzopyr[c]	8 + 3.2	76	67
Clopyralid	1.6	65	83
Clopyralid + diflufenzopyr[c]	1.6 + 0.6	88	97
LSD (0.05)		13	21

[a]All treatments were applied with X-77 at 1.25% + 28%N at 1.25% v/v.
[b]Months after treatment.
[c]Commercial formulation BAS-662.

Table 4. Evaluation of diflufenzopyr applied with various auxin herbicides for leafy spurge control in the field.

Treatment[a]	Rate	Foliage inj. 1.5 MAT[b]	Control 3 MAT[b]
	— oz/A —	%	
Dicamba	4	76	5
Dicamba + diflufenzopyr[c]	5.2 + 2.2	93	43
Picloram	2	56	10
Picloram + diflufenzopyr[c]	2 + 0.8	99	47
2,4-D	4	81	40
2,4-D + diflufenzopyr[c]	4 + 1.6	98	45
Picloram + 2,4-D	2 + 4	68	64
Picloram + 2,4-D + diflufenzopyr	2 + 4 + 0.8	95	71
Quinclorac	8	38	88
Quinclorac + diflufenzopyr[c]	8 + 3.2	95	96
Fluroxypyr	4	78	28
Fluroxypyr + diflufenzopyr[c]	4 + 1.6	100	76
LSD (0.05)		9	34

[a]All treatments were applied with X-77 at 0.25% + 28%N at 1.25% v/v.
[b]Months after treatment.
[c]Commercial formulation BAS-662.

Table 5. Evaluation of dicamba applied alone and with diflufenzopyr for leafy spurge control in the field.

Treatment[a]	Rate	Foliage inj. 1 MAT[b]
	— oz/A —	—— % ——
Dicamba	4	10
Dicamba + diflufenzopyr[c]	4 + 1.6	36
Dicamba	8	66
Dicamba + diflufenzopyr[c]	8 + 3.2	80
Picloram + 2,4-D	4 + 16	97
LSD (0.05)		22

[a]All treatments were applied with X-77 at 0.25% + 28%N at 1.25%.
[b]Month after treatment, 0 = no injury and 100 = all topgrowth killed (brown).
[c]Commercial formulation BAS-662.

THE CONTROL OF GRAY RABBITBRUSH (*CHRYSOTHAMNUS NAUSEOSUS*) AND DOUGLAS RABBITBRUSH (*CHRYSOTHAMNUS VISCIDFLORUS*) WITH VARIOUS HERBICIDE APPLICATIONS. Doug A. Reynolds[1], Tom D. Whitson[2], Roger Cox[3], and Kristi K. Rose[2], Extension Educator, Professor, Range Conservationist and Graduate Research Assistant, [1]Cooperative Extension Service, [2]Department of Plant Sciences, University of Wyoming, Laramie, WY 82071 and [3]NRCS, Carbon County, WY ZIP 82301.

Abstract. Two field experiments were established on the TA Ranch near Saratoga, WY to compare various herbicides for control of gray and Douglas rabbitbrush, two highly competitive brush species on rangeland.

Experimental design was randomized complete blocks with four replications. Plots were 20 by 27 feet. Soils were sandy loam, 73% sand, 10% silt and 17% clay with 1.2% organic matter and a pH of 7.1. Herbicides were applied June 6, 1996 to rabbitbrush in active foliar growth. Air temp was 82 F. Soil temp was 90, 82, and 82 F at 1, 2, and 4 inches with clear skies and calm wind, moisture was adequate for active growth. Herbicides were applied at 30 gpa and 41 psi.

Data collection on August 4, 1997, was based on counts of live compared to dead plants. When herbicides were applied to Douglas rabbitbrush no plant resprouting occurred but with applications on gray rabbitbrush resprouting occurred in all treatments (Table). With applications of 2,4-D low volatile ester LVE at 2 lb/A and the combination of 2,4-D LVE at 2 lb/A plus picloram at 0.25 lb/A control of Douglas rabbitbrush was 90 and 100%, respectively. No herbicide applications applied in a single year effectively controlled gray rabbitbrush. All treatment areas on gray rabbitbrush were split into retreatment areas 10 by 27 feet and were retreated with the same herbicide combinations in 1997. Initial treatments will be compared to two applications of the same herbicide in 1998.

Table. The effects of various herbicides on Douglas rabbitbrush and gray rabbitbrush.

Herbicide[a]	Rate	Control	
		Douglas rabbitbrush	Gray rabbitbrush
	lb/A	%	
Triclopyr	0.5	1	1
Triclopyr	1	30	3
Triclopyr	2	33	19
Picloram	0.25	0	1
Picloram	0.5	10	6
Triclopyr + 2,4-D LVE	0.5 + 2	63	5
Triclopyr + 2,4-D LVE	0.25 + 2	80	9
Triclopyr + picloram	0.5 + 0.25	44	26
Triclopyr + picloram	1 + 0.25	58	33
2,4-D LVE	2	90	18
Picloram + 2,4-D LVE	0.25 + 2	100	34
Picloram + 2,4-D amine	0.27 + 1	29	24
Triclopyr + 2,4-D amine + picloram	0.5 + 0.5 + 0.14	23	24
Untreated		0	0

[a]Herbicides were applied June 6, 1996.

THE INFLUENCE OF CATTLE GRAZING ON DIFFUSE KNAPWEED POPULATIONS IN COLORADO. K. George Beck, James R. Sebastian, and Larry R. Rittenhouse, Associate Professor and Research Associate, Department of Bioag Science and Pest Management and Professor, Department of Rangeland Ecosystem Science, Colorado State University, Ft. Collins, CO 80523.

Abstract. Diffuse knapweed is a noxious biennial weed in Colorado. It is a most notable problem along the Front Range where it infests numerous properties owned by the City of Boulder Open Space Department. Similar experiments were established at three City of Boulder properties, the Kelsall, Superior, and North Boulder Valley ranches. Each site was used in an experiment to assess the City's normal cattle grazing management practices on the population dynamics of diffuse knapweed. Topography on the properties varied from bottomland to hillsides to hilltops. One or two grazing events per year were compared to no grazing. Diffuse knapweed density and cover before grazing varied among land types at the Kelsall and North Boulder Valley Ranch properties; there were almost twice as many diffuse knapweed plants per unit area of land and 10% greater cover on bottomland than on hilltops. In June 1996, after two grazing events, diffuse knapweed density was decreased 52% at the Kelsall and North Boulder Valley Ranch properties. In June 1997, diffuse knapweed density was decreased 36% by two grazing events at the Kelsall and Superior properties. Immediately following two grazing events in both years, diffuse knapweed cover was decreased at all sites and land types compared to no grazing. In September, diffuse knapweed cover on bottomland was about 20% and 10% less in areas that were grazed twice compared to those that were not grazed in 1996 and 1997, respectively. Knapweed height at the Kelsall and North Boulder Valley Ranch properties decreased incrementally (from 20 to 38% in 1996 and from 33 to 53% in 1997) as grazing events increased. The number of diffuse knapweed seedheads produced per plant was decreased 40% by two grazing events compared to no grazing in 1996. In 1997, one grazing event decreased the number of seedheads per plant by 24% and two grazing events decreased them by 32%. There were twice as many *Urophora* spp. larvae found per seedhead in plants that were grazed twice than plants grazed once or not at all in 1997. In 1996, diffuse knapweed plants grazed twice on all land types at the Kelsall and North Boulder Valley Ranch properties or on bottomland at all properties produced 52% and 47% fewer seeds, respectively, than plants that were not grazed. On bottomland in 1997, seed production was decreased by 50% from plants grazed once or twice compared to those not grazed at all. Percent germination and percent pure live diffuse knapweed seed produced on plants that were grazed twice on bottomland was 9% and 10% less, respectively, than from plants that were grazed once or not at all in 1996 but no effect occurred in 1997. Cattle readily grazed diffuse knapweed and negatively influenced the reproductive aspects of diffuse knapweed population dynamics. The experiment will continue in 1998.

OBSERVATION: LIFE HISTORY OF SPOTTED KNAPWEED. Robert T. Grubb, James S. Jacobs, and Roger L. Sheley, Research Associate, Post-Doctoral Research Associate, and Assistant Professor, Department of Plant, Soil and Environmental Sciences, Montana State University, Bozeman, MT 59717.

Abstract. Spotted knapweed is a non-indigenous weed infesting large areas of rangeland in western North America. Life history models have been used to identify key processes regulating weed population dynamics and may be valuable in developing and testing integrated weed management strategies. Our objective was to characterize the life history of spotted knapweed. Demographic attributes were monitored monthly during snow free periods beginning August 1994 through October 1996 on two sites. Data were arranged into life history tables, and sensitivity analysis was performed to determine key transition phases affecting seed output. Spotted knapweed seed production ranged from 998 to 7815 viable seeds/m^2 at both sites during the study. Seed reaching the soil averaged 41 and 50% of seed output at sites 1 and 2, respectively. Less than 6% of the seed reaching the soil germinated in the fall at both sites. Recruitment peaked in April at 36% and in June at 20% of seed reaching the soil on sites 1 and 2, respectively. Spotted knapweed juvenile density peaked August 1995 and June 1996 at both sites. Peaks corresponded with the beginning of the summer dry period. Plants bolted beginning June 1995 and May 1996. Sensitivity analysis identified early-summer juvenile survivorship, late-summer adult survivorship, transition from juvenile to adult, and seeds produced per adult as critical stages for spotted knapweed seed output. Management strategies which reduce spotted knapweed populations at these stages are likely to have the greatest impact on spotted knapweed population growth and spread. A weed population dynamics model using the life history demographic data predicts spotted knapweed population peaking 4 to 6 years after initial seed input.

PREDICTING PLANT RESPONSE AND BIODIVERSITY ALONG A SPOTTED KNAPWEED GRADIENT. S. A. Kedzie-Webb and Roger L. Sheley, Graduate Research Assistant and Assistant Professor, Department of Plant, Soil and Environmental Sciences, Montana State University, Bozeman, MT 59715.

Abstract. Spotted knapweed displaces native vegetation, degrades wildlife habitat, increases soil erosion, and lowers water quality. It has also been suggested that spotted knapweed reduces biodiversity, although little is known about the issue. This study investigated the impacts of spotted knapweed on native bunchgrasses and biodiversity. Percent cover by species was determined at two sites to identify a spotted knapweed gradient and the associated understory of plants. At each site, five 20-meter transects were established along this gradient to determine the change in species composition from low to high spotted knapweed cover. Linear regression models were generated to predict diversity, species richness, and individual species density and cover based on spotted knapweed. Idaho fescue was reduced by 5 and 2.5 tillers for each increase in adult spotted knapweed density, respectively, at site 1 (Idaho fescue =120.2 to 5.3 X spotted knapweed, R^2=0.24) and site 2 (Idaho fescue = 94 to 2.56 X spotted knapweed, R^2=0.24). Biodiversity was negatively associated with spotted knapweed cover at both sites (site 1: Biodiversity = 2.80 to 0.014 X spotted knapweed, R^2=0.69; site 2: Biodiversity = 1.77 + 0.077 spotted knapweed, R^2=0.57). Understanding the relationship between spotted knapweed and desired species along a spatial and temporal gradient may allow land stewards to identify economic and ecological thresholds to optimize weed management.

COMPETITION AND RESOURCE PARTITIONING AMONG BLUEBUNCH WHEATGRASS, NORTHERN SWEETVETCH, AND SPOTTED KNAPWEED. James S. Jacobs and Roger L. Sheley, Post-Doctoral Research Associate and Assistant Professor, Department of Plant, Soil, and Environmental Sciences, Montana State University, Bozeman, MT 59717.

Abstract. Maximizing desired plant diversity has been suggested as a means to minimize non-indigenous plant invasion on rangeland by maximizing niche occupation. Competition between two desired indigenous species, bluebunch wheatgrass and northern sweetvetch, and a non-indigenous invader, spotted knapweed, was quantified using growth of isolated individuals and two additional series experiments with the three species in an environmental chamber (12 C, 12 h daylength, 200 $\mu E/m^2/s$ spectral light). Seeding densities of bluebunch wheatgrass remained constant at 0, 200, 400 and 800 seeds/m^2 in both experiments. Northern sweetvetch and spotted knapweed seeding densities were 0, 200, 400 and 800 seeds/m^2, respectively, in the first experiment and 0, 400, 800, and 1,600 seeds/m^2, respectively, in the second experiment. Densities were factorially arranged in a completely randomized design. Plants were allowed to grow for 90 days. The growth rate of bluebunch wheatgrass (92.1 mg/d shoot growth) was greater than that of the two forbs (1.6 mg/d and 5.5 mg/d for northern sweetvetch and spotted knapweed, respectively), and the growth rate of the two forbs were similar to one another. Curvilinear regression predicting shoot weight versus density of the three species indicated that intraspecific competition was more important in determining shoot weight than interspecific competition. In addition, the two forbs competed more directly with each other than with bluebunch wheatgrass. Competition coefficient ratios (1.42 and 1.53 for bluebunch wheatgrass with northern sweetvetch and spotted knapweed, respectively, and 1.03 for spotted knapweed with northern sweetvetch) indicated substantial partitioning of resources between bluebunch wheatgrass and each of the forbs. Little or no resource partitioning occurred between forbs. This study suggests that increasing desired plant diversity may minimize weed invasion by increasing niche occupation.

PERENNIAL GRASS SURVIVAL RESPONSE TO RUSSIAN KNAPWEED SOIL ALLELOCHEMICALS. Douglas W. Grant, K. George Beck, and Debra P. Coffin, Graduate Student and Associate Professor, Department of Bioag Science and Pest Management and Research Scientist, Department of Rangeland Ecosystem Science, Colorado State University, Ft. Collins, CO 80523.

Abstract. Russian knapweed is an aggressive, noxious weed of rangeland that dominates areas it infests by forming monocultures. Development of Russian knapweed monocultures can at least be partly explained by allelopathy. Russian knapweed exudes polyacetylenes from its roots throughout the growing season and these compounds have been shown to inhibit the growth of certain plant species. A field experiment was established to determine the influence of Russian knapweed soil allelochemicals *in situ* on the seedling growth of lettuce, blue grama, western wheatgrass, prairie junegrass, and sand dropseed. The experiment was a randomized complete block design with four replications. Each transect included 10 seedlings of each bioassay species transplanted inside and directly outside a dense stand of Russian knapweed. Seedlings were irrigated equivalently with a gravity driven irrigation system designed specifically for this experiment, over the course of 15 days. Seedling survival and vigor was ranked visually at 3-day intervals. Blue grama survival inside the stand was 30% less than outside 3 days after the experiment began. Survival of prairie junegrass inside the stand was 27, 19, and 21% less than outside 3, 9, and 15 days after experiment initiation, respectively. Sand dropseed seedling survival inside the Russian knapweed stand was decreased 40, 40, and 55% 3, 9, and 15 days after the experiment began. Survival of western wheatgrass was 60% less at 9 days and 50% less at 15 days. A greenhouse experiment was also completed to assess allelopathic potential of Russian knapweed infested soils at three soil depths, including 0 to 5, 5 to 10, and 10 to 15 cm. Soil was collected from inside and directly outside dense stands of Russian knapweed using a soil slicer designed to retain the soil structure and soil chemistry and reduce losses of volatile allelochemicals. The greenhouse experiment was a randomized complete block design with four replications. Response variables, including plant height, number of leaves/tillers, and a visual estimate of vigor, were measured at the onset of the experiment and after 1, 3, and 5 weeks. Differences were not detected between the treatments, but lettuce showed consistently

lower means for soil from inside the stand of Russian knapweed. Volunteer seedling emergence was significantly lower for soil from inside the stand. The results from these and future experiments will be used to develop an allelopathic parameter for a computer simulation model of Russian knapweed invasion dynamics.

IMPACTS OF YELLOW STARTHISTLE DENSITY ON THE SOIL MOISTURE PROFILE AND RANGELAND MANAGEMENT. Carri B. Benefield, Joseph M. DiTomaso, and Guy B. Kyser, Graduate Student, Extension Weed Ecologist, and Staff Research Associate, Department of Vegetable Crops, Weed Science Program, University of California, Davis, CA 95616.

Abstract. Yellow starthistle is one of the most invasive weeds encountered in non-crop areas of California. It is an aggressive below-ground competitor. In Central Valley alluvial soils, yellow starthistle roots can grow 1.25 cm/day to at least 2 m deep. We planted starthistle at five densities (0, 0.6, 27, 92, and 169 plants/m^2) and measured soil volumetric water content at six depths (30, 60, 90, 120, 150, and 180 cm) throughout the growing season. We also recorded biomass, seedhead production, and timing of flower development. Plants in low density plots depleted water from greater depths, while plants in high density plots used water from all depths in the soil profile. Individual plant biomass and seedhead production decreased with increasing density. Increased intraspecific competition also affected size/frequency distribution but did not significantly influence timing of flowering. In a second study we examined the establishment of drill seeded pubescent wheatgrass, a perennial grass, in a yellow starthistle infested rangeland. Untreated plots were compared with plots treated with clopyralid (1 oz/A), an herbicide selective against yellow starthistle and certain other broadleaf plants. Treatment with clopyralid reduced starthistle density and cover by 93 and 73%, respectively. Wheatgrass seedlings did not survive in untreated plots. By comparison, clopyralid treated plots contained 13.7 wheatgrass plants/m^2 making up 4.1% cover. These results suggest that reducing yellow starthistle density makes additional moisture available in the shallow soil, enhancing survival and establishment of pubescent wheatgrass.

POSTEMERGENCE CONTROL OF YELLOW STARTHISTLE IN NORTHERN CALIFORNIA RANGELAND. Steve B. Orloff, Joseph M. DiTomaso, and Guy B. Kyser, Farm Advisor, University of California, Cooperative Extension,Yreka, CA 96097 and Weed Ecologist and Staff Research Associate, Department of Vegetable Crops, University of California, Davis, CA 95616.

Abstract. Yellow starthistle is a serious problem in California rangeland. It has little feeding value and out-competes most desirable vegetation in a dryland setting. Picloram, the most commonly used herbicide for yellow starthistle control in other states, is not available in California. Multiple flushes of yellow starthistle emergence make it difficult to control with most postemergence herbicides. Field trials were established to evaluate different herbicides for yellow starthistle control, and to determine the most desirable application timing and rate for clopyralid, the most effective of the herbicides tested. Experiments were conducted in Butte, Calaveras, Yolo and Siskiyou counties in northern California.

Post-emergence applications of clopyralid, chlorsulfuron, 2,4-D, triclopyr, chlorsulfuron plus 2,4-D, chlorsulfuron plus triclopyr were compared in a Yolo County trial. Clopyralid at all rates (0.063, 0.12, 0.25, 0.38, and 0.5 lb/A) gave greater than 95% control. The only comparable treatment was the high rate of 2,4-D (2 lb/A).

Clopyralid was applied at monthly intervals from November through April in Yolo County and from February through May in the colder climate of Siskiyou County. The rates tested were 0.016, 0.031, 0.063, 0.12, 0.25, and 0.38 lb/A at the Yolo County site and 0.031, 0.063, 0.12, and 0.25 lb/A at the Siskiyou County site. In the Yolo study, rates of 0.063 or greater provided better than 90% yellow starthistle control, except in November, when

control tended to be slightly less. In the Siskiyou County study, the 0.25 lb/A rate completely controlled yellow starthistle, regardless of application time. Earlier applications tended to be more effective for the lower rates of clopyralid. The clopyralid treatment date and rate had an even more dramatic effect on the amount of desirable forage species (primarily common rye and filaree) present in the spring. The quantity of desirable forage decreased significantly with each month delay in clopyralid application. Increasing clopyralid rate also increased the amount of desirable forage species. Single application date studies in Butte and Calavaras Counties also showed that 0.12 lb/A was usually needed for complete yellow starthistle control. Additionally, the Butte County study demonstrated that control did not diminish when the skeletal remains of the previous year's yellow starthistle crop were present at the time of application.

EFFECT OF PENDIMETHALIN FORMULATION ON BEDDING PLANT TOLERANCE. Jeffrey F. Derr, Associate Professor, Department of Plant Pathology, Physiology, and Weed Science, Hampton Roads Agricultural Research and Extension Center, Virginia Tech, Virginia Beach, VA 23455.

Abstract. Preemergence herbicides are commonly used for weed control in the maintenance of bedding plants. Bedding plants vary in their response to preemergence herbicides, and herbicide formulation can impact the extent of tolerance. Studies were conducted using container and field-grown annual flowers to assess their tolerance to different formulations of pendimethalin. Two sprayable formulations of pendimethalin, a water dispersible granule (WDG) and an emulsifiable concentrate (EC), were compared to a 2% granular form. Sprayable formulations were applied overtop the bedding plants after transplanting using a backpack sprayer. The granular formulation was applied using a shaker jar after transplanting. Plant species evaluated were begonia, impatiens, salvia, and pansy.

In container studies, the WDG and EC formulations applied at 2 and 4 lb/A reduced flower count of 'Super Elfin Blue Pearl' impatiens by 70 to 97%, and reduced flower count in 'Whiskey' begonia by 51 to 78% at 4 weeks after treatment (WAT). Reduced flower production was also observed in these species at 8 WAT for the WG and EC formulations. The granular formulation of pendimethalin did not reduce flowering in either species. In another container study, the EC formulation applied at 4 lb/A reduced flower count of 'Super Elfin Blue Pearl' impatiens and 'Ambassador Scarlet' begonia by 49 and 86%, respectively, and totally prevented flowering in 'Red Hot Sally' salvia at 18 days after treatment (DAT). The WDG formulation at 4 lb/A reduced flower count in begonia and salvia by 33 and 91%, respectively, but did not affect flowering in impatiens at that date. However, at 4 WAT, the WDG form reduced flowering in impatiens by 71%. At 4 WAT, begonia and salvia treated with the WDG form had more flowers than plants treated with the EC. The granular formulation at 4 lb/A did not affect flowering in impatiens or begonia, but reduced flower count in salvia by 68% at 18 DAT. The EC form caused visible damage to salvia and begonia, while the WDG and G forms did not cause visible damage in the three bedding plant species. The EC formulation provided excellent control of large crabgrass and the WDG provided good control, while poor control was seen with the granular product.

In a field study, the WDG formulation was compared to the granular product. The WDG form applied at 4 lb/A reduced 'Imperial Purple and White' pansy flower count at 2 and 5 WAT by 34 and 57%, respectively. This formulation when applied at 2 lb/A reduced pansy flowering by 22% at 2 WAT but did not affect flowering at 5 WAT. The granular formulation did not affect flowering when applied at 2 lb/A. At 4 lb/A, the granular form reduced pansy flower count at 2 WAT by 26%, but did not affect flowering at 5 WAT. At 10 WAT, the WDG form provided excellent (>90%) control of yellow foxtail, fall panicum, large crabgrass, and smooth crabgrass, while the granular form applied at the same rate provided poor to fair (55-73%) control of these weeds. In a container study using the same application rates, the WDG formulation reduced flower count and shoot fresh weight of 'Imperial Frosty Rose' pansy at 8 WAT while the granular form did not affect flowering or shoot weight.

Sprayable formulations of pendimethalin can reduce flowering in certain bedding plants. The EC appears to be more injurious than the WDG formulation. In most cases, the granular form did not adversely affect flowering of the annual flowers tested but provided lower weed control than the sprayable formulations.

SOIL SOLARIZATION, MULCHES AND HERBICIDES FOR WEED MANAGEMENT IN FIELD CUT FLOWERS. Clyde L. Elmore, Ann I. King, and Cheryl Wilen, Weed Specialist, Farm Advisor, and Area Weed IPM Advisor, University of California, Davis, Half Moon Bay and San Diego, CA 95616.

Abstract. There are many species and varieties of field grown cut flowers. It is desirable to control most weeds in these flowers to optimize growth and yield of high quality flowers. Most weeds are controlled by cultivation and

hand weeding, with few herbicides available for broad spectrum weed control. Since it is unlikely that new herbicides will be available for weed control in these crops, field trials were conducted at Davis, Santa Clara or Half Moon Bay and Tustin. Soil solarization was applied preplant for 4 or 6 weeks before plastic removal and planting. Herbicides for evaluated for crop tolerance, weed control and yield. Crops were also treated post transplant, with two mulches of "green waste". Weeds evaluated were from natural stands.

At the central coast Santa Clara location, solarization before planting of China aster and snapdragon gave control of annual bluegrass, little mallow, shepherdspurse, common chickweed, California burclover, common purslane and henbit. Increased plant growth of the ornamentals was observed after solarization compared to the untreated plants. Significant injury occurred to snapdragon with isoxaben at 1.1 and 2.2 kg/ha. Slight injury occurred from 0.6 and 1.1 kg/ha of dithiopyr. China aster was less vigorous and had some injury from isoxaben and dithiopyr, compared to untreated plants. At Davis, a central valley location, solarization gave similar results. All weed control was excellent except some yellow nutsedge grew in the solarized plots. Solarization in conjunction with 50 gpa of metham metered through the drip system gave excellent control of all weeds. Solarization for 4 or 6 weeks at the South Coast location also gave good weed control with no injury to China aster, snapdragon and Delphinium. Finished "green waste" was applied post transplanting at 2 inches in depth to flower crops at Davis and Santa Clara. Annual weed control was excellent except at the base of the transplant. A course, non-finished (6 week) mulch, 2 inches in depth, also gave good weed control around the transplants. Field bindweed was not controlled with either mulch. China aster and small snapdragon transplants were injured with the finished "green waste" if the mulch covered the base of the transplant, otherwise growth was excellent. Delphinium transplants grew well in both mulches.

WEED CONTROL IN CONTAINERIZED NURSERY CROPS USING MULCHES AND SUBIRRIGATION. Cheryl A. Wilen, Ursula K. Schuch, and Clyde L. Elmore, Area IPM Advisor, San Diego, CA 92123; Assistant Professor, Department of Horticulture, Iowa State University, Ames, IA 50011; and Weed Science Extension Specialist, Department of Vegetable Crops, University of California, Davis, CA 95616.

Abstract. Plants grown in containers for longer than 3 months are often affected by weeds growing in the potting mix. Most commercial nurseries apply a preemergent herbicide soon after transplanting but must hand remove weeds that emerge before sale or prior to subsequent herbicide applications. This process is costly due to the labor involved and can result in non-target loss of herbicides during application. Consequently, experiments were conducted to examine alternative methods for weed control. Organic mulches (pine bark, composted green waste, pecan shells) and fabric disks were used with and without supplemental herbicides (oxyfluorfen plus oryzalin) or corn gluten meal (1996 only) for dicot weed control in containerized Indian hawthorn (*Rhaphiolepis indica*) in 1996 and bottlebrush (*Callistemon citrinus*) in 1997. Experiments were also conducted to examine the effect of subirrigation and mulch depth on weed control. The principal weeds in these studies were northern willow herb (*Epilobium ciliatum*), cudweed (*Gnaphalium sp.*), and creeping woodsorrel (*Oxalis corniculata*).

In 1996, all mulches or any oxyfluorfen plus oryzalin treatment provided excellent weed control for the 6 month duration of the study. Corn gluten meal did not control any of the weeds in this experiment. The addition of oxyfluorfen plus oryzalin to a mulch treatment did not enhance the efficacy of the herbicide or the mulch. In 1997, the effect of the herbicides on weed control was not significant but the use of any of the mulches significantly reduced total weed dry weight by at least 75% and total number by at least 89%. In the subirrigation/mulch depth study, treatments that were top irrigated with no mulch had the greatest weed pressure. Using pine bark mulch of 2.5, 5, or 7.5 cm or subirrigating reduced weed dry weight by 78% or more. Indian hawthorn plants that were subirrigated were smaller than those irrigated from the container surface but there was no difference in shoot:root ratio.

THE EFFECT OF IMAZETHAPYR ON ROTATIONAL CROPS. Carl E. Bell and Brent Boutwell, Weed Science Farm Advisor and Staff Research Associate, University of California Cooperative Extension, Holtville, CA 92250-9615.

Abstract. Imazethapyr is a relatively new herbicide for use in alfalfa in California. This herbicide is effective at very low rates, less than 0.1 lb/A, but it is also very persistent in the soil. Some crops, such as sugarbeet, are sensitive to very low concentrations of imazethapyr in the soil. Agriculture in the Lower Colorado River Desert utilizes mixed cropping systems with frequent rotations. Alfalfa is a key component of this farming, but so are vegetables and other crops. The purpose of this experiment was to study the soil residual effect of imazethapyr on crops grown in rotation with alfalfa in this area.

This was a multi-year study, started in October, 1994, utilizing three rotational schemes. All schemes began with alfalfa, planted on flat ground between raised borders in October, 1994. Each border was divided into three equal plots and treated with imazethapyr at 0, 1X (0.094 lb/A, the maximum allowed rate on the label), and 2X (0.19 lb/A, double the maximum rate). Scheme A was alfalfa for two seasons, then planted to rotational crops in the fall, 1996. Scheme B was alfalfa for the spring of 1995, then removed and planted to wheat in December, 1995, then planted to rotational crops in the fall, 1996. Scheme C was alfalfa for the spring, 1995, then planted to rotational crops in the fall, 1995, and replanted in row crops for successive seasons. The experiment used a split plot design, with three replications, with replant scheme as the main plot factor and herbicide rate as the subplot factor. Rotational crops have included sugarbeets, lettuce, carrot, onion, tomato, cotton, cantaloupe, broccoli, and sudangrass. These are all important crops grown in the low desert and are known to have different levels of sensitivity to imazethapyr. All crops were grown to harvest and yield data was used to determine the effect of the herbicide on the crop. Significant differences between yield were determined by factorial ANOVA.

There was no adverse effect from imazethapyr on alfalfa production from any harvest collected, except that at the first harvest in February, 1995, untreated plots had higher hay yields because of the contribution of weeds to the forage. Wheat yield was not effected by herbicide treatment when planted 13 MAT (months after treatment) and harvested 18 MAT. There was no effect on lettuce planted 11 MAT and harvested 15 MAT in Scheme C, so this crop was dropped from further plantings. Broccoli yield in the 1X treatment was about 25% less than the untreated plots when planted 11 MAT and harvested 14 MAT. In the 2X treatment, broccoli yields were reduced 82% compared to the untreated. When broccoli was planted 23 MAT and harvested 27 MAT, averaged over the three rotational schemes, yields from the 1X treatment were not lower than the untreated, but there was a 20% yield loss from the 2X treatment. Carrot yield in the 1X treatment, planted 11 MAT and harvested 17 MAT was 10% lower than the untreated, but the carrots were also shorter and wider than untreated carrots. The 2X treatment caused a 52% carrot yield reduction. When carrots were planted 23 MAT and harvested 29 MAT, there was no difference between yields of the three herbicide rates, although we still observed some abnormal carrots in the 2X treatment. Onion yields, when planted 11 MAT and harvested 17 MAT, were reduced about 15% by the 1X treatment and 84% by the 2X treatment. When planted 23 MAT and harvested 29 MAT, onion yields were not effected by imazethapyr. Cantaloupe and cotton, planted 17 MAT and harvested 19 MAT and 21 MAT respectively, were not effected by herbicide treatment. Tomato, planted 26 MAT and harvested 31 MAT was not effected by the 1X treatment, compared to the untreated control. The 2X treatment appeared to effect tomato yield, but the difference was not significant according to ANOVA. Sudangrass forage yield was 67% lower in the 1X treatment and 92% lower in the 2X treatment when planted 18 MAT and harvested 20 MAT. When sudangrass was planted 31 MAT and harvested 33 MAT, there was no difference between yields from the three herbicide rates. Sugarbeet yields were severely effected by imazethapyr when planted 11 MAT and harvested 17 MAT. The 1X treatment reduced yield 95% and the 2X rate 94% compared to the untreated. When sugarbeets were planted 23 MAT and harvested 30 MAT, there was no difference detected from the 1X treatment, but there was a 27% reduction from the 2X rate.

NEW APPLICATIONS OF PROMETRYN ON CELERY. Warren E. Bendixen, Farm Advisor, University of California Cooperative Extension, Santa Maria, CA 93455.

Abstract. Celery production in the Central Coast area of California has shifted plant establishment from direct seed to transplant. Prometryn is the herbicide being used by growers. The prometryn label for celery transplants restricts the application for 2 to 6 weeks after transplanting. Weeds can compete with the celery transplants during this delayed application.

Five field experiments, using various rates of prometryn, were established in commercial celery fields during the spring and summer of 1997. The objective of this research was to compare prometryn applications made pre-transplant and post-transplant for weed control, herbicide crop injury, and celery yields. The pre-transplant applications showed a high degree of crop safety and equal celery yields to the post-transplant applications. Broadleaf weeds, including common lambsquarters, nettleleaf goosefoot, redroot pigweed, malva, shepherdspurse and small nettle, were all effectively controlled in the pre-transplant applications and equal to, or better, than the post-transplant applications.

WEED MANAGEMENT IN CUCURBITS WITH SULFENTRAZONE, DIMETHENAMID, AND DIRECT-SEEDING. R. E. Peachey and R. D. William, Senior Research Assistant and Extension Weed Specialist, Department of Horticulture, Oregon State University, Corvallis, OR 97330.

INTRODUCTION

Loss of the chloramben registration, the marginal return for processing squash, and difficulty in managing pigweed, nightshade, and other broadleaf species in crop rotations has led to a search for economically viable weed management strategies. Though weed competition can severely reduce squash yield, another concern is extensive weed seed banks that threaten successful production of high value crops such as snap beans in subsequent years. Some cucurbits are marginally tolerant to herbicides that could be considered for use (Howard and Haglund, 1989; Barth et al.). One option is to manage summer annuals by shifting primary tillage to the fall and direct-seeding cucurbits in the spring (NeSmith et al.). Pigweed and nightshade emergence is dramatically reduced and marginal herbicides can then provide adequate weed control. The objectives of this research were to evaluate tolerance of cucumber, zucchini, and processing squash to herbicides and to develop use patterns for weed control in processing squash.

MATERIALS AND METHODS

Trials were conducted in 1996 and 1997 at the Oregon State University Vegetable Research Farm to determine the tolerance of winter processing squash (*Cucurbita maxima* var. Golden Delicious and *Cucurbita moschata* var. Dickinson), zucchini (*Cucurbita pepo* var. Elite) and cucumbers (*Cucumis sativus* var. Pioneer) to herbicides. Processing squash, zucchini and cucumbers were planted in paired rows 3 to 5 feet apart. Crop biomass was cut from one row at approximately 6 WAP to determine the growth response to herbicides. The other remaining row was thinned, hand weeded, and fruit harvested as in normal production practices. Additional trials were established in grower's fields to evaluate weed control efficacy of herbicide treatments and crop tolerance. In the direct-seed/cover crop experiment, cover crops were planted in the fall and killed with glyphosate in the spring. Winter processing squash was planted on 30 inch rows. Dimethenamid was applied PRE at 0.75 and 1.5 lb/A to subplots in four replications.

RESULTS AND DISCUSSION

Processing squash. Herbicides tested included dimethenamid, halosulfuron, BAY FOE 5043, clomazone, acetochlor, and ethalfluralin. Crop biomass cuts at 6 WAP indicated that winter processing squash was tolerant to sulfentrazone of rates up to 0.36 lb/A when applied PPI or PES. Squash fruit yield at harvest may have been reduced slightly by sulfentrazone at 0.36 lb/A in 1996 but was unaffected in 1997 (Table 1 and 2).

Dickinson squash (*Cucurbita maxima*)was less tolerant than Golden Delicious to the same rates of sulfentrazone although yield was not compromised at harvest (Table 2). Injury to Dickinson squash was greatest when the herbicide was incorporated with tillage.

Golden Delicious winter squash was slightly less tolerant to dimethenamid than sulfentrazone at rates that provided acceptable weed control. Dimethenamid at 1.5 lb/A caused more injury than sulfentrazone at 0.36 lb/A early in the season. Fruit size was also smaller in dimethenamid plots (Tables 1 and 2).

Golden Delicious winter squash was tolerant of halosulfuron at 0.032 lb/A but weed control was very poor because of the high density of nightshade at the site. Halosulfuron applied at 0.062 lb/A injured squash, particularly when applied postemergence. Biomass reduction in halosulfuron treatments may have been partially due to weed competition (Table 4). Surviving weeds were removed after the biomass harvest and squash yield was only slightly less in halosulfuron treatments than the check when the fruit was harvested in September. The tankmix of halosulfuron and dimethenamid PES did not reduce squash yield as much as halosulfuron applied alone (Table 1).

Clomazone did not injure squash or reduce yield but fruit color development was very poor at harvest and maturity was delayed. Winter processing squash growth was unaffected by BAY FOE 5043 but weed competition reduced yield. FOE 5043 had no activity on nightshade, the primary species at this site. Annual bluegrass control was exceptional in the succeeding wheat crop in areas that had been treated with BAY FOE 5043. Injury to the following wheat crop was not apparent. Acetochlor stunted squash growth early in the season and reduced squash yield (Table 1).

Emergence of nightshade and pigweed was reduced by as much as 90 percent in direct-seeded squash compared to conventional tillage. Dimethenamid provided acceptable control of summer annuals at 0.75 lb/A in the direct seed plot. Nightshade control was poor at 0.75 lb/A in the conventional tillage plot. Squash yield was greatest in the direct-seed/cover crop plot with dimethenamid at 0.75 lb/A and exceeded the yield in the conventional tillage plot with dimethenamid at 1.5 lb/A. Dimethenamid at 1.5 lb/A may have reduced squash yield in both conventional tillage and direct-seed/cover crop plots.

Zucchini was much less tolerant to sulfentrazone than winter processing squash. Injury was severe when sulfentrazone was applied PPI or PRE, even at 0.125 lb/A. Plant biomass at 6 WAP was greater than the check plot at 0.125 lb/A, but growth reduction was still severe when applied at 0.250 lb/A. At harvest, only the 0.375 lb/A rate of sulfentrazone applied PPI decreased yield of zucchini compared to the untreated check plot (Table 3).

Cucumbers were intolerant of sulfentrazone at all rates on the sandy loam soil at the Research Station (Table 3). A trial on a slightly heavier soil in a producer's planting indicated more tolerance to sulfentrazone than on the sandy soil, but the margin was still inadequate. Ethalfluralin applied one day before sulfentrazone application may have increased the cucumber tolerance to sulfentrazone.

SUMMARY

Golden Delicious winter squash was more tolerant to sulfentrazone than Dickinson squash. Sulfentrazone injury did not reduce squash yield of either species. Squash was slightly less tolerant to dimethenamid than sulfentrazone. Sulfentrazone seriously injured zucchini and nearly eliminated cucumbers on a sandy soil. Clomazone caused poor development and a light colored rind in Golden Delicious squash. Weed control was poor with dimethenamid in conventional tillage systems, but adequate in direct-seed systems.

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Table 1. Herbicide effects on Golden Delicious winter processing squash in hand-weeded plots, Corvallis, OR, 1996.

			Crop biomass at 6 WAP			At harvest		
Herbicide	Timing	Rate	No. plants	Ave. plant wt.	Total biomass	Fruit no.	Squash yield	Ave. fruit wt.
		lb/A	No./25 m	g/plant	kg/8 m	g/plant	T/A	kg
Halosulfuron	PES	0.062	32	107	3.33	28.0	14.5	4.3
Halosulfuron	POST	0.062	32	149	4.70	27.0	15.2	4.8
Clomazone 4E	PES	0.25	34	211	7.80	31.0	17.3	4.7
Clomazone 3ME	PES	0.25	30	264	8.30	27.7	15.9	4.9
Sulfentrazone	PES	0.1875	32	262	8.30	31.0	19.4	5.3
Sulfentrazone	PES	0.375	32	269	8.57	26.3	16.0	5.1
Dimethenamid	PES	0.75	32	239	7.57	27.7	16.7	5.1
Dimethenamid	PES	1.5	32	237	7.50	27.3	14.2	4.4
Dimethenamid + halosulfuron	PES	0.031 + 0.031	31	236	7.27	25.7	15.4	5.1
BAY FOE 5043	PES	0.9	31	221	6.70	22.7	13.1	4.9
Acetochlor	PES	1.25	32	211	6.55	27.0	14.0	4.4
Dimethenamid + ethalfluralin	PES	0.75 + 0.85	37	180	6.67	27.3	14.6	4.5
Weeded check	-	-	29	236	6.70	29.7	13.8	3.9
LSD (0.05)			NS	25	2.0	4.9	3.6	0.8

Table 2. Tolerance of *Cucurbita maxima* (var. Golden Delicious) and *Cucurbita moschata* (var. Dickinson) to sulfentrazone and dimethenamid, Corvallis, OR, 1997.

				C. maxima (var. Golden Delicious)			*C. moschata* (var. Dickinson)		
Herbicide	Timing	Rate	No.	Crop injury	Biomass (6 WAP)	Fruit yield	Crop injury	Biomass (6 WAP)	Fruit yield
		lb/A		%	kg/5 m	T/A	%	kg/5 m	T/A
Sulfentrazone	PPI	0.18	4	3	6.5	28.8	3	7.9	56.2
Sulfentrazone	PPI	0.36	4	8	8.1	28.5	35	4.4	52.5
Sulfentrazone	PES	0.18	4	20	6.6	27.4	15	7.5	48.4
Sulfentrazone	PES	0.36	4	5	6.5	27.5	30	7.4	52.2
Dimethenamid	PES	0.75	4	10	6.4	26.5	13	7.0	52.3
Dimethenamid	PES	1.50	3	37	3.6	26.8	27	6.1	41.0
Check	-		4	0	6.1	22.0	0	8.1	40.1
LSD (0.05)				13	2.5	3.4	25	2.8	10

Table 3. Cucumber and zucchini tolerance to sulfentrazone, Corvallis, OR, 1997.

Herbicide	Timing	Rate	Cucumber Emergence 3 WAP	Cucumber Growth red. est. 3 WAP	Cucumber Plant biomass 6 WAP	Zucchini Emergence 3 WAP	Zucchini Growth red. est. 3 WAP	Zucchini Plant biomass 6 WAP
		lb/A	No/m of row	%	kg	No/2.5 m	%	kg
Sulfentrazone	PPI	0.18	16	68	0.6	21	20	7.6
Sulfentrazone	PPI	0.36	7	86	0.3	20	43	2.2
Sulfentrazone	PES	0.125	17	63	0.5	22	31	0.2
Sulfentrazone	PES	0.25	7	91	0.1	23	13	7.0
Check	POST		20	0	2.3	23	0	8.5
LSD (0.05)			6	12	1.0	NS	29	2.0

Table 4. Weed control in processing squash, 6 WAP, Corvallis, OR, 1996.

Herbicide	Timing	Rate	Pigweed	Lambsquarter	Nightshade
		lb/A	% control		
Clomazone 4E	PES	0.25	37	87	53
Clomazone 3ME	PES	0.25	27	95	23
Dimethenamid	PES	0.75	100	67	48
Halosulfuron	PES	0.031	100	67	10
Halosulfuron	POST	0.031	100	50	0
Sulfentrazone	PES	0.1875	83	87	53
LSD (0.05)			36	57	39

WEED CONTROL IN MELONS USING PREEMERGENCE AND POSTEMERGENCE HERBICIDES.
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Abstract. Cantaloupes and watermelons are the predominant melon crops produced during two growing seasons in the desert Southwest United States. Bensulide is commonly applied as a banded preemergence herbicide treatment that has a limited spectrum of weed control activity. Several cultivations are supplemented by hand-hoeing to eliminate weeds before the vines spread to form a canopy to shade out later season weeds. Field testing is being conducted in Central Arizona to evaluate new preemergence and postemergence herbicides for developing future weed management programs in melons. Clomazone, sulfentrazone, carfentrazone, and halosulfuron were evaluated in comparison to bensulide for preemergence weed control efficacy and crop safety. Halosulfuron and bentazon were applied postemergence alone or sequentially following preemergence herbicides.

Clomazone at 0.5 and 0.75 lb/A, sulfentrazone at 0.25 and 0.5 lb/A, and halosulfuron at 0.1 lb/A demonstrated effective preemergence weed control. Cantaloupe injury was marginally acceptable for the three herbicides. Carfentrazone at 0.008 and 0.031 lb/A was not effective against pigweeds, lambsquarters, and common purslane in the test. Postemergence applications of halosulfuron at 0.05 and 0.1 lb/A and bentazon at 0.5 and 0.75 lb/A following bensulide at 6 lb/A or clomazone at 0.5 lb/A preemergence provided exceptionally good weed control compared to either herbicide applied alone postemergence. Bentazon caused marginally unacceptable injury in cantaloupe and halosulfuron was safer postemergence than preemergence. Watermelon demonstrated better tolerance to all herbicide treatments compared to cantaloupe.

EFFECTS OF CULTIVAR, SEEDRATE AND HERBICIDE DOSE ON WEED CONTROL IN WATER-SEEDED RICE. Kevin D. Gibson, Theodore C. Foin, and James E. Hill, Doctoral Student, Professor, and Chair, Department of Agronomy and Range Science, University of California, Davis, CA 95616.

Abstract. Cultural control techniques are necessary to slow the development of herbicide resistant weeds and to improve weed control in water-seeded rice. We conducted two field experiments in 1997 in California to determine the effect of rice cultivar (M202 and A301), rice seedrate (46, 92, 138 and 184 kg seed ha^{-1}) and herbicide rate (a no herbicide control, 0.25, 0.5 and recommended rate) on rice yields and weed control. Selective herbicides (propanil, bensulfuron methyl) were used to target watergrass (Echinochloa phyllopogon, E. oryzoides) in the first experiment and a mixed infestation of broadleaf and sedge species in the second experiment. The full rate (4.5 kg ha^{-1} of propanil, 0.07 kg ha^{-1} of bensulfuron methyl) resulted in the best weed control and highest yields across all cultivar and seedrate treatments. M202 reduced the growth of watergrass more than A301 and had higher yields than A301 across all treatments. At the 0.5 rate, M202 reduced watergrass dry weight to levels equivalent to those reached by A301 at the full herbicide rate. M202 yields at the 0.5 rate yield were equal to A301 yields at the full rate. Weed dry weight decreased with increasing rice seedrate; broadleaf and sedge species were more affected than watergrass. The data suggest that improving the competitive ability of rice either through seedrate or by selecting more competitive cultivars can improve weed control in water-seeded rice.

RIMSULFURON: A NEW HERBICIDE FOR TOMATO WEED CONTROL IN CALIFORNIA. J. Robert C. Leavitt[1], Wayne J. Steele[1], Hugo T. Ramirez[1], Fred W. Marmor[1], Robert H.N. Park[1], Michael T. Edwards[1], Robert J. Mullen[2], Jack P. Orr[3], Kurt Hembree[4], Vicki Rose[5], and Blane Manchester[5], Senior Development Representative, Senior Development Representative, Development Representative, Field Station Manager, Regional Development Manager, Product Development Manager, Farm Advisor, Farm Advisor and County Director, Farm Advisor, Development Specialist, Assistant Development Specialist, [1]Agricultural Products Department, E.I. DuPont, Wilmington, DE 19898; [2]University of California Cooperative Extension, San Joaquin County, Stockton, CA 95205; [3]University of California Cooperative Extension, Sacramento County, Sacramento, CA 95827; [4]University of California Cooperative Extension, Fresno County, Fresno, CA 93702; [5]Crop Production Research, John Taylor Fertilizers Co., Rio Linda, CA 95673.

Abstract. Rimsulfuron has been tested in California as a tomato herbicide since 1991. Rimsulfuron has proven to be an effective herbicide when applied preemergence or postemergence by itself, or when used in combination with other herbicides in a weed control program. Application rates range from 0.25 to 0.5 oz/A PRE or POST, with a maximum total application rate of 1 oz/A per year. Weeds controlled or suppressed include barnyardgrass; green, giant, and yellow foxtail; redroot pigweed, common purslane, smooth crabgrass, hairy nightshade, black nightshade, yellow nutsedge, and lambsquarters (preemergence only).

Irrigation timing tests have shown that rimsulfuron must be incorporated into the soil by rainfall or sprinkler irrigation within 5 days of application with a minimum of 0.75 inches of water for consistent preemergence weed control. Postemergence tests have shown that rimsulfuron must be applied with surfactant when weeds are less than 1 inch in height or 1 inch in diameter for consistent postemergence weed control. For black nightshade control, tests have shown that most consistent weed control is achieved when rimsulfuron is applied preemergence and incorporated by rainfall or sprinkler irrigation within 5 days, followed by a second rimsulfuron application postemergence with surfactant at the cotyledon stage of the second flush of black nightshade. Consistent black nightshade control can also be achieved by a postemergence application of rimsulfuron with surfactant followed by a timely hand hoeing.

Mode of action studies have shown that rimsulfuron is a potent inhibitor of acetolactate synthase enzyme in both tomato and weeds, and that the basis of selectivity is rapid metabolism in the tomato. Because of the rapid metabolism in the tomato, residue tests conducted in California and around the world have shown that there are no detectable residues in the harvested tomato fruit when the rimsulfuron is applied 45 days or more before harvest.

Crop response tests have shown that both direct seeded and transplant tomatoes are highly tolerant of postemergence applications of rimsulfuron under normal environmental conditions. Under environmental stress, tomatoes can exhibit a temporary chlorosis, and in some instances a temporary stunting, after rimsulfuron application. The crop response tests have not shown any long term stunting or chlorosis, and no negative effect on tomato yield or quality. A variety crop response test has shown that tomato varieties do differ in their tolerance to rimsulfuron, with Halley 3155 variety being the most sensitive of nine varieties tested. Crop response included temporary chlorosis, but all varieties fully recovered by the end of the trial period. Postemergence surfactant tests have shown increased crop response when rimsulfuron was applied with silicone based surfactants. Field soil dissipation studies have shown that rimsulfuron degrades rapidly in the soil with a calculated half life of 7.9 to 17.7 days. The main mechanism of dissipation is acid catalyzed hydrolysis.

Rotational crop tests have shown that all crops tested can be planted successfully (without crop response) 18 months after rimsulfuron application. Many crops that are partially or completely tolerant of rimsulfuron have been planted successfully in shorter intervals, such as winter wheat in four months, and cotton, dry beans, and sweet corn in 10 months.

A THREE YEAR STUDY ON DODDER MANAGEMENT WITH RIMSULFURON IN PROCESSING TOMATOES. Robert J. Mullen[1], Jack P. Orr[2], Ted C. Viss[1], and Scott W. Whiteley[1], Vegetable Crops and Weed Science Farm Advisor, Weed Management Farm Advisor, Field Technician, and Field Assistant, [1]University of California Cooperative Extension, Stockton, CA 95205 and [2]University of California Cooperative Extension, Sacramento, CA 95827.

Abstract. The value of the processing tomato industry in California is nearly $600 million. Over the past 10 years dodder, a true parasitic plant, has become an increasing problem for tomato producers. Due to the lack of profitability of other alternative crops, poor crop rotation practices have resulted in tomatoes being cropped in the same fields for 4 or more consecutive years. Resulting infestations of dodder, as well as black nightshade, have caused reduced crop stands and substantial yield loss. While rimsulfuron has shown excellent activity on nightshade, its overall efficacy on dodder in tomatoes is not as well documented. Starting in 1995, a series of annual studies were conducted to evaluate rimsulfuron for management of dodder as well as its safety to tomatoes.

A trial conducted in 1995 in Sacramento County evaluated postemergence treatments of rimsulfuron plus 0.25% (v/v) X-77 at rates from 0.019 to 0.062 lb/A. Dodder control was 95 to 100% when application of rimsulfuron was made to tomatoes in the cotyledon stage and the dodder was attached as a single strand (Table 1). Rimsulfuron as a split application with an initial rate of 0.019 lb/A followed 3 days later by rimsulfuron at 0.031 lb/A gave 100% dodder control. Tomato vigor was temporarily reduced and some plant yellowing occurred with all rates of rimsulfuron tested.

In 1996, a postemergence study with rimsulfuron at four different rates (0.016, 0.023, 0.031, and 0.062 lb/A) plus 0.25% (v/v) crop oil concentrate was established near Brentwood, California in a field with a cropping history of four consecutive years of tomatoes with an increasingly serious dodder problem. Multiple applications of each rate of rimsulfuron were made 7 days apart beginning when the tomatoes were 8 to 10 inches tall and heavily infested with dodder that had put out strands extending 4 to 18 inches along the bed and into adjoining tomato plants. None of the treatments controlled dodder but all treatments caused considerable weed suppression while maintaining good crop vigor, particularly with 3 applications of the 0.023, 0.031, or 0.062 lb/A rates. This allowed a nearly normal crop of tomatoes to be produced. The hand weeded control provided the highest yield at 40 T/A, while the rimsulfuron treatments increased yield over the untreated control from 6.8 to 19.9 T/A (Table 2).

A 1997 postemergence study in processing tomatoes, evaluating multiple applications of three rates (0.016, 0.023 and 0.031 lb/A) of rimsulfuron plus 0.25% (v/v) crop oil concentrate, was established near Byron, California. The trial site was a dodder infested field that had tomatoes for 6 years broken up by only one year of sweet corn. Treatments were begun when the tomatoes were at the second true leaf stage of growth and dodder attachment was just beginning. Applications continued on a 10 day spray schedule. Early on, some control and considerable suppression of dodder occurred, but the large seed bank of dodder continued to germinate over a two month period. Multiple applications of rimsulfuron only offered temporary suppression and after the final treatments were evaluated on May 18, 1997 the dodder rapidly colonized the trial (Table 3). Yields taken in late July were significantly below an average tomato crop of 35 T/A, although all treatments out-produced the untreated control.

In tomato fields with good crop rotation and a low dodder seed population, rimsulfuron applied postemergence followed by hand hoeing when tomatoes are thinned would result in a good dodder management program. Fields with multiple years of tomato cropping plus a history of moderate to heavy dodder infestation should be avoided or substantial economic loss could occur.

Table 1. Postemergence dodder control in direct seeded processing tomatoes.

Treatments[a]	Rate	Dodder	Tomatoes	Tomato yellowing[b]	Tomato vigor
	lb/A	No./20 ft.			%
Rimsulfuron	0.025	1	64	3	80
Rimsulfuron	0.031	1	58	3	70
Rimsulfuron	0.019 +0.031	0	59	2	80
Rimsulfuron	0.045	1	47	3	60
Rimsulfuron	0.062	2	48	3	70
Control	-	8	44	0	100

[a] Rimsulfuron treatments had 0.25% v/v X-77 surfactant added.
[b] Tomato yellowing: 1 = slight, 3 = severe.

Table 2. Postemergence dodder suppression in processing tomatoes.

Treatment[a]	Rate	Applications	Dodder suppression				Tomato vigor				Yield
	lb/A		%				%				T/A
Rimsulfuron	0.016	2	59	63	70	61	71	81	85	91	28.3
Rimsulfuron	0.023	2	68	68	74	64	75	84	88	91	21.9
Rimsulfuron	0.031	2	73	73	78	68	81	84	86	93	22.7
Rimsulfuron	0.016	3	69	66	68	74	80	83	88	89	35
Rimsulfuron	0.023	3	80	75	78	84	81	86	88	93	34
Rimsulfuron	0.031	3	85	81	81	85	83	84	88	91	33.8
Rimsulfuron	0.062	2	83	80	84	80	79	85	89	94	31.4
Rimsulfuron	0.062	3	81	78	83	86	80	84	85	90	34.9
Rimsulfuron + metribuzin	0.016 + 0.0625	2	78	74	73	65	80	85	85	90	21.9
Rimsulfuron + metribuzin	0.031 + 0.125	2	71	71	74	65	80	81	83	90	25.6
Metribuzin[b]	0.125 + 0.25	2	35	28	25	19	66	74	70	64	12.1
Hand weeded control	-	-	100	100	100	100	91	90	91	93	40
Control	-	-	20	15	15	11	74	73	68	60	15.1
LSD (0.05)											12.3

[a]Rimsulfuron treatments had crop oil concentrate added at 0.25% (v/v).
[b]Metribuzin treatment alone had sequential applications 9 days apart.

Table 3. Processing tomato postemergence dodder suppression trial.

			Pretreatment[a]	Post treatment dodder count[a]				Dodder suppression				Tomato vigor				
		Appli-	dodder	April		May		April		May		April		May		
Treatment[b]	Rate	cations	count	11	18	2	18	11	18	2	18	11	18	2	18	Yield
	lb/A							%				%				T/A
Rimsulfuron	0.016	2	18	19	20	17	45	74	81	75	45	84	80	86	81	15.5
Rimsulfuron	0.016	3	19	18	19	15	32	78	84	87	52	90	93	90	93	17.7
Rimsulfuron	0.023	2	20	20	19	17	48	77	84	79	47	89	89	90	86	18.4
Rimsulfuron	0.031	2	22	22	22	23	58	81	85	83	39	91	89	93	85	17.9
Rimsulfuron	0.031	3	19	18	21	18	36	81	87	90	57	88	88	90	90	23.7
Control	-	-	21	24	31	38	76	29	12	9	16	85	85	79	76	8.9
LSD (0.05)																6.8

[a] Dodder attachments to tomatoes per plot.
[b] Rimsulfuron treatments had crop oil concentrate added at 0.25% (v/v).

DEGREE DAY PHENOLOGY MODELS HOLD PROMISE FOR IMPROVING EFFICIENCY AND EFFICACY OF CONTROL. Timothy S. Prather, Scott J. Steinmaus, and Jodie S. Holt, IPM Weed Ecologist, Postdoctoral Researcher, and Professor, Statewide IPM Project, Kearney Agricultural Center, Parlier, CA 93648 and Department of Botany and Plant Science, UC Riverside, Riverside, CA 92521.

Abstract. Scheduling weed control measures to phenological stages is important for control of most species. Critical stages of plant development for several important weed species are often missed, rendering control less effective. Degree day phenology models for weeds have been developed but each species requires its own model. Calculations requiring multiple models will discourage their use in production agriculture. Scaling individual models to a single species= model allows flexibility in model use. Scaling allows for comparisons across species to define groups of species with similar emergence and growth patterns. For example, large crabgrass and common purslane were the first species to emerge and grow to 8-leaf stage followed by common lambsquarters and wild radish (Table). Species that developed slowly were black nightshade and annual sowthistle. One species group composed of large crabgrass, common purslane, common lambsquarters and wild radish could be controlled using a

postemergent method by waiting until wild radish emerged. Controlling weeds at less than 164 degree days would result in missing common lambsquarters and wild radish, reducing the efficiency and efficacy of that control event. Black nightshade and annual sowthistle would be single species in the second and third group, respectively (see Table). In-row cultivation, nitrogenous fertilizers, and flaming are efficacious when plants are small indicating control would be required before black nightshade emerged if using these methods. Additionally, knowledge of emergence times can allow practitioners to delay preemergent applications to just prior to emergence in order to extend the length of control farther into the season. For example, common purslane interferes with almond harvest and so delaying a preemergent herbicide to just prior to emergence extends the season of control. Developing assemblies of species would allow: 1) the practitioner to time control events to emergence of later emerging species within an assembly or 2) to target a particularly difficult species for preemergent control using earlier emerging species within its assembly as indicators.

Table. Degree days to emergence and the 8-leaf stage of six weed species using models scaled to a reference species.

Phenological stage	Large crabgrass	Common purslane	Common lambsquarters[a]	Wild radish	Black nightshade	Annual sowthistle
Emergence	120	122	164	168	230	428
8-leaf	188	190	243	275	408	886

[a]Reference species.

PREEMERGENCE HERBICIDES FOR WEED CONTROL IN POTATOES. Corey V. Ransom and Joey Ishida, Assistant Professor and Biology Research Technician, Malheur Experiment Station, Oregon State University, Ontario, OR 97914.

Abstract. Effective weed control and crop tolerance are important herbicide traits for maximizing tuber yield and quality in potatoes. Trials were conducted at the Malheur Experiment, Ontario, OR to evaluate new herbicides for weed control efficacy and crop tolerance in potatoes. Three potato varieties (Russet Burbank, Shepody, Umatilla) were planted in a silt loam soil with a pH 7.9 and 1.6% O. M. Seed pieces were planted every 9 inches in 36 inch wide rows. Plots were 12 by 30 feet and consisted of one row of each variety with border rows of Russet Burbank on each side. Potatoes were planted May 1 and 2. Preemergence herbicides were applied May 23 and postemergence applications of rimsulfuron were made June 10. Treatments were applied with a CO_2 pressurized backpack sprayer delivering 20 gpa at 30 psi. The experiment was a split-plot design with herbicide as the whole plot and varieties as the sub-plots. Treatments were replicated four times. Plots were irrigated with sprinklers according to crop requirements throughout the season.

EPTC when applied alone provided the least redroot pigweed control of all treatments, but still controlled 83% (Table). Ethalfluralin when applied alone had the lowest control of common lambsquarters (91%) and barnyardgrass (76%). Ethalfluralin and metribuzin applied alone and in a tank mixture provided less than 30% hairy nightshade control. Isoxaflutole injured all three potato varieties with the highest rate (0.118 lb/A) resulting in the greatest injury. Potato yield was increased by all herbicide treatment compared to the untreated check. The high rate of isoxaflutole had among the lowest yield of the herbicide treatments. Ethalfluralin alone and in tank mixtures with other herbicides did not injure potatoes and the yield with the tank mixture of ethalfluralin and EPTC was among the highest for any treatment.

Table. Weed control, potato injury and yield with preemergence herbicides.

Treatment	Rate	Timing	Weed control[a] AMARE	CHEAL	ECHCG	SOLSA	Potato Injury[a]	Yield[b]
	lb/A		%				%	cwt/A
Ethalfluralin	0.94	PRE	95	91	76	29	0	450
EPTC	3	PRE	83	100	100	74	3	461
Rimsulfuron	0.016	PRE	100	98	98	75	0	453
Metribuzin	0.25	PRE	100	100	96	21	0	443
Isoxaflutole	0.047	PRE	91	100	88	78	5	453
Isoxaflutole	0.071	PRE	96	100	100	98	18	445
Isoxaflutole	0.094	PRE	100	100	100	93	23	421
Isoxaflutole	0.118	PRE	100	100	100	99	41	403
Isoxaflutole + metribuzin	0.071 + 0.25	PRE	100	100	100	99	26	433
Isoxaflutole + EPTC	0.071 + 3	PRE	100	100	100	100	24	437
Ethalfluralin + EPTC	0.94 + 3	PRE	100	100	98	84	2	486
Ethalfluralin + metribuzin	0.94 + 0.25	PRE	100	100	100	16	0	443
Ethalfluralin + rimsulfuron	0.94 + 0.016	PRE	100	100	100	77	0	469
Isoxaflutole + rimsulfuron	0.071 + 0.016	PRE	100	100	100	93	3	462
EPTC + metribuzin	3 + 0.25	PRE	100	100	100	78	0	463
EPTC + rimsulfuron	3 + 0.016	PRE	100	100	100	90	0	476
Metribuzin + rimsulfuron	0.25 + 0.016	PRE	100	100	95	55	0	480
Ethalfluralin + EPTC + metribuzin	0.94 + 3 + 0.25	PRE	100	100	100	83	1	483
Ethalfluralin + rimsulfuron	0.94 + 0.016	PRE + POST	100	100	98	88	5	472
Isoxaflutole + rimsulfuron	0.071 + 0.016	PRE + POST	100	100	100	99	12	443
EPTC + metribuzin + rimsulfuron	3 + 0.25 + 0.016	PRE + POST	100	100	100	100	4	480
Untreated			0	0	0	0	0	348
LSD (0.05)			7.7	5.5	10	22	14	37

[a]Weed control and potato injury was evaluated June 24, 1997. AMARE = redroot pigweed, CHEAL = common lambsquarters, ECHCG = barnyardgrass, SOLSA = hairy nightshade.
[b]Potato yield taken September 17, 18, 19, 1997.

ETHALFLURALIN AS A WEED MANAGEMENT TOOL FOR POTATOES. Mary J. Guttieri and Charlotte V. Eberlein, Support Scientist and Professor, University of Idaho, Aberdeen Research and Extension Center, Aberdeen, ID 83210.

Abstract. Field studies were conducted at the Aberdeen Research and Extension Center near Aberdeen, ID, in 1996 and 1997 to evaluate weed control in 'Russet Burbank' potatoes with ethalfluralin, ethalfluralin mixtures with registered herbicides, and sequential applications of ethalfluralin and registered herbicides. Ethalfluralin alone applied preemergence provided poor control of hairy nightshade and brown mustard, poor to fair control of cultivated oats, and fair control of common lambsquarters, redroot pigweed, and kochia. Ethalfluralin preemergence provided good control of green foxtail. Ethalfluralin mixtures applied preemergence provided overall weed control comparable to standard mixtures. Sequential applications of ethalfluralin preemergence followed by rimsulfuron or rimsulfuron plus metribuzin provided excellent control of most weeds.

Weed-free tolerance studies also were conducted in 1996 and 1997 to evaluate Russet Burbank tolerance to preemergence or early postemergence applications of ethalfluralin or ethalfluralin plus metribuzin. In 1996, mild crop injury (<5%) was observed with postemergence ethalfluralin applications. In 1997, injury preemergence applications was mild, but postemergence applications resulted in moderate injury (9 to 17%). Leaves of injured plants were crinkled and smaller, which resulted in some stunting. Maximum injury from postemergence ethalfluralin plus metribuzin; however, was less severe than injury from postemergence pendimethalin plus metribuzin (27% injury). U.S. No. 1 and total tuber yields were not adversely affected by ethalfluralin treatments.

INTEGRATING HERBICIDES AND *BRASSICA* GREEN MANURES FOR WEED CONTROL IN POTATO. Charlotte V. Eberlein, Mary J. Guttieri, James R. Davis, Rick A. Boydston, Timothy Miller, Carl Libbey, and Kassim Al-Khatib, Professor, Support Scientist, Professor, Horticulturalist, Assistant Professor, Research Technician, and Associate Professor, University of Idaho, Aberdeen Research and Extension Center, Aberdeen, ID, 83210; Cascadian Farms, Grandview, WA, 98930; Washington State University, Mt. Vernon, WA, 98273; and Kansas State University, Manhattan, KS 66506.

Abstract. *Brassica* green manures have shown potential for providing biological control of several common potato pests, including soil borne diseases, nematodes, and weeds. *Brassica* species contain glucosinolates, which are enzymatically hydrolyzed to isothiocyanates, thiocyanates, nitriles, and other phytotoxic compounds when plant cells are disrupted. Multidisciplinary studies to evaluate pest control in a *Brassica* green manure-potato system were conducted at three locations. Three pest management systems were compared in a split plot design at Aberdeen, ID, Prosser, WA, and Mt. Vernon, WA. Main plots were low, medium, or high pest control input levels, and subplots were green manure treatments: no green manure, winter rape (*Brassica napus*), or white mustard (*Brassica hirta*). Green manures were planted in mid-to-late August, 1996, and were incorporated 1 to 3 weeks before planting potatoes in the spring of 1997. Incorporating winter rape reduced biomass of some weed species, but species response was location dependent. For example, early season hairy nightshade biomass was reduced at Aberdeen, common lambsquarters biomass was reduced at Prosser, and common chickweed biomass was reduced at Mt. Vernon. However, despite biomass reductions, weed control with winter rape incorporation alone was not commercially acceptable. Incorporating white mustard generally was less effective for weed control than incorporating winter rape. At all three locations, weed control with the combination of an incorporated green manure plus a low rate, postemergence application of rimsulfuron plus metribuzin was excellent and similar to the high input, standard practice herbicide treatment. Soil borne disease control with the green manure system also was evaluated. At Aberdeen, the winter rape and white mustard green manure treatments had a higher percentage of Rhizoctonia canker-free stems than the no green manure control, and Verticillium wilt was reduced in the winter rape treatment compared to the control. Columbia root knot nematode populations in the soil and tuber infection by nematodes were reduced by incorporating winter rape but were not reduced by incorporating white mustard residues. U.S. No. 1 yields were not affected by pest management input level at Prosser or Mt. Vernon, but medium and high input treatments had higher U.S. No. 1 yields than the low input treatment at Aberdeen. Lower yields in the low input treatment were due primarily to inadequate weed control. There were no effects of green manure treatments on total yield of U.S. No. 1 tubers at any location, but a size shift to larger tubers within the U.S. No. 1 grade was observed with the winter rape treatment at Aberdeen.

THE PREEMERGENCE ACTIVITY OF THIAZOPYR UNDER FIELD CONDITIONS IN CALIFORNIA NUT CROPS. John T. Schlesselman, Randy L. Smith, L. Douglas West, and Harvey A. Yoshida, Rohm and Haas Company, Fresno, CA 93710.

INTRODUCTION

Field research in California since 1994 has shown that thiazopyr provides excellent preemergence control of many weed species as well as showing outstanding crop safety in trees and vines. These trials were established as replicated small plot experiments designed to understand the activity of thiazopyr based on rate, moisture requirements, soil type, weed spectrum, residual activity, and crop tolerance. These small plot trials were conducted under very controlled conditions to insure accuracy and reduce as many variables as possible. The early trials were small for another important reason; there was no crop tolerance established by the EPA, and all crops treated with thiazopyr had to be destroyed.

The Federal Environmental Protection Agency approved a temporary tolerance for thiazopyr in tree nut crops and issued an Experimental Use Permit (EUP) on July 25, 1996. This 2-year EUP allows Rohm and Haas Company to conduct grower-applied thiazopyr trials in almonds, pecans, pistachios and walnuts totaling 247 ha/yr for each of these crops in California.

Between November 15, 1996 and February 26, 1997, 24 thiazopyr EUP trials were established in California. These trials were conducted in almonds (7), pecans (2), pistachios (7), and walnuts (8) and were spread throughout the nut crop growing regions of California. In these trials, 4 thiazopyr rates were evaluated; 0.42, 0.56, 0.84 and 1.12 kg/ha. Comparisons were made with the grower's standard herbicides which included oryzalin at 3.36 to 4.48 kg/ha (28% of the trials), simazine at 1.12 to 2.52 kg/ha (20%), norflurazon at 2.24 to 4.48 kg/ha (16%), pendimethalin in nonbearing nut crops at 2.8 to 3.7 kg/ha (16%), diuron at 3.58 kg/ha (12%), and napropamide at 4.48 kg/ha (8%). Since no single preemergence herbicide controls all weeds in an orchard, all grower programs in these 24 EUP trials included tankmixing oxyfluorfen at 0.84 to 1.68 kg/ha. Therefore the same rate of oxyfluorfen was tankmixed with thiazopyr and the respective grower standard at each of the trial locations. If weeds were present at application, glyphosate at 1.12 kg/ha or paraquat at 0.67 kg/ha was also used.

Most of these trials were established prior to the winter rains which totaled 15 to 33 cm. This resulted in excellent incorporation of the herbicides at most locations. The trials were equally split between light and heavy soils providing thiazopyr good representation in the various soils from sandy loam to clay.

The grower's application equipment varied as much as their individual herbicide programs. Spray volumes were from 31 to 115 L/ha. Prior to the establishment of each trial, the sprayers were calibrated, assuring the greatest accuracy possible with all herbicide applications.

The growers did allow small untreated areas within the trial sites, usually 2 rows by 10 trees. This generally gave a good representation of the weed spectrum and made meaningful evaluations possible. Forty-two weed species were evaluated in these EUP trials. Table 1 shows the weeds that were found within the trials and their frequency of occurrence.

Table 1. Weed species evaluated in the 1997 thiazopyr EUP trials.

Broadleaf weeds (30)		No. of trials			No. of trials
Annual sowthistle	(*Sonchus oleraceus*)	9	Pineappleweed	(*Matricaria matricarioides*)	3
Black mustard	(*Brassica nigra*)	2	Prickly lettuce	(*Lacuca serriola*)	3
Brassbuttons	(*Cotula australis*)	1	Prostrate knotweed	(*Polygonum aviculaire*)	2
California burclover	(*Medicago polymorpha*)	2	Prostrate Pigweed	(*Amaranthus blitoides*)	1
Chickweed	(*Stellaria media*)	6	Puncturevine	(*Tribulus terrestris*)	1
Common groundsel	(*Senecio vulgaris*)	3	Redroot pigweed	(*Amaranthus retroflexus*)	2
Common purselane	(*Portulaca oeracea*)	5	Russian thistle	(*Salsola kali*)	1
Fiddleneck	(*Amsinckia intermedia*)	2	Scented mayweed	(*Matricaria chamomilla*)	1
Flaxleaf fleabane	(*Conyza bonariensis*)	6	Shepherdspurse	(*Capsella bursa-pastoris*)	6
Green amaranth	(*Amaranthus hybridus*)	1	Smooth cat's ear	(*Hypochoeris glabra*)	1
Lambsquarters	(*Chenopodium album*)	2	Spiny sowthistle	(*Sonchus asper*)	2
Little mallow	(*Malva parviflora*)	4	Spotted spurge	(*Euphorbia maculata*)	10
London rocket	(*Sisymbrium irio*)	2	Strawberry clover	(*Trifolium fragiferum*)	1
Marestail	(*Conyza canadensis*)	9	Tumbling pigweed	(*Amaranthus albus*)	1
Pannicled willowherb	(*Epilobium paniculatum*)	3	Whitestem filaree	(*Erodium moschalum*)	2
Grasses (10):					
Annual bluegrass	(*Poa annua*)	4	Johnsongrass	(*Sorghum halepense*)	1
Barnyardgrass	(*Echinochloa crus-galli*)	5	Junglerice grass	(*Echinochloa colonum*)	3
Bearded sprangletop	(*Leptochloa fascicularis*)	1	Large crabgrass	(*Digitaria sanguinalis*)	3
Diffuse lovegrass	(*Eragrostis diffusa*)	1	Orchardgrass	(*Dactylis glomerata*)	1
Foxtail barley	(*Hordeum jubatum*)	4	Southwest cupgrass	(*Eriochloa gracilis*)	2
Sedges (2):					
Purple nutsedge	(*Cyperus halepense*)	3	Yellow nutsedge	(*Cyperus esculentus*)	11

RESULTS AND DISCUSSION

Thiazopyr provided excellent residual weed control with all rates and was still 75 to 90% effective 8 to 9 months after application. Table 2 shows the overall weed control with thiazopyr compared to the grower standard herbicides. Generally, there was a rate response with thiazopyr; however, even the 0.42 kg/ha rate demonstrated more effective control than the average activity of the commercial standard herbicides.

Table 2. Overall preemergence weed control activity of thiazopyr compared to the commercial standards in nutcrops.

		Preemergence weed control			
Treatment[a]	Rate	2 to 3 Months	4 to 5 Months	6 to 7 Months	8 to 9 Months
	(kg/ha)	%			
Thiazopyr	0.42	96	87	78	81
Thiazopyr	0.56	87	91	78	75
Thiazopyr	0.84	96	95	88	90
Thiazopyr	1.12	91	96	93	87
Commercial standard[b]		88	79	69	62

[a]Oxyfluorfen at 0.84 to 1.68 kg/ha added to all five treatments including commercial standards.
[b]Depending on trial location, commercial standard was oryzalin, pendamethalin, norflurazon, simazine, diuron, or napropamide.

To better understand the activity of thiazopyr, comparisons were made based on the strengths of the grower's preferred choice for their herbicide program. For example, oryzalin (all nutcrops) and pendamethalin (currently only labeled for nonbearing nutcrops) are usually selected for their good residual activity on annual grasses and many broadleaf weeds (excluding marestail and flaxleaf fleabane). Thiazopyr was as effective as oryzalin in providing excellent grass control up to 8 to 9 months after application (Table 3). For broadleaf weed control, thiazopyr was considerably more effective than oryzalin at both 4 to 5 months and 8 to 9 months.

Table 3. The preemergence activity of thiazopyr compared to oryzalin for the control of annual grasses and broadleaf weeds.

		Preemergence weed control			
		Grasses		Broadleaves[b]	
Treatment[a]	Rate	4 to 5 Months	8 to 9 Months	4 to 5 Months	8 to 9 Months
	(kg/ha)	%			
Thiazopyr	0.42	-	-	89	75
Thiazopyr	0.56	100	85	94	81
Thiazopyr	0.84	100	88	97	81
Thiazopyr	1.12	100	85	97	80
Oryzalin	3.36 to 4.48	100	84	82	63

[a]Oxyfluorfen at 0.84 to 1.68 kg/ha added to all five treatments.
[a]Broadleaf weeds do not include marestail or flaxleaf fleabane.

Thiazopyr provided even greater differences in activity when compared to pendamethalin (Table 4). The evaluations after 8 to 9 months show that the residual activity of pendamethalin was considerably less than the activity of thiazopyr, especially on the grasses where thiazopyr was 61to 93% effective, compared to only 38% control with pendamethalin. Even the pendamethalin activity on broadleaf weeds (64%) was much less than the 88 to 94% control with thiazopyr.

Table 4. The preemergence activity of thiazopyr compared to pendamethalin for the control of annual grasses and broadleaf weeds.

		Preemergence weed control			
		Grasses		Broadleaves[b]	
Treatment[a]	Rate	4 to 5 Months	8 to 9 Months	4 to 5 Months	4 to 5 Months
	(kg/ha)	%			
Thiazopyr	0.42	83	61	80	88
Thiazopyr	0.56	93	85	89	90
Thiazopyr	0.84	93	91	92	91
Thiazopyr	1.12	96	93	94	94
Pendamethalin	2.8 to 3.7	83	38	72	64

[a]Oxyfluorfen at 0.84 to 1.68 kg/ha added to all 5 treatments.
[b]Broadleaf weeds do not include marestail or flaxleaf fleabane.

For control of nutsedge, marestail, and flaxleaf fleabane, norflurazon is the only preemergence herbicide that offers fairly good suppression of those weeds. However, norflurazon is often not used due to grower concerns over crop injury. Table 5 shows the results when thiazopyr was compared to norflurazon in controlling nutsedge and the marestail/flaxleaf fleabane complex. For nutsedge control, thiazopyr at rates of at least 0.84 kg/ha was slightly more effective than norflurazon. After 4 to 5 months, thiazopyr was providing 90% to 99% marestail/flaxleaf fleabane control compared to only 80% control with norflurazon (no evaluations were possible after 8 to 9 months).

Table 5. The preemergence activity of thiazopyr compared to norflurazon for the control of nutsedge and marestail/flaxleaf fleabane.

		Preemergence weed control		
		Nutsedge		Marestail/FLP
Treatment[a]	Rate	4 to 5 Months	8 to 9 Months	4 to 5 Months
	(kg/ha)	%		
Thiazopyr	0.42	80	70	95
Thiazopyr	0.56	53	70	98
Thiazopyr	0.84	78	90	90
Thiazopyr	1.12	80	85	99
Norflurazon	2.24 to 4.48	63	73	80

[a]Oxyfluorfen at 0.84 to 1.68 kg/ha added to all five treatments.

SUMMARY AND CONCLUSIONS

Although the overall activity of thiazopyr showed excellent broadspectrum preemergence weed control compared to the current standard herbicides in nutcrops, there were some areas of potential "weaknesses" with the thiazopyr plus oxyfluorfen tankmixes that were evident in the 1997 EUP program. For optimum nutsedge control, the rate of thiazopyr should be greater than 0.56 kg/ha. The spotted spurge control with thiazopyr dropped off after 6 to 9 months when rates were equal or less than 0.56 kg/ha. Finally, although not specifically mentioned in this paper, the annual sowthistle control dropped off after 8 to 9 months. This was probably related to the oxyfluorfen rate in the thiazopyr plus oxyfluorfen tankmix where growers decided on a rate that did not give sufficient residual sowthistle control (0.84 to 1.12 kg/ha instead of 1.68 to 2.24 kg/ha).

The highlight of the 1997 research was undoubtedly the excellent residual activity of thiazopyr compared to the commercial standards. The longer the time between application and evaluation, thiazopyr increased the difference in activity compared to current preemergence herbicides (Table 6).

Table 6. Residual weed control activity of thiazopyr compared to the grower's commercial standards.

Residual time	Thiazopyr less active	Equal activity	Thiazopyr more active
		%	
2 to 3 Months	10	69	21
4 to 5 Months	15	37	48
6 to 7 Months	25	15	60
8 to 9 Months	8	13	79

The 1997 to 1998 field trials for the second year of the thiazopyr EUP program in nutcrops will be even more ambitious than the work conducted during this past year in anticipation of a registration in the near future.

COMPARISON OF ADDITIVES ON GLYPHOSATE SUPPRESSION OF WINTER WEEDS. W. Thomas Lanini, Ernie Roncoroni, Mariano Battista, Ryan Carner, and Carlos Fernandez[1], Extension Weed Ecologist, Staff Research Associate, Graduate Student, Student, and Market Development, Weed Science Program, Department of Vegetable Crops, University of California, Davis, CA 95616 and [1]Monsanto, Davis, CA 95616.

Abstract. Studies evaluating glyphosate with several preemergence herbicides or additives were established on Dec. 7, 1996, in a mature almond orchard and in a 3 year old prune orchard. Both orchards were located near Live Oak, CA. Weed cover on the berm (treated area) averaged 30% in the almonds and 40% in the prunes, at the time of treatment. The treatments were three rates of glyphosate (0.38, 0.56, and 0.75 lb/A) applied alone and in combination with (simizine at 1.35 lb/A or napropamide at 4 lb/A on almonds) and (oryzalin at 2.5 lb/A or napropamide at 4 lb/A on prunes). Spray volume was 33 gpa with a water hardness of 547 ppm. The primary weed species observed in the almond orchard were little mallow, redstem filaree, annual bluegrass, and chickweed, with the prune orchard composed of redstem filaree, and chickweed. Data was analyzed and averaged over glyphosate rates for each herbicide combination.

In almonds, control of little mallow and redstem filaree was greatest when glyphosate was combined with napropamide (Table). The high rate of glyphosate was better than the low rate for both little mallow and redstem filaree. All treatments were equally effective at controlling annual bluegrass and chickweed.

In prunes, redstem filaree control was similar among treatments. The high rate of glyphosate were better than the low rate at controlling redstem filareen (Table). At 40 days after treatment, control of redstem filaree declined compared to the 14 day evaluation. Overall control of weeds in prunes did not differ among treatments at 14 days, but was better at 40 days, on several treatments which contained either oryzalin or napropamide.

Overall, it appears that simazine was the only herbicide to reduce glyphosate activity. Adding the additive Choice, ammonium sulfate (AMS), or LI-700 to the glyphosate/simazine mix reduced antagonism slightly, but did not completely eliminate the effect.

Table. Weed control 40 days after treatment in almonds and prunes.

Treatment	Almonds					Prunes	
	Mallow	Filaree	Chickweed	Ann.Bluegrass	Overall	Filaree	Overall
	% control						
Average over glyphosate rate[a]							
Glyphosate	44.2	47.5	95.4	87.4	81.2	35.8	79.6
Glyphosate + simazine[a]	37.5	37.9	97.5	92.1	84.6	42.5	90.7
Glyphosate + simazine + AMS	42.8	44.3	97.5	93.8	86.2	44.5	90.8
Glyphosate + simazine + Choice	46.5	44.3	99.9	95.8	89.1	42.1	87
Glyphosate + simazine + LI 700	40.4	39.4	98.6	92.2	85.2	38.3	82.9
Glyphosate + napropamide	54.2	62.9	96.2	94.5	88.3	44.2	86.5
Glyphosate + napropamide + Choice	62	71.5	94.4	96.5	90.8	39.2	86.2
LSD (0.05)	11.5	12.4	NS	NS	NS	NS	6.9
Average over tank mix[b]							
Glyphosate 0.75 lb/A	51.2	53.8	98	94.1	87.7	48.3	87.6
Glyphosate 0.56 lb/A	47.1	51.8	98	95.3	87.4	37.3	84.3
Glyphosate 0.38 lb/A	43.5	44.5	95.8	90	84.5	35.8	84.3
LSD (0.05)	5.2	6.3	NS	NS	NS	6.7	NS

[a]Simazine was applied at 1.35 lb/A, napropamide at 4 lb/A, AMS at 8.5 lb/100gal, Choice at 4 pt/100 gal, and LI700 at 2 pt/100gal. Oryzalin was used rather than simazine in the prune location. Oryzalin was applied at 2.5 lb/a.
[b]Average over tank mix combination by glyphosate rate.

GLYPHOSATE APPLICATION RATE INFLUENCES COVER CROP BIOMASS PRODUCTION AND NITROGEN EXTRACTION. Terry L. Prichard and Robert J. Mullen, Water Management Specialist, Department of Land, Air and Water Resources and Farm Advisor, University of California Cooperative Extension, Stockton, CA 95205.

Abstract. Orchard vegetation management techniques used in California orchard crop growers vary widely. Practices range from total orchard floor vegetation control using soil residual herbicides to the use of full coverage resident and planted cover crops. Many benefits have been found to be associated with the use of cover crops. Improved soil characteristics such as increased infiltration rates have been associated with the use of annual and perennial cover crops (Prichard 1988). In the same study, increased water use also resulted with resident vegetation and remedial cover crops (Prichard 1989). Additionally, other researches have shown cover crops can modify disease and pest populations (Elmore 1989). On the nutrition front, covers have been used in apple orchards to extract nitrogen from the soil in competition with the tree crop.

This experiment was designed to develop a relationship between biomass production and nitrogen extraction as affected by various rates of spring-applied glyphosate. The study was conducted in a California mature walnut orchard on a silty clay soil. Irrigation was by solid set sprinklers. Normal irrigation practices to meet crop demand were used. Mechanical mowing was on a 30-day schedule. A split plot design was used to evaluate both two cover crops at three rates of herbicide in a randomized block design. The main plots consisted of the cover treatments of 1) rye grass and 2) resident vegetation. Sub-plots were rates of glyphosate at 0, 0.938, 0.1875, and 0.375 lb/A. All herbicide applications were applied at 10 gpa using 0.05% nonionic surfactant and 17 pounds of NH_4SO_4 per 100 gallons.

The entire experimental area was mechanically mowed on March 7 using a flail mower set at 3 inches above the soil surface. Fertilizer was applied on April 1 as urea at 150 lb/A nitrogen. Herbicide treatments were applied a single application on April 12, 1993. Biomass measurements were taken by clipping the total vegetation in a one square meter area within each treatment replicate. Measurements were made just prior to the flail mowing set at one inch above the soil surface. The clippings were then dried at 140 F and weighed sub-samples were taken for total nitrogen content.

The results indicate the relationship between the rate of glyphosate and cumulative biomass production from the May, June and July cuttings are non-linear in nature. Additionally, the relationship for the two cover crops are distinctly different in that the resident vegetation is less rate sensitive than ryegrass on a cumulative basis. Likewise, the nitrogen extracted mirrored the biomass results.

Using herbicide applications timed to reduce biomass growth shortly after fertilization can, depending on rate, provide significant quantities of available nitrogen to the target crop. This can be accomplished while production 30 to 60% of the biomass for soil improvement.

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CHEMICAL CONTROL OF AUSTRALIAN SALTBUSH IN BERMUDA GRASS TURF AND ORNAMENTAL SITES. Brent E. Boutwell and Carl E. Bell, Staff Research Associate and Weed Science Advisor, University of California Cooperative Extension-Imperial County, Holtville, CA 92250.

Abstract. Australian saltbush was introduced into California as a cattle forage and erosion control agent. It tolerates soils high in salt concentrations and is well adapted to climatic conditions found in the low desert of Southern California. Traditional methods of control consisting of hand hoeing, close mowing ,and string trimmer removal conducted by landscaping professionals have proven to be ineffective and labor intensive. Glyphosate and 2,4,D spray treatments made by pest control professionals have also been ineffective. Field studies were conducted at a golf course at El Centro, CA in 1997 to compare herbicides for control of Australian saltbush in turf. Herbicides tested were: metribuzin, bentazon, dithiopyr, halosulfuron-methyl, pelargonic acid, glufosinate, and acetic acid. These products are all available to landscape professionals in California that would minimize the risk exposure to themselves and possible impacts upon the environment. We determined that foliar applied metribuzin plus nonionic surfactant at 0.25 lb/A + 0.5% provided excellent control of Australian saltbush with minimal phytotoxic effects to bermudagrass turf and woody ornamentals.

CHEMICAL RENOVATION OF KENTUCKY BLUEGRASS WITH GLYPHOSATE. Janice M. Reed, Jerry B. Swensen, Donald C. Thill, and Glen A. Murray, Scientific Aide, Research Support Scientist, Professor, and Professor, Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83844-2339.

Abstract. The Pacific Northwest produces over 90% of the Kentucky bluegrass seed grown in the United States. Post-harvest burning of bluegrass fields is a typical practice for residue removal and stand regeneration. Opposition to smoke from open-burning of bluegrass has created a need to develop alternative methods of residue removal. Mechanical methods of residue removal have been used, however they result in shorter stand life and more frequent establishment periods as compared to burning. In addition, grass weeds are expected to increase when burning is eliminated. For older stands, spring-applied herbicides can be used following mechanical removal to increase the number of productive seed cycles, and reduce the build-up of annual grass weeds. No-till planting of spring annual crops in the chemically suppressed bluegrass may allow economic return during the renovation period. Two experiments were established in a 5 yr old stand of 16 Kentucky bluegrass varieties near Moscow, Idaho to evaluate the renovation of Kentucky bluegrass varieties with different rates of glyphosate and to evaluate the effect of glyphosate rate and bluegrass variety on lentil seed yield. Both experiments were arranged as strip plot designs. The main plots for the first experiment were five rates of glyphosate (1.12, 1.68, 2.24, 2.8, and 3.36 kg/ha), and five bluegrass varieties were the sub-plots. Each sub-plot was 1.2 by 2.4 m. The main plots for the second experiment were two rates of glyphosate (1.12 and 1.68 kg/ha) and 16 bluegrass varieties were the subplots. Each sub-plot was 2.4 by 3 m. Herbicide treatments were applied to both experiments on April 8, 1997, when the bluegrass was 2.5 cm tall. In experiment 2, 10.2 cm sod cores were taken from each bluegrass sub-plot two weeks after glyphosate application, grown for 6 weeks in the greenhouse, and compared to core samples taken 1 week prior to herbicide application. 'Pardina' small brown lentil was seeded into the bluegrass stand with a no-till drill 5 weeks after glyphosate application. In experiment 1, lentil seed yield increased with increasing glyphosate rate regardless of bluegrass variety. Yield from lentils seeded into early maturing bluegrass varieties was significantly higher than lentil yield from late maturing varieties. In experiment 2, pre-glyphosate rhizome weights were not different between varieties. Pre-glyphosate rhizome weights and tillers were not significantly correlated with post-glyphosate shoot re-establishment, rhizome sprouts, or lentil seed yield. The number of rhizomes that sprouted after application was not affected by glyphosate rate, but varied with variety. Late maturing varieties had the highest number of new rhizome sprouts, while early maturing varieties had the lowest. Post-glyphosate rhizome regeneration and lentil seed yield were not significantly correlated (P=0.05) with post-glyphosate shoot re-establishment, rhizome sprouts, or lentil seed yield. Grass shoot re-establishment did correlate significantly with lentil yield and had a correlation coefficient of -0.22. Yield was highest from lentil seeded into early maturing bluegrass varieties, while late maturing, aggressive varieties reduced lentil yield.

SMUTGRASS AND GREEN KYLLINGA, TWO "NEW" CHALLENGES TO TURF PRODUCTION IN SOUTHERN CALIFORNIA. David W. Cudney, David A. Shaw, and Cheryl Wilen, Extension Specialist, University of California, Riverside, CA 92521-0124 and Farm Advisors, University of California Cooperative Extension, San Diego, CA 92123-1219.

Abstract. Smutgrass and green kyllinga, although not really new to California, are increasingly seen as severe weed problems in turf. Both are perennial weeds, but differ in their favored niches. Smutgrass (a native of Asia) is most competitive in warm, dry, exposed sites, while green kyllinga (a native of tropical America) is found in well-watered areas. Smutgrass was named for a dark-colored fungus, often found on the upper leaves and seed-heads. The seed is usually quite small (about one mm in diameter) and amber in color. In California turf, when left unmowed, plants attain a height of approximately 65 cm. Smutgrass is very slow in becoming established, but once established it is quite hardy and survives best in drier sites (southern slopes or areas without sufficient irrigation for standard turfgrasses to be competitive). The grass stems are wiry and difficult to mow. Mowers often "ride up and over" smutgrass clumps (for this reason some turfgrass managers refer to smutgrass as "wiregrass"). Green kyllinga is a sedge which is often confused with yellow or purple nutsedge. Unlike the nutsedges, kyllinga does not produce

tubers but reproduces vegetatively with a vigorous system of rhizomes. It also produces numerous, small, (flattened 1 mm in diameter) seeds (over 2,000 per plant in a 90-day period). Green kyllinga forms a weak sod, reducing playability for sports purposes. It also re-grows quickly after mowing giving turf a clumpy, uneven appearance. Both species germinate in spring through the summer months (smutgrass started germinating at about 13 C and green kyllinga at about 17 C).

Control of both species, once established, is difficult. Smutgrass invasion can be slowed by increasing soil moisture in dry sites; this allows the standard turgfrasses to be more competitive. Preemergence herbicides will control germinating seedlings of both smutgrass and green kyllinga. In trials at UC, Riverside all of the common preemergence turf herbicides tested (atrazine, pendimethalin, prodiamine, pronamide, DCPA, dithiopyr, bensulide, and benefin) controlled both species. Repeated postemergence applications of MSMA (at least four applications annually for smutgrass) were successful in reducing both species. Smutgrass was also controlled with repeated applications of fenoxaprop in cool-season turfgrass, but fenoxaprop cannot be used in bermudagrass where most of the smutgrass infestations have occurred. Green kyllinga was reduced best by two, sequential applications of halosulfuron. Two, sequential applications of bentazon were also effective. Smutgrass was reduced non-selectively with postemergence, spot treatments of glyphosate and glufosinate. Control of smutgrass was also obtained from wick applications of concentrated solutions of glyphosate. Wick applications required careful coordination of mowing, watering, and wicking. Mowing had to be withheld for at least 10 days so that wick applications could be accomplished when there was at least a 10 cm height differential between the turf and smutgrass.

WEEDS OF AGRONOMIC CROPS

WEED CONTROL IN ESTABLISHING STANDS OF ALFALFA. Brenda M. Waters and Gary A. Lee, Scientific Aide and Professor, Department of Plant, Soil and Entomological Sciences, University of Idaho, Parma, ID 83660.

INTRODUCTION

Idaho grows approximately 1 million acres of alfalfa hay annually and ranks seventh nationally in total production (Idaho 1992). The average alfalfa crop is maintained for 5 years in rotation resulting in about 200,000 acres of new crop establishment each year. Annual weed competition in establishing a forage alfalfa crop has been identified by growers as a major production problem. Seedling alfalfa is not competitive with aggressive annual weeds during the early development phase and weak and thin stands often result from excessive weed competition. Growers commonly plant approximately 40 alfalfa seeds/ft^2 in order to attain an acceptable stand of between 9 to 12 plants/ft^2. When alfalfa must compete with annual weeds for light, water, nutrients and space, the alfalfa plants may be stress so that they never reach their genetic potential. Establishing an alfalfa crop is the first phase of a long-term commitment on the part of most growers and the vigor of the plants greatly influence the production throughout the life of the crop. Development of effective preplant and postemergence tactics to protect the establishing alfalfa plants and to improve the quality of the initial year's forage production were goals of the is study.

MATERIAL AND METHODS

A study was conducted at the Parma Research and Extension Center, Parma, Idaho to compare the effectiveness of both PPI and POST herbicides for control of annual weeds, crop tolerance and influence on first year alfalfa production. Both studies were arranged in a randomized complete block design with four replications and individual plots were 7 by 30 feet. Soil at the locations is a Greenleaf Owyhee Silt Loam (34% sand, 60% silt, 6% clay, 1.25% organic matter and pH 7.7). Surface condition at the time of applications was dry, smooth (no clods) without visible organic debris present. Herbicides were applied with a CO_2 pressurized backpack sprayer calibrated to deliver 10 gpa at 30 psi and 3 mph. On May 7, 1997, alfalfa (cultivar 'WD503') was planted as a broadcast seeding at a rate of 12 lb/A using a hand-held cyclone spreader and incorporated with a spring-tine harrow to a depth of 0.25 to 0.5 inch. Furrows were made on 30 inch intervals for subsequent irrigation. PPI herbicides were applied on April 18 and immediately incorporated with a Triple K to a depth of 2 inches. POST herbicide applications were made on May 30 and June 2 when the alfalfa was in the 2-trifoliate and 2- to 3-trifoliate stages, respectively. Weed control and crop tolerance were visually evaluated on June 1 and July 15. PPI evaluations were at 44 and 88 days after treatment (DAT) and POST evaluations were 2 and 46 DAT. Sub-samples were hand harvested on August 6 and October 15 using a Gerry Mower. Weeds were separated from alfalfa. Both the weeds and the alfalfa were then air dried, weighed and yields calculated in T/A.

RESULTS AND DISCUSSION

All PPI herbicide treatments provided 92% or better control of redroot pigweed and common lambsquarters at 44 and 88 DAT (Table 1). EPTC plus benefin at 2 + 1.2 lb/A and EPTC plus ethalfluralin at 2 + 1 lb/A resulted in significantly better control of all weed species at both evaluation dates compared to the other herbicide treatments. All PPI treatments except EPTC at 2 lb/A gave 93% or better control of barnyardgrass . However, EPTC at 2 lb/A was the only PPI herbicide that did not cause significant crop stunting and/or leaf malformation 44 DAT. The alfalfa plants recovered in all herbicide treated plots and no visual phytotoxic symptoms were observed 88 DAT.

Table 1. Effect of preplant incorporated herbicide treatments on weed control in forage alfalfa establishment.

Treatment	Rate	Weed control					
		Redroot pigweed		Common lambsquarters		Barnyardgrass	
		44 DAT	88 DAT	44 DAT	88 DAT	44 DAT	88 DAT
	- lb/A -	%					
EPTC	2	93.8	93.3	92	94.5	90.8	87.5
EPTC + trifluralin	2 + 1	98.5	99.5	99.5	96.5	97.8	93.8
EPTC + benefin	2 + 1.2	100	100	100	100	95.3	99.8
EPTC + ethalfluralin	2 + 1	99	100	98.8	100	99	97.3
EPTC + dimethenamid	2 + 1	100	95.3	100	97.5	97	95.8
Ethalfluralin + dimethenamid	1 + 1	98.8	92.5	100	96.5	97	97.5
Weedy check	-	0	0	0	0	0	0
LSD (0.05)		3.6	4.1	3.4	4	5.4	4.3

Redroot pigweed and common lambsquarters were rapidly affected by several POST herbicide treatments (Table 2). Bromoxynil at 0.38 lb/A, imazethapyr plus bromoxynil at 0.063 + 0.38 lb/A applied with both SOL 32 at 2% v/v and nonionic adjuvant at 0.43% v/v, bromoxynil plus fluazifop at 0.38 + 0.188 lb/A, bromoxynil plus clethodim at 0.38 + 0.094 lb/A and 0.38 + 0.125 lb/A, bromoxynil plus quizalofop at 0.38 + 1 lb/A, AC 299,263 plus bromoxynil at 0.047 + 0.38 lb/A and bentazon at 1 lb/A controlled 95% or better of the broadleaf weeds within 2 days after treatment (DAT). No treatment provided rapid control of barnyardgrass at 2 DAT, but all treatments except bromoxynil at 0.38 lb/A, 2,4-DB at 1 lb/A and bentazon at 1 lb/A gave 91% or better annual grass control 46 DAT. Imazethapyr alone and in combination with other herbicides showed improved control of all weed species at the later date of evaluation. Imazethapyr plus bromoxynil plus SOL 32 at 0.063 + 0.38 lb/A + 2% v/v, imazethapyr plus sethoxydim plus COC at 0.063 + 0.044 + 1% v/v, imazethapyr plus clethodim plus COC at 0.063 + 0.125 + 1% v/v and AC 299,263 plus bromoxynil plus SOL 32 at 0.047 + 0.38 + 2% v/v eliminated all annual weeds 46 DAT.

Weeds did germinate and grow in plots as the residual PPI herbicide dissipated in the soil. At the time of the first cutting (110 DAT), the weedy check plots averaged 1.02 T/A weed biomass which was significantly greater than any herbicide treated plots (Table 3). EPTC plus trifluralin at 2 + 1 lb/A, EPTC plus benefin at 2 + 1.2 lb/A, EPTC plus ethalfluralin 2 + 1 lb/A and ethalfluralin plus dimethenamid at 1 + 1 lb/A had significantly less weed biomass than EPTC at 2 lb/A at the first cutting (110 DAT). Removal of annual weed biomass at the first cutting, coupled with crop competition during the remainder of the growing season, resulted in complete elimination of weeds in the alfalfa forage of all the treated plots at the second cutting except in the EPTC at 2 lb/A. No differences in first cutting alfalfa production occurred as a result of PPI herbicide treatments. However, substantial improvement in hay quality was achieved with all herbicide treatments at the first cutting date (110 DAT) and all treatments except EPTC at 2 lb/A at the second cutting date (180 DAT).

Table 2. Efficacy of postemergence herbicide treatments for establishment of forage alfalfa.

		Weed control					
		Redroot pigweed		Common lambsquarters		Barnyardgrass	
Treatment	Rate	2 DAT	46 DAT	2 DAT	46 DAT	2 DAT	46 DAT
	- lb/A -	%					
Imazethapyr[a,d]	0.063	28.8	95.8	28.8	96.5	0	91.3
Imazethapyr[a,d]	0.094	45	100	45	100	0	95.8
Bromoxynil[d]	0.38	95	92.5	95.8	95.8	12.5	0
2,4-DB[d]	1	20	88.8	20	88.8	0	0
Imazethapyr[a,d] + bromoxynil[a,d]	0.063 + 0.38	98	100	98.3	100	45	100
Imazethapyr[a,d] + 2,4-DB[a,d]	0.063 + 1	30	100	28.8	100	0	96.5
Imazethapyr[a,b,d] + sethoxydim[a,b,d]	0.063 + 0.044	40	100	40	100	10	100
Imazethapyr[a,c,d] + bromoxynil[a,c,d]	0.063 + 0.38	98	100	98.3	100	28.8	96.5
Imazethapyr[a,c,d]	0.063	50	100	47.5	100	7.5	96.5
Bromoxynil[d] + fluazifop[b,e]	0.38 + 0.188	96.5	95.8	95.8	99.5	42.5	95.8
Bromoxynil[d] + clethodim[b,e]	0.38 + 0.094	97.3	95	98	100	37.5	99.5
Bromoxynil[d] + clethodim[b,e]	0.38 + 0.125	95	95.8	96.3	99.5	65	97.3
Bromoxynil[d] + quizalofop[b,e]	0.38 + 1	97.3	95.8	95.8	95.8	30	98.8
Imazethapyr[d] + clethodim[a,b,e]	0.063 + 0.125	38.8	100	41.3	100	12.5	100
AC 299,263[a,d] + bromoxynil[a,d]	0.047 + 0.38	98	100	98.5	100	37.5	100
AC 299,263[a,b,d] + clethodim[a,b,d]	0.047 + 0.125	52.5	99.5	47.5	99.5	7.5	100
Bentazon[d]	1	98	91.3	99.5	95.8	0	0
Weedy check		0	0	0	0	0	0
LSD (0.05)		3.8	1.7	4.2	1.3	4.6	1.9

[a]SOL 32 (32% nitrogen solution) added at 2% v/v.
[b]Crop oil concentrate added at 1% v/v.
[c]Nu-film-P nonionic adjuvant added at 0.4% v/v.
[d]Applied on May 30, 1997.
[e]Applied on June 2, 1997.

Table 3. Effect of preplant incorporated herbicide treatments on crop injury, alfalfa yield and weed biomass in forage alfalfa establishment.

		Weeds		Alfalfa			
		Biomass		Yield		Injury	
Treatment	Rate	110 DAT	180 DAT	110 DAT	180 DAT	44 DAT	88 DAT
	- lb/A -	T/A				%	
EPTC	2	0.7	0.04	2.43	1.9	0	0
EPTC + trifluralin	2 + 1	0.46	0.00	2.57	1.4	57.5	0
EPTC + benefin	2 + 1.2	0.33	0.00	2.65	1.7	13.8	0
EPTC + ethalfluralin	2 + 1	0.31	0.00	2.68	1.5	37.5	0
EPTC + dimethenamid	2 + 1	0.5	0.00	2.54	1.6	80	0
Ethalfluralin + dimethenamid	1 + 1	0.42	0.00	2.16	1.3	85	0
Weedy check	-	1.43	0.04	2.32	2	0	0
LSD (0.05)		0.25	NS	NS	0.59	7.8	NS

Imazethapyr at 0.063 and 0.094 lb/A and 2.4-DB at 1 lb/A were the only POST herbicide treatments that did not cause significant phytotoxicity to alfalfa seedlings 2 DAT (Table 4). Air temperatures exceeded 80° F the day after herbicide applications that accounts for the excessive initial alfalfa leaf burn and stunting observed in plots receiving bromoxynil alone and in combination with other herbicides. Significant stunting was visible in plots treated with bromoxynil in combination with fluazifop, clethodim, quizalofop and AC 299,263 and AC 299,263 plus clethodim plus COC at 0.047 + 0.125 + 1% v/v 46 DAT, but no leaf burn or chlorosis was observed.

Table 4. Effect of postemergence herbicide treatments on crop injury, alfalfa yield, and weed biomass in forage alfalfa establishment.

		Weeds		Alfalfa			
		Yield				Injury	
Treatment	Rate	68 DAT	138 DAT	68 DAT	138 DAT	2 DAT	46 DAT
	– lb/A –	T/A				%	
Imazethapyr[a,d]	0.063	0.6	0	2.48	1.69	0	0
Imazethapyr[a,d]	0.094	0.61	0.01	2.6	1.72	0	0
Bromoxynil[d]	0.38	1.07	0.02	2.26	1.73	30	0
2,4-DB[d]	1	1	0.01	2.09	1.7	0	0
Imazethapyr[a,d] + bromoxynil[a,d]	0.063 + 0.38	0.47	0	2.74	1.46	30	0
Imazethapyr[a,d] + 2,4-DB[a,d]	0.063 + 1	0.57	0	2.95	1.57	3.8	0
Imazethapyr[a,b,d] + sethoxydim[a,b,d]	0.063 + 0.044	0.32	0	2.98	1.44	3.8	0
Imazethapyr[a,c,d] + bromoxynil[a,c,d]	0.063 + 0.38	0.36	0	2.23	1.14	31.3	0
Imazethapyr[a,c,d]	0.063	0.61	0.01	2.51	1.84	3.8	0
Bromoxynil[d] + fluazifop[b,e]	0.38 + 0.188	0.37	0.01	2.7	1.62	30	5
Bromoxynil[d] + clethodim[b,e]	0.38 + 0.094	0.43	0.03	2.29	1.16	30	5
Bromoxynil[d] + clethodim[b,e]	0.38 + 0.125	0.33	0	2.66	1.74	30	5.5
Bromoxynil[d] + quizalofop[b,e]	0.38 + 1	0.37	0	2.56	1.38	30	9.3
Imazethapyr[d] + clethodim[a,b,e]	0.063 + 0.125	0.33	0	2.62	1.88	2.5	10
AC 299,263[a,d] + bromoxynil[a,d]	0.047 + 0.38	0.99	0	2.85	1.5	30	9.3
AC 299,263[a,b,d] + clethodim[a,b,d]	0.047 + 0.125	1.12	0.02	2.5	1.55	10	10.5
Bentazon[d]	1	1.28	0.02	2.07	1.6	17.5	0
Weedy check	-	1.43	0.04	2.32	2	0	0
LSD (0.05)		0.6	0.03	0.6	0.54	2.5	1.3

[a]SOL 32 (32% nitrogen solution) added at 2% v/v.
[b]Crop oil concentrate added at 1% v/v.
[c]Nu-film-P nonionic adjuvant added at 0.4% v/v.
[d]Applied on May 30, 1997.
[e]Applied on June 2, 1997.

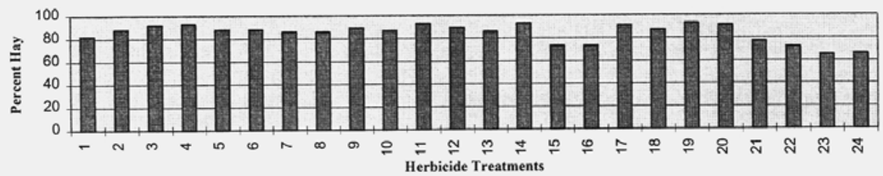
Imazethapyr plus 2,4-DB plus SOL 32 at 0.063 + 1 lb/A + 2% v/v and imazethapyr plus sethoxydim plus COC at 0.063 + 0.044 lb/A + 1% v/v treated plots produced significantly higher alfalfa yields than the weedy check at the first cutting 68 DAT. The weedy check plot produced significantly higher alfalfa yields than imazethapyr plus bromoxynil plus nonionic adjuvant at 0.063 + 0.38 lb/A + 0.4% v/v and bromoxynil plus clethodim plus COC at 0.38 + 0.094 lb/A + 1% v/v treated plots at the second cutting. Reduced alfalfa yields cannot, however, be attributed to herbicide phytotoxicity. Barnyardgrass was the predominant weed species infesting the study area at the second harvest date. All plots treated with herbicides except bromoxynil at 0.38 lb/A, bromoxynil plus clethodim plus COC at 0.38 + 0.094 lb/A + 1% v/v, AC 299,263 plus clethodim plus COC at 0.047 + 0.125 lb/A + 1% v/v and bentazon at 1 lb/A produced significantly less weed biomass than the weedy check plots at the second cutting.

Comparisons of hay to weed ratios from the PPI and POST treated plots indicates that seven herbicide treatments provided sufficient weed control for the total forage to contain 92% or less weed biomass (Figure 1). The nontreated weedy plots produced forage containing 65% alfalfa and 35% weed biomass.

CONCLUSIONS

Although significant initial injury was observed with all PPI treatment except EPTC at 2 lb/A, the alfalfa plants recovered so no visible damage was present at the first harvest date. POST treatments containing bromoxynil caused significant initial phytotoxicity to the alfalfa seedling because of high temperatures after application. The alfalfa seedlings did recover and only imazethapyr plus bromoxynil plus SOL 32 plus NIS at 0.063 + 0.38 lb/A + 2% + 0.4% v/v treated plots yielded significantly lower alfalfa biomass than the nontreated plots. A combination of effective initial herbicidal weed control and mechanical harvesting provided season-long control of annual weeds during the establishment year. In comparing weed control tactics, both PPI and POST herbicide treatments can provide adequate weed kill to significantly enhance the quality of hay during the establishment year. Premiums received for high quality hay can offset the cost of herbicides and increase economic returns to the grower (Larsen 1998).

Ratio of hay to weed biomass in percent for both PPI and POST treatments.



1. EPTC 2.0
2. EPTC + trifluralin 2 + 1
3. EPTC + benefin 2 + 1.2
4. EPTC + ethalfluralin 2 + 1
5. EPTC + dimethenamid 2 + 1
6. Ethalfluralin + dimethenamid 1 + 1
7. Imazethapyr 0.063
8. Imazethapyr 0.094
9. Imazethapyr + bromoxynil 0.063 + 0.38
10. Imazethapyr + 2,4-DB 0.036 +1.0
11. Imazethapyr + sethoxydim 0.063 + 0.044
12. Imazethapyr + bromoxynil 0.063 + 0.38*
13. Imazethapyr 0.063*
14. Imazethapyr + clethodim 0.063 + 0.125
15. Bromoxynil 0.38
16. 2,4-DB 1
17. Bromoxynil + fluazifop 0.38 + 0.188
18. Bromoxynil + clethodim 0.38 + 0.094
19. Bromoxynil + clethodim 0.38 + 0.125
20. Bromoxynil + quizalofop 0.38 + 1
21. Bromoxynil + AC 299,263 0.38 + 0.047
22. AC 299,263 + clethodim 0.047 + 0.125
23. Bentazon 1
24. Weedy check

*Indicates addition of Nu-film-P nonionic adjuvant at 0.4% v/v.

Figure 1. Percent alfalfa hay to weed biomass from herbicide treated plots.

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PUNA GRASS *(Stipa brachyaeta* GODR.) BIOLOGY AND CONTROL IN ESTABLISHED ALFALFA.

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Abstract. In August 1996, Puna grass was identified from a sample collected in an alfalfa field at Tracy, California. This perennial bunch grass is native to South America and classified as an "A" rated pest in California. This is the only known area where Puna grass infests a commercial agriculture commodity, making it subject to eradication and quarantine measures.

Puna grass germinates under field conditions from November through May. Panicle flowers emerged in April with mature seed development by July. Only those plants which were not harvested during the alfalfa cutting cycle had enough time to form flowers. Puna grass also has self fertilizing flowers located at the basal part of the plant called cleistogamous flowers. These cleistogamous flowers began blooming in June and continued through November.

Post emergence treatments of herbicides were compared at two application timings. Clethodim or sethoxydim applied two times, November and repeated in March, achieved 97 and 96% control, respectively. Spot treatments of glyphosate at 2% by volume provided 100% control of existing plants at all growth stages. There was no crop injury for all treatments except glyphosate which killed the alfalfa around the spot treatment areas.

WEED CONTROL IN ALFALFA WITH AC 299,263. Roger M. Hybner and Stephen D. Miller, Superintendent Sheridan Research & Extension Center and Professor, Department of Plant Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Alfalfa is the major leguminous forage crop grown in Wyoming. Weed control is essential in alfalfa to produce high yielding, top quality hay. Weeds in alfalfa can often mean the difference between profit and loss for the grower. Field experiments were conducted at six locations in Wyoming during 1996 and 1997 to evaluate factors influencing weed control and crop tolerance to AC 299,263 in seedling and established alfalfa. AC 299,263 applied at 0.032 lb/A provided better control of common lambsquarters, downy brome and sandbur than imazethapyr. However, control of redroot pigweed, kochia, nightshade, wild buckwheat and mustard was similar. Additives influenced both alfalfa tolerance and weed control with AC 299,263.

FIELD BINDWEED CONTROL WITH REPEATED HERBICIDE TREATMENT. Randall S. Currie and Phillip W. Stahlman, Associate Professor, Southwest Research-Extension Center, Kansas State University, Garden City, KS 67846 and Professor, Agricultural Research Center-Hays, Kansas State University, Hays, KS 67601.

Abstract. No single herbicide treatment provides long-term control of field bindweed. Experiments were initiated near Hays and Garden City, KS in 1994 and near Hays in 1995 to evaluate repeated herbicide applications for field bindweed control in a winter wheat-grain sorghum-fallow cropping system. Herbicides were applied postemergence in the fall following wheat harvest, the following spring or summer either preplant or postemergence in grain sorghum, and again that fall after sorghum harvest, 11 to 12 months after the first application. Plots were tilled between applications and after final herbicide treatment as needed. Herbicides treatments each time were: quinclorac plus 2,4-D amine at 0.28 + 1.1 kg/ha, glyphosate plus 2,4-D isopropylamine at 0.65 + 1.1 kg/ha, dicamba plus 2,4-D LVE at 0.56 + 1.1 kg/ha, picloram plus 2,4-D LVE at 0.28 + 1.1 kg/ha, 2,4-D LVE at 1.1 kg/ha, and quinclorac plus 2,4-D amine at 0.28 + 1.1 kg/ha for the first application followed by quinclorac plus 2,4-D amine at 0.14 + 0.56 kg/ha for the second and third applications. The control treatment consisted of tillage as needed. Most herbicide treatments controlled field bindweed topgrowth by 85 to 100% in early summer following the first fall application; the glyphosate plus 2,4-D and the half-rate sequential quinclorac plus 2,4-D treatments at Garden City were slightly less effective. Two years after the final herbicide application, the picloram plus 2,4-D treatment provided 95% control at one of two locations measured, compared with 60% or less control for other treatments. Three years after the final treatment at two locations, the quinclorac plus 2,4-D, picloram plus 2,4-D, and dicamba plus 2,4-D treatments provided better than 85% field bindweed control. Moderate-level or better herbicidal control resulted in higher grain sorghum yields compared with the tilled control.

EVALUATION OF HERBICIDES FOR FIELD BINDWEED CONTROL. Johnny R. Roberts, Jason P. Kelley, and Thomas F. Peeper, Graduate Research Assistant, Senior Agriculturalist, and Professor, Department of Plant and Soil Sciences, Oklahoma State University, Stillwater, OK 74078.

Abstract. Field research is being conducted at two locations in north central Oklahoma to evaluate herbicide programs for field bindweed control on hard red winter wheat fields. Quinclorac plus 2,4-D (Paramount) was applied sequentially in 1995, 1996, and 1997. Glyphosate plus 2,4-D (Landmaster BW) and dicamba plus 2,4-DLV were also applied sequentially each fall. Glyphosate was applied in the fall of 1995 as a standard. Postharvest (June to July) control programs included picloram plus 2,4-DLV, and quinclorac plus 2,4-D. One program included dicamba applied in June 1996, followed by a sequential application of dicamba in July 1997. Control varied with location and was less than desired. Postharvest applied quinclorac plus 2,4-D was ineffective, while fall applications look promising.

Table. Field bindweed control.

Herbicide program/yr 1 + yr 2	Rates	Application dates	Control in September 1997 Lahoma	Stillwater
	oz/A		%	
Quinclorac + 2,4-D[a] + COC	5+15	Sept. 1995		
Quinclorac + 2,4-D + COC	2.5+7.5	Sept. 1996	83	70
Quinclorac + 2,4-D + COC	5+15	Sept. 1995		
Quinclorac + 2,4-D + COC	5+15	Sept. 1996	81	73
Quinclorac + 2,4-D + COC	5+15	June 1996		
Quinclorac + 2,4-D + COC	5+15	July 1997	23	-
Picloram + 2,4-DLV	4+16	June 1996		
Picloram + 2,4-DLV	4+16	July 1997	59	0
Glyphosate + 2,4-D[b] + AMS	7.84+13.12	Sept. 1995		
Glyphosate + 2,4-D + AMS	7.84+13.12	Sept. 1996	68	45
Dicamba	32	June 1996		
Dicamba	16	July 1997	53	20
Dicamba + 2,4-DLV	8+16	Sept. 1995		
Dicamba + 2,4-DLV	8+16	Sept. 1996	88	55
Glyphosate	72	Sept. 1995	60	20
Glyphosate				
No herbicide			0	0
LSD (0.05)			18	15

[a]Paramount.
[b]Landmaster BW.

1997 EUP RESULTS FOR BAY FOE 5043 PLUS METRIBUZIN IN CORN AND SOYBEANS. J. R. Bloomberg, R. H. Ackerman, L. R. Cobia, and H. Lin, Bayer Corporation, Kansas City, MO 64120.

Abstract. BAY FOE 5043 plus metribuzin premix formulation (4:1 ratio, 68 DF) is a new soil-applied graminicide under development by Bayer Corporation for the corn and soybean markets in the United States. The major activity of BAY FOE 5043 plus metribuzin is on annual grasses and small-seeded dicot weeds. Proposed usage rates range from 0.55 to 1.1 lb/A. During 1997, the product was evaluated in nonreplicated, crop destruct experimental use permit (EUP) trials in the corn and soybean producing areas of the United States. BAY FOE 5043 plus metribuzin treatments were compared directly to grower standard treatments.

Efficacy and crop tolerance results of BAY FOE 5043 plus metribuzin from trials in the western United States indicated good to excellent control of annual grasses and certain dicot weeds, including barnyardgrass, giant foxtail and pigweed species. No corn phytotoxicity was observed. Performance of BAY FOE 5043 plus metribuzin was equal to the standards for annual grass control but was superior for dicot weed control. These results from the western United States are similar to those observed in other trials across the country. Besides the weeds already mentioned as controlled by BAY FOE 5043 plus metribuzin, several additional important weeds which are well controlled include green foxtail, yellow foxtail, large crabgrass and common lambsquarters. Registration of BAY FOE 5043 plus metribuzin for the corn and soybean markets is expected in early 1998.

EFFECT OF POLYACRYLAMIDE (PAM) ON WEED CONTROL AND WEED SEED LOSS IN FURROW-IRRIGATED CORN. Don W. Morishita[1], Robert E. Sojka[2], Robert W. Downard[1], and J. Foerster[2], Assoc. Professor, Soil Scientist, Support Scientist, and Technician, [1]Department of Plant, Soil, and Entomological Sciences, University of Idaho, Twin Falls, ID 83303 and [2]USDA-ARS, Northwest Irrigation and Soils Research Lab, Kimberly, ID 83341.

Abstract. Surface irrigation accounts for >60% of Earth's 600 million irrigated acres. Erosion seriously threatens irrigated agriculture's ability to sustain yield and economic advantages over rainfed agriculture. In addition to soil loss from furrow irrigation, weed seed often moves from one field to another, which can exacerbate weed management problems within or between farms. Previous research at the USDA-ARS Northwest Irrigation and Soils Research Laboratory in south central Idaho has shown that furrow irrigation-induced erosion is nearly eliminated by the addition of water-soluble PAM to irrigation water. PAM is an environmentally safe industrial flocculent widely used in municipal water treatment, paper manufacturing, food processing and other applications. In cultivated furrows, PAM is applied at a rate of 1 lb/A by either metering into the irrigation inflow at 10 ppm or simply placed on the soil surface in its dry crystalline form where water from gated irrigation pipe is released into the furrow. If mixed into irrigation inflow, PAM is added during water advance only, i.e. until the water reaches the end of the furrow at the bottom of the field. A field study was conducted at the USDA-ARS Northwest Irrigation and Soils Research Laboratory in 1997 to compare the effect of PAM-treated irrigation water on weed control with two soil-applied herbicides and to determine the effect of PAM on weed seed movement off a field. Experimental design was a split plot randomized complete block with three replications. Three herbicide treatments were the main plots and three PAM treatments were the sub-plots. Each sub-plot was two rows wide by 546 feet. Metolachlor, EPTC plus safener, and a control were the herbicide treatments. The herbicides were applied preplant and incorporated into the soil. The PAM treatments consisted of the Natural Resource Conservation Service standard application method (NRCSstd), a Patch method, and an untreated control. The NRCSstd method was metering PAM into the irrigation water at a rate to obtain a concentration of 10 ppm. The Patch method was simply placing 50 grams of PAM on the soil surface just below the opening of gated pipe. The corn was irrigated four times and the PAM treatments applied with each irrigation. Weed control was evaluated June 20, which was 20 days after the first irrigation. Weed species density also was counted three different times within the furrow of each treatment. Weed seed were collected from water samples taken at water advance, 1 hour later, and 3 hours later. No differences in weed control were observed between herbicides for any of the weed species. Weed density usually did not differ among herbicide treatments. Where differences were observed, no logical trend could be attributed to any particular treatment. Differences in weed seed moving from the field were observed among the PAM treatments. Herbicide treatment had little or no effect on weed seed movement. Where no PAM was applied, weed seed loss was greater than when PAM was applied. Weed seed loss when the water advanced was usually not different among PAM treatments. The only exception was at the third irrigation where weed seed loss at advance was reduced 80% where PAM was used compared to no PAM used. Weed seed loss 1 hour after advance also was reduced 80% compared to no PAM used, and weed seed loss 3 hours after advance was reduced 56% compared to no PAM used. The reduction in soil erosion from furrow irrigation has shown that PAM can be an important soil management tool. This study shows that PAM may also be an important weed management tool as well.

INFLUENCE OF SEEDING RATE AND SEEDING DATE OF ANNUAL MEDICS ON IRRIGATED GRAIN AND FORAGE CORN. C. M. Alford, J. M. Krall, S. D. Miller, and D. E. Legg, Graduate Student, Professor, Professor, Department of Plant Sciences, and Associate Professor, Department of Natural Resources, University of Wyoming, Laramie, WY 82071.

Abstract. Farmers in the Great Plains have shown an interest in inter-cropping corn with annual legumes. Advantages of farming systems, which contain an annual legume, include reduced soil erosion, improved soil fertility and improved forage quality. We reported in previous studies that several medic species fit well in this inter-cropping system with corn. No information is available on seeding rates or seeding dates for inter-cropping annual medics with corn. Two studies were conducted at Torrington WY, under sprinkler irrigation, one study was

designed to measure grain yield and medic production in full season corn, the second study was designed to measure silage yield and medic production following early corn removal. Plots were 3.05 by 6.1 m with four replications. Main plots were medic seeding dates (2 weeks before, at, and 2 weeks after corn planting) and subplots a factorial arrangement of medic species (*Medicago lupulina* and *Medicago sphacrocarpus*), medic seeding rate (86, 172, and 344 plants/m^2) and herbicide input level (low = imazethpyr plus pendimethalin and high = imazethpyr plus pendimethalin plus bentazon). Corn forage yields were not influenced by any treatment. There were; however, significant differences between medic species, medic seeding rate, and herbicide input level on grain yield. Corn grown with *Medicago lupulina* yielded 6% better than *Medicago sphacrocarpus*. Corn yields were 16 and 13% higher when the medics were seeded with or 2 weeks after corn than when seeded 2 weeks before corn. The high herbicide input level increased grain yield 9%, compared to the low input level.

WEED CONTROL IN GLUFOSINATE AND GLYPHOSATE RESISTANT CORN. Stephen D. Miller and Abdel Mesbah, Professor and Post Doctoral Research Associate, Department of Plant Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. The introduction of glufosinate or glyphosate resistant genes into corn has made direct applications of these herbicides to actively growing plants possible. Although both herbicides control a broadspectrum of weeds, the herbicides have very little herbicidal activity in soil. This lack of soil activity may mean that weed control may not be acceptable with a single application. Therefore, field trials were conducted under sprinkler irrigation at the Research and Extension Center, Torrington, WY to compare weed control with single or multiple applications of these herbicides and to evaluate weed control with complementary pre/postemergence or postemergence mixtures of glufosinate or glyphosate with atrazine, acetochlor, metolachlor and dimethenamid. Weed control was better with multiple compared to single applications of glufosinate or glyphosate. Further complementary pre/postemergence or postemergence applications of these herbicides with acetochlor, atrazine, dimethenamid or metolachlor provided excellent broadspectrum weed control with excellent crop safety. Corn yields with the various herbicide treatments were 30 to 70 bu/A higher than in the weedy check and were closely related to weed control.

POTENTIAL CARRYOVER OF PYRITHIOBAC IN TWO NEW MEXICO SOILS. Martina W. Murray and Jill Schroeder, Graduate Research Assistant and Associate Professor, Entomology, Plant Pathology and Weed Science Department, New Mexico State University, Las Cruces, NM 88003.

Abstract. Pyrithiobac herbicide, an acetolactate synthase (ALS) inhibitor, is registered for postemergence over-the-top (POT) application on cotton for broadleaf weed control. Most crops are sensitive to pyrithiobac, but little is known of potential injury to rotational crops from carryover. The study objective was to determine if pyrithiobac injures rotational crops the year following application. This study was conducted at Artesia and Las Cruces, NM. The Artesia soil was Rakor loam (pH 7.6, 1.3% O.M., 36% sand, 38% silt, 26% clay) and the Las Cruces soil was Belen clay loam (pH 7.7, 1.2% O.M., 46% sand, 19% silt, 35% clay). Cotton was planted in both locations in 1996. Pyrithiobac was applied to each plot in one of four possible treatments: 0.07 or 0.14 kg/ha applied either 4 weeks (POTE) or 7 to 8 weeks (POTL) after planting. In 1996, six crops were planted in each plot, including lettuce, onion, chile, alfalfa, sorghum, and sorghum sudangrass hybrid. There was no injury nor significant yield reduction detected in any of the crops at either location. The number of onions was reduced at the Artesia site in plots treated with 0.14 kg/ha or treated POTL, though total weight was not affected. Soil samples taken from each plot in Las Cruces in September, 1996, and at both locations in February, March, and June of 1997 were bioassayed to estimated pyrithiobac concentrations. The study data suggests that pyrithiobac may be safely used in a rotational system with many crops.

EFFECT OF ROW SPACING AND SEEDING RATE ON WEED COMPETITION IN PINTO BEANS.

Abdel O. Mesbah, Stephen D. Miller,and Paul H. Koetz, Postdoctoral Research Associate, Professor, and Graduate Research Assistant, Department of Plant Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Pinto beans account for approximately 80% of the dry bean production in Wyoming. Weed competition is considered one of the major obstacles preventing the achievement of maximum yield. Weeds compete vigorously with dry beans and yield reductions exceeding 70% have been recorded. Field experiments were conducted in 1994 and 1995 under sprinkler irrigation at the Research and Extension Center, Torrington, Wyoming to determine the effect of two row spacings (22 and 30 inches) and three seeding rates (60000, 90000 and 120000 seed/A) on sunflower and green foxtail competitiveness with pinto beans. Sunflower and green foxtail densities were 3 and 9 plants/m of row, respectively. Row spacing did not show any significant effect on pinto bean yield. Similarly, sunflower and green foxtail weights were not significantly affected by row spacing. However, seeding rate had a significant effect on pinto bean, green foxtail and sunflower. Pinto bean yield increased as seeding rate increased, while sunflower and green foxtail biomass production decreased. Seeding rate and row spacing did not show any significant effect on weed competition. Sunflower was more competitive with pinto beans than green foxtail. Pinto bean yield reductions from the mixed densities were less than additive. Bean yield decreased as the duration of competition increased. Yield reduction by foxtail competition was significant at 10 weeks; while, with sunflower and foxtail plus sunflower, the significance was shown at 6 weeks. Pinto bean weekly losses from foxtail and sunflower were estimated to be around 60 and 140 lb/week, respectively.

EFFICACY OF SULFOSATE, GLYPHOSATE, AND CLETHODIM IN SPRING CHEMICAL FALLOW.

Robert N. Klein, Jeffrey A. Golus, and Rex Wichert, Professor, and Extension Research Technologist, University of Nebraska West Central Research and Extension Center, North Platte, NE 69101 and Zeneca Field Development Representative, Lincoln, NE 68516.

Abstract. A study was conducted to evaluate downy brome control in spring chemical fallow with sulfosate, glyphosate, and clethodim. Various combinations of herbicide and additives were applied. Plots were established in a randomized complete block design with four replications. Treatments were applied on April 17 to winter wheat stubble. Application was made using a tractor mounted sprayer. Sprayer consisted of a 15 foot shielded boom (six 11004XR nozzles on 30 inch spacing). Carrier volume was 10 gpa, nozzle pressure was 20 psi, and speed was 5.5 mph. Nonionic surfactant was applied at 0.25% v/v, ammonium sulfate at 136 oz/100 gal, crop oil concentrate at 1 qt/A, and 28% N at 2 qt/A. Downy brome growth was 1 to 3 inches tall. Visual evaluations as percent control of downy brome were made May 11 and May 28.

The addition of NIS, AMS, and NIS plus AMS to sulfosate increased control of downy brome significantly on the May 28 ratings at the 0.25 and 0.375 lb/A rates of sulfosate, but not at 0.5 lb/A (Table). Adding dicamba plus NIS plus AMS or 2,4-D amine plus AMS to sulfosinate did not significantly increase control over sulfosate with the same additives on May 28. The addition of dicamba to glyphosate significantly reduced control of downy brome on May 28 at 0.25lb/A glyphosate, but not the higher rates. The addition of 2,4-D amine to any rate of glyphosate did not significantly affect control.

Table. Efficacy of sulfosphate, glyphosate, and clethodim on downy brome.

	Rate	Downy brome control May 11	May 28
	lb/A	%	
Sulfosate	0.25	53	59
Sulfosate	0.375	70	78
Sulfosate	0.5	89	96
Sulfosate + NIS	0.25	73	76
Sulfosate + NIS	0.375	88	95
Sulfosate + NIS	0.5	94	97
Sulfosate + AMS	0.25	76	85
Sulfosate + AMS	0.375	88	96
Sulfosate + AMS	0.5	91	98
Sulfosate + NIS + AMS	0.25	87	93
Sulfosate + NIS + AMS	0.375	94	97
Sulfosate + NIS + AMS	0.5	98	99
Sulfosate + dicamba + NIS + AMS	0.25 + 0.125	87	93
Sulfosate + dicamba + NIS + AMS	0.375 + 0.125	93	99
Sulfosate + dicamba + NIS + AMS	0.5 +0.125	96	100
Glyphosate[a] + AMS	0.25	89	96
Glyphosate[a] + AMS	0.375	95	100
Glyphosate[a] + AMS	0.5	98	100
Glyphosate[a] + dicamba + AMS	0.25 + 0.125	82	89
Glyphosate[a] + dicamba + AMS	0.375 + 0.125	92	97
Glyphosate[a] + dicamba + AMS	0.5 +0.125	98	100
Sulfosate + 2,4-D amine + AMS	0.25 + 0.5	81	90
Sulfosate + 2,4-D amine + AMS	0.375 + 0.5	92	99
Sulfosate + 2,4-D amine + AMS	0.5 + 0.5	96	100
Glyphosate[a] + 2,4-D amine + AMS	0.25 + 0.5	82	91
Glyphosate[a] + 2,4-D amine + AMS	0.375 + 0.5	92	97
Glyphosate[a] + 2,4-D amine + AMS	0.5 + 0.5	97	100
Clethodim+ COC + 28% N	0.0625	41	49
Clethodim+ COC + 28% N	0.0938	50	63
Clethodim+ COC + 28% N	0.125	55	69
LSD (0.05)		5.8	7.0

[a]Glyphosate is Roundup Ultra.

EFFECTS OF IMAZETHAPYR AND PENDIMETHALIN ON LENTIL. Bradley D. Hanson and Donald C. Thill, Graduate Research Assistant and Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83844-2339.

Abstract. In the Palouse region of Idaho and Washington, pea and lentil are two important crops grown in rotation with winter wheat. Imazethapyr plus pendimethalin was registered recently by the EPA for weed control in lentil and pea. Area growers are concerned about the effects these herbicides have on lentil seed yield, and on growth and grain yield of the subsequently planted winter wheat crop. The herbicide effects of 16 treatment combinations (0, 0.5X, 1X, and 2X) of imazethapyr and pendimethalin were measured in lentil crops grown under weed-free conditions at two locations in 1997. Herbicide treatments containing pendimethalin at 2.24 kg/ha (2X dose) visibly injured lentil. However, herbicide treatments did not affect lentil biomass or seed yield when compared to no herbicide treatment. The effects of nine imazethapyr and pendimethalin combinations (0, 1X, and 2X) applied to pea or lentil on winter wheat growth and yield are being measured during the 1997 to 1998 growing season. In the 1997 establishment year, seed yield of the pea and lentil crops were not affected by herbicide treatment even though lentil injury was observed in treatments containing 2.24 kg/ha pendimethalin. Overall, imazethapyr, pendimethalin,

or combinations of these two herbicides did not adversely affect seed yield of lentil or pea. The weed-free study will be repeated in 1998 and a greenhouse bioassay experiment has been initiated to study the effects of different soil moisture levels on the degradation of imazethapyr and pendimethalin.

RESPONSE OF GRAIN SORGHUM TO RESIDUAL MON 37503. K. Todd Heap, Jason P. Kelley, and Thomas F. Peeper, Graduate Research Assistant, Senior Agriculturalist, and Professor, Department of Plant and Soil Sciences, Oklahoma State University, Stillwater, OK 74078.

Abstract. Field experiments were conducted at eight locations across Oklahoma to determine the response of grain sorghum to residues of the sulfonylurea herbicide MON 37503. The soil pH at the sites varied from 5 at the Eastern Research Station to 7.5 at the Irrigation Research Station in southwestern Oklahoma. MON 37503 was applied at 0.5 oz/A preemergence at each location to hard red winter wheat during the fall of 1996. Postemergence treatments of the same rate were applied at 3 week intervals until mid-March. Wheat was harvested in June.

Immediately after wheat was harvested, two 30-inch wide rows of grain sorghum were planted no-till down the center of each 7 by 25 foot plot. Crop injury was visually estimated. Effects on stand, stunting, heads produced, and grain sorghum yields were determined. Crop injury and yield reductions varied from very severe to none. Soil pH was the dominant soil property controlling herbicide persistence.

WEED EMERGENCE AND CONTROL IN SUGARBEETS. Steve L. Young, Don W. Morishita, and Robert W. Downard, Research Assistant, Extension Associate Professor, and Research Support Scientist, Twin Falls Research & Extension Center, University of Idaho, Twin Falls, ID 83303-1827.

Abstract. Timing of sequential postemergence herbicide applications is extremely critical for successful weed control in sugarbeets. A narrow time frame exists in which most broadleaf weeds are susceptible to low herbicide rates. Many growers spend additional money controlling late emerging weeds. Research has shown that hand labor-free weed control can be achieved with timely herbicide applications. A study was conducted to monitor emerging weed patterns and their effect on sugarbeet yield and quality. Four different herbicide treatments were applied to sugarbeets and emerged weeds were counted prior to each application. In the untreated check, the density of common lambsquarters, redroot pigweed, and hairy nightshade peaked at 34 to 40 plants/m^2 from May 7 to May 14 and then declined. Kochia populations peaked at 28 plants/m^2 on June 3 while green foxtail density fluctuated between 46 to 64 plants/m^2 from June 3 to June 24. No additional weeds emerged after June 24. Kochia, lambsquarters, and foxtail control ranged from 91 to 98% with ethofumesate applied PRE followed by two sequential POST applications of desmedipham plus phenmedipham plus ethofumesate and triflusulfuron plus clopyralid with and without cycloate applied at lay-by. Ethofumesate applied PRE with no POST treatments controlled pigweed, nightshade, and foxtail 90 to 100%. It did not satisfactorily control kochia or lambsquarters. Sugarbeet yields did not differ significantly among those treatments, with at least one POST herbicide application. Sugarbeet yield was least in the ethofumesate alone and in the untreated control treatments compared to all other treatments. Continued monitoring of weed emergence in field trials will provide information to predict weed growth stages and allow for more timely application of herbicides.

WEED MANAGEMENT AFTER MID-SEASON SUGARBEET DEFOLIATION. K. James Fornstrom and Stephen D. Miller, Departments of Civil Engineering and Plant Sciences, University of Wyoming, University Station Box 3295, Laramie, WY 82071.

Abstract. Defoliation of sugarbeet by mid-season hail storms opens the field up for late season weed invasion. This research was conducted at the Torrington Research and Extension Center in 1995, 1996 and 1997 to develop weed management guidelines for sugarbeet fields that have been defoliated in mid-season. Sugarbeet plot areas were treated as a production field with best management practices until lay-by herbicides were applied and included: planting sugarbeet to stand, preplant incorporated herbicide, and post emergence herbicide application. Three replications were arranged in a split plot randomized complete block. Defoliation date treatments were split to include application timing and herbicide treatments. Herbicides were applied lay-by and after defoliation and included dimethenamid, EPTC and trifluralin. Weed populations were higher with early season defoliation than when sugarbeets were not defoliated. Weed control with post defoliation treatments was 8 to15% higher than with layby treatments. Dimethenamid provided the best weed control in 1995 but EPTC plus trifluralin was better than dimethenamid in 1996 and 1997. Sugarbeet returns were 20% less with mid-July and 30% less with mid-August defoliation than when sugarbeets were not defoliated.

GLYPHOSATE AND GLUFOSINATE FOR WEED CONTROL IN HERBICIDE TOLERANT SUGARBEET. Robert G. Wilson, Professor, Department of Agronomy, University of Nebraska, Scottsbluff, NE 69361.

Abstract. Experiments were initiated near Scottsbluff, NE. to evaluate the sucrose yield of glyphosate and glufosinate tolerant sugarbeet varieties and to examine the efficacy of both herbicides for selective weed control in the crop. Two sugarbeet varieties tolerant to glufosinate and one variety tolerant to glyphosate were compared to the same varieties without the herbicide tolerant gene and three approved standard varieties at two locations. Sucrose yields were similar between varieties with and without herbicide tolerance and the average of the three standard varieties.

Weed control improved when glyphosate and glufosinate were applied to sugarbeet in the 4-leaf stage compared to treatments applied when the crop was in the 2-leaf growth stage. At the earlier sugarbeet growth stage weed emergence was not complete and later emerging weeds missed herbicide treatment. Glyphosate at 0.84 kg/ha and glufosinate at 0.3 kg/ha applied when the crop was in the 4-leaf growth stage and again when the crop was in the 6-leaf growth stage controlled 99% of the weed population. There was no advantage in weed control to three sequential glyphosate or glufosinate applications compared to two sequential treatments.

Sequential treatments of glyphosate provided similar weed control and less early season crop injury than a conventional weed control program which consisted of phenmedipham plus desmedipham plus triflusulfuron methyl followed by phenmedipham plus desmedipham plus triflusulfuron methyl plus clopyralid followed by phenmedipham plus desmedipham plus sethoxydim. In a similar fashion a sequential treatment of glufosinate gave similar weed control and less early season crop injury than a conventional weed control program which consisted of phenmedipham plus desmedipham plus triflusulfuron methyl followed by phenmedipham plus desmedipham plus clopyralid.

WEED CONTROL WITH GLUFOSINATE AMMONIUM IN TRANSGENIC HERBICIDE-RESISTANT SUGARBEETS. James F. Stewart, Kevin B. Thorsness, Dean W. Maruska, and Terry W. Mayberry, Field Development Representatives, Paul G. Mayland and Kevin J. Staska, Field Research and Development Coordinator and Marketing Manager, AgrEvo USA Company, Wilmington, DE 19808.

Abstract. Weed control is a critical aspect of sugarbeet production. Researchers have shown that uncontrolled weed growth in sugarbeets results in dramatically reduced yields. Even relatively light weed infestations can reduce sugarbeet yields significantly. The present herbicide systems in sugarbeets in conjunction with cultivation and hand labor generally provide acceptable weed control. However, the application timing of these herbicides is critical and only small weeds are controlled adequately.

Glufosinate ammonium (Liberty) is a broad-spectrum postemergence herbicide that will control virtually all of the grass and broadleaf weeds in a sugarbeet field. Glufosinate ammonium will also control much larger weeds than can be controlled by the present herbicides being used in sugarbeets. Glufosinate ammonium can only be applied to transgenic herbicide-resistant (Liberty Link) sugarbeets. Non-transformed sugarbeets are killed by glufosinate ammonium.

Field studies were conducted in North Dakota, Minnesota, Idaho and Washington in 1997. Most of the weeds common to sugarbeet fields including redroot pigweed, kochia, foxtails, barnyardgrass, common lambsquarter, wild oat and volunteer cereals were present in the trials. Glufosinate ammonium was applied at rates of 0.18 to 0.36 lb/A at two growth stages (1 and 3 inch weeds) alone and in combination with ammonium sulfate (AMS) at 2 to 3 lb/A. The herbicide treatments were applied 2 to 3 times at 1 to 2 week intervals. The plots were not cultivated or hand weeded.

Glufosinate ammonium provided significantly better weed control than the standard treatment of desmedipham plus phenmedipham plus ethofumesate plus triflusulfuron plus sethoxydim at each location. Weed control with glufosinate ammonium increased steadily as the rate increased. Glufosinate ammonium at 0.18, 0.27 and 0.36 lb/A provided 81, 92 and 97% overall weed control, respectively. Glufosinate ammonium at 0.18 and 0.27 lb/A + AMS provided 90 and 96% control, respectively. Weed control was improved by beginning applications at the early (1 inch weeds) stage. However, higher rates alone and intermediate rates with AMS provided 90% weed control at the later stage (3 inch weeds). Sugarbeet yields increased as the percent weed control increased. Sugarbeet yields ranged from 1.1 T/A in the untreated plots to 19.4 T/A with glufosinate ammonium at 0.36 lb/A applied early. The standard treatment had an average yield of 9.1 T/A. Sugarbeet yields were lower at the later application timing even in treatments that had similar efficacy to an early application timing treatment. This yield loss is probably caused by a longer period of weed competition due to the later removal of weeds at the later timing. None of the glufosinate ammonium treatments caused sugarbeet injury.

Demonstration trials were also conducted in 1997 at 15 sites in the same states. Glufosinate ammonium was evaluated at 0.27 to 0.36 lb/A at two growth stages (1 and 3 inch weeds). Ammonium sulfate was not added in the demonstration trials. Glufosinate at 0.27 and 0.36 lb/A gave 92 and 96% control at the early timing and 89 and 94% control at the later timing. The standard treatments provided 78% control. These trials were not cultivated or hand weeded.

EFFECT OF APPLICATION RATE, METHOD, AND AMMONIUM SULFATE ON GLUFOSINATE EFFICACY. Robert W. Downard and Don W. Morishita, Research Support Scientist and Associate Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Twin Falls, ID 83301.

Abstract. Glufosinate is a herbicide that is minimally translocated making application rate, timing, and method important in improving or maintaining weed control. Field trials were conducted in sugarbeets to investigate application rate and timing and in fallow to more closely examine application method. These studies were conducted at the University of Idaho Research and Extension Center near Kimberly, Idaho. In sugarbeets the herbicide

treatments were band-applied as is the practice in commercial fields. Glufosinate applied at the 2-leaf growth stage compared to 4-leaf growth stage at 0.268 or 0.357 lb/A did not significantly increase kochia, common lambsquarters, redroot pigweed and volunteer wheat control. Increasing the rate from 0.268 to 0.357 lb/A increased kochia and common lambsquarters control at the 2-leaf application timing. At the 4-leaf application common lambsquarters was the only weed which resulted in significantly higher control. Redroot pigweed and volunteer wheat did not respond to a rate increase. Adding ammonium sulfate at 2 lb/A to glufosinate at 0.268 lb/A significantly increased kochia and common lambsquarters control at the 2- and 4-leaf application timing. Ammonium sulfate plus glufosinate had a similar effect on weed control as did increasing the rate.

In fallow the application methods compared were broadcast, banded with an even flat fan nozzle and banded with a twin-jet flat fan nozzle. Addition of ammonium sulfate did not increase glufosinate efficacy, which may be due to a higher rate used on the second sequential application. Application method was significant in controlling volunteer wheat and common lambsquarters. Applying glufosinate broadcast significantly improved volunteer wheat and common lambsquarters control compared to banding. Band application with a twin-jet flat fan nozzle was statistically better than a band application with even flat fan for volunteer wheat and common lambsquarters control. Broadcast application with glufosinate resulted in overall weed control ranging from 98 to 100%. Glufosinate rate, ammonium sulfate, and application method all influenced glufosinate efficacy.

FOXTAIL BARLEY MANAGEMENT IN REDUCED TILLAGE CROPPING SYSTEMS. Robert E. Blackshaw, John T. O'Donovan and K. Neil Harker, Weed Scientists, Agriculture and Agri-Food Canada, Lethbridge, Alberta T1J 4B1; Alberta Research Council, Vegreville, Alberta T0B 4L0; and Agriculture and Agri-Food Canada, Lacombe, Alberta T4l 1W1.

Abstract. Foxtail barley is a shallow-rooted perennial bunchgrass that has become a greater weed problem in conservation tillage systems. Long-term field experiments were initiated on a site naturally infested with foxtail barley to determine the combined benefits of crop rotation, row spacing, seeding rate, fertilizer placement and rate, and herbicide timing and rate on foxtail barley control and crop yield. Uncontrolled foxtail barley reduced the yield of wheat and flax by 40 to 70%. Glyphosate applied pre-seeding at 400 or 800 g/ha killed foxtail barley seedlings but only suppressed the growth of large established plants. Glyphosate applied pre-harvest or post-harvest at 800 g/ha provided 80% control of perennial plants, and when applied in three consecutive years it nearly eliminated foxtail barley. Increased seeding rates of spring wheat reduced foxtail barley biomass slightly and increased wheat yield 15 to 30%. Wheat row spacing and flax row spacing or seeding rate had no consistent effects on foxtail barley biomass or crop yield. Foxtail barley and wheat yield both responded positively to increasing rates of nitrogen fertilizer. Banded compared to broadcast nitrogen resulted in less foxtail barley biomass and greater wheat yield. At 120 kg/ha nitrogen, wheat yield was 58% greater with banded than broadcast applications. The ranking of graminicides used in flax to control foxtail barley was quizalofop > sethoxydim = clethodim > fluazifop. MON 37500 at 15 to 20 g/ha selectively controlled foxtail barley in spring wheat. A weed management program combining several methods is required to keep foxtail barley populations at low levels in reduced tillage cropping systems.

CONTROL OF HOOD CANARYGRASS WITH FENOXAPROP-P-ETHYL. Matthew H. Ehlhardt and W. Mick Canevari, AgrEvo USA, Chico, CA 95928 and University of California Cooperative Extension, Stockton, CA 95205.

Abstract. Fenoxaprop-p-ethyl plus mefenpyr-diethyl is an annual grassy weed herbicide. Hood canarygrass has developed into a problem weed in California small grains. Post-emergence herbicide control of this weed is limited to diclofop applied at the 1- to 2-leaf stage of growth. Research was conducted during 1996 and 1997 to evaluate the

efficacy of fenoxaprop-p-ethyl plus mefenpyr-diethyl at rates of 0.067, 0.089 and 0.112 lb/A when applied to the 1- to 4-leaf and 6- to 7-leaf stage of weed development. All treatments were applied using a CO_2 backpack sprayer and replicated three times. Weed control and crop phytotoxicity ratings as percent control were recorded at 14 and 28 days after treatment and prior to harvest. Results at the pre-harvest assessment, averaged across three locations, had control ratings of 95.9, 98.5, and 100%, respectively for the three rates at the early timing and 84.4, 85, and 100%, respectively, at the latter timing. At 14 days after treatment crop phytotoxicity ratings had early damaged expressed as chlorosis ranging from 6.7 to 8.3% with the early timing and 10.1 to 11.8 % with the late timing. No crop symptoms were evident by the pre-harvest evaluation. Yield data did show an increase response in removing the species early with yield increases ranging from 4.6 to 23.7% with the early applications when compared to the same rates applied at the latter timing.

THREE YEARS EVALUATION OF TRALKOXYDIM FOR PROBLEM GRASS CONTROL IN MONTANA AND NORTH DAKOTA SMALL GRAINS. Jim T. Daniel, J. Jessen, T. D'Amato, and J. Hackett, Zeneca Ag. Products, Northern Regional Technical Center, Champaign, IL 61821.

Abstract. Tralkoxydim has been evaluated for control of wild oat, Persian darnel, green foxtail, and yellow foxtail for several years. Data presented was from many trials conducted in Montana and North Dakota for the past 3 seasons. Experiments included effects of rates, timings, tankmix combinations, additives (especially ammonium sulfate), and rainfastness. Tralkoxydim at 0.18 to 0.25 lb/A gave control of each species at a relatively large growth stage window of application timings. Several tankmix combinations were found. There was significant antagonism with 2,4-D ester. The addition of ammonium sulfate generally improved grass control, and often reduced antagonism. Tralkoxydim was found to be rainfast at between 2 and 3 hours after application, and will be sold by Zeneca Ag Products under the trade name ACHIEVE upon EPA approval (expected in the spring of 1998).

HERBICIDE TREATMENT OF CHEAT [*BROMUS SECALINUS* (L.)] SEEDS FOR CONTROL AT HARVEST. A. E. Solie[1], J. B. Solie[2], and T. F. Peeper[1], Undergraduate Student, Professor, and Professor, [1]Department of Plant and Soil Science, and [2]Department of Biosystems and Agriculture Engineering, Oklahoma State University, Stillwater, OK 74078.

Abstract. During wheat harvest, most cheat seed passes through grain combines, providing the opportunity to catch and spray the seed with herbicides before returning it to the field. In preliminary research in 1995, seed-applied trifluralin reduced cheat emergence up to 95%.

In 1996, an experiment assessed three rates (0.5X, 1X, and 1.5X) of five herbicides. Cheat seed was treated in a small rotating drum mixer, and planted in replicated field plots. Trifluralin and pendamethalin at 1X rates reduced cheat emergence 58 to 84% at one location, but results were variable. Herbicide-seed mixing times in the rotating drum mixer (15, 30, and 60 seconds) did not affect control. However, increasing spray volume from 1.4 to 5.6 gpa, based on the harvesting collection area, improved control. To confine spray and provide continuous material flow, a grain auger was fitted with five 8001 flat fan nozzle tips. When the auger was compared with the rotating drum mixer, all 1X and 1.5X treatments applied in 10 gpa of water carrier reduced cheat emergence 97%.

In 1997, experiments compared three carrier volumes used with the nozzle equipped auger (2.5, 5, 10 gpa). Control increased with carrier volume. Increasing volume above 10 gpa (680 ml/min) caused occasional auger plugging, thus 10 gpa was considered the maximum practical carrier volume. Neither nonionic surfactant nor a crop oil improved control with auger-applied trifluralin.

EFFECT OF WHEAT CULTIVAR ON COMPETITION FROM JOINTED GOATGRASS AND CHEAT.
Jason P. Kelley, Thomas F. Peeper, and Eugene G. Krenzer, Senior Agriculturist and Professors, Department of Plant and Soil Sciences, Oklahoma State University, Stillwater, OK 74078.

Abstract. Jointed goatgrass and cheat are troublesome weeds in the winter wheat fields of Oklahoma, because no herbicides consistently control them. Thus, cultural controls are necessary. One cultural control method that has not been fully investigated is planting competitive wheat cultivars to reduce competition from these weeds.

Eight popular hard red winter wheat cultivars were chosen for their different growth characteristics, (i.e. forage production potential, juvenile growth habit, and mature plant height). All cultivars were planted at 60 lb/A with 6 inch row spacing. Each cultivar was planted alone or with 30 lb/A of jointed goatgrass spikelets or cheat seed mixed with the wheat. Experiments were conducted at four locations for 2 years with jointed goatgrass and 1 year for cheat. Plots were 8 rows by 25 feet, replicated six times. All sites were fertilized according to soil tests for a 50 bu/A yield goal.

In the jointed goatgrass suppression experiments, a very wide range of competitive ability was observed. Cultivars 2180 or TAM 107 contained the highest amount of jointed goatgrass in the harvested grain in five of eight experiments. In the cheat suppression experiments, cultivars with poor competitive ability contained 3 to 5 times as much cheat at harvest as more competitive cultivars.

EVALUATION OF CULTURAL PRACTICE OPTIONS FOR SUPPRESSION OF JOINTED GOATGRASS IN WINTER WHEAT. Michelle L. Franetovich, Thomas F. Peeper, and John B. Solie, Graduate Research Assistant Professor, Department of Plant and Soil Sciences and Professor, Department of Biosystems and Agricultural Engineering, Oklahoma State University, Stillwater, OK 74078.

Abstract. Three field experiments were established in 1996 and continued in 1997 and three additional experiments were established in 1997, to evaluate multiple cultural options for suppression of jointed goatgrass in winter wheat. Treatments for all experiments include: three tillage systems (moldboard plow, offset disk, sweep plow - primary tillage), two wheat row spacings (4 and 8 inch), and four wheat seeding rates (37, 64, 86, amd 135 lb/A). Wheat stand counts were recorded following planting for all experiments to establish true seeding rates. Jointed goatgrass density was determined by plant counts following planting in 1996 and prior to planting in 1997. Jointed goatgrass suppression was determined by counting spikelets/100 g of harvested wheat. Averaged over other factors, the moldboard plow tillage system decreased jointed goatgrass spikelet production. Averaged over other factors, jointed goatgrass spikelet production was greater when wheat was seeded at 37 lb/A than when seeded at higher seeding rates. Averaged over other factors, the narrow row spacing increased jointed goatgrass spikelet production at one location.

IMI® WHEAT: NEW WEED MANAGEMENT TECHNOLOGY. Randall H. White and Robert A. Morrison, North America Product Development, American Cyanamid Company, Princeton, NJ 08543-0400.

Abstract. American Cyanamid has expanded its research efforts to develop crops that are tolerant to the imidazolinone herbicides. Currently, IMI-tolerant corn and canola varieties in combination with specific imidazolinone products are being used commercially. Wheat, rice, sugarbeets and sugarcane, all tolerant to the imidazolinone herbicides, are also under development at this time. Concurrent with this effort is the field evaluation (efficacy) of all the imidazolinones, alone and in various combinations, to identify product(s) best suited for these crops and the diverse cropping systems in which they are grown.

One product is AC 299,263 (common name imazamox). Imazamox is a new imidazolinone herbicide developed by American Cyanamid that is currently registered for use in soybeans. However, because of its high unit activity, weed control spectrum and environmental properties, relative to other imidazolinones, it has the potential to become a significant weed management tool for other crops. While most monocot crops, including wheat, are sensitive to AC 299,263 at efficacious use rates, researchers at American Cyanamid, with the cooperation of many other public and private research organizations, have developed imidazolinone-tolerant wheat. These wheat lines, generated by seed mutagenesis, have an altered AHAS gene that significantly reduces binding of the herbicide to the active site of the enzyme. Key partnerships with both public and private wheat breeding programs, covering all wheat classes, have been established to rapidly transfer this trait into numerous commercial wheat lines. Results of initial efficacy trials indicate commercial levels of control of many key cereal grass and broadleaf weeds. Key development and regulatory studies for registration of AC 299,263 in IMI wheat are underway or completed.

GRASS CONTROL WITH AC 299,263 IN IMI® WHEAT IN THE PACIFIC NORTHWEST. Pamela J. S. Hutchinson, Theodore Alby, III and Robert A. Morrison, Field Research Agriculturists and Product Development Manager, P.O. Box 400, American Cyanamid Company, Princeton, NJ 08542.

Abstract. Imidazolinone-tolerant wheat, known as IMI wheat, was planted in various locations in Idaho, Oregon, Montana and Washington 1995 to 1997. AC 299,263 was applied at five rates (0.024 to 0.063 lb/A) at fall and/or spring application timings. Target grass weeds included downy brome, Italian ryegrass and jointed goatgrass. Control ≥ 90% of all three grasses was achieved across all locations at AC 299,263 rates as low as 0.032 lb/A. Downy brome control by fall-applied AC 299,263 was slightly higher than control resulting from similar spring-applied rates. Field trials are being repeated during the 1997 to 1998 growing season to confirm control of these three grass weeds and to determine control of other weed species in IMI wheat.

GRASS CONTROL WITH IMAZAMOX IN IMI® WHEAT IN THE NORTHWEST. Pamela J. S. Hutchinson, Ted Alby, and Robert Morrison, Field Research Agriculturist, American Cyanamid Company, Meridian, ID 83642-3445; Senior Field Research Agriculturist, American Cyanamid Company, Vancouver, WA 98683-3813; and Robert Morrison, Global Product Development Manager, American Cyanamid Company, Princeton, NJ 08543-0400.

Abstract. Imidazolinone-tolerant wheat, known as IMI wheat, was planted in various locations in Idaho, Oregon, Montana and Washington from 1995 to 1997. Imazamox was applied at five rates (0.024 to 0.063 lb/A) at fall and/or spring application timings. Target grass weeds included downy brome, Italian ryegrass and jointed goatgrass. Control of greater than 90% of all three grasses was achieved across all locations with imazamox rates as low as 0.032 lb/A. Downy brome control with fall-applied imazamox was slightly higher than control resulting from similar spring-applied rates. Field trials are being repeated during the 1997 to 1998 growing season to confirm control of these three grass weeds and to determine control of other weed species in IMI wheat.

LAMBSQUARTERS (*CHENOPODIUM ALBUM*) INTERFERENCE IN GRAIN CORN AND RESPONSE TO HERBICIDES. Alberto Pedreros and Philip Westra, Graduate Research Assistant and Associate Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523.

Abstract. Field experiments were conducted in Fort Collins, CO during 1996 and 1997, to evaluate the competitive effect of lambsquarter in irrigated corn. Greenhouse experiments were conducted in 1997 and 1998 to evaluate the effect of commercial herbicides in 25 lambsquarters accessions collected in Colorado. Corn was planted at a density of six plants/m of row and common lambsquarter was planted at densities between 0 to 18 plants/m of row. Non-destructive corn and lambsquarters growth data were recorded every 14 days after emergence.

Corn yield declined at densities greater than three lambsquarter plants/m of row, suggesting that lambsquarters density is an important component of the competitive effect of weeds on corn. Corn leaf nitrogen and corn shelling percentage decreased with increased lambsquarters densities during both years. About 25 lambsquarters accessions from Colorado were evaluated in response to commercial herbicides showing, in general, similar response in spite of their differences in emergence and growth. Prosulfuron plus primsulfuron and glufosinate sprayed in post emergence provided less control on three lambsquarters accessions.

ROTATIONAL CROP RESPONSE TO MON 37500 HERBICIDE. Sandra L. Shinn, Donald C. Thill, and Daniel A. Ball, Graduate Research Associate and Professor, Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83344-2339 and Associate Professor, Columbia Basin Agriculture Research Center, Oregon State University, Pendleton, OR 97801.

Abstract. Winter wheat often is grown in rotation with barley, pea, lentil, and canola. Some herbicides used to control weeds in the winter wheat can persist in the soil, causing injury to these crops. Sulfonylurea herbicide persistence is affected most by soil pH, temperature, and precipitation. A study was established during fall, 1995 in winter wheat near Moscow, ID, Pendleton, OR, and Endicott, WA to evaluate rotational crop sensitivity to MON 37500, a sulfonylurea herbicide. MON 37500 was applied at 0.018 (1/2X), 0.035 (1X), and 0.072 (2X) kg/ha in fall, 1995 and spring, 1996. Triasulfuron at 0.018 kg/ha and an untreated control also were included in the experiment. MON 37500 at 0.072 kg/ha applied during fall or spring reduced biomass and yield of barley, lentil, pea, and canola at all locations, except pea at Moscow and Endicott. Fall applied MON 37500 at 0.036 kg/ha injured canola and barley at Moscow. Crop injury always was greatest at Pendleton. Precipitation from fall 1995 through spring 1997 at Pendleton was least (526 mm) compare to Endicott (657 mm) and Moscow (862 mm). Soil pH was highest at Pendleton (6.1) compared to Endicott (5.4) and Moscow (5.4). Soil was collected at each site before herbicide application and 2 hr, 11, 22, 45, 90, 180, and 360 days after spring treatments were applied and was used in a growth chamber sorghum bioassay to compare dissipation of MON 37500 in each soil over time. Results from the bioassay showed that MON 37500 dissipated slowly in Pendleton soil compare to soil from the other two sites.

QUACKGRASS CONTROL IN WHEAT WITH MON 37500. Suzanne Sanders and Donald C. Thill, Graduate Research Assistant and Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83844.

Abstract. Selective control of quackgrass in wheat is difficult; no currently labeled herbicides provide selective control. Field studies were established in Potlatch and Bonners Ferry, Idaho to evaluate MON 37500 for quackgrass control in winter wheat. The experimental design at each location was a randomized compete block factorial with four replications and individual plots were 2.4 by 8.2 m. MON 37500 was applied at the 3- to 5- and the 6- to 8-leaf stages of quackgrass and at rates of 4.5, 9.1, 18.2, 26.1, 36.3, 72.6 g/ha, and an untreated check. At the Potlatch site, MON 37500 at 26.1 g/ha and higher controlled quackgrass 88 to 95% except MON 37500 at 26.1 g/ha applied to

6- to 8-leaf quackgrass (47%). MON 37500 at 26.1 g/ha and above controlled quackgrass 75 to 83% at Bonners Ferry. At Potlatch, wheat grain yield ranged from 2,093 to 3,851 kg/ha. Wheat yield was greater in all herbicide treated plots when compared to the untreated control, except the 4.5 g/ha rate at the 6- to 8-leaf timing, and the 9.1 g/ha rate at the 3- to 5-leaf timing. Wheat grain yield ranged from 2,428 to 4,581 kg/ha at Bonners Ferry and varied greatly among treatments. However, grain yield was greater than the untreated control for all but four treatments. Greenhouse studies were established during fall, 1997 to evaluate longer term quackgrass control from MON 37500. Soil cores containing quackgrass rhizomes were taken post-harvest in each plot at each location. Rhizomes were removed and weighed, replanted in potting soil, and allowed to grow for 4 weeks. Shoot number and rhizome dry weight were determined. No consistent pattern emerged relating regrowth to application rates or timings, possibly indicating no effective residual quackgrass control after one year of treatment with MON 37500.

SOIL WATER USE AND GROWTH OF RUSSIAN THISTLE AFTER WHEAT HARVEST. William F. Schillinger and Frank L. Young, Research Agronomists, Department of Crop and Soil Sciences and USDA-ARS, Washington State University, Pullman, WA 99164.

Abstract. Russian thistle is a major broadleaf weed in the low-precipitation dryland wheat production region of the inland Pacific Northwest. Russian thistle infestation is frequently acute when wheat stand establishment is poor, during drought years, and in spring crops. This weed is a problem in the growing crop, after harvest, and during the summer fallow year. After harvest, Russian thistle produces substantial dry matter and seed, and extracts soil water until it is killed mechanically, chemically, or naturally (killing frost). This growth may not always be a problem in a winter wheat-fallow system, however, postharvest Russian thistle management is an important factor for the successful adoption of continuous spring crops, especially where moisture is limiting. Previous studies have documented total postharvest dry matter and seed production but not soil water use.

In a 2-year study at Lind, WA (240 mm average annual precipitation), Russian thistle plants were allowed to grow without intraspecific competition, from harvest in early August until killing frost in October. Soil water was measured with neutron attenuation techniques from 0.3 m to 3 m from the base of the plant. At each increment from the plant, soil moisture was measured to a depth of 1.8 m. At the same time soil water was measured, Russian thistle plants in an adjacent area were harvested for seed and dry matter production. Individual Russian thistles extracted an average of 51 liters of soil water from a distance less than a 1.5 m radius. Dry biomass increased from 260 to 1240 g/thistle during this time period. Results from this study show the value of controlling Russian thistle after wheat harvest in marginal production years to conserve soil water and minimize weed seed production.

BAY FOE 5043 PLUS METRIBUZIN: MULTIYEAR SUMMARY OF WINTER WHEAT TRIALS CONDUCTED IN THE WESTERN UNITED STATES. R. G. Brenchley, A. C. Scoggan, J. R. Bloomberg, and H. Lin, Bayer Corporation, Kansas City, MO 64120.

Abstract. BAY FOE 5043 plus metribuzin is a new herbicide mixture under development by Bayer Corporation that will be marketed in winter wheat. This combination has demonstrated excellent soil activity against certain common annual grasses and small-seeded broadleaf weeds. Field studies conducted in the western United States with BAY FOE 5043 at 0.222 to 0.375 lb/A plus metribuzin at 0.0625 to 0.188 lb/A confirm selective control of many regionally important weeds common in winter wheat, especially annual ryegrass. Weeds also controlled are downy brome and many mustards such as *Brassica* sp., purple mustard, tansy mustard, tumble mustard and small-seed false flax. BAY FOE 5043 plus metribuzin offered similar levels of annual grass control and superior broadleaf control when compared to the standard soil applied graminicides. Bayer Corporation will market BAY FOE 5043 plus metribuzin as a prepackage mix containing 4 parts BAY FOE 5043 plus 1 part metribuzin under the trade name of AXIOM intended for use in winter wheat at 0.312 to 0.425 lb/A.

THE INFLUENCE OF F-8426 AND ADDITIVES ON WINTER WHEAT CULTIVARS. Stephen M. Van Vleet, Stephen D. Miller, and David E Legg, Research Associate and Professor, Department of Plant Sciences and Professor, Department of Natural Resources, University of Wyoming, Laramie, WY 82071.

__Abstract__. The response of five varieties of hard red winter wheat (cultivars: Buckskin, Halt, Laredo, Pronghorn and Yuma) to F-8426, (proposed common name of carfentrazone-ethyl) and several additives in an irrigated and dryland system were studied in 1997. Additives included in the experiment were 2,4-D ester, 28:0:0 N, surfactant (NIS) and a safening agent (ACA). The dryland experiment was located at the Research and Extension Center, Archer, WY. The irrigated experiment site was located at the Research and Extension Center, Torrington, WY. Wheat was analyzed based on injury, tillers, leaves, height, heads/m, 200 seed wt, % lodging, test wt, protein and yield. The wheat cultivar Yuma was the most susceptible to the herbicide F-8426 but yielded the highest at both the dryland and irrigated sites. Pronghorn had significantly more heads/m but Yuma had significantly more seeds/head thus accounting for the larger yield. There were no significant differences in the number of wheat heads/m, number tillers, number leaves, height, seeds/head, seed wt, and yield for all herbicide treatments in the irrigated or dryland sites, however, there were a number of differences between varieties.

ANALYSIS OF VOLUTEER RYE ECONOMIC THRESHOLDS IN WINTER WHEAT. Todd A. Pester[1], Philip Westra[1], Tim J. D'Amato[1], Kirk A. Howatt[1], Randy L. Anderson[2], Phillip W. Stahlman[3], Gail A. Wicks[4], Drew J. Lyon[5], and Stephen D. Miller[6], Graduate Research Assistant, Associate Professor, Research Associate, Graduate Research Assistant, [1]Department of Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523; Research Leader, [2]USDA-ARS, Akron, CO 70720; Professor, [3]Kansas State University, Hays Agricultural Research Center, Hays, KS 67601; Professor, [4]University of Nebraska-Lincoln, West Central Research and Extension Center, North Platte, NE 69101; Associate Professor, [5]University of Nebraska-Lincoln, Panhandle Research and Extension Center, Scottsbluff, NE 69361; and Professor, [6]Department of Plant, Soil, and Insect Sciences, University of Wyoming, Laramie, WY 82071.

__Abstract__. Volunteer rye is a serious weed problem in winter wheat. To determine the economic threshold of volunteer rye on winter wheat yield, field experiments resulting in 16 data sets were conducted over 4 years from 1992 to 1996 at Akron, Nunn, and Fort Collins, Colorado; Hays, Kansas; North Platte and Sidney, Nebraska; and Archer, Wyoming. Winter wheat density was held constant at normal planting densities while target rye densities were 0, 5, 10, 25, and 50 plants m^{-2}. To examine variation in winter wheat-volunteer rye interference relationships across locations and years, the standard, negative hyperbolic yield loss function was fit to the 16 data sets. Two parameters: *i*, which represents the percent yield loss as rye density approaches zero, and *a*, the maximum percent yield loss as rye density becomes very large, were estimated for each data set using nonlinear regression. The variable rye reproductive tillers per m^{-2} typically described more variability than rye plants per m^{-2}; likely due to the inherent ability of rye to aggressively produce tillers in areas of low plant densities and when resources are available. Despite variation among location and years, five data sets (KS 1994, 1995, and 1996, and Sidney, NE 1995 and 1996) were able to be pooled and a single line was fit to the data allowing predictions of winter wheat yield loss across two locations and three years. Based on arbitrarily assigned crop production and weed management costs, economic threshold values ranged from 4 (NE 1996, WY 1996) to 70 (KS 1992) rye reproductive tillers m^{-2}.

TRALKOXYDIM DOSE AND WILD OAT DENSITY EFFECT ON WILD OAT SEED PRODUCTION IN SPRING BARLEY. David S. Belles and Donald C. Thill, Graduate Research Assistant and Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83344-2339.

__Abstract__. High wild oat control costs and pressure to reduce pesticide use have caused some barley growers to use reduced rates of herbicides. The consequences of this practice are not understood. A field study was conducted to determine the effect of wild oat density and tralkoxydim dose on wild oat seed production in barley. Tralkoxydim

was applied at 0.05, 0.1, 0.15, and 0.2 kg/ha to five wild oat densities (6, 34, 51, 91, and 127 plants/m^2). An untreated control also was included. Barley and wild oat plants were counted before herbicide application. Wild oat control, barley and wild oat biomass, wild oat panicle and seed numbers, and barley yield were determined. Wild oat control at heading was 93% or greater with all tralkoxydim rates at all wild oat densities. Barley was not injured. Wild oat panicles/m^2 ranged from 0 with the high herbicide rates and low wild oat densities, to 72/m^2 for the control at the highest wild oat density. The number of wild oat seeds, averaged over wild oat density, was 1235/m^2 in the control and 66, 18, 16, 0.3 seeds/m^2 for the 0.05, 0.1, 0.15, and 0.2 kg/ha tralkoxydim rates, respectively. The wild oat seed number averaged 266, 1117, 1283, 1622, and 1890 seeds/m^2 in the control plots with 6, 34, 51, 91 and 127 wild oat plants/m^2, respectively. Wild oat densities of 6 to 34 plants/m^2, sprayed or unsprayed, did not affect barley yield. Unsprayed wild oat densities equal to or greater than 51 plants/m^2 reduced barley yield. At these wild oat densities, barley yield was equal for all rates of tralkoxydim.

WILD OAT CONTROL IN WHEAT AND BARLEY WITH TRALKOXYDIM. Kurt Volker, Robert Stougaard, and Michael C. Hubbard, Field Development Biologist, Zeneca Ag Products, Yakima, WA 98908; Associate Professor, Montana State University, Northwestern Agricultural Research Center, Kalispell, MT 59901; and Agricultural Consultant, Bonners Ferry, ID 83805.

Abstract. Tralkoxydim (Achieve®) herbicide will be registered for use on wheat and barley for post-emergence control of wild oat, green foxtail, and yellow foxtail. Herbicide treatments were applied to wild oat in the 2- to 4-leaf and/or 5- to 7-leaf stage at trial sites located at Zillah, Washington; Bonners Ferry, Idaho; and Kalispell, Montana. Treatments were applied in a randomized block design with three replications using a backpack sprayer calibrated to deliver 10 to 20 gpa in trials conducted from 1995 to 1997. Visual evaluation of wild oat control and crop injury were recorded as was yield, if appropriate.

Tralkoxydim plus TF8035 (Turbocharge®) adjuvant with and without ammonium sulfate (AMS) and broadleaf herbicides was evaluated for wild oat control. Most treatments of tralkoxydim plus TF8035 alone or in combination with a broadleaf herbicide with or without AMS provided excellent (≥95%) wild oat control with little, if any, injury to the crop. Addition of 2,4-D ester to tralkoxydim frequently reduced the level of wild oat control. The antagonism of tralkoxydim tank-mixed with 2,4-D ester was overcome with the addition of AMS at 1.5 lb/A. Crop injury, if observed, was generally seen as the result of the broadleaf herbicide component of tank-mixes.

Tralkoxydim was compared to other herbicides for control of wild oat in wheat and barley (Table 1). Tralkoxydim at 0.125, 0.18, and 0.25 lb/A + TF8035 with or without AMS; fenoxaprop-ethyl; and fenoxaprop-P-ethyl at 0.1287 lb/A gave excellent control of wild oat. Diclofop provided very good to excellent wild oat control. Fenoxaprop-P-ethyl plus 2,4-D plus MCPA and fenoxaprop P-ethyl plus MCPA gave very good wild oat control but resulted in significant crop injury. Imazamethabenz plus NIS and fenoxaprop-P-ethyl at 0.0644 lb/A gave fair to very good control of wild oat (Table 2).

Table 1. Wild oat control in cereals with tralkoxydim plus adjuvant and broadleaf herbicide combinations.

Treatment[a]	Rate	Wild oat control		
		Trial 1[b]	Trial 2[c]	Trial 3[d]
	lb/A		%	
Tralkoxydim	0.18	100	100	
Tralkoxydim + AMS[e]	0.18	100	100	97.3
Tralkoxydim + bromoxynil + MCPA	0.18 + 0.7511	100	100	
Tralkoxydim + bromoxynil + MCPA + AMS	0.18 + 0.7511	100		99
Tralkoxydim + bromoxynil	0.18 + 0.5	100	100	
Tralkoxydim + bromoxynil + AMS	0.18 + 0.5	100		
Tralkoxydim + fluroxypyr	0.18 + 0.125	98.7		
Tralkoxydim + fluroxypyr + AMS	0.18 + 0.125	100		98.3
Tralkoxydim + 2,4-D ester	0.18 + 0.5	94.3	90	
Tralkoxydim + 2,4-D ester + AMS	0.18 + 0.5	97.7	95	
Tralkoxydim + clopyralid + MCPA	0.18 + 0.3463	99.7		
Tralkoxydim + clopyralid + MCPA + AMS	0.18 + 0.3463	100		
Tralkoxydim + prosulfuron	0.18 + 0.0089	98.7		
Tralkoxydim + prosulfuron + AMS	0.18 + 0.0089	99.7		94.3
Tralkoxydim + prosulfuron	0.18 + 0.0178	97.3		
Tralkoxydim + prosulfuron + AMS	0.18 + 0.0178	99.3		92.7
Untreated check	-	0	0	0
LSD (0.05)		2.4	18.7	2.8

[a]All tralkoxydim treatments plus TF8035 at 0.5% v/v.
[b]Trial 1 conducted at Kalispell, MT on 4-leaf Gallatin barley, 1997. Applications to 2-leaf wild oat.
[c]Trial 2 (selected results) conducted at Zillah, WA on fully tillered spring wheat, 1995. Applications to 2- to 4- and 5- to 7-leaf wild oat.
[d]Trial 3 conducted at Bonners Ferry, ID on 3 to 6 leaf W926 wheat, 1996. Tralkoxydim at 0.2 lb/A applications to 2- to 3-leaf wild oat.
[e]AMS added at 1.5 lb/A.

Table 2. Wild oat control in cereals with tralkoxydim plus adjuvants compared to other wild oat herbicides.

Treatment[a]	Rate	Wild oat control/crop injury)	
		Trial 1[b]	Trial 2[c]
	lb/A	%	
Tralkoxydim	0.125	95.7	97.6
Tralkoxydim + AMS[d]	0.125	100	100
Tralkoxydim	0.18	99.3	100
Tralkoxydim + AMS	0.18	99.3	100
Tralkoxydim	0.25	100	100
Tralkoxydim + AMS	0.25	98.3	100
Tralkoxydim + AMS	0.18 +1.5	100	98.3
Tralkoxydim + 32% UAN	0.18 + 2.5% v/v	100	99.3
Diclofop	1	89.7	96
Imazamethabenz + NIS	0.47 + 0.25	60	94.3
Fenoxaprop-P-ethyl + 2,4-D + MCPA	0.6545	86.7	86.6 (7.6)
Fenoxaprop-P-ethyl + MCPA	0.4725	89.7 (30)	90 (21.6)
Fenoxaprop-P-ethyl	0.0644	66.7	91.6
Fenoxaprop-P-ethyl	0.1287	98.3	100
Fenoxaprop-ethyl	0.05	100	100
Fenoxaprop-ethyl	0.06	100	100
Untreated Check	-	0	0
LSD (0.05)		13.3	5.6

[a]All tralkoxydim treatments plus TF8035 at 0.5% v/v.
[b]Trial 1 conducted at Kalispell, MT on 4-leaf Gallatin barley, 1997. Applications to 2-leaf wild oat. Crop injury in ( ).
[c]Trial 2 conducted at Bonners Ferry, ID on 1-tiller Weston wheat, 1997. Applications to 2- to 3-leaf wild oat. Crop injury in ( ).
[d]AMS added at 1.5 lb/A.

TEACHING AND TECHNOLOGY TRANSFER

MONTANA'S STATEWIDE NOXIOUS WEED AWARENESS AND EDUCATION PROGRAM. Carla Hoopes and Roger Sheley, Program Coordinator and Assistant Professor, Montana State University, Department of Plant, Soil and Environmental Sciences, Bozeman, MT 59717-3120.

Abstract. Historically, Montanans have been concerned about noxious weeds. All Montana Weed Control Association committees, the 20/20 Vision Committee, and a recent statewide survey agree that Montana needs a comprehensive, well-designed statewide noxious weed awareness and education program for the general public so they will continue and increase their support for noxious weed management programs. A survey of county weed districts, county Extension agents, the Montana Department of Agriculture, the Noxious Weed Advisory Council, and other weed managers was conducted asking what messages about noxious weeds and the modes of delivery they consider most effective. Respondents of the survey agreed that a large-scale, long-term multimedia program using television, radio, billboards, and newspapers and popular press should be designed to support local community-specific awareness programs. They also suggested that educating school children is very important. A working group was formed in 1995 to design and implement such a program. The working group involves agency and organization representatives who can communicate a vision from their agencies' perspectives, and then effectively use the resources available in their organizations to communicate a coordinated, statewide educational message.

During the past 2 years, the Statewide Noxious Weed Awareness and Education Campaign Working Group, a committee of the Montana Weed Control Association, has developed a comprehensive media campaign directed toward the general public of Montana. The mission of the working group is for the people of Montana to realize the economic and environmental impacts of noxious weeds and to become supportive of all aspects of noxious weed efforts. Seven educational messages were defined and eight target audiences were identified. Within each target audience direct channels of communication have been established and projects created to deliver the messages that support the mission. Members from within the working group have currently taken on 17 of these projects, secured funding, and are in the stages of implementation. The mission is for the people of Montana to realize the economic and environmental impacts of noxious weeds and to become supportive of all aspects of noxious weed efforts.

A working group in which interested parties can develop a unified and comprehensive statewide awareness and educational program was initiated in 1995. The working group comprises representatives of many state and federal land management agencies, as well as other organizations with an interest in and/or responsibility for land management. Meetings were conducted to introduce the program's concept and to start developing a statewide educational vision and plan.

A Mission Statement was agreed upon and written, "For the people of Montana to realize the economic and environmental impacts of noxious weeds and to become supportive of all aspects of noxious weed efforts." Seven noxious weed "messages" were agreed upon: 1) explanation of a noxious weed; identification of individual plants and infestations; 2) how people are affected by noxious weeds; 3) how the environment is affected by noxious weeds; 4) why the general public needs to support all aspects of noxious weed efforts (including the Noxious Weed Trust Fund); 5) what the general public can do; 6) successful weed management programs in Montana; and 7) there are many ways to manage weeds. Specific target audiences to receive one or more of the messages were identified: Joe average citizen, youth, environmental groups, government, realtors/developers/small landowners, recreation/sportsmen/tourists, producers, and utilities/transportation. Noxious Weed Trust Fund success stories were written and have been published in papers such as the *Prairie Star*, Glendive's *Ranger Review*, *The Glasgow Courier*, and Harlowton's *Times Courier*. Subcommittees were formed to focus on specific target audiences; a comprehensive list of noxious weed resources was compiled; delivery systems for messages were established. Tasks were defined and prioritized within the target audiences. A campaign slogan and identifying logo were designed by the working group. Public service announcements for both television and radio were produced as a cooperative effort between the working group, the Montana Department of Agriculture, and Governor Marc Racicot. Copy containing the educational messages was written by the working group for placement in hunting, fishing, and recreational publications. Leaders from the working group have come forward to develop, implement, and in many cases, fund the tasks defined as highest priority. A presentation portfolio was prepared for use in securing funding from outside the Noxious Weed Trust Fund for a full-time campaign coordinator by the end of 1998. Plans for the February 1998 meeting call for further defining and prioritizing of tasks within each target audience; encouraging participants to continue accepting responsibility for specific parts of the program; and preparation of presentation materials for the working group to spread the messages effectively within their own organizations to increase the leadership pool.

The cooperative projects created by this working group are the beginning of a highly effective and cohesive long-term awareness campaign for the general public of Montana. The on-going success of the program is a result of the dedicated members of the working group becoming leaders and implementors of group defined tasks. The campaign focus, "Pulling Together Against Noxious Weeds", is designed for the people of Montana to become supportive of all aspects of the noxious weed effort. The working group is a successful example of Montanans working together to optimize noxious weed efforts.

LIVESTOCK TRAMPLING OF GRASS SEEDINGS FOR ENHANCED ESTABLISHMENT ON YELLOW STARTHISTLE-INFESTED RANGELANDS. Timothy W. Miller, Sandra L. Shinn, Robert H. Callihan, Lawrence W. Lass, and Donald C. Thill, Extension Weed Scientist, Northwest Washington Research and Extension Unit, Washington State University, Mt. Vernon WA 98273 and Graduate Research Assistant, Emeritus Extension Professor of Weed Science, Extension Support Scientist, and Professor of Weed Science, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow ID 83844.

Abstract. The objectives of this research were to examine the effect of 1) intensive livestock trampling as a means to plant broadcast-seeded grass in yellow starthistle-infested canyonland, and 2) temporary suppression of resident vegetation by herbicides to enhance grass establishment. Two experiments were conducted. In 1996, treatments were 1) broadcast seeding followed by trampling with sheep, 2) picloram application, and 3) timing of glyphosate application. In 1997, treatments were 1) broadcast seeding at two rates followed by trampling with cattle, and 2) post-trampling treatment with picloram plus glyphosate. Both sites were on moderately sloping rangeland, and were located on the same ranch near Whitebird, Idaho. Vegetation at the sites was dominated by yellow starthistle (CENSO) and downy brome (BROTE). Other common forbs included lupine, St. Johnswort, fiddleneck tarweed, European cornsalad, catnip, and western yarrow. Other common grasses included rattail fescue, Japanese brome, medusahead, and ventenata. Perennial grass species were largely absent, although intermediate wheatgrass and Canada bluegrass were present at a very low frequency.

Sheep trampling experiment: Sheep were confined for 1 day (approximate stocking density = 100 sheep/A) in one of two half-acre paddocks in each of four replicates. Each paddock was broadcast-seeded on April 1, 1996 with 'Oahe' intermediate wheatgrass, a rhizomatous species, at the rate of 1000 pure live seeds/m^2 prior to the trampling treatment. Half of each paddock was treated with glyphosate before seeding; the other half was treated with 1 lb/A glyphosate after seedlings of resident annual weeds recovered from the trampling treatment, but prior to emergence of the broadcast perennial grasses (7 days after trampling). Picloram at 0.38 lb/A was applied across all treatments in a 20 foot band on June 11, 1996. Intermediate wheatgrass seedlings were counted in two 0.6 m^2 quadrats in each plot in late July, 1996 (approximately four months after seeding/trampling). Total biomass was estimated on July 2, 1997. Two 0.25 m^2 quadrats were placed in each split-split plot, and vegetation clipped to 1 inch of the soil line and divided into three categories: annual grasses, perennial grasses, and forbs. Plants were then dried for 72 hours at 90 F and weighed.

Cattle trampling experiment: Two plots in each of four replicates were broadcast-seeded on April 19, 1997 with either 20 or 40 lb/A of a mix of 'Oahe' intermediate wheatgrass and 'Durar' hard fescue (84% and 16% by wt, respectively); a third plot was not seeded. Each replicate was fenced into two quarter-acre paddocks (split-plot arrangement) and 22 head of yearling heifers were confined in one of the paddocks (approximate stocking density = 88 cattle/A) on April 24, 1997. Cattle were kept moving using dogs for approximately 45 minutes during trampling in each paddock, but were allowed to rest for an hour between the four trampling sessions. Trampling was conducted during a light drizzle. Each split-plot was then split again, resulting in four split-split plots. Half the split-split plots were treated with picloram at 0.38 lb/A plus glyphosate at 0.5 lb/A on April 28, 1997. There was no visible emergence of seeded grasses at the time of herbicide application.

1996 results: Four months after sheep trampling, vegetation in pre-trampling glyphosate treatments did not appear to differ from that in untreated plots, but the post-trampling glyphosate treatment suppressed most of the BROTE (data not shown). There was a significant interaction of glyphosate, picloram, and trampling on perennial grass density and height (Table 1). Intermediate wheatgrass density was greatest when seed was trampled and then treated with glyphosate, either with or without picloram (14.2 and 17.9 plants/m^2, respectively).

Picloram provided excellent control of most weedy forbs at 4 months after trampling, including CENSO. Mean CENSO height was reduced from 26.6 to 0.2 cm and CENSO density was reduced from 52.9 to 0.1 plants/m^2 by picloram application (Table 2). CENSO height was greatest with glyphosate applied after trampling, as compared to the control. CENSO density also tended to be higher with this treatment, although the difference was not statistically significant. Both CENSO height and density tended to be decreased by trampling. There were no significant interactions between trampling, glyphosate or picloram on CENSO height or density.

1997 results: Perennial grass establishment in the sheep trampling experiment varied widely among the treatments, as shown by biomass sampling after two growing seasons, ranging from 54 to 562 lb/A (data not shown). Forb and annual and perennial grass biomass was not affected by either trampling or glyphosate timing after two growing seasons (data not shown). Intermediate wheatgrass production, however, was significantly higher after the post-trampling picloram treatment (from 132 to 379 lb/A), and annual grass biomass also increased from 755 to 2533 lb/A after the picloram application (Table 3). Picloram applied after trampling was still providing effective CENSO control after two growing seasons, reducing forb biomass from 2429 to 119 lb/A (Table 3). There were no significant interactions between trampling, glyphosate, or picloram.

The cattle trampling study was not sampled the first season due to lack of visible perennial grass growth from either seeding rate. Observations of the site indicated that the greatest impact on the vegetation was the herbicide application. Picloram plus glyphosate controlled CENSO, but there was little apparent difference between vegetation in the sprayed/trampled split-plots and the sprayed/not trampled split-plots. Rattail fescue was the dominant grass resulting from the herbicide treatment. The CENSO appeared to be more dense in the trampled/not sprayed split-plots than in the not trampled/not sprayed split-plots. Biomass of weedy forbs, annual grasses, and perennial grasses will be estimated during the 1998 growing season to better assess the response of this vegetation to treatments.

Table 1. Intermediate wheatgrass height and density four months after planting.

Trampling[a]	Glyphosate[b] timing	Picloram[c] application	Intermediate wheatgrass Height	Intermediate wheatgrass Density
			cm	plants/m^2
Yes	Pre	Yes	14.3	8.3
Yes	Pre	No	2.8	2.5
Yes	Post	Yes	11.1	14.2
Yes	Post	No	8	17.9
Yes	None	Yes	3.5	0.8
Yes	None	No	7.9	4.4
No	Pre	Yes	0	0
No	Pre	No	3.8	0.8
No	Post	Yes	7.8	4.8
No	Post	No	1.9	0.4
No	None	Yes	7	2.9
No	None	No	0	0
LSD (0.05)			8.6	3.0

[a]Trampled after seeding at approximately 100 sheep/A for one day.
[b]Glyphosate applied at 1 lb/A before trampling (Pre) or after trampling (Post).
[c]Picloram applied at 0.38 lb/A after trampling.

Table 2. Response of yellow starthistle to sheep trampling, and glyphosate, or picloram application four months after treatment.

		Trampling[a]			Glyphosate[b]				Picloram[c]		
Yellow starthistle		Yes	No	LSD	Pre	Post	None	LSD	Post	None	LSD
Density (plants/m^2)	20	33	NS	25.7	27.6	26.3	NS	0.1	52.9	11.8	
Height (cm)		11.7	15.1	NS	13.4	15.5	11.2	NS	0.2	26.6	2.3

[a]Trampled after seeding at approximately 100 sheep/A for one day.
[b]Glyphosate applied at 1 lb/A before trampling (Pre) or after trampling (Post).
[c]Picloram applied at 0.38 lb/A after trampling.

Table 3. Biomass of annual and perennial grasses and weedy forbs two growing seasons after picloram application.

Picloram[a] treatment	Annual grasses	Perennial grasses	Weedy forbs
	(lb/A)		
Yes	2533	379	119
No	755	132	2429
LSD (0.05)	475	188	468

[a]Picloram applied at 0.38 lb/A.

REGIONAL BIOECONOMIC WEED MANAGEMENT MODELS: EXPECTATIONS AND REALITY.
Bruce D. Maxwell, Associate Professor, Plant, Soil and Environmental Sciences Department, Montana State University, Bozeman, MT 59717.

Abstract. Regional bioeconomic weed management models are currently under development throughout the world. The basis for most of these models is the negative hyperbolic relationship between weed density and crop yield. The expectation is that crop yield measured over a range of weed densities in additive experiments conducted across the region of interest and over several years will allow parameterization of the models. The reality is that yield loss due to weed density parameters are highly variable over sites and years and therefore it is difficult to know what parameter values to use to predict the biological or economic response to a given weed density, even at the site where the original experiments were conducted. There are several factors which may account for a large proportion of the variation in crop yield response to weed density. Studies that assess the importance of these factors may improve our understanding of temporal variability, however variability over sites may be more complicated. Site specific (georeferenced) information on weed population dynamics and crop impacts may play a major role in improving the accuracy and subsequent utility of bioeconomic models.

BIOECONOMIC MODEL FOR GRASS WEED CONTROL IN SPRING-PLANTED CANOLA. Traci A. Rauch and Donald C. Thill, Scientific Aide and Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83844-2339.

Abstract. Canola is an important oil seed crop that does not compete well with many broadleaf and grass weeds. Wild oat and volunteer cereal infestations can reduce canola yield and oil content significantly. Sethoxydim, one of the herbicides registered for grass weed control in canola, is expensive ($20 to $60/ha). Also, no locally adapted weed loss information is available to assist growers in herbicide application decisions. A study was established at the University of Idaho Plant Science Farm near Moscow, ID to determine the effect of wild oat and volunteer barley density and sethoxydim rates on wild oat and volunteer barley control in canola, and on canola seed yield and oil content. Information from this study will be used to determine economic thresholds for grass weed control in

canola. Main plots were canola cultivars (9.8 by 48.8 m), subplots were volunteer spring barley or wild oat density (9.8 by 9.8 m) and sub-subplots were sethoxydim dose (2.4 by 9.8 m). The treatments were replicated four times in a randomized split-block design. Wild oat and 'Russell' barley were seeded in rows spaced 8.9 cm apart. Both species were seeded to attain established densities of 0, 20, 70, 120, and 170 plants per m^2. 'Helios' and 'Westar' spring canola were seeded perpendicular to wild oat or volunteer spring barley in rows spaced 17.8 cm apart to achieve an established plant density of 100 plants/m^2. Sethoxydim was applied at 0, 0.16, 0.21, and 0.31 kg/ha. Weed control was evaluated visually. Canola seed was direct combine harvested with a small plot combine from a 1.4 by 4.9 m area. A seed sample from each sub-subplot was analyzed for oil content using nuclear magnetic resonance (NMR) spectroscopy. All sethoxydim rates controlled volunteer barley 90% or better and wild oat 93% or better. Canola seed yield was the same among sethoxydim doses and was significantly greater than the untreated check. Wild oat and volunteer spring barley density reduced canola seed yields as densities increased. Total oil content of canola seed was not affected by sethoxydim dose or weed density (wild oat or volunteer spring barley) but was different between canola cultivars. Sethoxydim applied at 0.16 kg/ha rate effectively controlled spring barley and wild oat and resulted in the highest net return ($34.00/ha).

TALKING ABOUT WEED PRESSURE: AN INTERVIEW SURVEY OF FARMER AND CROP CONSULTANT DESCRIPTIONS OF WEED DENSITY LEVEL. Lori J. Wiles, Stephen R. Canner, and D. Bruce Bosley, Plant Physiologist, USDA-ARS, Water Management Unit, AERC, Colorado State University, Fort Collins, CO 80521; Research Associate, USDA-ARS, Great Plains Systems Research Unit, P.O. Box E., Fort Collins, CO 80522; and Director, Morgan County Cooperative Extension, P.O. Box 5717, Fort Morgan, CO 80701.

Abstract. Acceptance of computerized weed management decision support systems (WMDSS) is limited in part by requirements for extensive input information about weed density. Weed density counts are particularly time consuming, yet several existing and developing WMDSS depend on weed count data for implementation. A pilot survey of several farmers and crop consultants was conducted to evaluate their translation of numerical and photographic descriptions of a weed population density into commonly used terms such as "light", "medium" or "heavy". The survey also evaluated respondents' assessment of weed pressure in a specific field in their experience. Weed counts were conducted in four of these fields to calibrate early predictions of weed pressure against actual weed densities and weed spatial distributions. Photographs were a promising method of communicating the pressure level of a weed infestation. For some respondents, drawing maps was useful for describing the spatial pattern of weed infestation in a field. Results of these interviews will be useful in improving interfaces for WMDSS, printed or computerized IPM guides, and general communication between weed scientists and crop managers. An ideal interface for describing weed pressure should probably be customizable for the varying perspectives of different managers. More research of this kind is needed to further clarify assessment of weed pressure by crop managers.

SEED LONGEVITY OF TEN WEED SPECIES SIX YEARS AFTER BURIAL AT TWO DEPTHS. David W. Wilson, Stephen D. Miller, Stephen M. VanVleet, and Rita K. Parker, Research Scientist/Instructor, Professor, Research Associate, and Seed Analyst Technician (retired), Department of Plant Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. The longevity of weed seeds is a primary factor in determining potential weed population problems. The ability to anticipate successive weed generation effects enables the formulation of control strategies, before populations reach a yield impact level. A burial study plot was established in the last week of October of 1990 at four different dryland locations in Wyoming. Ten weed species were buried at two depths in replicates of four at each of the sites. Packets made from 100 micron mesh screen, containing 100 seeds of each species were buried at 1 and 6 inch depths in 4 inch diameter holes, spaced 12 inches apart. Soil was firmly tamped after packet placement and a grass cover was allowed to develop over each study site. Seed packets were carefully removed from each of

the four sites in October of 1991, 1992, 1994 and 1996. Holes were refilled and the packets were transported to the laboratory for comparison with stored samples using the tetrazolium chloride viability test. Average seed viability declined over 2 and 4 % between the first and second year of the study and 6 and 7% between the second and fourth years of the study at the 1 and 6 inch depths, respectively. Of the four monocot species tested only jointed goatgrass and green foxtail retained nearly 1% viability after 6 years. Field bindweed, cutleaf nightshade, spotted knapweed and Canada thistle retained the highest viability of the weed species tested with viability remaining greater than 34, 20, 3 and 3%, respectively.

UTILITY OF IMAZAMOX IN DRY BEANS. Richard K. Zollinger and Scott A. Fitterer, Associate Professor and Research Scientist, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105-5051.

Abstract. Dry beans are grown in regions where sugarbeet and other crops sensitive to herbicide residues are grown. Imazethapyr is registered for use in dry bean but can leave a residue for 40 months or more. Soybean registration, lack of soil residue, and excellent broad-spectrum grass and broadleaf control make imazamox a viable candidate for use in dry beans. Three experiments were conducted to evaluate weed control and dry bean safety from imazamox applied at different rates, alone or in tankmix combinations, with different adjuvants, or as sequential applications. 'Othello' pinto and 'Norstar' navy beans were seeded at Minto, ND. 'Othello' pinto, 'Norstar' navy, and 'Montcalm' kidney beans were seeded at Casselton, ND in 1997. Imazamox efficacy without dry bean crop response was evaluated at Barney, ND. POST treatments were applied 1 trifoliolate (V1) beans and LPOST treatments were applied to 2 to 4 trifoliate (V2-V4) beans. Treatments were applied to the center 8 feet of the 10 by 30 feet plots with a bicycle-wheel-type plot sprayer equipped with a shield delivering 8.5 gpa at 40 psi through 8001 flat fan nozzles. The experiment had a randomized complete block design with three replicates per treatment.

Research conducted at NDSU in 1995 and 1996 showed dry bean injury from imazamox. High temperature and humidity prior to and after application were attributed as the primary cause. However, imazamox, in all studies conducted in 1997, did not produce any visible injury. The environment was moderate with less temperature and humidity compared to conditions in 1995 and 1996 (data not shown). No rainfall occurred after application until July 1 at Minto.

Imazethapyr at 0.5 oz/A was enhanced more by Sun-It II than a nonionic surfactant. Research has shown safening of dry bean to imazethapyr by adding bentazon but no dry bean injury was recorded with either additive. Adding bentazon to imazethapyr plus nonionic surfactant increased general weed control over imazethapyr plus a nonionic surfactant alone. However, addition of bentazon to imazethapyr plus Sun-It II did not increase weed control compared to imazethapyr plus Sun-It II applied alone. Increasing the bentazon rate from 0.25 to 0.5 lb/A increased weed control with imazethapyr plus a nonionic surfactant but did not further increase weed control with imazethapyr plus Sun-It II.

Imazamox is registered in soybean at 0.625 oz/A or 0.5 oz/A only if a soil herbicide is applied prior to imazamox. Imazamox gave greater common lambsquarters control than imazethapyr with similar adjuvants. Imazamox at 0.375 oz/A plus Sun-It II gave greater weed control than imazamox at 0.375 oz/A plus a nonionic surfactant and equal or greater weed control than imazamox at 0.5 oz/A plus a nonionic surfactant of green and yellow foxtail, wild mustard, redroot pigweed, common lambsquarters, and common cocklebur. Evaluations of weed control from imazamox at 0.25 oz/A plus Sun-It II initially was lower but equaled imazamox at 0.5 oz/A plus Sun-It II and the July 17 evaluation. Addition of bentazon to imazamox antagonized grass and broadleaf weed control. Substituting Sun-It II for nonionic surfactant did not overcome bentazon antagonism of imazamox. However, reducing the rate of Sun-It II from 1.5 to 0.5 pt/A resulted in less weed control. With the exception of cocklebur control at low rates, imazamox applied in sequential applications at rates from 0.125 oz/A to 0.25 oz/A resulted in almost complete weed control. Previous research has shown that sequential applications of imazamox at reduced rates increases dry bean safety. Present research shows that adequate weed control can be obtained using this same method of application.

At Minto, bentazon antagonized weed control from imazamox. Antagonism increased as imazamox rates decreased. However, Sun-It II overcame bentazon antagonism of imazamox even though weed control was poor. Imazamox at 0.5 oz/A plus Sun-It II did not control green foxtail, redroot pigweed, or common lambsquarters.

At Barney, POST applications of imazethapyr or imazamox alone or in tank-mix combination gave excellent weed control of green and yellow foxtail, wild mustard, redroot pigweed, common lambsquarters, eastern black nightshade, and Pennsylvania smartweed. Imazethapyr gave poor control of common lambsquarters. Reduced rates of imazethapyr plus imazamox or imazamox alone gave excellent weed control. Imazamox applied twice in sequential applications at 0.25 or 0.125 oz/A gave complete control of all weeds except common lambsquarters at the lowest rate.

FALLOW PRACTICES FOLLOWING WINTER WHEAT HARVEST IN 1997. Gail A. Wicks and Robert N. Klein, Extension Specialists, University of Nebraska, North Platte, NE 69101.

INTRODUCTION

Surveys have been used for years to study various aspects of importance in many social, political, and educational matters. Surveys are also used in agriculture. Weed surveys can identify existing weed control problems, weed distributions, and can aid future weed management decision making. Agronomic surveys can identify various aspects of crop production that are important to the future growth of agriculture.

In Nebraska, most winter wheat is planted between September 1 and October 15. In western Nebraska, the optimum planting date is September 1 to 15, largely because of the higher elevation and shorter growing season. Some winter wheat is planted the last part of August on soils that are subject to wind erosion. In southeast Nebraska planting usually begins the latter part of September and ends in October. Normally winter wheat harvest begins about June 25 in southeast Nebraska and ends about August 15 in northwest Nebraska.

During 1996 and 1997, winter wheat fields were surveyed 2 to 3 months after wheat harvest to determine what weed management practices were being used to control weeds. Ninety-six percent of the winter wheat in Nebraska is non-irrigated. Basically, the state can be divided up into five rotations involving 2.1 million acres of winter wheat. In western Nebraska it is winter wheat-fallow rotation; in west central Nebraska it is a winter wheat-corn or sorghum-fallow rotation; and in southeast Nebraska, the rotations are winter wheat-soybean, winter wheat-corn or grain sorghum-soybean, or continuous winter wheat.

The objectives of this survey were to determine what practices farmers were using to control weeds following winter wheat harvest and to identify production problems that could be addressed by extension agronomists and weed scientists.

MATERIALS AND METHODS

A survey was taken of 1989 winter wheat stubble fields across the winter wheat growing areas of Nebraska during the period of September 5 to October 17, 1997 (Table 1). Data were collected to determine the weed control practices used on these fields following winter wheat harvest. The categories were no weed control after harvest (nothing); tillage with a tandem-disk harrow, sweep tillage, or plow; treated with a herbicide (sprayed), or grazed by cattle. The fields that were tilled were divided into three groups: tilled early, tilled timely, or tilled late. In addition, wheat fields that had thin stands or short stubble were identified. The fields treated with herbicides were rated on a scale of poor, fair, good, or excellent. These were rated as one drove slowly by the fields, thus speeding up the data collection process. If green weeds were observed in the field, a closer inspection was made to identify the weed species. Since most fields are sprayed by ground rigs, wheel tracks were obvious in the fields. If wheel tracks were not visible and good to excellent weed control was observed, stops were made for closer examination of these fields.

Table 1. Number of fields surveyed in 1997.

Rotation	No. of fields
Winter wheat-fallow	615
Winter wheat-corn or sorghum-fallow	983
Winter wheat-sorghum-soybean[a]	119
Center pivot corners	272
Total	1989

[a]Also includes continuous wheat.

Poor meant that many weeds were present and they were not controlled with the herbicide, fair meant that some weeds were missed and spraying was late, good meant the field contained larger weeds that were dead but some produced seeds before herbicides were applied, and excellent meant weeds were controlled timely and fields had excellent winter wheat stubble. Some of the fields rated as good had poor stands of winter wheat, indicating that winter kill probably occurred. These areas had taller weeds as wheat was not as competitive.

The majority of the winter wheat in Nebraska is produced in two agro-ecological zones: the High Plains Rainfed (western Nebraska) and Low Elevation Rainfed Zones (eastern two-thirds of Nebraska). These areas were further partitioned into four zones according to precipitation amounts across Nebraska. These were 16 to 18 inches, 18 to 23 inches, 23 to 28 inches, and 28 to 34 inches. Rainfall amounts increase as you move from west to east across Nebraska. Also, the winter wheat stubble in the first corner of center pivot fields was surveyed.

RESULTS AND DISCUSSION

The highest percentage of fields that were either tilled or sprayed with a herbicide (98%) occurred in the 28- to 34-inch precipitation zone, while the lowest percentage occurred in the 16- to 18-inch zone (59%) (Table 2). When averaged across zones 50% of the winter wheat stubble fields were sprayed with herbicides following harvest. But when averaged across fields 40% were treated. Fewer wheat stubble fields were treated with herbicides in the 28- to 34-inch precipitation zone than the other areas. However, there is more risk in soil erosion in higher rainfall areas. The southeastern counties had more fields where weed control practices were used.

For the 16- to 18-inch precipitation zone, 35% of the wheat stubble fields were sprayed with a herbicide (Table 2). The predominant rotation in this area is winter wheat-fallow. However, 10% of the 35% group is credited to fields in a winter wheat-ecofallow corn-fallow rotation (data not presented) since the stubble fields were adjacent to ecofallow corn. Also, included in the 35% group were 27 fields that did not have wheel tracks from sprayers but weeds were killed. These fields were most likely sprayed with a harvest-aid herbicide before harvest and are considered to be in the winter wheat-fallow rotation. Three of 213 fields where nothing was done were grazed by cattle. Utilization of the straw in some fields may have been done before spraying as the straw and chaff appeared to have been removed as indicated by short stubble and no loose straw, and straw bales piled in the corner of the field. Also, some fields may have been semidwarf wheats and harvested by combines equipped straw choppers. The sweep plowed fields were apparently tilled soon after wheat harvest because they had more volunteer wheat and downy brome visible. Some of the sweep-plowed fields were tilled twice indicating good weed management. In general, the tandem disked fields were done after the weeds had produced seed. None of the fields observed were plowed. Only three winter wheat stubble fields were observed to be no-tilled back to winter wheat. One proso millet stubble field was no-till planted back to winter wheat.

Overall, in the 18- to 23-inch precipitation zone 75% of the fields were sprayed with herbicides after winter wheat harvest (Table 2). The predominate rotation in this zone is winter wheat-ecofallow corn or sorghum-fallow and 87% of the fields in this rotation were sprayed (data not presented). However, only 46% of fields associated with the winter wheat-fallow rotation were treated with herbicides following wheat harvest. Four of the 29 fields where nothing was done after wheat harvest were grazed with cattle. Again, as was true in the 16- to 18-inch zone, sweep plowing was more timely than disking. Of the 11% of the fields that were tilled, 14% needed to be tilled again because of volunteer wheat or missed weeds. Three of the winter wheat stubble fields were no-till planted back to winter wheat. None of the fields observed were plowed.

Table 2. Stubble management practices following winter wheat harvest across precipitation zones in Nebraska in 1997.[a]

Practice	Precipitation zones (inches) 16–18	18–23	23–28	28–34	Pivot corners[b]	Mean
	%					
Sprayed	35	75	59	18	61	50
Tandem-disk harrow	13	1	30	80	17	28
Sweep plow	11	10	4	0	8	7
Nothing	41	14	7	2	14	16

[a]Fields disked and planted back to winter wheat were not included.
[b]Only the first corner of the center pivot was included.

In the 23- to 28-inch precipitation zones, 59% of the stubble fields were sprayed (Table 2). The use of the tandem disk for controlling weeds following winter wheat harvest increased from 1% in the 18- to 23-inch zone to 30% in the 23- to 28-inch zone. Some think that the additional precipitation reduces the need for water conservation. None of the fields were plowed.

In the 28- to 34-inch rainfall zones only 18% of the wheat stubble fields received herbicides after harvest to control weeds (Table 2). The amount of fields sprayed decreases rapidly as one moves to eastern Nebraska. The popularity of using the tandem disk to control weeds increased to 80% in this zone. One field was plowed and none were tilled with a sweep plow. Thirty-seven percent of the fields that were tilled in the 28- to 34-inch precipitation zone needed to be tilled again to control volunteer wheat. Some of the fields that were tilled more than once probably would be planted back to winter wheat. Tillage was more timely in eastern Nebraska than in western Nebraska.

The amount of wheat stubble sprayed in center pivot corners was 61% which is similar to the amount sprayed in the 18- to 23-inch and the 23- to 28-inch precipitation zones (Table 2). These two areas have most of the center pivots so one would expect a high percentage of the corners to be sprayed with herbicides following wheat harvest. These pivots will probably be planted to corn in 1998 so it is logical to treat the corners with a herbicide and plant ecofallow corn next spring.

Atrazine, glyphosate, paraquat, and 2,4-D are the herbicides commonly used to control barnyardgrass, bristly foxtail, carpetweed, common eveningprimrose, common milkweed, common purslane, common sunflower, downy brome, fall panicum, field bindweed, green foxtail, lanceleaf sage, large crabgrass, longspine sandbur, kochia, Pennsylvania smartweed, redroot pigweed, shattercane, stinkgrass, tall waterhemp, tumble pigweed, tumble thistle, volunteer wheat, wild buckwheat, witchgrass, and yellow foxtail. The fields that contained shattercane were probably harvested early and sprayed immediately. Then shattercane emerged after the treatment. Glyphosate tended to miss certain weeds: barnyardgrass, carpetweed, common sunflower, common eveningprimrose, Pennsylvania smartweed, stinkgrass, wild buckwheat, witchgrass, and yellow foxtail. Witchgrass plants that were headed seem to be more difficult to control. Also, some weeds such as carpetweed, and stinkgrass may have emerged after the glyphosate had been applied. A new weed, *Panicum hillmanii* Chase, was identified in a stubble field near North Platte that had escaped a treatment of glyphosate plus atrazine at 0.45 + 2 lb/A. Paraquat plus atrazine failed to control barnyardgrass, fall panicum, large crabgrass, longspine sandbur, and yellow foxtail. In one field paraquat plus atrazine killed 4 foot common sunflower and kochia but yellow foxtail plants had regrowth. Many of the fields in western Nebraska had inadequate control of witchgrass. Most of these fields were sprayed with glyphosate. These fields may have been sprayed too late, sprayed with too low of a rate, or precipitation occurred before the glyphosate was rainfast.

In the fields that common milkweed and field bindweed were observed, spot treatment in September or early October should have occurred. Fall is an ideal time to treat perennial weeds with a herbicide.

This survey points out several areas of concern that need to be addressed in order to improve weed control in winter wheat stubble. Improve cultural practices in establishing the winter wheat crop. Select competitive wheat cultivars. Use efficient sprayers that can apply herbicides accurately. Apply herbicides in the growing wheat to greatly reduce broadleaf weeds. Scout fields so that the correct herbicide and rate can be used to control the weeds timely following wheat harvest. In many fields it is wise to make two applications, especially when winter annual weeds may be a problem.

An additional concern is that some weeds escape the post-harvest treatments. The major weeds that were missed were annual grasses (32%), kochia (11%), volunteer wheat (19%), and several other weeds (4%) (Table 4). Good weed management would improve control of these weeds.

Considerable improvement has occurred during the past 10 years in weed control following winter wheat harvest. In 1997, 7% of the fields were rate poor and 12% rated fair (Table 3), compared with 33% of the fields treated after harvest that were rated as unacceptable for weed control in 1986 (Wicks et al. 1989). This improvement is due to better spray equipment, educational programs for improving application, and probably more glyphosate being used. About 1% of the problem fields were directly associated with sprayers (Table 4). Strips of uncontrolled weeds in the field were caused by plugged tips, skips between spray swaths, or improper boom height. These problems could be reduced by using self-cleaning strainers, larger spray tips, improved marking systems, and adjusting the boom height or nozzle angle to match the weed height. Using 100% nozzle overlap would insure that all weeds would receive at least a half dosage if a plugged tip occurred. Undoubtably, some fields were double sprayed because of uncontrolled weeds or it was a planned program. The uncontrolled weeds may have been due to weeds under stress from being cutoff by the combine harvester, moisture stress, water logging, rain occurring before herbicides were rainfast, and wrong herbicide or rate used. Summer annual grass weeds continue to be a problem in 1997 as 34% of the problem fields did not have adequate control with similar results in 1996 (Wicks and Klein 1997).

Based on the surveys taken in 1996 and 1997 continual emphasis must be made to improve the competitiveness of winter wheat through better fallow procedures, selection of more adapted wheat cultivars, proper fertilization, and timely harvest. Herbicide selection should be based on the weed species present and their growth stage. Treating the fields twice should be considered in many areas. Lastly, there needs to be more effort to eliminate volunteer wheat in stubble fields before the new crop of wheat is planted in order to prevent leaf-curl mites from moving to the newly emerging wheat.

Table 3. Weed control ratings following winter wheat harvest across precipitation zones in Nebraska in 1997.

Control rating	Precipitation zones (inches) 16-18	18–23	23–28	28–34	Pivot corners[a]	Mean
	%					
Poor	7	4	11	5	9	7
Fair	8	12	14	10	14	12
Good	39	27	12	23	22	24
Excellent	46	57	63	62	55	57

[a]Only the first corner of the center pivot was included.

Table 4. Breakdown of the problem areas in controlling weeds after winter wheat harvest.

Annual grass[a]	Kochia	Volunteer wheat[b]	Other weeds[c]	Sprayed late	Wheat stand	Spray patterns
%						
32	11	19	4	21	12	1

[a]Includes barnyardgrass, bristly foxtail, fall panicum, green foxtail, large crabgrass, longspine sandbur, stinkgrass, witchgrass, and yellow foxtail.
[b]Includes downy brome.
[c]Includes carpetweed, common milkweed, common eveningprimrose, field bindweed, lanceleaf sage, Pennsylvania smartweed, redroot pigweed, shattercane, tall waterhemp, wild buckwheat.

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GIS-BASED ANALYSIS OF THE SPATIAL INTERACTION OF WHEAT STEM SAWFLY AND WILD OATS IN SPRING WHEAT. Sharlene E. Sing[1], Bruce D. Maxwell[1], and Sue L. Blodgett[2], Graduate Research Assistant and Professor, [1]Department of Plant, Soil and Environmental Sciences, [2]Department of Entomology, Montana State University, Bozeman, MT 59717.

Abstract. Throughout the 8 to12 week adult emergence period, wheat stem sawfly colonization of spring wheat spreads across the field, with oviposition beginning and continuing at the edge and occurring later and at a decreased density in the center of the field. Large, well-defined patches of wild oats occur within many of these fields. Dryland wheat yield in Montana's "Golden Triangle" can be significantly impacted by either of these pests and their effects may be amplified when they occur simultaneously. Three 10 ha farm site plots located within this region were GPS-mapped for wild oat patch location and density, and grid-sampled stems of both spring wheat and wild oats were dissected to develop a map of sawfly location and abundance. GIS analysis indicates that the spatial distribution of the wheat stem sawfly is locally variable and correlated with abiotic and biotic elements present in individual fields, but not exclusively with wild oat patches.

WETLANDS AND WILDLANDS

A VERY-LOW VOLUME HERBICIDE APPLICATION METHOD FOR VEGETATION MANAGEMENT IN CONSERVATION FORESTS. Philip Motooka, Guy Nagai, Galen Kawakami, and Lincoln Ching, Extension Specialist in Weed Science, University of Hawaii at Manoa, Kealakekua, HI 96750; Noxious Weed Specialist, Department of Agriculture, Lihue, HI 96766; Protection Forester, Division of Forestry and Wildlife, Department of Land and Natural Resources, HI 96766; and Extension Agent, University of Hawaii at Manoa, Lihue, HI 96766.

INTRODUCTION

Management of alien invasive plants in native forests and along forest trails is difficult and expensive because of their location in remote areas and rough terrain. Spraying at conventional spray-volume rates (SVR) of 20 to 30 gpa requires the transport of large volumes of water. Where vehicles cannot traverse, which includes the larger part of the forests, water has to be backpacked over long distances. Thus, a great deal of work must go into merely transporting water before spraying. Then during application, workers will have to carry a sprayer weighing 40 lb or more when full, and refill frequently. Kauai has 109 miles of trail in the state Na Ala Hele Trail System, trails dedicated to recreational and educational hiking. The Division of Forestry and Wildlife of the Hawaii Department of Land and Natural Resources (DOFAW) expended 12,000 worker-hours/yr to maintain those trails, with most of the effort directed at mechanical control of alien plants that obstruct the trails. This left little time for other tasks such as trash pickup, trail repair, native plant protection and outplanting native plants. Booms are impractical in forests but spraying with a single nozzle provides too narrow a spray swath to cover the width of a trail in a single pass. Thus, 1 mile of trail will be equivalent to 2 or more miles for the worker who has to spray each side of the trail separately. The logistical difficulty of transporting large volumes of water and the work involved in conventional spraying were major reasons preventing DOFAW from utilizing herbicides to their full potential. Instead, DOFAW has relied heavily on mechanical methods for vegetation management which was inefficient, ineffective, and dangerous. Reducing the carrier volume to very low rates and increasing the "throw" of the application equipment would solve the logistical problem and make herbicide applications in forests less laborious, much more efficient, and safer.

Shigeo Uyeda, weed control supervisor (retired) of the former McBryde Sugar Company, developed a very-low volume drizzle application system (Motooka et al. 1983) in which the conventional atomizing nozzle is replaced by an orifice disc. An orifice of 0.002 inch diameter was used in all work described herein. The applicator then delivers a fine straight stream which can be aimed at plants for very precise spot application or, by waving the wand, broadcast over a wide swath, up to 20 feet at a SVR as low as 1.5 gpa. Although the large, sparsely distributed droplets do not constitute an ideal herbicide deposition pattern, the method has been effective with several herbicides on many species. However, because of label restrictions, there are only two herbicides that can be applied by the drizzle method: triclopyr, a dicot killer, and the non-selective glyphosate. Other herbicides have been effectively applied by the drizzle method but their labels do not allow the application of the high concentrations required in very-low volume applications (Motooka et al. 1983, Motooka et al. 1993). Drizzle application is very efficient for a manual operation. A worker on foot can treat an acre in 0.5 hour in an open area or, on a trail 8 feet wide, 1mile in the same time. Where triclopyr in an aqueous carrier is ineffective in drizzle application, the herbicide in an oil carrier, especially a non-phytotoxic oil, may increase efficacy as Scifres et al. (1973) demonstrated with 2,4,5-T applied by conventional spraying on honey mesquite. Preliminary results (unpublished data) indicate that the efficacy of triclopyr applied by drizzle application to catsclaw and gorse is enhanced with an oil carrier. The very-low volume makes the use of oil carriers affordable.

Three major weeds impeding hikers in Waimea Canyon on Kauai were largeleaf lantana, Sacramento bur and sisal. Lantana is a prickly woody shrub tolerant of most hormone type herbicides. Sacramento bur is a shrub with prickly burs readily controlled by hormone type herbicides. Sisal, imported into Hawaii in the last century for a failed cordage industry, is a large plant with long fleshy leaves that cannot be pushed aside by hikers. Where it grows on the upper side of cliff side trails, it forces hikers to the edge of precipices if not controlled. Sisal was tolerant of aqueous sprays of triclopyr, glyphosate and hexazinone (unpublished data) but sensitive to conventional foliar sprays of triclopyr at 1 lb/A in diesel (HITAHR 1993).

A cooperative project between DOFAW, the Hawaii Department of Agriculture and the University of Hawaii at Manoa College of Tropical Agriculture and Human Resources, Cooperative Extension Service addressed the problem of herbicide applications for managing invasive alien plants and maintaining trails in remote areas of native forests. The objective was to evaluate and demonstrate the efficacy and efficiency of the drizzle method.

PROCEDURE

Trials were conducted to determine the susceptibility of lantana to herbicides applied in conventional sprays and by the drizzle method at Kokee, Kauai. Because lantana was tolerant of foliar applications of triclopyr (HITAHR 1989), the first trial was an evaluation of oil as an adjuvant. Triclopyr was applied at 1 lb/A in aqueous sprays emulsified with diesel at 2, 4 and 8% and a crop oil at 8% to plots 6 by 15 feet with a floodjet nozzle on an extended wand at an SVR of 18 gpa. A CO_2 powered sprayer was used in all trials, set at 40 psi for spraying with the extended wand and at 30 psi for drizzle application. There were four replicates. A followup application of the same respective treatments to each plot was applied at 5 MAT. A second trial to evaluate lantana response to glyphosate applied by a low volume conventional spray as above was also conducted. Plots 6 by 15 feet were treated with 1, 2, and 3 lb/A of glyphosate. There were three replicates. A final lantana trial was conducted to compare drizzle application of a 10 and 20% glyphosate solution (percentages of herbicides herein refer to commercial product), equivalent to 0.5 and 1 lb/A respectively, at a SVR of 1.5 gpa. The new label allows a concentration of no more than 10%.

In previous research sisal was susceptible to triclopyr in diesel carriers applied as broadcast sprays (HITAHR 1993). Its response to drizzle application was unknown. A trial was installed near Hanapepe, Kauai on sisal in which a 1% solution of triclopyr in either diesel or a crop oil carrier was applied with a drizzle applicator in a broadcast treatment at 1.5 gpa or as a directed application to the base of the apical shoot. There were four replicates of individual-plant plots.

A pilot trail maintenance project was conducted on a 3-mile segment of Koaie Trail in Waimea Canyon in which a mixture of triclopyr and glyphosate at 1 lb/A each was applied as a broadcast drizzle application on the trail to 8 feet wide. In addition, an 8% triclopyr in crop oil solution was applied in spot applications to a few sisal plants along the trail. A second application of both treatments was made at 12 MAT. Most of the remaining sisal was treated at that time. Labor and other costs were calculated.

RESULTS AND DISCUSSION

In the lantana trials all treatments in the oil adjuvants trial induced severe defoliation at both applications, the lantana recovered apparently without loss of vigor (data not presented) despite earlier trials that demonstrated that triclopyr applied in diesel as a basal bark treatment was effective (HITAHR 1993). On the other hand, glyphosate in the second trial was very effective as a conventional spray with glyphosate at 1 lb/A providing 90% control (Table 1). Apparently complete control was not achieved only because the lantana plants were large and the application was not sufficiently thorough. In the drizzle application trial (Table 2), defoliation by 0.5 and 1 lb/A of glyphosate were not significantly different. However, the lower rate resulted in greater survival of the stems at 5 MAT as evidenced by resprouting of leaf shoots. This suggested that glyphosate applications must be made at 1 lb/A or that less efficacy be accepted in the expectation that repeat treatments will ultimately provide complete kill. Further trials will determine if repeat applications of the lower rate of 0.5 lb/A will be as effective as a single application at 1 lb/A.

In the sisal trial, both oil carriers seemed equally effective and the apical treatment seemed at least as effective as the broadcast treatment (Table 3). Because of the moderate response of sisal to the 1% triclopyr concentration, a triclopyr concentration of 8% was used in the trail maintenance pilot trial.

Table 1. Largeleaf lantana response to glyphosate, at 4 MAT.

Rate	Defoliation
lb/A	%
0	0
1	90
2	95
3	98

Excluding check, means not significantly different.

Table 2. Largeleaf lantana response to glyphosate applied by the drizzle method.

Rate	Defoliation
lb/A	%
0	0
0.5	88
1	98

Excluding check, means not significantly different.

Table 3. Sisal response to drizzle applications of triclopyr in oil carriers, at 4 MAT.

Carrier	Application	Injury rating
		%
Diesel	Broadcast	52
Diesel	Apical	72
Crop Oil	Broadcast	72
Crop Oil	Apical	78

Means not significantly different.

The pilot trail maintenance trial conducted on 3 miles of Koaie Trail was treated in 3 hours. Backtracking was required to treat sisal because only one applicator was available. With four workers that amounted to 1.5 worker days, although only three workers would be necessary in a routine operation. At one year after treatment, lantana, Sacramento bur and sisal had not recovered, although there were carpets of seedlings of Sacramento bur at old sites of Sacramento bur infestations. Other weeds were also suppressed except grasses in sunny areas. In a prior attempt to clear this trail, DOFAW expended 12 worker-days to mechanically clear 0.5 miles. By extrapolation, 72 worker-days would have been required to clear 3 miles at a cost of $33,768, not including helicopter charges (Table 4). Because mechanical clearing required more workers and more operational days, helicopter charges were substantially greater for mechanical operations than for chemical treatments. Chemical control costs were 5% of the extrapolated mechanical control costs and probably would get lower with further treatments. The second application on Koaie Trail required 41% as much herbicide as the first. At 6 months after the second treatment, the entire length of the trail was cleared to the targeted 8 feet wide. In spots, Sacramento bur seedlings were infesting the edges and sides of the trail but were too young to be bearing burs. Hikers could comfortably walk the trail without being impeded by weeds. Furthermore mile markers, hidden by weeds since installation, were plainly visible again.

Chemical control was not only more effective than mechanical control, but longer lasting as well. Clearly, trail maintenance is possible with chemical methods but not with mechanical methods. Further extrapolating these data, drizzle treatments of the entire 109 miles of Na Ala Hele trail system on Kauai would require 167 worker hours per year, not including preparation, cleanup and travel, in contrast to the 12,000 worker-hours now required for inadequate mechanical maintenance. Of course, DOFAW cannot rely entirely on chemicals or on the drizzle method, but the efficiency provided by the drizzle method will allow them to redirect perhaps 90% of the resources formerly applied to vegetation management on trails to other conservation tasks. Furthermore the method can be utilized in their noxious weed management programs to increase their efficiency there. A potential problem is that glyphosate can be used only up to a 10% concentration which provides only 0.5 lb/A of glyphosate at a SVR of 1.5 gpa. Therefore, glyphosate applications will require a SVR of 3 gpa unless 0.5 lb/A proves as effective in repeat applications as the higher rate in a single application. Alternatively, lantana can be double dosed with the 10% solution. Grasses, the other target of glyphosate, can probably be controlled by 0.5 lb/A. The very-low volume method of application makes use of oil carriers affordable when an oil carrier is necessary as with triclopyr to control sisal. However, some crop oils are labeled for pesticide use and cannot be used as carriers unless allowed by the label. Other future work will evaluate the drizzle method in different ecozones and the feasibility of using two teams after initial weed suppression, each applying a different herbicide for selective vegetation management and to avoid the unnecessary release of herbicides into the environment.

Table 4. Comparative costs of mechanical and chemical methods of trail maintenance, 3 miles of Koaie Trail, Kauai.

Method	Labor	Labor	Helicopter	Herbicide	Total cost
	hr	$	$	$	$
Mechanical[a]	576	33,768	8,720	0	42,488
Spray[b]	40	2,345	1,600	123	4,068
Drizzle	4.5	263	436	123	822

[a]Extrapolated from mechanical clearing of 0.5 mile of trail.

[b]Hypothetical.

CONCLUSION

In order to protect native forests and trails from invasive alien plants, vegetation management must be made more efficient. The very-low volume drizzle herbicide application method can suppress weeds effectively and very efficiently and thereby allow the redirection of about 90% of the resources DOFAW formerly expended on mechanical vegetation management to other conservation activities. Moreover, the high efficiency of very-low volume application of herbicides makes vegetation management in remote areas of forests and on trials practical.

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WARM SEASON GRASS ESTABLISHMENT SYSTEMS. Roger L. Becker and Douglas W. Miller, Associate Professor and Extension Agronomist, and Scientist, Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN 55108.

Abstract. The objective of this study was to observe the effects of various herbicide treatments and cultural establishment methods on weed control, crop injury, and establishment of five warm season grass species. The experiment was repeated for 3 years at Rosemount, MN on a Waukegon silt loam soil. Big bluestem, sideoats grama, indiangrass, little bluestem, and switchgrass were seeded at rates of 10, 10, 10, 7, and 5 pounds pure live seed per acre, respectively. All seed was "de-bearded" to facilitate seeding. The experimental design was a split block. Whole plots were grass species planted in strips 5 feet wide. Sub plots consisted of preemergence (PRE) or postemergence (POST) herbicide treatments or combinations of oat cover crop and clipping treatments. The sub plot treatments were applied to strips 10 feet wide across the five grass species. Plant residue was removed from the plot for the oat companion plus clip treatment but was left on the plot area following the subsequent clipping, and was left on the plots for each clipping of the no herbicide or companion crop plus clip treatment. Residual yields were determined by harvesting a 21 ft^2 area within each plot the following year. Percentages of warm season grasses, broadleaf and grass weeds were determined by visual observation and hand separations.

Imazapic (AC 263,222) application resulted in poor stands of switchgrass the seeding year at all rates tested (0.047, 0.063, 0.125, 0.188 lb/A) but the lower rates did cause less injury applied PRE or POST based on stand establishment. The 0.63 and 0.47 lb/A rate of imazapic applied PRE resulted in less stand reduction compared with POST applications and resulted in the highest residual forage yield. Little bluestem showed poor to moderate tolerance to imazapic with stand reductions of 43% or more in 1996, for example, with stand reduction reduced to 27% at the lowest rate, 0.047 lb/A, by the second year. There was a slight trend for improved establishment of little bluestem with PRE application of imazapic. Big bluestem showed excellent tolerance to imazapic applied either POST or PRE at all rates tested. By the end of the establishment season, big bluestem stands typically ranged from 61 to 91% of full stand in 1996, for example. Yields did not differ within application method across rates. Indiangrass showed moderate tolerance to imazapic. Rates of imazapic of 0.063 lb/A or lower resulted in the best stands and residual yield. Slightly better stands, but clearly better residual year forage yields were obtained with PRE applications.

Imazamox (0.047 lb/A) PRE and POST resulted in moderate to excellent stands of all grass species tested. Little bluestem and indiangrass had the least tolerance with establishment year season end stands reduced 36 to 52%. Tolerance of switchgrass, sideoats grama, and big bluestem was good to excellent at the 0.047 lb/A rate tested whether applied PRE or POST. High residual forage yields were obtained with all species. Imazethapyr (0.063 lb/A) resulted in moderate stands of little bluestem, indiangrass, and switchgrass. Tolerance was equal to or better for each of these species when applied PRE compared with POST. Big bluestem and sideoats grama had good to excellent tolerance to imazethapyr whether applied PRE or POST. Residual year yields were high relative to other treatments with imazethapyr despite stand and growth reductions. Yields were equal to or higher with PRE applications compared with POST.

Use of metsulfuron-methyl (0.018 lb/A) resulted in very poor stands of indiangrass the establishment year when applied POST and poor indiangrass stands applied PRE. Both application methods resulted in more than 70% stand reduction the second year. Little bluestem also showed moderate and poor tolerance to metsulfuron applied PRE and POST, respectively. Switchgrass, sideoats grama, and big bluestem showed good tolerance POST and good to excellent tolerance PRE to metsulfuron. The use of an atrazine standard (2 lb/A) resulted in poor to moderate stands of little bluestem and indiangrass. Sideoats grama showed moderate to good tolerance and switchgrass and big bluestem good tolerance to atrazine. Residual year yields reflected establishment year crop tolerance with the best yield within species with atrazine on switchgrass.

Use of no herbicide and allowing weeds to complete with warm season grasses resulted in poor stands of all species in two of three years depending on soil moisture during seedling germination and emergence. Switchgrass, big bluestem and to a lesser degree, sideoats grama produced good residual year forage yields with clipping without herbicide use to manage weeds. Indiangrass and little bluestem did not result in acceptable yields without herbicide use.

Weed control was excellent with all rates of imazapic tested applied PRE or POST, with the exception of POST treatments giving poor to fair control of common lambsquarters. Imazamox provided excellent control of eastern black nightshade and redroot pigweed applied PRE or POST, fair control of giant foxtail, common lambsquarters, and velvetleaf applied PRE, and fair to good control of common lambsquarters POST. Imazethapyr provided excellent control with the exception of poor common lambsquarters control POST, and fair to good velvetleaf control PRE. Metsulfuron and atrazine provided only moderate suppression of giant foxtail, but enough to release warm season grass seedlings. Metsulfuron appeared to release eastern black nightshade from competition with other weeds as well, which would be a toxicity concern if seedbanks were present and the site would be grazed the establishment year. Clipping provided fair control of weeds.

BAY FOE 5043 PLUS METRIBUZIN: A POTENTIAL NEW HERBICIDE FOR SEED GRASSES. J. W. Warren, A. C. Scoggan, and J. R. Bloomberg, Bayer Corporation, Kansas City, MO 64120.

Abstract. BAY FOE 5043 plus metribuzin is a new graminicide under development by Bayer Corporation for weed control in seed grasses grown in the Western United States. This product has been shown to have potential for the selective preemergence and early postemergence control of a number of important problem grasses including annual bluegrass, rattail fescue, ventenata and volunteer crop seed grasses. Seed grasses which are tolerant to BAY FOE 5043 plus metribuzin are perennial ryegrass, fine fescue, tall fescue, highland bentgrass, orchardgrass and Kentucky bluegrass. Bayer Corporation will market BAY FOE 5043 plus metribuzin as a prepackage mix containing 4 parts BAY FOE plus 1 part metribuzin under the trade name AXIOM. AXIOM will be formulated as a 68% dry flowable (DF). Suggested use rates for weed control in seed grasses are 0.38 to 0.55 lb/A.

THE EFFECTIVENESS OF MOWING AND HERBICIDES TO CONTROL PERENNIAL PEPPERWEED IN RANGELAND & ROADSIDE HABITATS. Mark J. Renz and Joseph M. DiTomaso, Graduate Research Assistant and Cooperative Extension Specialist, Weed Science Program, Department of Vegetable Crops, University of California, Davis, CA 95616.

Abstract. Perennial pepperweed (tall whitetop) can establish large monocultural stands in many different habitats throughout the west. Experiments were initiated to evaluate the use of mowing and herbicides as a potential new control strategy in rangeland and roadside habitats. These experiments consisted of mowing perennial pepperweed once or twice per season at the flower bud stage, and then applying a herbicide to the recovering stems when they returned to the flower bud stage. Unmowed areas were treated with herbicides at the flower bud stage. In rangeland situations the use of herbicides with one mow generally increased the level of control and significantly reduced the amount of litter present from 10 to 5 cm. Chlorsulfuron at 0.052 kg/ha provided excellent control (98%) after one year. Along roadsides, first year data indicates that imazapyr at 0.138 kg/ha, and 1 to 2 mows followed by glyphosate at 3.33 kg/ha or chlorsulfuron at 0.052 kg/ha will also provide excellent control ($\geq$ 91%). 2,4-D at 2.109 kg/ha did not provide adequate control (< 72%) even when used in conjunction with mowing in either habitat. These data indicate that mowing can increase the effectiveness of some herbicides in controlling perennial pepperweed by depleting below ground energy reserves.

DIRECTING SUCCESSION THROUGH NUTRIENT AVAILABILITY. Gretchen Herron and Roger Sheley, Graduate Research Assistant and Assistant Professor, Department of Plant, Soil, and Environmental Science, Montana State University, Bozeman, MT 59717.

Abstract. Successional trajectories may be altered or halted as a result of introduction of noxious weeds into a native plant community. Nutrient availability to plants may be used to accelerate succession away from spotted knapweed. Early successional plant communities often have high nutrient availability, whereas late-successional communities are often found on lower nutrient soils. We hypothesized that removal of nutrients will change the competitive advantage from spotted knapweed to bluebunch wheatgrass (late seral). In two addition series matrices, background densities of annual rye and bottlebrush squirreltail (3,000 seeds/m^2) were used to remove nutrients from the soil. In another set of addition series matrices, nitrogen and phosphorus (66 kg/ha) were added to the soil. Nutrient analysis of soil and vegetation indicates that annual rye and bottlebrush squirreltail reduced nutrient availability in soils. In another matrix, neither a background density nor nutrients were added. Data were fit into Watkinson's curvilinear model to determine the competitive relationship between bluebunch wheatgrass and spotted knapweed. Without nutrient manipulation, spotted knapweed was more competitive than bluebunch wheatgrass. The competition coefficient for predicting bluebunch wheatgrass was 0.17. Annual rye changed the competitive balance in favor of bluebunch wheatgrass (competition coefficient = 9.9). Addition of nitrogen, phosphorus, or the midseral species did not change the competitive relationship between the two species. This preliminary study suggests that succession from spotted knapweed to bluebunch wheatgrass may be accelerated by altering resource availability.

DESIGNING WEED-RESISTANT PLANT COMMUNITIES BY MAXIMIZING COMMUNITY STRUCTURE AND RESOURCE CAPTURE. Michael F. Carpinelli, Roger L. Sheley, and Bruce D. Maxwell, Graduate Research Assistant, Assistant Professor, and Associate Professor, Department of Plant, Soil, and Environmental Sciences, Montana State University, Bozeman, MT 59717.

Abstract. In order to develop an ecological basis for designing weed-resistant plant communities, we tested the hypothesis that susceptibility to weed invasion is determined by temporal and spatial resource availability, and by the ability of weeds to capture those resources. In two multiple replacement series experiments, each replicated

twice, three desirable species (crested wheatgrass, intermediate wheatgrass, and alfalfa), and one weed (spotted knapweed) were used to determine the potential for predicting community structure and dynamics and weed invasion based on species growth, phenology, and root distribution. In both experiments, the number of desirable species present varied, while the total number of desirable plants was held constant. In one experiment, spotted knapweed was fall-sown (500, 1000, 1500, and 2000 seeds per m^{-2}) into a series of communities where the desirable species (total of 60 plants per m^{-2}) were established for 2 years. In the following growing season, soil water use was positively correlated with number of desirable species. Spotted knapweed establishment, survival, and growth were not correlated with soil water use by desirable species for those depths where soil water content was monitored. We suspect that the amount, type, and distribution of litter present at the time of sowing had an overwhelming influence on the microclimate affecting spotted knapweed germination and establishment. In another experiment, spotted knapweed (500, 1000, 1500, and 2000 seeds per m^{-2}) and the three desirable species (total of 2000 seeds per m^{-2}) were spring-sown simultaneously and harvested at the end of the second growing season. For a given level of spotted knapweed density, soil water use was positively correlated with number of desirable species and spotted knapweed production was negatively correlated with number of desirable species.

LEAFY SPURGE CONTROL WITH FLEA BEETLES (*APHTHONA* SPP.). Donald R. Kirby and Robert B. Carlson, Professors, Department of Animal and Range Sciences and Department of Entomology, North Dakota State University, Fargo, ND 58105.

Abstract. Leafy spurge is a persistent introduced plant from Eurasia that infests millions of acres of rangelands in the United States. It would appear to be a prime candidate for biological control efforts because it is a perennial plant providing a continuous source of food to controlling organisms and it has a propensity to invade a variety of habitats such as grasslands, woodlands, riparian areas and waterways where alternative control efforts may have limited usage. Eight insects for leafy spurge control have been released in North Dakota with the root-feeding flea beetles being the most successfully established.

A study was initiated in 1988 and evaluated in 1995 to determine the effects of flea beetle releases on above- and belowground characteristics of leafy spurge infested rangeland at two locations in southeastern North Dakota. Aboveground, leafy spurge cover and density were reduced approximately 7 and 5 fold, respectively, on both insect influenced study sites. Leafy spurge yields in insect released areas were reduced to approximately 10% of the controls while grass yields increased approximately 50% over the controls.

Belowground feeding of flea beetle larva reduced leafy spurge root density and dry weight in the top 6 inches of soil by nearly 75% over controls. Reproduction by root buds would also be severely reduced in flea beetle released areas as root bud density declined over threefold in the top 6 inches of soil.

Table 1. Aboveground effects of flea beetle releases on leafy spurge-infested rangeland.

	Leafy spurge[a]						Grass yield[a]	
	Foliar cover		Density		Yield			
	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
	%		No./yd²		lb/A		lb/A	
Control	52.1a	39.4a	191a	196a	1101a	1123a	925a	854a
Insect releases	6.9b	6.7b	46b	32b	130b	67b	1384b	1336b

[a]Means in a column followed by a different letter differ (P >0.05).

REVEGETATION OF LEAFY SPURGE-INFESTED GRASSLANDS WITH NATIVE GRASS AND LEGUME MIXTURES. Daniel D. Beran[1], Robert A. Masters[1], and Roch E. Gaussoin[2], Research Assistant and Rangeland Scientist, USDA-ARS, and Associate Professor, [1]Department of Agronomy and [2]Department of Horticulture, University of Nebraska, Lincoln, NE 68583.

Abstract. Leafy spurge is a non-endemic perennial weed in the northern and central Great Plains that reduces rangeland carrying capacity by competing with desirable forages and rendering infested areas undesirable to cattle. This noxious weed threatens diversity of grassland communities by displacing native plants. Research was conducted to determine the feasibility of using herbicides to control leafy spurge and resident vegetation and to facilitate seeding and establishment of native warm-season grass and legume mixtures. Imazapic (AC 263,222) at 0.14 and 0.21 kg/ha were applied in combination with glyphosate at 1.6 kg/ha in early October 1995 at separate locations within leafy spurge-infested range sites near Ansley and Tilden, Nebraska. Study locations were burned in late April 1996 and 1997 to remove plant residue that would otherwise interfere with planting seeds into the herbicide-suppressed sod. Mixtures containing the grasses, big bluestem, switchgrass, indiangrass, little bluestem, and sideoats grama, and the legumes, Illinois bundleflower and purple prairieclover, were no-till planted at 440 pure live seed/m^2 in April 1996 at each location. These native plants were seeded because they are adapted to the Great Plains and provide productive, high quality summer forage and wildlife habitat. Yield and frequency of the planted mixtures and leafy spurge yield and density were measured in August 1997. Grass and legume establishment and leafy spurge suppression were greatest where imazapic and glyphosate were applied in combination before planting compared to where glyphosate or no herbicide were applied.

EVALUATION OF AC 263,222 FOR LEAFY SPURGE CONTROL. Denise M. Markle and Rodney G. Lym, Graduate Student and Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Abstract. AC 263,222 (imazapic), formerly known as imazameth, has shown promise for leafy spurge control in North Dakota. However, grass injury especially to cool season species has been observed. The labeled rate for optimal leafy spurge control is AC 263,222 at 2 oz/A, applied with a methylated seed oil and nitrogen fertilizer 2 weeks before a killing frost. The objectives of this research were to evaluate AC 263,222 applied with and without adjuvants and applied in the mid-summer or fall to maximize leafy spurge control with minimal grass injury.

The first experiment evaluated AC 263,222 applied in the mid-summer or fall for leafy spurge control at locations near Valley City and Jamestown, ND. Mid-summer treatments were applied to the flowering stage of leafy spurge in early July and fall treatments during regrowth in September. The treatments included AC 263,222 at 2 or 4 oz/A alone, or at 1 or 2 oz/A plus methylated seed oil (MSO) at 1 qt/A applied in mid-summer or fall. The standard treatments for comparison were picloram plus 2,4-D at 4 plus 16 oz/A applied in mid-summer, or at 8 plus 16 oz/A applied in the fall. Mid-summer treatments were reapplied when leafy spurge control was 70% or less 12 months after treatment (MAT). All treatments at Jamestown were reapplied, but only two treatments (AC 263,222 at 1 oz/A plus MSO and AC 263,222 at 2 oz/A) were reapplied at Valley City.

Leafy spurge control with AC 263,222 applied in mid-summer increased from 3 to 10 MAT. AC 263,222 did not visibly control leafy spurge topgrowth 3 MAT, regardless of rate or adjuvant. However, AC 263,222 at 4 oz/A alone or 2 oz/A plus a MSO averaged 90% control 10 MAT. Grass injury 10 MAT at Valley City averaged 28%, but was not visible at Jamestown. AC 263,222 at 4 oz/A provided 82% control 15 MAT, but 4 oz/A is twice the labeled rate.

AC 263,222 provided better leafy spurge control when applied in the fall than mid-summer. All fall-applied AC 263,222 treatments 9 MAT averaged 100% control and 22% grass injury. AC 263,222 at 4 oz/A alone or 2 oz/A plus a MSO maintained 96% control 12 MAT with no grass injury.

The second experiment evaluated AC 263,222 applied with or without adjuvants near Walcott, ND. The treatments were AC 263,222 at 1 or 2 oz/A alone, or with 1 qt MSO, 1 qt 28% N, or 1 qt MSO plus 1 qt 28% N.

Picloram plus 2,4-D at 8 plus 16 oz/A was applied as a standard treatment. Treatments were applied September 4, 1996, to leafy spurge at the fall regrowth stage. Herbage and leafy spurge were harvested 10 MAT, and dry weights were obtained to evaluate the effect of AC 263,222 on herbage and leafy spurge yield.

AC 263,222 provided better leafy spurge control at 2 oz/A than at 1 oz/A, but a MSO was necessary to provide long term control. AC 263,222 at 2 oz/A, regardless of adjuvant, and AC 263,222 at 1 oz/A plus MSO averaged 98% leafy spurge control 9 MAT. Leafy spurge control 12 MAT was the best with AC 263,222 at 2 oz/A plus MSO and AC 263,222 at 2 oz/A plus MSO plus 28% N, which averaged 66% with only 6% grass injury.

AC 263,222 plus MSO decreased leafy spurge dry weight more than the herbicide alone at comparable rates. For example, leafy spurge yield with AC 263,222 at 1 oz/A plus MSO averaged 13 g/m^2 versus 74 g/m^2 at the same rate alone. In addition, AC 263,222 at 2 oz/A plus MSO alone or with 28% N decreased leafy spurge dry weight by 91 and 93%, respectively, compared to only a 55% reduction with AC 263,222 at 2 oz/A alone. All treatments 10 MAT tended to decrease herbage dry weight an average of 10% compared to the control.

In summary, AC 263,222 provided better control when applied in the fall compared to mid-summer. AC 263,222 plus MSO provided better leafy spurge control than AC 263,222 alone. In general, grass injury was minimal by 12 MAT regardless of treatment.

INTEGRATION OF HERBICIDES WITH THE BIOLOGICAL AGENT *APHTHONA NIGRISCUTIS* FOR LEAFY SPURGE CONTROL. Jeff A. Nelson, Rodney G. Lym, and Calvin G. Messersmith, Graduate Research Assistant and Professors, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Abstract. *Aphthona nigriscutis* is a flea beetle introduced for biological control of leafy spurge. *Aphthona nigriscutis* has reduced the density of leafy spurge at many locations. However, there are locations where *A. nigriscutis* has not established or is found at densities too low to be effective. Therefore, it may be necessary to integrate biological and chemical control to reduce leafy spurge densities to non-economic levels. The objective of this experiment was to evaluate the integration of picloram plus 2,4-D and *A. nigriscutis* for leafy spurge control.

Experiments were conducted at Chaffee and Fort Ransom, North Dakota. Approximately 450 *A. nigriscutis* were released into 1.8 by 1.8 by 1.8 m cages. Picloram plus 2,4-D at 0.56 plus 1.1 kg/ha were applied on four dates, August 15, September 1 or 15, or October 1. There were two additional treatments, a flea beetle only and a check (no flea beetles and no herbicide). Cages were not returned to plots the following year so flea beetles could disperse throughout the experiment. The experiment at each location was repeated the following year on leafy spurge without prior introduction of flea beetles.

The density of leafy spurge was estimated counting the number of stems in a 0.25 m^2 frame. The effect of picloram plus 2,4-D on the *A. nigriscutis* population was estimated by counting the number of adults emerging in the field. A standard insect sweep was used to collect *A. nigriscutis* from the caged plot area including a portion of the border for a total of 4.5 m^2. Counts of flea beetles from the check were used to determine beetle dispersal within the experiment. *Aphthona nigriscutis* was collected and counted from experiments in 1996 and 1997. Collected flea beetles were returned to the plot.

Stem density 12 months after treatment was similar across all four herbicide application dates. However, there was a 30% reduction in number of flea beetles collected from plants when sprayed on October 1 compared to August 15. Counts of flea beetles were similar from the flea beetle only, and where herbicides were applied on August 15 or September 15. Picloram plus 2,4-D applied August 15 through September 15 will be least injurious to the *A. nigriscutis* population. Few flea beetles were collected in the checks both across locations and years. Thus, the probability is low that flea beetle dispersal affected individual treatment counts.

Leafy spurge density was lowest when picloram plus 2,4-D were applied to leafy spurge infested with *A. nigriscutis* compared to herbicides or *A. nigriscutis* alone. This integrated treatment had an additive effect for leafy spurge control and is beneficial in those areas where the flea beetles have been ineffective.

BASIC SCIENCES, ECOLOGY, BIOLOGY, PHYSIOLOGY, GENETICS AND CHEMISTRY

THE ABSORPTION, TRANSLOCATION, METABOLISM, AND SOIL ACTIVITY OF QUINCLORAC IN FIELD BINDWEED (*CONVOLVULUS ARVENSIS* L.). Stephen Enloe[1], Scott Nissen[1], Philip Westra[1], Gus Foster[2], Vince Ulstad[2], Reggie Sterling[2], and John Hardin[2], Graduate Research Assistant, Associate Professor, Professor, Field Biologist, Field Biologist, Field Biologist, and Technical Manager, [1]Department of Bioagricultural Science and Pest Management, Colorado State University, Ft. Collins, CO 80523; and [2]BASF Corporation, P.O. Box 13528, Research Triangle Park, NC 27709.

Abstract. Laboratory and greenhouse experiments were conducted to examine the absorption and fate of quinclorac in field bindweed and determine the importance of quinclorac soil activity for bindweed toxicity. Foliar absorption of ^{14}C-quinclorac was nearly 0 when applied alone but increased to 24% when ^{14}C-quinclorac was applied with 2,4-D, 28% urea ammonium nitrate, and methylated seed oil. Quinclorac translocation was limited as >75% of the absorbed radiolabeled material remained in treated leaves 168 hours after treatment. Less than 5% of the absorbed material was found in any other plant part analyzed. Quinclorac metabolism in the treated leaves was limited as 95% of the recovered ^{14}C was intact herbicide. Greenhouse experiments examined the efficacy of preemergence and subsurface layering of quinclorac on field bindweed. Plants were harvested 45 days after treatment. Field bindweed shoot growth was reduced by 97, 95, 86, and 61% when plants emerged through a surface layer treated with 280, 140, 70, and 35 g ha^{-1} quinclorac, respectively. Field bindweed shoots exhibited auxin type herbicide symptoms at all rates of quinclorac applied. Subsurface layering of quinclorac below the root system at 280 g ha^{-1} reduced shoot and root growth by 69 and 53%, respectively, while 35 g ha^{-1} reduced shoot and root growth 38 and 12%, respectively. Both herbicide rates induced malformation in root structure with a proliferation of lateral branching, swollen and fused root tips, and malformed root buds. Shoot growth from surviving roots replanted in untreated medium was also reduced in both herbicide treatments.

SITE-TO-SITE AND YEAR-TO-YEAR VARIATION IN WINTER WHEAT-JOINTED GOATGRASS INTERFERENCE PARAMETERS. Marie Jasieniuk[1], Bruce D. Maxwell[1], Randy L. Anderson[2], John O. Evans[3], Brian M. Jenks[4], Drew J. Lyon[4], Stephen D. Miller[5], Don W. Morishita[6], Alex G. Ogg, Jr.[7], Steven Seefeldt[8], Phillip W. Stahlman[9], Philip Westra[10], and Gail Wicks[11], [1]Montana State University, Bozeman, MT 59717; [2] USDA-ARS, Akron, CO 70720; [3]Utah State University, Logan, UT 84322; [4]University of Nebraska, Scotsbluff, NE 69361; [5]University of Wyoming, Laramie WY 82071; [6]University of Idaho, Twin Falls, ID 83301; [7]P.O. Box 53, Ten Sleep, WY 82442; [8]USDA-ARS, Pullman, WA 99164; [9]Kansas State University, Hays, KS 67601; [10]Colorado State University, Fort Collins, CO 80523; and [11]University of Nebraska, North Platte, NE 69101.

Abstract. The crop yield loss-weed density relationship critically influences economic threshold values and the resulting management recommendations made by a bioeconomic model. To examine site-to-site and year-to-year variation in winter wheat-jointed goatgrass interference relationships, the standard, negative hyperbolic yield loss function was fit to 31 data sets from multi-year field experiments conducted at CO, ID, KS, MT, NE, UT, WA, and WY. Two parameters: i, which represents the percent yield loss as jointed goatgrass density approaches zero, and a, the maximum percent yield loss as goatgrass density becomes very large, were estimated for each data set using nonlinear regression. Both i and a did not vary across winter wheat varieties within years when two locally adapted varieties were included in experiments at a specific site. Parameter i was stable across years at seven sites, but varied significantly across years at two sites. Parameter a exhibited greater variation than i. It was stable across years at five sites, but varied across years at four sites. Both parameters varied across sites in 1995 and 1996. The site-to-site and year-to-year variation in interference parameters indicates considerable economic risk is associated with management recommendations made by a bioeconomic model which uses a single economic threshold for the winter wheat-producing region. The predictive ability of such a model will only be improved when factors causing the variation in parameter estimates are built into its structure.

POTENTIAL FOR GENE TRANSFER BETWEEN WHEAT AND JOINTED GOATGRASS. Jennifer L. Hansen[1], Robert S. Zemetra[2], and Carol Mallory-Smith[2], Scientific Aide Sr., Associate Professor and Assistant Professor, [1]Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83844 and [2]Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331.

Abstract. Jointed goatgrass is a major weed in the wheat producing areas of the western United States. One method proposed to control jointed goatgrass is the use of herbicide resistant wheat. Of concern is whether a herbicide resistance gene could be transferred from wheat to jointed goatgrass. Jointed goatgrass shares the D genome with wheat and interspecific hybrids between the two species occur in the field. A backcrossing program was initiated in the greenhouse between wheat x jointed goatgrass hybrids and either jointed goatgrass or wheat to determine the potential for seed set and the restoration of self-fertility. Seed was set by backcrossing with either species as the recurrent parent. Female fertility increased from 2% in the hybrid to 37% in the BC_2 plants with jointed goatgrass as the recurrent parent. Partial self-fertility was restored in the second backcross (BC_2) generation following backcrossing by jointed goatgrass. Seed set in BC_2S_1 plants ranged from 0% to 73%. The level of self-fertility in the BC_2S_1 plants was partially related to chromosome number. This indicates that genes could be transferred between wheat and jointed goatgrass after only two backcrosses. An additional backcross was necessary to restore self-fertility when wheat was used as the recurrent parent. The number of bivalents observed in the plants during meiosis appeared to be key to increasing female fertility and self-fertility. Based on the results of this study, it is possible for genes to move from wheat to jointed goatgrass and the release of a herbicide resistant wheat should be accompanied by a management plan that would minimize the potential for gene movement between these species.

INTROGRESSION BETWEEN *AEGILOPS CYLINDRICA* AND *TRITICUM AESTIVUM*. Jeremy R. Snyder, Carol A. Mallory-Smith, Jennifer L. Hansen, Sarah Balter, and Robert S. Zemetra, Graduate Student and Assistant Professor, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331-3002 and Scientific Aide Senior, Undergraduate Student, and Associate Professor, Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83844.

Abstract. Jointed goatgrass (*Aegilops cylindrica*) is a problem weed of winter wheat (*Triticum aestivum*) production areas. Because wheat and jointed goatgrass are closely related and share a genome, hybrids occur naturally in the field. In 1996 and 1997, field studies were conducted to determine the rate at which seeds were produced on wheat x jointed goatgrass hybrids in varying populations of jointed goatgrass and wheat. The subsequent germination rate of the seeds also was determined. In a second study, BC_1 plants were planted in the field in a population of jointed goatgrass to determine seed production and germination. In 1996, the highest average seed set per hybrid plant was 104 seeds/plant, occurring in a pure jointed goatgrass plot. Seeds were produced in all plots, ranging from 0 to 7 seeds/head. In 1997, the highest average seed set per plant was 55.5 seeds/plant, occurring in a pure wheat plot. Seeds were again produced in all plots. Seed production ranged from 0 to 11 seeds/head. The parent population had no effect on germination rate of seeds produced on hybrids in 1996, averaging 87.8%. Seeds also were produced in the BC_1 study, ranging from 0.25 to 5.23%. Seeds were produced in an average of 2.5% of florets, and seeds were produced in all plots. These results indicate that viable seed will be produced on wheat x jointed goatgrass hybrids and subsequent backcross generation plants under natural conditions.

POPULATION SAMPLING TO MONITOR THE PHENOTYPIC RESPONSE OF KOCHIA TO DICAMBA. Kirk A. Howatt, Philip Westra, Scott J. Nissen, and Gus Foster, Research Assistant, Associate Professor, and Associate Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523-1174 and Field Development Research Specialist, BASF, Fort Collins, CO 80524.

Abstract. Kochia populations have historically exhibited a differential response to dicamba applications resulting in less than 100% control. However, dicamba has exhibited good control of kochia, whether the kochia population is resistant to other chemicals or not. In recent years, concern has arisen regarding kochia populations that do not exhibit traditional response to dicamba. To retain dicamba as an effective kochia management tool, kochia populations are being examined to understand the historical response to dicamba. Five sites were selected based on the kochia's response to dicamba. From these sites, seed was collected from 90 plants located in and around an agronomic field. This seed was grown in greenhouse flats and treated with 0.062 and 0.125 lb/A dicamba when the plants reached the 8- to10-leaf stage. Plant response was evaluated 28 days after treatment. Plants were individually rated for visual per cent control using a range from 0 for unaffected plants to 100 for death. Kochia response was averaged within each mother plant and replication to obtain a control rating for the original field plant. This resulted in a field population response as well as a plant progeny response. Field populations that have exhibited reduced control with dicamba contain a large proportion of susceptible plants. Seed from a single kochia plant varies widely in the proportion of progeny that survive and in the vigor of those survivors when treated with dicamba.

DIFFERENTIAL GENE EXPRESSION PATTERNS IN SUSCEPTIBLE AND DICAMBA-RESISTANT KOCHIA. Anthony J. Kern, Harwood J. Cranston, and William E. Dyer, Graduate Research Assistant, Graduate Research Assistant, and Associate Professor, Department of Plant, Soil and Environmental Sciences, Montana State University, Bozeman, MT 59717-0312.

Abstract. Dicamba is a selective auxinic herbicide used to control broadleaf and perennial weeds in cereal crops. In 1995, populations of kochia (*Kochia scoparia* L. Schrad) were identified in Montana that were resistant (R) to dicamba treatment at field use rates. Previous studies in our lab showed that dicamba resistance in kochia was not due to altered herbicide uptake, translocation, or metabolism patterns. Because the auxinic herbicides are thought to mimic the natural phytohormone indole-3-acetic acid (IAA) which is known to elicit rapid changes in gene expression, we reasoned that altered gene expression in R kochia after dicamba treatment may be associated with and possibly responsible for the R phenotype. Therefore, we treated 5-cm tall greenhouse-grown R and susceptible (S) kochia seedlings with the recommended field rate of dicamba and harvested shoot tissue 0, 30, 60, 90, and 120 minutes after treatment. To isolate differentially expressed genes, we used mRNA differential display to obtain mRNAs that were either up-regulated or attenuated in R seedlings shortly after treatment. Consistent with similar studies using IAA, dicamba caused dramatic and rapid changes in gene expression. Northern blot analysis was used to confirm differential transcript accumulation levels, and nucleic acid sequences for several candidate clones have been obtained.

GROWTH ANALYSIS OF WEED SEEDLINGS. Khalid F. Al-Sayagh and Robert L. Zimdahl, Graduate Student, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331 and Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523.

Abstract. Experiments to determine growth of seedlings of eight annual weeds were conducted. The objective was to determine the pattern of growth and the end of the seedling stage for each weed. Analysis included length and area of roots and stems, leaf number, total leaf area, and dry weight over time. The experiment was conducted twice in the greenhouse and twice in the field. Growth pattern of all weed components was exponential except root

elongation of redroot pigweed, kochia, and black nightshade that were linear in green house experiments. Shoot dry weight was the best indicator of the growth pattern of weed seedlings. Two-phase linear regression was used to detect differences in shoot dry weight over time. The seedling stage ended and the juvenile stage began when the rate of change in shoot dry weight increased after emergence.

WEEDS @ LTRAS: THE EARLY YEARS. Robert F. Norris and R. Ford Denison, Associate Professors, Weed Science Program, Department of Vegetable Crops, and Department of Agronomy and Range Science, University of California, Davis, CA 95616.

Abstract. The University of California at Davis initiated a multidisciplinary 100-year experiment in the fall of 1993 under the title of Long Term Research in Agricultural Systems (LTRAS). The main objectives of the project are to evaluate level of irrigation (rainfed only, rain plus supplemental irrigation, or fully irrigated) and nitrogen fertility (none, full synthetic, or nitrogen fixed by legume cover crops) on long term agroecosystem sustainability. An organic system is also included. A list of treatments is provided in Table 1. All rotations are for 2 years, and both entry points were used when the experiment was initiated. Plot size is 0.4 ha, and each treatment is replicated three times.

Table 1. Treatment list for long term research in agricultural systems project.

Treatment No.	Crop rotation Year 1	Year 2	Irrigation	Nitrogen fertility
1	Wheat	Fallow	Rainfed	None
2	Wheat	Fallow	Rainfed	Full
3	Wheat	Green fallow	Rainfed	Winter legume cover crop
4	Wheat	Fallow	Supplemental	None
5	Wheat	Fallow	Supplemental	Full
6	Wheat	Green fallow	Supplemental	Winter legume cover crop
7	Wheat	Tomatoes	Full	Full
8	Corn	Tomatoes	Full	Full
9	Corn	Tomatoes	Full	Winter legume cover crop
10	Corn	Tomatoes	Full	Organic system

The nature of the differences in rotation and cultural practices offer the possibility to evaluate the impacts of the treatments on weed population dynamics. At initiation a set of soil samples were collected from each plot. Weed seeds were germinated or extracted, identified, and counted to provide a base-line weed population in each plot at initiation. Since that time weed counts have been made, by species, prior to weed management practices in each crop, and prior to harvest, to evaluate changes in weed populations. Overall weed populations have declined in all the wheat/fallow rotations; this is attributed to annual applications of herbicides to control broadleaf weeds in the crop cycle and non-selective herbicide application during the fallow year. Wild oat and canarygrass are present at low density and the population has been maintained at low levels by hand roguing. Weeds have been more prevalent prior to harvest in the supplemental irrigated wheat plots that do not receive nitrogen fertilizer; this is attributed to water late in the season applied to a crop with relatively poor canopy development. The use of the winter legume cover crop appears to be increasing the incidence of common chickweed in the treatments which receive nitrogen using this technique. In the fully irrigated rotations the frequency of occurrence of barnyardgrass has increased. Overall weeds have increased in the corn/tomato rotation that employs the winter legume cover crop for nitrogen supply. A 10-fold increase in weeds in the organic rotation has occurred in comparison with the similar conventional rotations. Redroot pigweed now dominates the organic rotation, and black nightshade has increased in frequency. Dodder, present in the field prior to initiation of the experiment has decreased to low levels due to a vigorous program of hand roguing. All data to date are considered preliminary, and apparent trends may change with time. A full set of soil samples was taken from all plots in the fall of 1997 in order to establish what changes, if any, have occurred to the weed seedbank during the first 4 years of the experiment. These samples have yet to be analyzed.

GROWTH ANALYSIS OF YELLOW AND PURPLE NUTSEDGE IN GREENHOUSE EXPERIMENTS.
R. Cinco-Castro and W. B. McCloskey, Graduate Student and Associate Specialist, Department of Plant Sciences, University of Arizona, Tucson, AZ 85721.

Abstract. Growth analysis experiments were conducted to determine the physiological processes and plant characteristics that influence the competitive ability of nutsedge species in the desert Southwest. Greenhouse experiments were conducted in 1995 and 1997 in which one tuber of yellow or purple nutsedge was planted in a 7 L pot in a randomized complete block design with five replications. Plants were harvested every 2 weeks for 8 or 10 weeks.

Growth analysis showed that purple nutsedge produced significantly more total dry weight than yellow nutsedge. The relative growth rate (RGR) was greater in purple nutsedge than in yellow nutsedge at the first harvest, but RGR was consistently higher in yellow nutsedge at subsequent harvests. In both species, RGR decreased during the growing period because of a decrease in leaf assimilation rate (LAR). In all experiments, LAR was higher in yellow nutsedge than in purple nutsedge for the first two or three harvests. This may be the result of the greater allocation of biomass to leaves rather to roots in yellow nutsedge compared to purple nutsedge. Analysis of the components of RGR revealed a significant positive correlation between RGR and NAR. The greater NAR of purple nutsedge was due to the greater photosynthetic rates of this species. Purple nutsedge also had greater transpiration and lower stomatal resistance than yellow nutsedge in the afternoon. In summary, the greater photosynthetic rate, NAR and lower stomatal resistance characteristic of purple nutsedge are important determinants of the competitive ability and predominance of this plant in the low desert areas.

RECOVERY OF PHOTOSYNTHESIS IN COTTON AND PURPLE NUTSEDGE AFTER WATER STRESS. W. B. McCloskey and R. Cinco-Castro, Associate Specialist and Graduate Student, Department of Plant Sciences, University of Arizona, Tucson, AZ 85721.

Abstract. Photosynthesis is an important process involved in the competition between plant species that is affected by water stress. Two greenhouse experiments were conducted to measure the recovery of photosynthesis in purple nutsedge and cotton following an irrigation that terminated a period of water stress. The experiments were arranged in a randomized complete block design with six blocks. Either one tuber or one cotton seed was planted in a 30 L pot. When the cotton plants were at the 10-leaf growth stage, water was withheld until both cotton and purple nutsedge leaf water potentials were between -2.6 to -2.3 MPa. At this time, the photosynthetic rates of both species were recorded and the plants were irrigated. One hour after the irrigation, photosynthetic rates, leaf water potentials, and fluorescence measurements were initiated and repeated every 2 hours throughout the day. The osmotic adjustment of both purple nutsedge and cotton was determined by measuring leaf osmotic potentials in well-watered and water-stressed plants using the pressure-volume curve method.

The photosynthetic rate of purple nutsedge was greater than the rate in cotton in well watered conditions throughout the day. Under water-stressed conditions, cotton had a greater photosynthetic rate than purple nutsedge. One hour after the irrigation that ended the stress treatment, the photosynthetic rate of both species increased; however, photosynthesis recovered faster in cotton than in purple nutsedge. Cotton and purple nutsedge plants under well watered conditions both maintained an osmotic potential of -1.16 MPa. Water-stressed cotton plants had an osmotic potential of -1.89 MPa. No changes in leaf osmotic potential were detected between well-watered and water-stressed purple nutsedge plants. The leaf water potential after the stress period was -1.37 MPa in cotton and -0.79 MPa in purple nutsedge. No differences in quantum yield were detected between species during the water stress recovery period indicating that photosynthetic electron transport was not affected by the degree of water stress imposed. These data suggest that the faster recovery of photosynthesis in cotton plants is due to the osmotic adjustment that occurs in the cotton leaves that may protect the enzymes and other cellular components during the water stress. In summary, photosynthesis was reduced more in purple nutsedge than in cotton by water stress and recovered more slowly following irrigation in purple nutsedge than in cotton.

GENOTYPE BY GERMINATION TEMPERATURE INTERACTION IN DORMANT AND NONDORMANT WILD OATS. Steven A. Fennimore and Michael E. Foley, Assistant Weed Ecologist, Department of Vegetable Crops, University of California, Salinas, CA 93905 and Associate Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Abstract. Germination temperature response is an important adaptive trait of weed seeds that permits them to germinate under conditions most favorable to the survival of the species. Control of germination response in wild oats is a heritable trait and dependent upon the allelic state at several "dormancy genes". Our hypothesis is that alleles promoting nondormancy facilitate the germination of freshly harvested wild oat caryopses over a wider range of temperatures than do alleles promoting dormancy. Crosses between wild oat parents with high and low levels of seed dormancy were used to produce F_1, F_2, and backcross generations. All generations were germinated at 15 and 20 C. The F_1 and F_2 generations germinated more rapidly at 15 C than at 20 C, i.e., there was a genotype by germination temperature interaction. In contrast the backcross to the nondormant parent germinated rapidly at both 15 and 20 C, while the backcross to the dormant parent germinated slowly at both 15 and 20 C. Generation means analysis was conducted to classify the action of "dormancy genes" segregating in these populations. The generation means analysis at 15 C revealed additive gene action, while epistatic interactions between two genes were detected at 20 C. Genotype by environment interaction likely plays a major role in the persistence of wild oats in diverse ecosystems.

EDUCATION AND REGULATORY

AN INFORMATION-GATHERING/DISSEMINATION EFFORT TO CATALYZE ACTIONS AGAINST INVASIVE ALIEN PLANT SPECIES IN HAWAII. Philip A. Thomas, Robert Teytaud, and Lloyd Loope, Hawaii Ecosystems at Risk Project, Cooperative Studies Unit, Department of Botany, University of Hawaii, Honolulu, HI 96822 and Research Scientist Haleakala National Park Station, Pacific Islands Ecosystems Research Center, Biological Resources Division, U.S. Geological Survey, Makawao, HI 96768.

INTRODUCTION

The biotas of oceanic islands in general, and the Hawaiian Islands in particular, are highly susceptible to damage caused by alien plants and animals transported by humans. The high susceptibility is related to the evolutionary history of island organisms in relative isolation. Although habitat destruction by humans was a very important factor in the decimation of native Hawaiian ecosystems in the past, the greatest current threats are from alien species. Although native species have been eliminated from most lowland areas in Hawaii, extensive largely intact native ecosystems survive at higher elevations, especially above 1000 m elevation. Such remaining intact areas are threatened by continuing biological invasions of plants and animals.

THE PROBLEM OF PLANT INVASIONS IN HAWAII

Invasion by alien plants can alter the population dynamics and community structure of native species and change the large-scale functioning of native ecosystems. The prevention of recruitment of native plant species by invasive alien plant species is often the mechanism of long-term conversion of ecosystem structure and function. For example, invasion of the vine banana poka (*Passiflora mollissima*) reaches elevations as high as 1500 m and smothers koa and 'ohi'a forest, killing mature trees and preventing recruitment, and eliminating native forest. Shrubs and trees such as clidemia (*Clidemia hirta*), strawberry guava (*Psidium cattleianum*), kahili ginger (*Hedychium gardnerianum*), firetree (*Myrica faya*), Australian tree fern (*Sphaeropteris* [formerly Cyathea] *cooperi*) and miconia (*Miconia calvescens*) can potentially reach similarly high elevations, alter ecosystems, and eliminate native biological diversity.

THE NEED FOR ACTIONS TO ADDRESS CURRENT AND FUTURE PLANT INVASIONS

Alien plant invasions already pose an acute problem in preservation of native ecosystems in Hawaii. Natural area managers and agencies are struggling to address immediate problems through manual, chemical, and biological control of invasive alien plants. However, most weed control programs get underway only after an alien species is an obvious problem. Managers and agencies normally have their resources directed at dealing with major weed problems that are already highly conspicuous. However, it is obvious in many cases that prevention of introduction and/or eradication of incipient populations is much more cost effective than waiting until species have become well-established. Also, early action may prevent loss of irreplaceable natural resources (e.g. in cases where alien species impact rare species).

There is an urgent need for dealing concurrently with incipient and future plant invasions is only beginning to be addressed. Whereas approximately 100 plant species are currently recognized as serious invaders of native ecosystems in Hawaii, over 13,000 plant species (or roughly 3 to 4% of the world's known vascular species) have been introduced to Hawaii, and over 900 have been recognized as exhibiting reproduction in the wild. A substantial number of the world's most invasive plant species are already present in Hawaii but not yet widely perceived to exhibit alarming invasiveness. Examples include *Arundo donax, Cryptostegia grandiflora, Hiptage benghalensis, Ligustrum spp., Lonicera japonica, Pittosporum undulatum*, and *Thunbergia grandiflora*. They may be in a so-called "lag phase", and increasingly recognized phenomenon in which invasiveness is not at first apparent.

Furthermore, whereas there is currently government scrutiny of proposed legal introductions of animal species in Hawaii and many other Pacific islands, there is still very little government-sponsored effort to prevent the potentially invasive plant species which have not yet reached the shores from being introduced. The phasing out of sugar cane and pineapple in Hawaii may be contributing to a quest for agricultural diversification and experimentation. And with increasing travel combined with botanical curiosity, industry, and changed in land use, the number of possible future experiments in invasive potential becomes enormous. For example, one proponent of enriching Hawaii's flora with more introductions recently wrote in a landscape industry newsletter: "After visiting Ecuador, I realize we have barely tapped the potential for new plant material ... in Hawaii." The danger inherent in such "experiments" is dramatized by case of the neotropical tree (*Miconia calvescens*) in Tahiti. Introduced to Tahiti in 1937, dense thickets of miconia had by the 1980s replaced the native forest over most of the island--often in dense monoculture--, with dramatic reduction of biological diversity: 40 to 50 of Tahiti's 107 endemic plant species are currently believed to be on the verge of extinction primarily because of invasion of this Miconia species. Experience in Hawaii and elsewhere suggests that plant species which have proved invasive when introduced to one part of the world are highly likely to be invasive when introduced to similar habitats elsewhere. However, there is often a "lag phase", in which a newly introduced potentially invasive species is slow in spreading and therefore easily controllable. Recognizing the desirability of early detection and local eradication of such species and the increasing danger of arrival of additional potentially invasive species because of accelerating international trade, prompt action to deal with newly emergent and future plant threats is obviously needed urgently.

THE HAWAII ECOSYSTEMS AT RISK PROJECT

The Hawaii Ecosystems at Risk (HEAR) project was developed in response to the concerns described for alien plant species above, was well as concerns about animal invaders. The project was initiated in 1995 to provide information and infrastructure to the natural resource management community (federal, state, and private) in Hawaii to aid in efforts in the fight against harmful alien species.

The HEAR project coordinates information-gathering efforts by organizing and/or participating in statewide and local working groups. HEAR helps organize data collection efforts by providing infrastructure to land managers, including database software and a central repository for species distribution data. Additionally, HEAR provides land managers and cooperating organizations with training on technical products and technical (mapping, data organization, and computer) support. The majority of HEAR's products are available on the internet at the HEAR website (http://www.hear.org).

Databases designed by HEAR which deal directly with alien species include a harmful non-indigenous species (HNIS) database (including information about invasive/disruptive alien species); an island matrix database (containing island-by-island distribution information for selected alien species); an alien plant control and herbicide use log; as well as a database of more detailed biological information and characteristics of invasiveness of certain species. Other databases--dealing with species and systems impacted by alien species--include the Hawaii Natural Resources Monitoring Database (for collection of alien and native species data, with flexible design to accommodate custom data sets); a species of concern tracking database (with information about endangered/threatened/candidate species); and others.

Prime considerations in the design of databases produced by HEAR have been good relational structure, data integrity checks, abundant metadata, and compatibility of data structures with local and international standards (including IUCN standards). All species-based databases use a set of standard "taxon codes" which are based on standard nomenclature of organisms in Hawaii as maintained by the Hawaii Biological Survey (Bernice P. Bishop Museum).

Hear databases are currently in use by the U.S. Fish and Wildlife Service; the National Park Service; the Natural Area Reserve System (State of Hawaii, Department of Land and Natural Resources, Division of Forestry and Wildlife); the University of Hawaii (Department of Botany); The Nature Conservancy of Hawaii; the Maui County Water Department; and Maui Land and Pineapple Company (a local private organization protecting watershed).

Other products-in-progress currently include a flexible spreadsheet-based "risk assessment model" for assessing an "index of relative impact", as well as a method for prediction of potential range for alien plant (and possibly other) species in Hawaii (based on a modified Holdridge Life Zone system).

Hear provides an internet-based clearinghouse for information about selected alien species of concern to land managers in Hawaii, including distribution maps; harmful non-indigenous species (HNIS) reports; current "island matrix" information; and dedicated pages RE: certain particularly noxious species (e.g. *Monica calvescens*). HEAR's website (http://www.hear.org) also provides documentation of HEAR methods, standard, and conventions; HEAR databases; and details about HEAR's products and activities. Additionally, the site provides links to high quality related information maintained elsewhere on the web.

AN OVERVIEW OF GPS TECHNOLOGY AND DATA COLLECTION CONSIDERATIONS. Shannon McElvaney, Hawaii Pacific Regional GIS Manager, Honolulu, HI 96822.

BACKGROUND HISTORY

The Global Positioning System (GPS) is a satellite-based positioning system operated by the U.S. Department of Defense (DoD). The 24 operational NAVSTAR satellites orbiting the earth every 12 hours provide worldwide, all-weather, 24-hour time and position information. There are 4 satellites in each of 6 different planes orbiting at an altitude of about 12,000 miles. The entire satellite constellation looks very much like a typical atom model, with 24 electrons spinning around the nucleus.

The first GPS satellite was launched in 1977. The entire system was originally designed to provide the DoD with an accurate positioning and navigation to avoid errors such as led to the destruction of Korean Airlines Flight 007 over Soviet Union airspace. As a result, President Reagan made GPS technology available to civilian users, in the hopes that it would lead to better air traffic control and safer skies. This opened the door to private sector companies that began experimenting with the new technology and designing new receivers for the commercial market.

Today's applications based on GPS technology are virtually limitless and generally fall into four major categories: GPS surveying, navigation, tracking and field data collection. GPS technology is currently being used to create or update geographic information system (GIS) databases in disciplines as diverse as archaeology, forestry, fishing, wildlife management, agriculture, mining, urban planning, utilities, energy, emergency response, and health and social services.

HOW GPS WORKS

GPS receivers determine positions by using satellite trilateration: the measurement of the distance from a satellite to a particular position in space. Unlike triangulation, trilateration refers to the length of legs (not angles) and is based on the travel time of a radio signal between the satellite and the ground receiver. The time interval is determined by comparing the time a coded signal left the satellite with the time it arrived at the receiver antenna. In code-based receivers, multiplying this interval by the speed of light gives you the distance or range. In carrier-phase receivers, distances are calculated by determining the number (N) of whole and partial wavelengths between the satellites and receiver. Multiplying N by the wavelength of the carrier signal plus the partial wavelength gives you a much more accurate distance measurement. Once distance from a satellite is known the position can be narrowed down to the surface of a sphere surrounding that satellite. If the distance from a second satellite is known, this narrows the position down to the intersection of the 2 spheres, which appears as a circle. Add the intersection of a third satellite and the position is narrowed down to 2 points. Ranges from at least four satellites are needed for a receiver to produce a 3-D fix on the ground.

HOW DO WE DETERMINE THE ACCURACY OF A POSITION

Many factors affect the accuracy of a GPS position. Variations in accuracy can result from selective availability[1], satellite geometry, number of satellites, satellite health, multi-path, atmospheric delays, solar storms, signal strength, battery strength, clock errors, ephemeris errors, distance between base station and rover, terrain and receiver characteristics, and methodology and processing errors.

No GPS unit on the market today, if operated in the autonomous mode can achieve better than 100-meter accuracy. Military units are the only exception because they have special decryption codes. The only way you can achieve the optimum specified receiver accuracy is by using differential correction and proper GPS collection techniques.

Differential correction is a technique that involves using a receiver at a known location, the base station, to record the error for each satellite directly into a compute file. This data can then be utilized later for post-processing or radioed real-time to a GPS receiver in the field, the rover. The information from the base station is then applied to the data collected by the rover and the offset differences are used to remove errors from the rover positions. Differential correction can remove such potential sources of error as selective availability, receiver clocks, satellite position, ionospheric and atmospheric delays.

Maintaining good satellite geometry is one of the most important factors influencing the collection of quality GPS data. Positional Dilution of Precision (PDOP) is a kind of strength-of-signal quality index that is determined by the current (and ever changing) geometry of the satellite constellation relative to your receiver's antenna. The strongest set of signals result when the satellites being tracked are equally separated in the sky. To reduce uncertainty to a minimum it is best to keep your PDOP as low as practical. A good rule of thumb is to configure your GPS ahead of time to only collect data with a PDOP of four or less. The lower the number, the better the separation, the more confident you will be that you have collected good data.

An often minor but potentially severe source of error can result from multi-path effects. Multi-path errors occur when a GPS signal bounces off of a building, car, or other reflective surface before reaching your antenna. Since these "bounced" signals take longer to reach the receiver antenna, the receiver automatically calculates its position as farther away from the satellite than it actually is. These effects cannot be corrected once the have occurred, although they can be controlled to some extent. Some receivers have been designed to be more-or-less multi-path resistant. The use of a ground plane directly under the antenna helps eliminate multi-path signals that arrive at angles from below the antenna. Also, be aware that multi-path signals are generally reflected off surfaces that are electrically conductive, including anything with a thin sheet of water on it. This means that wet leaves are more prone to produce multi-path than dry ones. Having a clear view of the sky is one of the best ways to avoid multi-path effects.

These are just a few of the factors to consider when collecting GPS data. It is the responsibility of the field personnel actually using the GPS to constantly monitor their GPS environment and to follow proper GPS collection protocol. Only then can the user feel confident that the accuracy levels advertised by the receiver were achieved.

WHAT KIND OF GPS RECEIVER BEST SUITS YOUR NEEDS?

GPS receivers vary in size, cost, quality, accuracy, GIS compatibility, and a host of other features. Deciding which GPS receiver is right for you depends a great deal on the accuracy demands of your particular mapping application, the riggers of the project, the time frame for completion, budgetary constraints. Some GPS units withstand extreme environmental conditions better than others do. Maybe time is an issue, and you want a unit that

[1] Selective availability is the deliberate degradation of the satellite signal by the Department of Defense. It causes errors in a GPS position of up to 100 meters.

is easy to use yet sophisticated enough to collect attribute data while in the field. It is very important to read the fine print on GPS merchandising material when it comes to the unit's advertised accuracy levels. Inexpensive units that boast a high accuracy should be carefully examined. Typically, the greater the accuracy demands the higher the cost. Talk to others in your field to see what they are using. In the end, no matter what unit you buy, get some training from a professional to ensure that you learn how to use all of the unit's capabilities to collect the most accurate data possible.

Here are some examples of GPS receiver grades along with their potential mapping application, accuracy and associated costs.

Grade	Use	Accuracy	Cost
Recreation	Hunting/fishing	100 m (autonomous only)	$200 to 400
Resource	Resource management: Mapping of soil, vegetation, wildlife ranges, nesting sites, archaeological features, roads, agricultural features, sampling sites, utilities, etc.	2 m to 10 m 10 cm to submeter (assumes use of DGPS, specialized software and up to a 20 minute occupation time in some cases)	$1200 to $3500 $5000 to $12000
Survey	Photogrammetric surveying, geodetic surveys, utilities, engineering, etc.	1 to 5 cm (assumes use of DPGS, specialized software, and long occupation times, in some cases)	$15000 to $30000 (and you need two of them)

1998-99 WESTERN SOCIETY OF WEED SCIENCE OFFICERS AND EXECUTIVE COMMITTEE
Front Row (L to R): Dan Ball, Education and Regulatory Section Chair; Carol Mallory-Smith, Research Section Chair; Barbra Mullin, Immediate Past President; Jill Schroeder, Secretary; Wanda Graves, Treasurer/Business Manager.
Back Row (L to R): Jeff Tichota, President-Elect; Rod Lym, President; Steve Miller, CAST Representative; Rick Arnold, Member-At-Large; Donn Thill, WSSA Representative.

RESEARCH PROJECT MEETINGS

PROJECT 1: WEEDS OF RANGE AND FOREST
Chairperson: Roger Sheley

This report is recorded in a transcript format to capture the discussion between the leader, Roger Sheley and the audience. There were 40 people in attendance and participated in the discussion.

Roger Sheley (RS) - Do we have a solution to the weed problem, and do we know what to do?

Audience (Aud) - Yes and No. Yes, on spotted knapweed in small infestations, where we search and destroy. In Wyoming, we have a very small infestation and we can follow a search and destroy strategy.
- No, in the case of Russian Knapweed and many other weeds. In Wyoming, we had 20,000 A, 20 years ago. Today, we have 30,000 A. We don't know what to do with this large of an infestation of these species.

RS - Seems like we can't/don't handle large infestations, but we can handle small ones.

Aud - We haven't been in the wildland weed business very long. We haven't really tried to solve the wildland weed problem yet. Nor have we really tried to develop a systems approach. However, I believe we can and will.

RS - Are systems approaches affordable?

Aud - We don't have good economic analysis. The question really is, What will society really be willing to pay in the arena of noxious weed control?

RS - I think grazing is the answer. What do you think?

Aud - Yes and No. With proper grazing we can make a difference. We need to develop cost effective herbicides and other methods that help with a systems approach. The low cost herbicide with be an effective tool for the rancher.

RS - Is our objective to kill weeds?

Aud - No! If we just kill the weeds, we get another weed in its place, then what have we accomplished? Our goal must be to strive for some desirable vegetation or plant community.
- Yes, yellow starthistle will be our way out. Every trail head with yellow starthistle on it should be closed to the public and signed as to why this action was taken. That way the public will feel the impact of the weed, when they are told why the closure is in existence. Then, through this understanding, where it hits/directly effects them, they will start to support weed management efforts. They will let their desires be know to their public officials, and then, this issue will be put on the front burner.

RS - I think revegetation will be the answer, what do you think?

Aud - I think existing remnants of native plant communities will be the answer, where they still exist. I think we need to better understand the biology and ecology/attributes of noxious weeds, to be able to work on them. We need to understand them!

RS - Roger asked individuals in the audience what they wrote on their papers as to possible solutions to the weed problem on wildlands.

Aud - I think managing noxious weeds is like the National Welfare program. It is kind of a good program, but there is a lot of waste. These need to be focused and well channeled efforts. Like prioritizing key areas that are not totally lost to weeds, and being able to save them.

- Today, we have 1000 introduced plants into California. One question posed to the people of the state is relative to goals. The question is, is our goal to re-establish native vegetation and native plant communities? If so, I hope you have plenty of money, because that is a monumental task!

- What is native? At the Hanford Nuclear site, it was estimated the reclamation costs for putting an acre of land back into native vegetation would be $2,000,000/A. That is too much in my estimation!

- In Glacier National Park, reclamation of one acre of land back to native vegetation has actually cost as much as $10,000.00. That is too much for us!

- Is anyone doing basic research on weeds? What would that be?

- It would be on such aspect as moisture stress, etc.

- Are there any documented cases where a plant system has all of its niches occupied, therefore rendering it resistant to invasion by noxious weeds?

RS - Actually, some people are suggesting that there are several examples of systems that are vulnerable because they have unoccupied niches. Getting back to your question, yes, I have seen native plant communities that seem to have all it's niches filled, seemingly making it resistant to invasion by invasive exotics. An example is the sheep fescue/bluebunch wheatgrass community that was surrounded by a dense monoculture of yellow starthistle. After many years of this situation being in existence, the sheep/fescue/blue bunch wheatgrass community still maintained its integrity.

RS - Do we really know how to stop weeds from spreading? Do we really know how to apply preventative methods?

Aud - Yes we do! In fact the federal agencies are more excited about the prevention dimension than anyone else and are aggressively promoting prevention activities. They view it as the best way to get the biggest bang for their buck.

RS - I recently did a literature review and tried to find any refereed paper that demonstrated how to manage cattle so as to prevent the spread of into currently uninfested areas. My literature search came up empty. No papers on this topic. We need to do more research on this topic.

Aud - Has anyone ever figured that exotic animals are associated with the invasion of noxious weeds? What about going back and re-establishing native animals like bison, and just eating those animals instead of cattle?

- No! Bison caused disturbance too, therefore, are not the answer. The real answer in this trend of thinking would be to stop people from being so mobile across the country, or even the world. However, this is not going to happen, so we have to go to plan B.

RS - I think we need to focus more on seedbanks of the weeds. That if we plan out treatments strategies accordingly, we can have a reasonably affordable program and eventually progress into seedbank reduction and more affordable programs. The change would be increasing the interval when treatment could over, i.e., initially spray every 2 years, then every 5 years, etc.

Aud - We must be conscious of the potential problem of tipping the balance of nature, as we continue to introduce what we consider beneficial exotics like biological control insects and or pathogens. We currently have pretty good protocols to screen agents prior to introduction, however, there may be negative consequences associated with our actions due to things we haven't even thought of. An example might be, will the *Apthona* beetles displace native flea beatles, or some other insect in the community and somehow throw off the balance of the system? Another example is the introduction of goats and sheep to eat leafy spurge. This action set up a new food source for Grizzly bears, which in turn put the bears in jeopardy because their attraction to goats/sheep put them more frequently in the proximity of man. This, in turn, threatened man and sets the scene for more bears falling in situations that allow them to be shot. (Scribes thoughts: I tend to think of systems being more in a dynamic equilibrium. An ever shifting balance, a resilient and accommodating system, readily adaptative to change and chaos, (even man caused chaos).

Aud - I tend to have a more positive attitude about our situation. My perception if that the general public is learning more and more about the threat and impacts of invasive exotic plants and is building support for the war on weeds. Also, relative to treatment efforts and associated positive effects against various weeds, we are beginning to see patterns that are, in fact, turning into what we might call management systems. Again, I feel very positive about our situation today. However, we need to know more about the autecology and synecology of our enemies, to be able to understand them better; classify and or group them, so we apply seem focused management efforts.

RS - It seems that all basic sciences have a set of principles that are the basis, the foundation, upon which everything else is built. Do we have such principles in the science of wildland weeds? What are the principles of wildland weed management?

Aud - The basic principles of weed management are: prevent seed production and competition principles.
- What makes a weed a weed? We must understand which species are invasive and the mechanism of that invasion.
- We have a problem. We rely on antidotal evidence a lot of the time because there is no research to back up a lot of our weed management action.
- The science community really hasn't been in the wildland weed arena very long. I'm very hopeful we will be making progress. However, there is in fact a lot we know from experience. Lets' not waste our time trying to prove the obvious with research that we could only publish in the international journal of DA! Just do it!
- We need to acknowledge that we must seek to find some beneficial uses for some of these invasive exotic species. Today, some ranchers have learned to graze their cattle on Alasdair thistle. They are happy to have 2 to 3 weeks of early spring grazing, versus none at all.
- We do have some current research in the works, such as that being done on Orange Hawkweed. We have learned that it really uses up the nitrogen in the soil which gives it a competitive edge.

RS - Who wrote something different on their paper? Is biological control the answer?

Aud - It is for some species, like leafy spurge in Wyoming.
- In Idaho biological control doesn't seem to be the answer yet. Two species come to mind in this regard, St. John's wort and yellow starthistle.

RS - Can we research bugs to know what will work before we do full scale application?

Aud - We already know to do that, but the public and land managers won't give the researchers a chance to do it. They want the insects now! They refuse to wait. We already know that groups of insects are actually needed. We must couple research and application to improve efficiency and do everything we can to get effective treatments in place.

Aud - Does anyone worry about the potential impact of exotic insects upon native plants? Yes, that is why today we regulate the importation of insects a lot better than ever.

RS - Does anyone worry about introduction of positive exotics into a system and it's overall effects, especially those effects we cannot anticipate?

Aud - Yes, risks and benefits are involved here.

RS - We are so interested in IPM, that we just put things together and call it IPM.

Aud - I think IPM is really happening now. There is more knowledge available now to provide science basis for IPM combinations and actions, and we need to educate the non-choir.

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PROJECT 2: WEEDS OF HORTICULTURAL CROPS

Chairperson: Carol Regusci

Subject: Endangered Herbicides on Vegetables. Now What?

Four speakers facilitated the discussion among 24 participants in the session. Carl Bell, Farm Advisor, University of California Cooperative Extension, presented "Farming with Antiques". He provided a review of the few herbicides that are currently registered for use in vegetable crops. Prior to the Food Quality Protection Act (FQPA) of 1996, IR-4 was successful in receiving 54 tolerances between January 1996 and August 1996. Since the signing of the FQPA in August 1996, only one tolerance has been issued. Vegetable crop weed control programs will be vulnerable and severely impacted with new and "safer" herbicides receiving regulatory priority for registration, new herbicides being limited to registrations and use in major crops (ie. corn, soybeans, wheat, cotton, and rice), and implementation of the FQPA to review all pesticides. Products will be lost due to voluntary withdraw from the market (DCPA), enforcement of the Clean Air Act (methyl bromide), and FQPA (potential carcinogens and organophosphate or carbamate chemistries). Vegetable crop registrations are doubly difficult to obtain due to ensuring crop safety and potential liability by manufacturers due to the injury on valuable crops. Emphasis is needed to stress that agriculture is more than the major crops of corn, soybeans, wheat, cotton, and rice. Regulatory agency personnel need to be better informed about the difficulties of registering and using herbicides in vegetable crops.

Steve Fennimore, Extension Specialist, University of California Cooperative Extension, presented "Impacts of FQPA on Vegetable Weed Control Programs". In his presentation, he ranked vegetable weed control programs in order of those that are most to least vulnerable to FQPA impact. He also discussed University of California Cooperative Extension strategies to address FQPA by identifying new potential vegetable herbicides and defending viable existing herbicides. He presented Tim Prather's proposal that a vegetable crops working group could use the WSWS annual meeting as a forum to formally share ideas and results of weed control projects. He discussed herbicide defense strategies such as determining the cost of weed control in vegetable crops with and without herbicides to estimate the value of herbicides in the production systems. He distributed a protocol to screen new potential herbicides for vegetables that included: carfentrazone, sulfentrazone, cloransulam, dimethenamid, imazamox, halosulfuron, rimsulfuron, and trisulfuron. Crops suggested for the screen included broccoli, cantaloupe, carrot, lettuce, onion, snap bean, spinach, squash, tomato, and sweet corn.

Corey Ransom, Extension Specialist, Malheur Experiment Station, Oregon State University, presented "The Trials of Weed Control in Vegetables". He expressed the concerns and difficulties with respect to difficult to control weeds, increase in labor costs, late emerging weeds, rotational restrictions, furrow irrigation practices, environmental impacts, and FQPA. More herbicide options are needed for vegetable weed control.

Tony Shepherd, branch manager, UAP Pacific, Maui, Hawaii, described Hawaiian agriculture with small acreage crops being grown the year around with three to four crops per year. Sugarcane is being replaced by more vegetables and included are watermelon, cucumber, tomatoes, onions and cabbage. Transplants are used for crops on drip irrigation. Environmental sensitivities exist for movement of chemicals into the groundwater. Replacement herbicides are needed for the triazines, especially for the seed corn industry.

Participants were involved in questioning and discussion of topics with the presenters. All were in agreement to continue the session at next year's annual WSWS meeting to provide a forum to address the serious concerns facing future weed control options in vegetable crops.

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PROJECT 3: WEEDS OF AGRONOMIC CROPS

Chair: Carol Mallory-Smith

Subject: Herbicide Injury Symptomology and Investigation.

Dr. Don Morishita, University of Idaho, and Dr. Dale Shaner, American Cyanamid, led the discussion of "Herbicide Injury Symptomology and Investigation." Morishita provided an extension perspective and Shaner presented some up to the minute information on laboratory tests that can be conducted to determine which herbicide caused plant injury.

Don Morishita. After being called to investigate claims, Morishita developed a crop injury investigation form. (Published at the end of this report.) Additions to the form he developed were suggested by members of the audience. Some of the additions included dealership name, above and below ground symptoms, and yield information.

Dale Shaner. Shaner addressed the technical side of an investigation. Assays have been developed to answer some questions about which herbicide caused injury. It is now possible to tell if plants were exposed to glyphosate or an ALS inhibitor by measuring amino acid profiles. The protocols for these procedures will be published in *Weed Technology* or can be obtained by contacting Shaner.

Discussion. One major concern is what to recommend to growers about the extent of crop injury and if the crop will recover. Many investigators recommend that the grower continue good agronomic practices for the crop but this raised the question of liability to the investigator. If the grower does not, it could jeopardize any claim for crop loss. However, illegal residues could mean that the crop would be rejected by a processor and the continued input could cost the grower dollars if the claim is not settled. There have been cases where the crop was rejected because of drift of a herbicide onto a crop. Also, there may be no yield loss but crop maturity might be delayed and the processor would refuse to accept the crop. The grower must make the final decision.

Industry would appreciate an early report. It makes investigation much easier if it is done before harvest.

Universities need to educate growers in the proper procedure for claims. It is essential to have a formal protocol to document how samples were taken and stored. Also need a chain of custody for the samples. Often State Departments of Agriculture have protocols for sampling. But often the protocols are not specific enough for different situations. Montana will split samples and send to the company, a laboratory of the grower's choice, and to the state laboratory. If there has been a claim of illegal application, a state will investigate. Most states will not investigate injury or nonperformance claims.

Many university personnel present stated that they provide reports to both parties. Most also felt that within a state, the university is the loser in any litigation and most try to avoid being called as expert witnesses, especially within a state. Often they will suggest a qualified person in another state as a possible expert witness.

There was a discussion as to whether or not county agents should be the first contact for growers with a complaint. Most felt that this was a case by case question since the county agents' background, experience, interest might or might not qualify them to investigate a claim.

Robert Norris cautioned that it is wrong to assume that damage is caused by a herbicide and that investigators need to keep an open mind and not enter the investigation with preconceived ideas about the problem. The symptoms could be caused by other pests or environmental factors.

For example, low pH symptoms can mimic ALS inhibitor injury. Bill Cobb concurred and stated that about 25% of the time in his investigations the cause is not what was originally proposed. Advice to investigators ranged from taking high quality photographs, videos and aerial photographs to keeping your mouth shut during the investigation and not offering any opinion while in the field.

The final area of discussion was on the development of good reference materials for herbicide injury and symptomology. The Southern Weed Science Society had initiated a project but found that it was too complicated because of the number of herbicides and the number of crops involved. It was suggested that it might be possible to produce the materials by crop but still would be a large challenge because of the need to put in growth stages and possible mimics including other pests and environmental interactions. Several states including Kansas, North Dakota, and Minnesota have publications on herbicide injury symptoms.

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Weed Science

CROP INJURY INVESTIGATION FORM

Date investigated__________
Claimant name________________ Others present____________________________
Address________________ ____________________________
City________________ ____________________________
State________________ ____________________________
Zip______ Phone____________

BACKGROUND INFORMATION

Crop and variety ____________________ Planting date__________ Seeding rate________

Date injury first noticed _________ Crop growth stage when applied ________________

Crop growth stage when noticed_________Field size_________ Size of injured area_______

CHEMICAL APPLICATIONS

Herbicide(s)________________________ Formulation(s) ________ Date applied _______

Rate _______ Acres treated ______ Adjuvant used _______Application equipment________

Application method_______ Boom width _____________Nozzle size and type__________

Application volume_______Incorporation equipment______________ Depth __________

OTHER PESTICIDES APPLIED (Insecticides, Fungicides, etc.)

Pesticide(s) ________________________ Formulation(s) ________ Date applied _______

Rate _______________ Acres treated ________________ Adjuvant used _____________

OTHER PEST PROBLEMS IN FIELD

Insects _____________ Diseases _________________ Nematodes __________________

FERTILIZER APPLIED

Type and analysis applied_____________________ Application rate__________________

Application date ____________________ Application method ______________________

FIELD HISTORY

Previous crop ______________________ Tillage method__________________________

Herbicides used_____________________ Other pesticides _________________________

Fertility __________________________ Irrigation ______________________________

Other information ____
____

WEATHER/SOIL INFORMATION

Temperature before application _______________ During__________ After ________

Rainfall before application __________________ During__________ After ________

Wind speed at application______________ Direction__________

Irrigation: Before application_____________________ After ___________________

Unusual temperature changes ____

Soil texture ________________________ Organic matter ______________________

OBSERVATIONS
Injury pattern in field____
____

North↑

(map here)

Sequence of injury development in field and on plants____________________________
____

Description of injury symptoms____
____

Description of pictures taken____
____
____

PROJECT 4: TEACHING AND TECHNOLOGY TRANSFER
Chairperson: Tim Miller

Subject: Weed Scientists and Extra-mural Funding: What's Your Time "Really" Worth? Oh Yea?

Much of the discussion centered around the need for support of a program or programs, versus support of trials and product evaluation. This support is generally grants and aid to support research or extension programs, and normally such funds can be used as desired by the University. Individual support ranges from $2000 on up. With minor crops, most of the support comes from the commodity groups; with major crops, more support comes from industry. It was reported that grants from some sources were very stable while others were highly variable. The commodity groups in general have been more supportive of items (such as equipment purchases) rather than support of programs.

Both industry and commodity groups support those who submit timely results. Some faculty in attendance said that they usually let the industry and others set the price rather than setting a particular price for trial entries. They determine if they want or can do the trials or the product evaluations for the price offered. It was also stated that there may be a problem with extramural support in the case of a lawsuit. For example, if you only have support from a single company, there may be the perception of impropriety or loss of credibility. If you get support from several companies for a given commodity, this may not be an issue.

It was also stressed that one needs to keep balance in a program: investigators should use conventional rates as well as reduced rates. They should also look at new compounds and products that are not registered for a given commodity, even rates that may not be economical at today's prices. But given potential changes in marketing of herbicides, what is not practical today may practical several years down the road, and it is important to build data that may be of good use if economic conditions change. After a period of time, researchers probably need to drop investigations into particular herbicides if the manufacturers do not indicate an interest to get the product labelled on a given commodity.

Many agreed that they like to fund "programs" rather than selling research on a 10 by 30 feet plot area. Attendees realized that the industry funds projects from year to year, and that they have no way to guarantee funding for several years. Of course, this presents a problem since it normally requires several years of data to draw valid conclusions about herbicide efficacy and crop safety. This soft money also may limit the growth of non-herbicide projects (due to lack of availability for these projects). What most of the universities do is pool money from various sources for overall program support (for capital purchases, for example).

Discussion was also held on what drives the research and extension programs. It was felt that it is very important to stay in contact with farmers. By determining their needs, a research can design a program aimed at solving their problems. It was generally believed, however, that grant opportunities do play an important part in the determining the direction of research programs, because if a faculty member cannot fund a project, it is very difficult to complete that research.

Another major concern among the attendees was what activities/programs do you give up (when you already have more than you can do) and how you determine the direction of a program? Good graduate students let one expand a program. Some universities are also creating non-tenured positions for special projects and that they will help find funding. Several universities are now hiring faculty on 9-month appointments, requiring the researcher to bring in at least one additional month of salary and operating money (assuming approximately one month would be equivalent to annual leave).

Does industry have a problem with funding university trials and product evaluation and the restrictions they place on them? It was reported that in most situations, there are very few restrictions. Occasionally, there may be limits on data that might be published (due to privacy agreements, etc.), but usually there are no restrictions from industry for most of the product evaluation trials. It was also felt that there is a need for weed science researchers to work collectively to obtain support, combining research from several locations so that information is available sooner and over a wider range of environmental conditions.

Chairperson: Bob Klein
Agronomy
University of Nebraska
Rt. 4, Box 46A
North Platte, NE 69101
308-532-3611

Chairperson-elect: Khosro Khodayari
Zeneca Ag. Products
Western Research Center
1200 S. 47th St., Box 4023
Richmond, CA 94804
510-231-5008
510-231-1235

PROJECT 5: WETLANDS AND WILDLANDS

Chairperson: Larry Lass

Subject 1: Methods of Surveying Wetland and Wildland Weeds.

Discussion Leader: Larry Lass, University of Idaho, Moscow, ID.

Approximately 20 people attended these discussions. Larry Lass introduced the methods most frequently used to survey weed populations. These include:

1. Color aerial photography.
2. Near infrared photography which utilized the light spectrum between 800 and 1200 nm.
3. Multi-spectral sensors. This technique splits wavebands into green, blue, red, and infra-red and compares these bands for differences.
4. Electronic distance measure. A new technique using laser technology. Allows surveyor to map weed patch by tracing boundaries from great distances (500 m).
5. Global Positioning Systems (GPS). Widely used on-the-ground or aerial population mapping technique.

The subsequent discussion focused on the variety of surveying studies currently being conducted by participants in the session. These included surveying yellow starthistle and perennial pepperweed populations by GPS to determine rates of spread, mapping *Aphthona* beetle distribution, and using GPS in helicopters to determine biocontrol release sites. Other projects were also discussed.

This conversation led to a further discussion of the new equipment which allows for on-time correction. Two new satellites were launched by OmniSTAR. These satellites beam down on-time corrections. A subscription to the OmniSTAR system is approximately $600 a year. An OmniSTAR receiver can be purchased which is compatible with the current Trimble Navigation system. Accupoint also provides on-time corrections using FM radio stations. A subscription is also required to utilize this system ($300 for a pocket pager and an additional $300 for 1 m accuracy). The newest Trimble Pro XRS system has both the satellite and OmniSTAR receiver built-in. There are still limitation to using this GPS equipment in forested areas or under high tension power lines. However, the new Trimble units are better in shaded areas than older systems. It is still common to receive false signals around power lines, but the use of shields around the antennae can help prevent this problem. Larry Lass discussed why GPS systems differ in accuracy. This is due to differences in clock accuracy within the unit.

Subject 2: Mapping Changes in Wetland and Wildland Weed Populations.

Discussion Leader: Diane Cooksey and Elizabeth Roberts, Montana State University, Bozeman, MT

Diane Cooksey provided two excellent handouts published through Montana State University. The first is a 4 page pamphlet entitled "Montana Noxious Weed Survey and Mapping System." It briefly describes the procedures used to map weed populations. The second publication was a more in-depth bulletin entitled "Mapping Noxious Weeds in Montana." This 23 page publication was co-authored by Roger Sheley at Montana State University and discussed mapping procedures for biocontrol releases, how to use and submit data, data recording and management. In addition, it provides form sheets which help standardize the data entry process. More information on this publication and project can be obtained by contacting their website at www.montana.edu/places/mtweeds.

Elizabeth Roberts discussed issues related to database management and maintenance, including compatibility of equipment and methods, choosing a mode, streamlining database structure, updating data and in what format, who does the updating, and how to document where the data is coming from. She also discussed methods of distributing the data. The final product can be made available as map plots, spatial layers, statistical summaries and can be disseminated by conventional mail, electronic mail, FTP, or the World Wide Web.

Subject 3: Putting All this Mapping to Good Use.

Discussion Leader: Diane Cooksey and Elizabeth Roberts, Montana State University, Bozeman, MT.

Diane Cooksey and Elizabeth Roberts discussed the many important benefits and uses from mapping noxious weed populations. With these maps it is possible to identify both locations and total acreage of infestations of specific noxious weed species. In addition, over time it will be possible to establish a systematic historical weed inventory which will can be used to calculate changes in infestations over time and will be very helpful in developing, implementing and evaluating the progress of weed management strategies. Such maps will also allow researchers to predict areas potentially subject to weed invasion, assess the economic impact of invasions, and increase public awareness of the impact of noxious weeds in wildlands and wetlands.

1999 Officers of Project 5:

Chairperson:	Joe DiTomaso Weed Science Section University of California Davis, CA 95616 530-754-8715	Chairperson-elect:	Scott Stenquist U.S. Fish and Wildlife 911 NE 11th Avenue Portland, OR 97232-4181 503-231-6172

PROJECT 6: BASIC SCIENCES

Chairperson: Scott Nissen

Subject: Understanding and Defining Auxinic Herbicide Resistance.

Herbicide resistance has been a common topic in Weed Science since the early 1980s. Triazine, ALS and ACCase resistance has been thoroughly characterized in a number of species to the point of understanding molecular mutations, inheritance and impacts on plant fitness. The first suspected case of auxinic herbicide resistance was reported in 1963 and since then only six weed species with increased levels of tolerance to auxinic herbicides have been reported. This discussion topic was prompted by reports of kochia being more difficult to control with dicamba in several western states. The wide spread occurrence of ALS resistant kochia has significantly increased the use of dicamba to control ALS resistant kochia in small grains. This added selection pressure could be selecting for less susceptible biotypes. The interest of university and industry researchers is to understand the potential impacts of auxinic herbicide resistance.

The discussion panel participants included: Bill Dyer and Marie Jasieniuk, Montana State University; Tracy Sterling, New Mexico State University; Kirk Howett, Colorado State University and John Kaufmann, Monsanto. In addition to the discussion panel, 28 people attended the meeting with good representation from the public and private sector.

Bill Dyer began the discussion with a short review of herbicide resistance. Current mechanisms of resistance can be divided into several groupings. The most familiar mechanisms of resistance result from modified sites of action or enhanced detoxification; however, there are a number of unknown mechanisms of resistance. Rigid ryegrass resistance to glyphosate, lambsquarters resistance to bromoxynil, and yellow starthistle resistance to picloram are examples of unknown resistance mechanisms. Bill continued with a short discussion of auxin activity in plants and described the various concepts of auxin binding proteins that are thought to occur at the cell membrane and inside the cell. The cascade effects of auxins have been well documented and include calcium calmodulin activation of protein kinase, hydrogen ion ATPase cell wall acidification, endoplasmic reticulum stimulation resulting in new cell wall synthesis. Since these are just a few of the mechanisms of auxin action the occurrence of a single mutation that could confer resistance to auxinic herbicides was thought to be remote.

Marie Jasieniuk described her research with the inheritance of dicamba resistance in mustard. This research represents one of the few examples where the inheritance of auxinic herbicide resistance is understood. The standard hypothesis has been that auxinic herbicide resistance was rare because multiple loci would be necessary for the expression of resistance. Inheritance of dicamba resistance was conferred by a single completely dominant nuclear gene in this mustard biotype. Unlike other types of resistance, dicamba resistant mustard continues to be a very localized population in west-central Manitoba. The mechanism of resistance remains unknown.

The current status of picloram resistant yellow starthistle was discussed by Tracy Sterling. Resistance could not be attributed to absorption, translocation or metabolism and could not be explained by differential ethylene biosynthesis. There was cross resistance to clopyralid, fluroxypyr and to a lesser extent dicamba; however, plants were not cross resistant to triclopyr or 2,4-D. The herbicide response of resistant to susceptible biotypes produced an R/S ratios of 3 to 10. This is much lower than R/S ratios commonly reported for ALS, ACCase and triazine resistant weeds. At the present time the mechanism of inheritance has not been determine. The resistant biotpye was discovered in Dayton, WA in 1989 and remains a small isolated population.

The potential for reduced susceptibility of kochia to dicamba has been a significant topic of discussion in several areas of the western US. Kirk Howatt reported on some of his Ph.D. research to characterize the extent of kochia populations showing reduced susceptibility to dicamba. When comparing historical kochia control data to current greenhouse and field screening programs, there has been very little change in kochia susceptibility to dicamba over the past 20 years. The vast major of kochia populations screened for dicamba resistance have been highly susceptible with control averaging above 85%. A small number of populations have been less susceptible with control averaging 65%. These populations have been screened at 0.125, 0.25, 0.5 lb/A and all populations have shown significant physiological responses to dicamba. Less susceptible populations remain stunted for extended periods showing typical auxinic herbicide responses and then producing normal shoots from axillary buds. Like mustard and starthistle populations, these kochia populations appear to be limited to small areas that do not appear to be spreading at this time.

John Kaufmann provided both a historical prospective and information about an analogous issue facing plant pathologists with sterol inhibiting (SI) fungicides. The first reported case of auxinic herbicide resistance was published in the Canadian Journal of Plant Science (43:255-262) in 1963. A wild carrot biotype showed resistance to 2,4-D in a manner very similar to the response of kochia to dicamba. Resistant wild carrots had typical injury symptoms but eventually grow out of the symptoms. Resistance to fungicides apparently has both the "all or nothing" resistance similar to ALS and ACCase resistance and other forms that produce a gradient response similar to auxinic herbicide resistance. In many cases the fungi populations were highly susceptible to SI fungicides when there were applied according to label directs with good spray coverage. The same is true for many of auxinic herbicide resistant weeds.

The overall sentiment of the groups was that while there is reason to be concerned there is no reason to expect wide spread resistance to auxinic herbicides. With full use rates, timely applications, good coverage and competitive crops, these herbicides should continue to be effective tools for weed management; however, anti-resistance strategies should still be employed. Auxinic herbicide resistance does appear to be significantly different from ALS, ACCase or triazine resistance and the analogy of apple scab resistance to SI fungicides provides a good reference point to examine auxinic herbicide resistance weeds. At this point, there are many more questions than answers.

1999 Officers of Project 6:

Chairperson: Peter Dotray
Dept. of Plant & Soil Sci.
Texas Tech University
19th and Detroit
Lubbock, TX 79409-22122
806-742-1634

Chairperson-elect: Kassim Al-Khatib
Dept. of Agronomy
Kansas State University
Throckmorton Plant Science Ctr
Manhattan, KS 66506-6101
785-532-5155

1998 WSWS STUDENT PAPER WINNERS IN SECTION 2
(L to R): Sandra L. Shinn (1st) and Martina W. Murray (2nd) [not pictured: Mark J. Renz (2nd)]

MINUTES OF THE 51st ANNUAL BUSINESS MEETING
WESTERN SOCIETY OF WEED SCIENCE
THE ROYAL WAIKOLOAN
KONA, HAWAII
MARCH 12, 1998

The WSWS Annual Business Meeting was called to order by President Barbra Mullin at 7:05 AM on March 12, 1998. Minutes from the 1997 Annual Business Meeting were approved as printed in the 1997 WSWS Proceedings.

Financial Report - Wanda Graves

There were 412 people registered for the 1998 WSWS meeting, including 62 spouses and 43 students. Wanda thanked those who pre-registered and indicated how much that helps in organizing the conference.

The society is in very good financial standing with a balance of $311,840. Of this $152,748 is in revolving accounts (Bio Weed Control Handbook, Noxious Weed Short Course, Herbicide Resistance Video, and Weeds of the West book) for a balance of $159,092.

Immediate Past President's Report - Charlotte Eberlein

The Members Welcome and Retirees Reception was a great success. Appreciation was extended to Doug Ryerson for organizing the food and refreshments for this event and to Monsanto for sponsoring the reception. Thanks also was extended to Arnold Appleby for preparing the tribute for Chuck Stanger who is retiring this year.

The WSWS Executive Committee has agreed to facilitate development of a graduate level weed biology course to be offered by a distance education. The means of distance education has not been determined yet. It could be satellite, compressed video, or perhaps even a Web based course. Charlotte asked for input from graduate students on the type of course they would prefer. She also asked for volunteers to serve on a committee to develop a plan for the course. Volunteers were asked to contact Charlotte.

Sustaining Membership Report - Paul Walgenbach (presented by Charlotte Eberlein)

We have 21 Sustaining Members, the same number as last year. One member was lost and one gained.

Member-at-Large Report - Shafeek Ali

Sections 10-13 of the WSWS Bylaws were revised to bring consistency to Article VII, Duties of Standing Committees. It was moved and seconded to accept these changes to the bylaws. The motion passed unanimously.

Shafeek worked with Dave Cudney to develop a promotional/informational brochure for the WSWS. The brochure should be completed in the next few months.

Program Committee - Rod Lym

There were 104 papers and 57 posters submitted for the 1998 program for a total of 161 presentations. Due to the number of posters, there were two poster sessions during the meeting. Appreciation was extended to Phil Motooka and the Local Arrangements Committee for making things go smoothly.

Local Arrangements Committee - Philip Motooka

The pre-conference tour on Monday is expected to return a profit of $400 to $600 due to the strong interest in attending the tour. The separate tours were completely sold out.

Phil acknowledged and expressed his appreciation for all the help he received from the Local Arrangements Committee and from local volunteers. He jokingly indicated that "this is not an amateur effort, but an effort by amateurs".

WSSA Representative Report - Donn Thill

The 38th meeting of the WSSA was held in Chicago on February 9-12 with 694 people registered. The attendance was down by 90 people from the previous year. The 1999 meeting will be held in San Diego, CA, on February 6-10, 1999. There will be major changes in the program. The General Session will start on Sunday afternoon. The meeting will go from Sunday afternoon through Wednesday evening with the banquet to be the last item on the program.

The WSSA Board voted unanimously to hire a full-time Washington Liaison pending approval of the regional societies. They voted to discontinue support for the Congressional Fellow.

The WSSA will begin implementing nine priorities identified during the 1997 summer retreat. These priorities are listed on the WSSA Web site.

The WSWS is well represented at the national level. The President this year is Dan Hess, who was recently an Honorary Member of the WSWS. The upcoming Secretary will be Jill Schroeder. Jill is also the incoming Secretary for the WSWS. Two members of the Western were named as Fellows of the WSSA: Charlotte Eberlein and Steve Miller. The Outstanding Extension Award went to Phil Westra.

CAST Representative - Steve Miller

CAST's financial picture changed dramatically in a very short period of time and CAST is now operating in the black under the direction provided by Richard Stuckey.

Two new member societies joined CAST at the fall board meeting: The American Oil Chemist Society and the Society for Range Management. The brings the number of society members to 36.

Individual membership in CAST is declining. Steve strongly encouraged everyone who is not a member of CAST to join. Individual membership is $40 per year. The next CAST meeting will be in Washington DC on March 20-22, 1998.

Several major bylaw changes were approved at the fall meeting: 1) the addition of a treasurer to the executive board and 2) a three point change on representation, reimbursement and society member dues. Society representation will be cut to one member regardless of society size, reimbursement for travel to board meetings will be $500 annually, and dues will range from $500 to $5000 per year based on society size.

<u>Committee Reports</u>

Awards - Arnold Appleby

The Awards Committee selected Don Colbert and Clyde Elmore as the Outstanding Weed Scientists from the Private and Public Sectors, respectively.

Nominations - Tracy Sterling

There were 156 ballots submitted during the election. The following candidates were elected:
President-Elect: Jeff Tichota
Secretary: Jill Schroeder
Research Section Chair: Jesse Richardson
Education and Regulatory Section Chair: Gil Cook

Site Selection - Robert Zimdahl (presented by Keith Duncan)

The 1999 WSWS meeting will be in Colorado Springs, CO. The 2000 Meeting will be in Tucson, AZ. The Committee recommended Spokane, WA, in 2001. Boise, ID, was their second choice. The WSWS Board asked the Committee to consider Coeur d'Alene, ID, as a possible site for the 2001 meeting.

Fellows & Honorary Members - Steve Miller

The Fellows and Honorary Members Committee received a number of good nominations. However, nominations are good for only three years and several of those packets need to be updated plus members need to nominate new deserving individuals. Send nominations to Gary Lee.

Tom Whitson and Doug Ryerson were selected as WSWS Fellows for 1998.

Affiliations - Tom Whitson

The Affiliations Committee did not meet this year in Hawaii because several members could not attend.

Finance - Richard Zollinger

Expressed thanks to Wanda for the orderly and accurate fashion she has kept the financial statements. The members may be interested to know that 1) the books are open to any society member, 2) WSWS has been in the black for 20 years, 3) in keeping with the bylaws, the Society has 2 ½ years of operating funds, 4) industry has paid for meals and refreshments which has saved the Society thousands of dollars, and 5) several members of the Board and WSWS representatives to other organizations pay for their own expenses when they could be reimbursed by the Society.

Necrology - Paul Isakson (presented by Neal Hageman)

Dr. Virgil Freed, Professor Emeritus at Oregon State University, died March 31, 1997. His death followed a 44 year career at OSU in which he retired in 1984 as the chairman of Agriculture Chemistry Department.

Dr. Luis Figuerola died March 30, 1997 at his home in Germantown, TN. Dr. Figuerola, who earned his M.S. from East Texas State University and Ph.D. from Oregon State University was internationally known for his field research and product development. Although not a member of WSWS, Dr. Figuerola was considered a friend and colleague, and was an active member of WSSA, ASA, and SSA.

Operating Guide Update - Joan Campbell

The Operating Guide has been revised and updated. The Operating Guide will be added to the WSWS Web site after the March meeting.

Herbicide Resistant Plants - Steve Seefeldt

The Herbicide Resistance Workshop was held in Bozeman, MT, from July 28-30, 1997. The committee would like to sponsor a symposium on Topics Concerning Pesticide Resistance at the 1999 WSWS meeting. Dr. Carol Mallory-Smith was elected as the next chairperson for the Herbicide Resistant Plants Committee. The 1998 Herbicide Resistance Workshop will be organized by Dr. Steven Seefeldt and will take place in Elk River, ID.

Resolutions - Shaffeek Ali

One resolution was submitted for consideration by the members of the WSWS. It is as follows:
Whereas; The 1998 WSWS program presented thought provoking messages, and
Whereas; The various meeting sessions were run smoothly and efficiently, and
Whereas; The facilities were excellent and the staff helpful and courteous,
Be it resolved that the Western Society of Weed Science expresses its appreciation to Rod Lym and the Program Committee, Philip Motooka and the Local Arrangements Committee and to the Management and Staff of the Royal Waikoloan Resort.

The above resolution was approved as read.

Student Educational Enhancement - Claude Ross

The Student Education Enhancement program continues to be a well liked program with the students. Two students from the 1997 program were asked to give a review of their trip: Mack Thompson from Colorado State University and Craig Alford from the University of Wyoming. There was a wide variety of experience gained with just a week exposure by these students. Five students were involved in 1997 and there will be eight students in 1998. Appreciation was extended to all the sponsors.

Legislative - Vanelle Carrithers

The National Research Council, Board of Agriculture is soliciting comments on the future role of pesticides in agriculture. The WSSA Washington Liaison Committee is coordinating a response that will be offered to the committee in written form and also verbally by Dr. Harold Coble.

The Federal bill on the reauthorization of Research, Extension, and Education is still working its way through the legislative process. The House passed the House Resolution which sends HR 2537, the House Research Title, to conference with the Senate.

At the September 20th meeting of the WSSA Noxious Weeds Working Committee, American Nursery and Landscape Association's board of directors reviewed the group's statement of purpose (evaluating new plant introductions), and offered it's endorsement of the direction outlined in the statement. There is a continuing project to cooperate with the nursery industry on avoiding the introduction of potentially weedy plants.

There will be a Weed Summit on April 8-10, 1998, in Denver to help identify research and technical needs with the pulling together projects in the federal agencies.

Vanelle encouraged members to become familiar with the Food Quality Protection Act. EPA is in the process of judging how risk assessments will be made. They are talking about using default assumptions, not data, to look at risk assessments of pesticides. We all need to be aware of that and encourage our legislators and EPA to use real data rather than theoretical default assumptions as critical components for the tolerance safety assessment.

Publications - Don Morishita

The WSWS newsletter has historically been an infrequent and irregular newsletter. This will change, as Barb Mullin has volunteered to be the editor of the WSWS Newsletter.

There are currently about 3000 Weeds of the West books in inventory. We have published a total of 80,000 copies of this book. It continues to be a very popular publication. The Committee has discussed either a second Weed Seedlings of the West or adding weed seedlings to the current book. The Committee is seriously considering doing a second edition of Weeds of the West that would include weed seedlings.

Placement - Bruce Maxwell

The Committee received 18 position descriptions including academic, agency, non-profit organizations and private industry announcements. In addition, a list of Web sites was posted that list positions available in agronomy, weed science, and biology.

Editor Report - Kathy Christianson, Editor, WSWS Proceedings

Anyone with revised versions of abstracts or full papers to be printed in the Proceedings need to send both a paper copy and disk copy to Kathy. Section Chair reports need to written and submitted to Kathy as soon as possible after the meeting. Minutes, financial reports, etc. need to be submitted as soon as possible.

Editor Report - Steve Miller, Editor, WSWS Research Progress Reports

The 1998 Research Progress Report contained a total of 190 pages. There were 175 pages of reports (would have been 375 pages without reduction) and a 15-page index. Total cost for the Research Progress Report was $2512. The University of Wyoming did the printing and binding again this year. There were a total of 156 reports. Steve resigned as Editor of the Research Progress Report. Volunteers were requested for his replacement.

Poster - Bob Stougaard

Participation in this year's poster session was up from previous years. For the past six year we were tracking at about 25 posters per year. This year there were a total of 57 posters. The increased participation in 1998 necessitated the use of two poster sessions. Due to the split sessions, it was very important that people put up and take down posters on time. Everything went very smoothly.

Public Relations - Jack Schlesselman

As in the past, there was a table near the registration area for Continuing Education Credit. Most of the states are allowing us to use the standardized Sign-In/Sign-Out forms we've been using the last few years. Several states also require some additional form specific for their state.

Weed Management Short Course - Celestine Duncan (presented by Rick Arnold)

The Weed Management Short Course sponsored by the WSWS was held in Bozeman, MT, during April and September, 1997. Both sessions were filled very quickly.

This year, two sessions of the short course will be held in Bozeman on April 21-24 and 26-29, 1998. Both sessions have been filled since mid December. There continues to be strong interest in the course from federal and state agencies.

Internet-WWW - Joan Campbell

The judging criteria for the student paper contest has been online since November. The WSWS annual program was available on the Web site in early January. Publication information has also been added to the Web site. Bylaws and the Operating Guide will be added after the March meeting. The Newsletter will also be added to the site when it is published.

The University of Idaho is continuing to provide space on their Web server at no charge and design and implementation is still donated by Affirmative Technologies. Affirmative Technologies was contracted by the Board to continue maintenance and to host the WSWS Web site.

The Board voted to register the domain name http://www.WSWeedSci.org/ with InterNIC.

Student Paper Judging - Drew Lyon

A total of 28 student papers were entered in the Student Paper Contest this year. Eight posters entered in the Student Poster Contest. Papers were randomly separated into two sections of 14 papers each. The following awards were approved for the winners:

Oral Paper Contest	1st	$100 plus a gift certificate for WSSA monograph
(two sections)	2nd	$75
	3rd	$50
Poster Contest	1st	$100 plus a gift certificate for WSSA monograph
	2nd	$75

The winners of the Poster Contest were:

1st place - Dawn Y. Wyse-Pester, Colorado State University
2nd place - W. Mack Thompson, Colorado State University

The winners of the Oral Paper Contest were:

Section 1	1st place - Carrie B. Benefield, University of California - Davis
	2nd place - Suzanne Sanders, University of Idaho
	3rd place - Jeff A. Nelson, North Dakota State University
Section 2	1st place - Sandra L. Shinn, University of Idaho
	2nd place - Mark J. Renz, University of California - Davis
	3rd place - Martina W. Murray, New Mexico State University

New Business

There was no new business presented.

President Barb Mullin introduced the incoming President, Rod Lym. Barb presented Rod with a copy of Modern Parliamentary Procedures so he understands exactly how these meeting are to be run and the "hoe gavel" from the WSWS. Rod presented Barb with a plaque in appreciation of all her time and service to the Society.

The meeting was adjourned at 8:15 AM.

Respectfully submitted,

Neal R. Hageman
WSWS Secretary

1998 WSWS STUDENT POSTER WINNERS
(L to R): Dawn Y. Wyse-Pester (1st) and W. Mack Thompson (2nd)

WESTERN SOCIETY OF WEED SCIENCE
FINANCIAL STATEMENT
APRIL 1, 1997 THROUGH MARCH 31, 1998

CAPITAL

1996-97 Balance Forward	$165,927.48
Current Income	136,378.76
	$302,306.24

REVOLVING ACCOUNTS

Bio Weed Control Handbook	$47,198.38
Noxious Weed Short Course	14,854.22
Herbicide Resistance Video	1,874.81
Weeds of the West Book	88,821.20
	152,748.61

DISTRIBUTION OF CAPITAL

Mutual Funds	$145,031.79
Certificate of Deposit	19,993.04
Money Market Savings	107,150.07
Checking Account	30,131.34
	$302,306.24

INCOME	**1997**	**1998**
Registration & Membership Dues	$ 1,635.00	$23,848.00
Proceedings	752.54	3,611.50
Sustaining Membership Dues		7,000.00
Research Progress Report	640.55	2,411.50
Noxious Weed Short Course	20,860.00	
Bio Weed Control Handbook	4,536.16	
Weeds of the West Book	102,741.00	
Herbicide Resistance Video	180.00	
Bank Interest (portion is investment interest)	29,828.60	
WSU Reimbursement (Jointed Goatgrass Seminar)	657.26	
OSU Reimbursement (Winter Annual Grass Mtg)	464.92	
		$199,167.03

EXPENSES		
Office Supplies & Equipment	$ 370.65	
Postage & Shipping	3,370.20	
Telephone	490.30	
Business Manager Salary	6,300.00	
Tax Accountant	200.00	
Secretary of State & State Tax Filing Fee	20.00	
CAST Membership Dues		780.00
WSSA AESOP & Congressional Fellow	3,924.00	
Noxious Weed Short Course	24,119.46	
Herbicide Resistance Video	35.00	
Weeds of the West	955.00	
Bio Handbook	696.26	
Representatives - WSSA Retreat	817.00	
Printing		
Proceedings	2,868.40	
Research Progress Report		2,512.73
Programs		1,566.24
Stationary	721.33	
Newsletters	516.07	
Speaker Expenses	367.45	450.18
Portland Visitor's Bureau	39.00	
Preconference Tour	312.50	
Awards Luncheon		6,756.25
Student Awards & Plaques	487.71	760.00
Audio Visual		41.67
Executive & Committee Planning Meetings	450.54	1,517.58
Editor's Travel		786.00
Refund of Registration Fees		410.00
Awards Plaques (Fellows, President, Honorary, etc)		146.75
		$62,788.27

1998 FELLOW AWARD
WESTERN SOCIETY OF WEED SCIENCE
Doug Ryerson

Dr. Doug Ryerson grew up in Bozeman, Montana and realized early in life that weeds were a serious problem when he worked as a summer laborer for Montana State University. Doug got his B.S. in Agricultural Science from Montana State University and his M.S. and Ph.D. in Crop Physiology from the University of Wisconsin, Madison. Dr. Ryerson worked 3 years as an area crop specialist for the University of Idaho before going to work as a Product Development Specialist for Monsanto.

Dr. Ryerson has served the Western Society of Weed Science in numerous capacities as Past President, President, Program Chair, President-Elect, Secretary, and twice served as chair of the Agronomic Crops Section. In addition, he has actively participated in the student educational enhancement program.

Dr. Ryerson's efforts during the past 17+ years have been directed toward developing new and expanding existing markets for crop protection chemicals in diversified irrigated and dryland agriculture in Idaho, Montana, and North Dakota. He is the recognized authority on triallate within the cereal growers and Monsanto Company. He has been very instrumental in evaluating various alternative formulations and in screening various wheat varieties for tolerance/susceptibility to triallate. His work has been effective in neutralizing the wild oat resistance issue for this product in Montana and North Dakota. Dr. Ryerson's efforts and work have been instrumental in protecting the products base and increasing volume. Doug has been actively involved in bringing Landmaster BW and Fallow Master to the cereal markets. He has been the driving force for minimum and no-till dryland wheat production in Montana through utilization of glyphosate products for weed control. Further, he has undertaken a significant leadership role in developing strategies for returning CRP land back to crop production.

Dr. Ryerson is an individual who is respected and admired as a weed scientist and as an individual by his peers, colleagues and the scientific community. He brings sound technical skills and knowledge to the weed science profession. He constantly is striving for new and innovative ways to improve weed science and production agriculture. These traits earned him the Monsanto Distinguished Development Award, the highest recognition available within Monsanto.

1998 FELLOW AWARD
WESTERN SOCIETY OF WEED SCIENCE
Tom Whitson

Dr. Tom Whitson grew up on a farm/ranch operation in West Texas where he got his first exposure to weeds. Tom got his B.S. in Agricultural Education from Texas Tech; his M.S. in Plant and Animal Science from East Texas State and his Ph.D. in Weed Science from the University of Wyoming. Dr. Whitson's work experience includes a farm chemical plant manager for Rowland Gordon Company in Plainview, Texas and American Cyanamid in Kress, Texas; a science teacher for Spring Lake Earth Schools in Earth, Texas; a county extension agent and 4-H specialist for Kansas State University Extension Service; a county agricultural extension agent for the Wyoming Agricultural Extension Service; a county agent for the Texas Agricultural Extension Service; an extension specialist and research assistant for the Plant Science Department for the University of Wyoming; a research and extension crop and weed scientist for Oregon State University; and presently serves as extension weed specialist for the University of Wyoming Cooperative Extension Service.

Dr. Whitson has made numerous contributions to the Western Society of Weed Science serving as Past President; President; Program Chair and President-Elect; twice served as Extension and Regulatory Chair and also served as chair of the Publication Committee. Tom initiated the publication, *Weeds of the West*, serving as both editor and distributor. This publication has made over $100,000 profit for the society with more than 60,000 copies sold world wide.

Dr. Whitson has also made significant contributions to western agriculture. He has conducted research on over 30 problem weeds in western rangeland, introduced the concept of sagebrush thinning to wildlife managers for improved habitats; worked extensively with Federal Land Managers to develop noxious weed management programs and has been instrumental in developing special local needs registration for several herbicides in the Pacific Northwest and Great Plains regions. In addition, Tom worked tirelessly with Washington, Oregon, and Idaho to develop the first Pacific Northwest Weed Control Handbook and most recently, with Montana and Utah to develop Weed Management Handbooks for agricultural and horticultural crops in this area.

1998 OUTSTANDING WEED SCIENTIST
PRIVATE SECTOR
Donald R. Colbert

Donald Colbert is Senior Field Agriculturist with the American Cyanamid Co. in Lodi, CA. He received the B.S. degree in Agricultural Chemistry from California State University at San Luis Obispo and the M.S. degree in Weed Science from Oregon State.

He was with the Pennwalt Chemical Co. from 1965 to 69 and was a researcher with Oregon State from 1969 to 73. He has been with American Cyanamid since that time. He has received Awards of Excellence from American Cyanamid for development of Arsenal, Assert, Prowl, and Pursuit. He was presented with the California Weed Science Society Award of Excellence, and he has been named Fellow in WSWS.

Don Colbert's accomplishments to weed science have been oriented to the development of several important herbicides leading to the implementation of weed management systems for California and western United States. One such development was with the herbicide Avenge. The development of Prowl for dry beans, cotton, and a number of other crops has significantly benefitted Cyanamid and the agricultural producers in his territory. He has worked diligently on the majority of efficacy and tolerance data for pendimethalin on ornamental and container plants with over 40 different species on the label.

Don Colbert has displayed a high standard for scientific research. He has been an advocate of recognizing the importance of education. He has been a long-time supporter of cooperative extension workers in providing them resources for field research and their educational programs. His understanding of commercial agriculture and relating to the farmers' concerns are always uppermost in his dedication to providing the best information possible. He is always willing to share his knowledge with students, farmers, and other researchers.

One support letter states, "Don Colbert is not only a fine weed scientist, with many accomplishments under his belt, he has also worked to advance the discipline of weed science at the society level. His hard work, technical expertise, and people skills have earned him the respect and friendship of weed scientists from both academia and industry."

1998 OUTSTANDING WEED SCIENTIST AWARD
PUBLIC SECTOR
Clyde L. Elmore

Dr. Clyde Elmore is currently professor of Weed Science in the Department of Botany, University of California, Davis. He received his B.S. and M.S. degrees in Agronomy at Oklahoma State University and his Ph.D. degree at University of California, Davis in Weed Science and Botany. He has spent his entire career in Extension at Davis.

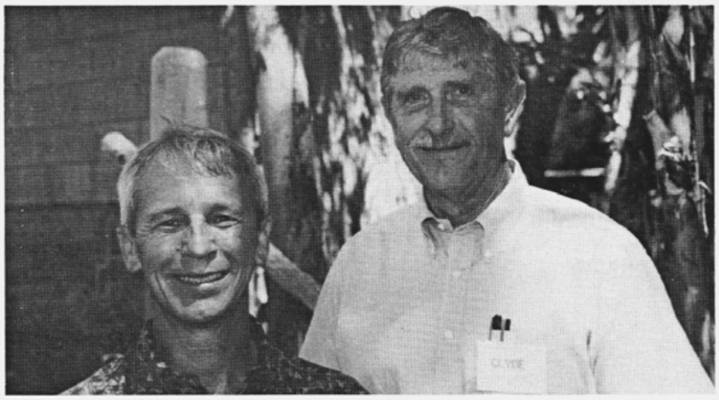
Dr. Elmore has made significant research and educational contributions to the field of weed science at the state, national, and international level over his 30+ years of service. His original findings and recommendations are still the basis for a large share of the weed control recommendations used in California, especially in horticultural crops.

He also has spent considerable time as a technical expert to several foreign countries as part of the USAID program and has led several "people to people" tours of China and Russia. Numerous foreign faculty members have come to Davis to spend sabbatical leaves with him. He has taken sabbatical leaves at Oregon, the Washington, DC area, and Pennsylvania; each time he demonstrates local impact on educational programs and thinking among colleagues.

He has been elected Fellow of WSWS, Fellow of WSSA, and Vice President, President of WSWS. Dr. Elmore is a leader, educator, and scientist who encourages each person to discover and apply their expertise and values toward improving weed science and management within agricultural and urban settings.

One of the supporting letters states, "Because of his high quality research standards, his high volume output, his awareness and response to industry and societal concerns, Clyde Elmore capably represents all Weed Scientists and deserves their support and honor as Outstanding Scientist."

1998 WESTERN SOCIETY OF WEED SCIENCE FELLOWS
(L to R): Doug Ryerson (Private Sector) and Tom Whitson (Public Sector)



1998 WESTERN SOCIETY OF WEED SCIENCE OUTSTANDING WEED SCIENTISTS
(L to R): Don Colbert (Private Sector) and Clyde Elmore (Public Sector)

1998 WSWS STUDENT PAPER WINNERS IN SECTION 1
(L to R): Carrie B. Benefield (1^{st}) , Suzanne Sanders (2^{nd}), and Jeff A. Nelson (3^{rd})

1998 NECROLOGY REPORT

Dr. Virgil Freed, Professor Emeritus at Oregon State University, died March 31, 1997. His death followed a 44 year career at OSU in which he retired in 1984 as the chairman of Agriculture Chemistry Department. Dr. Freed was one of the original investigators to apply the principles of physical chemistry to the study of herbicides and plant growth regulators.

Dr. Luis Figuerola died March 30, 1997 at his home in Germantown, TN. Dr. Figuerola, who earned his M.S. from East Texas State University and Ph.D. from Oregon State University was internationally known for his field research and product development. Throughout his career, Dr. Figuerola held numerous international positions in industry and most recently was an independent contract researcher working with surfactants in Mexico and Brazil. Although not a member of WSWS, Dr. Figuerola was considered a friend and colleague, and was an active member of WSSA, ASA, and SSA.

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AUTHOR INDEX

CROP INDEX

WEED INDEX

HERBICIDE INDEX

Common name or Code designation,
Trade name and Chemical name **Page**

Common name or Code designation,
Trade name and Chemical name **Page**

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