PROCEEDINGS

WESTERN SOCIETY OF WEED SCIENCE

Volume 53, 2000
ISSN: 0091-4487

WESTERN SOCIETY OF WEED SCIENCE

2000 - 2001

OFFICERS AND EXECUTIVE COMMITTEE

PRESIDENT
Don Morishita
University of Idaho
P.O. Box 1827
Twin Falls, ID 83303-1827
Ph: 208-736-3616
Fax: 208-736-0843
don@uidaho.edu

PRESIDENT-ELECT
Bob Parker
Washington State University
24106 N. Bunn Road
Prosser, WA 99350
Ph: 509-786-9234
rparker@wsu.edu

IMMEDIATE PAST PRESIDENT
Jeff Tichota
Monsanto Co.
9785 Maroon Circle, Suite 300
P.O. Box 6544
Englewood, CO 80155-6544
Ph: 303-768-7326
Fax: 303-799-9441
Jeffery.M.Tichota@stl.monsanto.com

SECRETARY
Mark Ferrell
Department of Plant Sciences
P.O. Box 3354
University of Wyoming
Laramie, WY 82071
Ph: 307-766-5381
Fax: 307-766-5549
ferrell@uwyo.edu

CHAIR, RESEARCH SECTION
Phil Stahlman
Kansas State University
1232 240th Ave.
Hays, KS 67601
Ph: 785-625-3425 ext. 214
Fax: 785-623-4369
pstahlma@oz.oznet.ksu.edu

CHAIR, EDUCATION AND REGULATORY
Rich Zollinger
Department of Plant Sciences
North Dakota State University
Fargo, ND 58105
Ph: 701-231-8157
Fax: 701-231-8474
rzolling@ndsuext.nodak.edu

WSSA REPRESENTATIVE
Donn Thill
Department of Plant, Soil, and Entomological Sciences
University of Idaho
Moscow, ID 83844-2339
Ph: 208-885-6214
Fax: 208-885-7760
dthill@uidaho.edu

MEMBER-AT-LARGE
Bob Stougaard
Montana State University
4570 Montana 35
Kalispell, MT 59901
Ph: 406-755-4303
Fax: 406-755-8951

TREASURER-BUSINESS MANAGER
Wanda Graves
Western Society of Weed Science
P.O. Box 963
35806 Ruschin Dr.
Newark, CA 94560
Ph: 510-790-1252
Fax: 510-790-1252
Wgraves431@aol.com

CHAIR-ELECT, RESEARCH SECTION
Scott Nissen
Plant Path/Weed Sci Dept
Colorado State University
Fort Collins, CO 80523
Ph: 970-491-3489
Fax: 970-491-3862
snissen@lamar.colostate.edu

CHAIR-ELECT, EDUCATION AND REGULATORY SECTION
Phil Banks
Marathon Ag/Environ Consulting
2649 Navajo Road
Las Cruces, NM 88005
Ph: 505-527-8853
marathonag@zlanet.com

CAST REPRESENTATIVE
Rodney G. Lym
Department of Plant Sciences
Loftsgard Hall 474D
P.O. Box 5051
North Dakota State University
Fargo, ND 58105
Ph: 701-231-8996
Fax: 701-231-8474
lym@plains.nodak.edu

WSWS EXECUTIVE COMMITTEE CONTACTS FOR WSWS COMMITTEE CHAIRS

PRESIDENT
Don Morishita
Nomination
Awards
Site Selection

PRESIDENT-ELECT
Bob Parker
Program
Poster
Student Paper Judging
Local Arrangements

IMMEDIATE PAST-PRESIDENT
Jeff Tichota
Fellows
Sustaining Members

SECRETARY
Mark Ferrell
Necrology
Finance

RESEARCH SECTION CHAIR
Phil Stahlman
Editorial
Placement

EDUCATION AND REGULATORY CHAIR
Rich Zollinger
Public Relations
Education

WSSA REPRESENTATIVE
Donn Thill
Legislative
Publications

MEMBER-AT-LARGE
Bob Stougaard
Student Educational Enhancement
Herbicide Resistance
Resolutions

2000

PROCEEDINGS

OF

THE WESTERN SOCIETY OF WEED SCIENCE

VOLUME 53

PAPERS PRESENTED AT THE ANNUAL MEETING

MARCH 14 TO 16, 2000

HOLIDAY INN CITY CENTER

TUCSON, ARIZONA

PREFACE

The Proceedings contain the written summary of the papers presented at the 2000 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: American Goldfinch (*Carduelis tristis*) feeding on bull thistle (*Cirsium vulgare*). Cover photograph by Rod Lym, North Dakota State University. All other photographs by Steve Dewey.

Proceedings Editor: Kathy Christianson

TABLE OF CONTENTS

GENERAL SESSION

POSTER SESSION

EDUCATION AND REGULATORY

RESEARCH PROJECT MEETINGS

GENERAL SESSION

PRESIDENTIAL ADDRESS
Agriculture 2000 - World of Change
Jeff Tichota
Monsanto Co.
Littleton, Colorado

Change has become part of our lives and this morning I would like to explore with you some thoughts about change at the University, within Industry and on the farm. I hope to stimulate ideas and you may agree or disagree with my comments but either way your mission as a member of the WSWS is to help organize our Society so that it continues to grow and benefit the needs of our members.

I want to touch on four topics in these next few minutes and look at A) the commodity production aspect of Agriculture, B) offer a viewpoint on Industry's investment in new crop protection chemistry, C) offer an opinion on Biotechnology and D) delve into resource allocation at the State level and in Industry.

Production of our country's four major crops, corn, cotton, soybeans and wheat is tightly intertwined with world production. A wheat grower in Kansas competes with wheat growers in Australia as California cotton growers compete with cotton farmers in India and China. Farmgate profits are low and market analysis does not speculate major increases in prices paid for these crops in the next five years. Successful producers are specializing to take advantage of every opportunity to cut costs and production will be driven to lowest cost areas. We are seeing some movement by grower groups toward vertical integration and formation of specialty coops to improve profit margins. Farming is no longer a lifestyle but a business and those that make a profit will thrive while those with higher production costs will find farming difficult to continue.

How does this change affect our Western Society of Weed Science organization? I believe we must decrease emphasis on single weed and crop research and turn more attention to a Systems Approach to crop production. Weed control will always remain an important consideration in successful cropping but instead of looking at nightshade control in drybeans for this season we should study what could we have done to decrease nightshade problems in the three previous crops prior to planting those drybeans.

Earlier I said I wanted to talk about changes in our profession. Let us take a look at possible changes within our University institutions. State support and funding consistent with that support is an issue. Is funding for your institution growing, remaining flat or decreasing? What changes is funding likely to have on your Weed Science program and how will you cope? Within Industry, you will see continued mergers accompanied by downsizing in staff and likely a reduction in industry support to University Weed Science research. Industry will invest less to screen, register and develop new pesticides. Why? We now enjoy the ability to control most all serious pests in our major crops. As a shareholder in any company engaged in the production of crop protection chemicals, would you be jumping at the chance to spend fifty million dollars on ten years of research and registration timelines to gain a 20% share of a market that already offers good control alternatives? Most shareholders will require greater returns in a shorter time.

We may have seen the "Golden Age of Weed Science" with the invention of many of the products that have and are serving us so well, but I believe Biotechnology will provide us with a host of new opportunities to tackle crop production problems with new tools. If atrazine was part of the "Golden Age of Weed Science" then Biotechnology can provide us with a spectacular future and leapfrog production to meet new environmental and world food demands.

Why do I believe in Biotechnology and what does the science of Genomics offer? We already have access to bioengineered corn borer resistance in corn and soon corn rootworm control will be offered. Genes are identified to improve disease resistance, reduce water stress and increase crop yields. Animal feeds can be altered to increase oil content and decrease phosphorus excretion. For consumers, plants as factories will provide pharmaceutical proteins such as human growth hormone. Increasing vitamin A content in rice will help combat night blindness and increasing folic acid levels in food will reduce birth defects. The race for Biotech is on; the major crops will have their gene sequences isolated and important action sites will be identified in the next three to five years. When the genetic map is drawn; new or improved products will quickly follow. Biotechnology is too powerful to ignore and without this tool the world will be a poorer place to live.

You might ask yourself "Where do I fit in this new production agriculture?" The answer may lie in what must change in our present agricultural practices. Soil organic matter content is still decreasing while soil erosion by wind and water is continuing to decrease soil productivity and add to our environmental issues. I believe all of us recognize that NoTill and Reduced Tillage practices can halt and even improve organic matter content and contribute significantly to reducing soil loss. Each of us alone are unlikely to impact agriculture in a way to cause significant change, however working together and combining our talents and resources gives us fantastic new opportunities to research and demonstrate sustainable crop production methods. Commodity prices for our crops and world competition require us to examine that we harvest maximum economic yields but not at the cost of sacrificing soil health. We must prove and demonstrate cropping practices that will keep our growers competitive in world markets. To do that, University research and extension and Industry must forge alliances. Often research and demonstration is less effective at the local level while regional cooperation can accomplish significant gains. Gone are the days when any of us can all go it alone in an agricultural market large enough for everyone to make a living. We must think in terms of developing Agronomic Systems that entail not one year of crop production practices but multiple years. The effect of each field operation on not only the current crop but succeeding crops must be questioned. We need a blueprint for sustainable crop production that improves soil health while maintaining and improving crop yields and providing opportunities for more profitable crop rotations. We need to work together.

New concepts, new practices and new approaches requires all of us to improve and learn new skills. To Weed Science graduate students, I predict a bright future if you are willing to broaden your horizons to include a larger agricultural package. Weed Science is a cornerstone in your training. Positions are limited for those who only want to practice weed control or research the effect of chemical A on weed B; you must be able to integrate your knowledge into a grander scheme. You have learned from some of the best and our WSWS organization is fortunate to include your teachers as our members. Now take your Weed Science training and add courses in Plant Pathology and Entomology; try to learn all you can about plant breeding and genomics. Plant ecology training is a plus. Agriculture needs people who can listen to a wide range of audiences and hear their concerns. Then you must be able to inform and communicate not only to growers but to a questioning public. Most importantly, you must have a passion for agriculture and a desire to make a difference in a world that needs your talents. Yours is an honorable profession. Never forget that your are helping to provide food, clothing and fiber. You are improving the nutrient content of our foods, harnessing the power of plants to produce nutriceuticals and increasing the food supply for a growing population. You can make a difference and you must make a difference.

Now let me finish with a question and a challenge to all of our WSWS members. Why do you come to this meeting? What take home messages do you hope to hear? What will keep you coming back next year and the year after? These are the questions and now for the challenge. If you think this meeting is not meeting your needs and if you are not gaining the information you seek, then it is up to you to give your opinion to one of your WSWS board members. Discuss, call or email Don Morishita and let him know your concerns and more importantly your ideas to improve our Society. I do not believe we can continue to just talk about weed control in this meeting and hope to remain a viable organization. Among all of us we have the ideas and vision to build a grand and exciting future. Let us work together to build an organization that offers more to each of us and more to Agriculture.

PARAGON SDC - BIOSPHERE AND BEYOND. Jane Poynter and Taber MacCallum, Paragon Space Development Corporation, Tucson, AZ.

Paper Not Submitted for Publication.

PUBLIC PERCEPTIONS AND UNDERSTANDING OF AGRICULTURAL BIOTECHNOLOGY[1]. Thomas J. Hoban, Ph.D. Professor, Department of Sociology and Anthropology, North Carolina State University, Raleigh, NC 27695-8107.

Consumer perceptions and understanding of agricultural biotechnology have been strongly influenced by the type of information provided by the media, confidence in governmental safeguards, and cultural preferences, says Thomas J. Hoban. Research indicates that consumers from different parts of the world have different perceptions and understanding of agricultural biotechnology. In this article, Hoban who has studied this issue for the past decade discusses consumer perceptions about biotechnology in food production and provides guidelines for meeting consumer information needs.

The first agricultural products of biotechnology have reached world markets. These products have received a frosty response in some parts of the world. But despite some recent sensational headlines in the press, North American markets have so far remained calm as foods containing ingredients developed through biotechnology have started arriving in stores. It is clear from a review of consumer surveys conducted in the United States, Japan, and Europe that consumer perceptions about biotech foods are strongly influenced by type of information, confidence in government, and cultural preferences.

VARYING VIEWPOINTS

In general, consumers worldwide see considerable value in the development of new medicines to combat disease and the use of biotechnology to develop new types of insect-resistant crop plants. Consumers are less likely to accept the use of biotechnology with animals (even to enhance human health), and they appear less accepting of food products developed through biotechnology, compared to crop plants -- which some consumers don't even directly connect with food. The most acceptable applications are those that offer a clear consumer benefit, as well as those that are perceived to be ethical and safe.

However, public attitudes about agricultural biotechnology vary considerably among countries. Consumers from Canada, Finland, Italy, Japan, the Netherlands, Portugal, and the United States are more positive about biotechnology than most other countries. Support for biotechnology is much lower in Austria, Denmark, Germany, and Sweden. Two countries -- the United Kingdom and France -- used to be quite positive toward biotechnology but have become more hostile in the past year or so. The United Kingdom has become more negative for a number of reasons, including fallout from mad cow disease, anti-biotechnology comments made by Prince Charles, food retailer panic, and an effective network of activist groups. France has become more negative partly due to French farmers' opposition to American grain imports and a broader French cultural opposition to what they see as the globalization (that is, Americanization) of the food supply.

Surveys in the United States (as recently as the spring of 1999) have consistently shown that between two-thirds and three-quarters of American consumers are positive about biotechnology, and about three-quarters have consistently expressed a willingness to buy insect-protected produce developed through biotechnology. One of the reasons cited for this willingness is that these products require fewer chemical pesticides. Support is highest among men and people with more formal education.

This is not to say that consumers don't have questions. Consumer groups have raised a number of concerns about agricultural biotechnology, particularly that it might somehow involve long-term or unexpected effects. Environmentalists often focus on possible ecological impacts from the use of biotechnology. While these raise important questions, they are not usually on the top of an average consumer's mind. Furthermore, consumers usually associate ethical issues with human or animal genetics, rather than with plants.

[1]Paper Published on the internet by the US Information Agency in November, 1999 at **http://www.usia.gov/journals/ites/1099/ijee/bio-toc.htm** For more information on this work or a set of slides on his talk, contact Dr. Hoban by phone at (919) 515-1676 or be e-mail at **tom_hoban@ncsu.edu**

AN INFORMED PUBLIC?

Surveys indicate fairly high awareness of biotechnology in Austria, Denmark, Luxembourg, and Sweden. But these are exceptions. In the United States, surveys since 1992 show that only about one-third of U.S. consumers have heard or read much about biotechnology -- except for a brief period in 1997, when increased media attention on the cloning of a sheep raised awareness to almost 50 percent. Only about one-third of Japanese consumers reported much awareness of biotechnology in 1995 or 1998. Awareness in France and the United Kingdom (as measured a couple years ago) was comparable to that in the United States, but it has risen for reasons discussed earlier.

Most people get their information on biotechnology from media coverage. If the media do not cover a particular story, the public tends to ignore that issue. The tone of information in the media has an important impact on consumer perceptions. Up until now, media coverage in the United States has tended to be positive and balanced (which helps account for the relatively high levels of acceptance of biotechnology).

This is a sharp contrast to the media coverage in the European Union. In fact, media coverage in the United Kingdom has taken on the characteristics of sensational tabloid journalism. The British media tend to rely on the use of emotional terms such as "Frankenfood." They also have been quick to jump on any negative allegations even when scientific consensus refutes the charge (as was the case with a controversy over the safety of insect-protected potatoes). That accounts for some of the negative consumer and food industry response in the United Kingdom.

Contributing to misinformation on biotechnology is the low knowledge in most countries of basic agricultural and biological sciences. This lack of understanding generates concern, especially when coupled with negative media coverage. There also appears to be a lack of understanding about traditional plant breeding. Countries with the highest levels of knowledge are Canada, the Netherlands, Sweden, and the United States. Countries with the least knowledge include Austria, Greece, Ireland, Portugal, and Spain. Survey results show that providing factual information increases consumer acceptance (at least in the United States, Canada, and Japan).

However, surveys also show that the source of the information may be an important factor in consumer preferences, and that a source trusted in one country is discredited in another. North American consumers have the most trust in independent health and scientific experts. In particular, acceptance increases significantly when American consumers learn that groups such as the American Medical Association, the U.S. Food and Drug Administration (FDA), and others have determined that the foods from biotechnology are safe. Japanese consumers also report high levels of trust in third-party scientific information sources. On the other hand, European consumers express the most trust in consumer and environmental groups. Their trust in government and industry is much lower than in North America.

LABELING FOR WHOM?

The most challenging issues surrounding agricultural biotechnology involve labeling. European consumers have generally been encouraged by consumer activists to demand labels identifying foods that have been developed through biotechnology. Several food retailers (especially in the United Kingdom) have tried to exploit the public concern as a marketing tool. Europe has labeling policies in place, but they have not yet been able to establish workable regulations or procedures. They are now grappling with difficult technical issues such as which methods to use to identify traces of biotechnology-derived ingredients. They also are trying to determine what percent of ingredients in processed foods can be derived from biotechnology and still allow the food to qualify as "biotechnology-free."

For the U.S. consumer, the Food and Drug Administration, an agency within the U.S. Department of Health and Human Services, has determined that a food product should be labeled as a product of biotechnology only if it has been changed in a significant way. FDA policy, supported by over 75 percent of U.S. consumers according to two national surveys, ensures product availability while providing consumers with relevant information about food safety or nutritional changes.

Recent focus groups in the United States also have demonstrated that the wording on labels has a significant effect on consumer understanding and acceptance of biotechnology. Many U.S. consumers are already overwhelmed by the level of detail on food labels and do not really want more information that has no scientific justification. Consumers want to know how a product has been changed and whether it has been approved by a government agency. Any label information needs to be simple, relevant, and clear.

The labeling of processed foods presents a number of logistical challenges and costs for everyone involved. For example, U.S. consumers have reported little need to label a bottle of ketchup that includes tomatoes developed through biotechnology in addition to traditionally bred varieties. In fact, most people don't even understand that different varieties of vegetables or fruits are currently blended during processing. In addition, consumers are not willing to pay extra to have foods labeled as a product of biotechnology (especially when this information has no meaning). Consumers want meaningful choices that are truly different. The "organic" market niche already provides a viable opportunity for consumers who do not want to consume foods developed through biotechnology, for whatever reason.

WHERE TO FROM HERE?

Biotechnology is at a crossroads in terms of public acceptance. Actions and statements by industry, government, and scientists over the next year will have a major influence on the long-term viability of the agricultural biotechnology enterprise. Without a major commitment to consumer education, opposition will continue to grow. Such efforts must be based upon ongoing research into the knowledge and attitudes held by consumers and opinion leaders. Different parts of the world clearly require different approaches.

Research results to date suggest that biotechnology should not become a major issue for most North American consumers. Most U.S. consumers (as well as others around the world) remain cautiously optimistic about the benefits of biotechnology. They will accept the products if they see a benefit to themselves or society and if the price is right. In fact, we are finding that consumers' responses to foods developed through biotechnology are basically the same as for any other food. Taste, nutrition, price, safety, and convenience are the major considerations. How seeds and food ingredients are produced will be relevant only for a small group of concerned "organic" consumers.

In countries where consumers are more negative about biotechnology -- Austria, Germany, Denmark, and Sweden -- media coverage and activist opposition have been more pronounced. In these four countries, discussion of the benefits of biotechnology has generally been ignored, while the potential risks have been emphasized. Basic social values and cultural beliefs also explain much of the differences in responses between countries. These are not necessarily amenable to educational efforts.

There also are a number of fundamental cultural differences. For example, consumers' attitudes about biotechnology are closely related to their general beliefs about science, technology, and food. European consumers tend to view farms as public natural areas where they can visit on weekends. Farms in the United States tend to be concentrated in the midsection of the country, far away from the urban population centers. Also in the United States, there has always been strong public support for and appreciation of new technology. Such support has not been as strong in parts of Europe. Some Europeans tend to view their food with an almost spiritual reverence, which is quite different from the common American view of food as fuel. These and other issues need more careful attention.

Another reason for the sustained U.S. support for biotechnology has been a long-term commitment to the education of opinion leaders and consumers. Beginning in the early 1990's, there has been an unprecedented partnership between the government, industry, universities, and third-party groups (such as the American Dietetic Association) to understand and address public concerns well before the products of agricultural biotechnology are released. There is a critical need to renew that commitment to education, information, and social science research.

Our experience in the United States provides some guidelines for a global program of information and education. Consumers need to recognize the existing benefits and future promises of biotechnology. The opportunity that biotechnology provides for feeding the world (while protecting the environment) will be compelling for many consumers. It is also important to build trust in government and scientists to serve the public interest. This requires that farmers, scientists, government officials, and others work together to ensure that consumer decisions are based on balanced information.

POSTER SESSION

REDUCTION OF YELLOW STARTHISTLE POPULATIONS INFLUENCES EFFICACY OF BIOCONTROL AGENTS. Guy B. Kyser, Joseph M. DiTomaso, and Michael Pitcairn, Staff Research Associate and Cooperative Extension Non-Crop Weed Ecologist, Weed Science Program, Department of Vegetable Crops, University of California, Davis, CA 95616 and Associate Environmental Research Scientist, California Department of Food and Agriculture, Biological Control Program, Sacramento, CA 95832.

Abstract. Insects introduced for biological control of yellow starthistle show potential for long-term suppression. California populations of yellow starthistle gall fly, yellow starthistle peacock fly, yellow starthistle hairy weevil, and yellow starthistle bud weevil have become sustainable. We used multiple regression to estimate effectiveness of individual agents. Results indicate that an individual hairy weevil consumes the most starthistle seeds (34.7 seeds on average), followed by peacock fly (26.4), bud weevil (13.7), and gall fly (5.1). However, California is so heavily infested with yellow starthistle that biocontrol alone probably cannot reduce starthistle populations to manageable levels.

Reducing starthistle populations by applying the selective herbicide clopyralid may funnel biocontrol agents onto starthistle plants which escape the herbicide treatment. We applied a low rate (0.5 oz/A) of clopyralid to 500-m^2 plots in a field near Folsom, CA that is heavily infested with starthistle and that supports a dense population of gall flies, peacock flies, and hairy weevils. The herbicide treatment reduced starthistle cover by 70%. We monitored the presence of biocontrol agents in untreated plots and on escapes within treated plots. Gall fly attacks increased by 3.7 times in treated plots (16.2% of flowerheads attacked vs 4.4% in untreated plots), and peacock fly attacks increased by 1.5 times (108.4% vs 70.3%). However, hairy weevil attacks decreased to 2.8% from 11%. Hairy weevils are univoltine and complete their reproductive cycle by early summer. Because most starthistle plants in untreated plots matured earlier than escapes in treated plots, we postulate that hairy weevils migrated to untreated plots.

BIOLOGICAL CONTROL OF YELLOW STARTHISTLE IN THE WEST. Linda M. Wilson and Christine Kuykendall, Research Support Scientist, University of Idaho, Moscow, ID 83344-2339 and Director, Nez Perce Biocontrol Center, Lapwai, ID 83540.

Abstract. Biological control of yellow starthistle, *Centaurea solstitialis*, is a well-established program in the western US. Five insect species, all seed feeding, have been introduced and established. Among the introduced species are two fruit flies, *Urophora solstitialis* and *Cheaetorellia succinea*, and three weevils, *Bangasternus orientalis*, *Eustenopus villosus*, and *Larinus curtus*. Larvae of these insects develop in the seedhead, feeding on young achenes. Up to 95% seed reduction has been recorded in some studies. Yellow starthistle is an annual weed that relies on seeds to maintain population size. Significant reduction in reproductive output may mediate population levels, and studies are currently being conducted to evaluate the impact of seed reduction on the population dynamics of yellow starthistle. Biological control is a valuable component of large scale, integrated weed management programs that minimize the spread of this noxious weed, decrease established infestations, revegetate following control, and modify land use patterns.

MANAGEMENT OF ARTICHOKE THISTLE, *CYNARA CARDUNCULUS*. Virginia A. White, Jodie S. Holt, and Amanda B. Boose, Graduate Student Researcher, Professor, and Staff Research Associate, University of California, Riverside, Riverside, CA 92521.

Abstract. Artichoke thistle, *Cynara cardunculus*, is an invasive perennial weed occurring on thousands of acres of California grassland. Effective management will require biological information such as phenology, growth rate, and length of time until the plant is functionally perennial. A phenology experiment was conducted to observe emergence, growth, and development of *C. cardunculus* over 18 months. In an irrigated field at the UCR Experiment Station, seeds were planted each month for one year in a randomized complete block design. The number of days required to reach specified phenological stages (emergence, 2 to 10 leaves, bolting, 1 to 10 flowers, and seed set) was recorded. A clipping experiment was conducted to determine when plants become functionally perennial. At predetermined phenological stages, all aboveground plant matter was removed and the number of days until resprouting was recorded. In the phenology experiment, rate of rosette formation and reproductive maturity were greatly affected by month of planting. In the clipping experiment, every treatment resprouted but the number of days necessary to resprout was affected by the stage at which the plant was clipped. Furthermore, even plants clipped at the cotyledon stage resprouted, indicating that plants become functionally perennial soon after emergence.

LEAFY SPURGE AND RUSSIAN KNAPWEED ENCROACHMENT ON COLORADO RANGELAND.
James R. Sebastian and K. G. Beck, Research Associate and Associate Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80538.

Abstract. Russian knapweed (ACRRE) and leafy spurge (EPHES) are aggressive, colony-forming perennials. Both reproduce from seed as well as vegetative buds in their extensive root systems. Once established, both Russian knapweed and leafy spurge can completely dominate rangeland and adapt well to poor range conditions. Although these weeds are known to be aggressive and displace native vegetation, few studies have monitored their expansion and dominance.

ACRRE and EPHES cover, density, and frequency, and grass cover was monitored from 1994 to 1999. Each study was conducted on a square grid system with permanent transects running perpendicular to each other at 1.5 meter intervals. A 0.1 m^2 quadrat was used at 1.5 meter intervals along each transect to determine EPHES or ACRRE cover, density, and grass cover. ACRRE patch radius was monitored from the center of the grid to permanent markers along the border. The outer-most ACRRE canopy cover distance along a line-intercept was recorded for each grid marker. Outside (X,Y) coordinates were recorded on a graph and ACCRE patch area was calculated each year of the study. The ACCRE and EPHES study sites were located in the same pasture approximately 200 meters apart. Western wheatgrass comprised 90% of the grass composition at the EPHES site, while smooth brome and western wheatgrass contributed 50% each to the grass composition at the ACRRE site. Data collected from individual quadrats were averaged over a transect and cover, density, and frequency of individual species in a patch were determined by averaging data from all transects.

EPHES frequency increased from 27 to 71%, density from 10 to 49 shoots/m^2, and cover from 8 to 34% from 1994 to 1999. EPHES density increased from 284 to 1,413 total shoots in the study site during this time. Grass cover increased from 8 to 47% from 1994 to 1999, however, grass cover decreased as EPHES increased in cover and density. Grass cover was 60% where no EPHES was present compared to a low of 35% with EPHES at 95% cover and 12 EPHES shoots/m^2. The trend from 1994 to 1999 was an increase in both EPHES and grass cover, and a dramatic increase in EPHES frequency. EPHES patch expansion was considerable throughout the study site over 6 years. The continual increase in EPHES shoots within the study site illustrates EPHES aggressive nature.

ACCRE frequency increased from 31 to 37% from 1994 to 1999. ACCRE cover was static with a high of 23% in 1995 to low of 13% in 1999. ACCRE density decreased from 26 to 18 shoots/m^2 while grass cover increased from 11 to 35% from 1994 to 1999, respectively. Grass cover was 40% where no ACCRE was present compared to 5% grass cover with 80% ACCRE cover and 11 shoots/m^2. The ACCRE patch area increased from 239 m^2 to 279 m^2 from 1994 to 1999. This is an increase of approximately 15% over 6 years. ACCRE cover and density did not increase or decrease substantially from 1994 to 1999, but fluctuated each year. Grass cover increased approximately 3-fold from 1994 to 1999 possibly due to increased precipitation and improved grazing management. Although ACCRE frequency and patch radius slightly increased from 1994 to 1999, ACCRE reduced grass cover within the ACCRE patch. The ACCRE patch seems relatively stable other than minor expansion along the perimeter that provided a 15% increase in surface area over 6 years. Russian knapweed seems to be more dependent upon root than seed propagation. No seedling emergence was noted for the duration of the study and shoot recruitment was confined to the outer boundary of the patch.

The grid system illustrates the increase and decrease in cover, density, and frequency as well as directional shifts in populations. This system has the potential for multiple uses. The grid could provide a valuable tool in monitoring endangered species, soil and vegetation surveys, and shifts in specie's composition. Correlating direction of patch expansion to soil texture and plant community composition may help identify habitats at greatest risk for noxious weed invasion.

INTER- AND INTRA-SPECIFIC VARIATION AMONG ACCESSIONS OF *CARDARIA* SPP. IDENTIFIED WITH AMPLIFIED FRAGMENT LENGTH POLYMORPHIS. D. K. Jewett, N. R. Spencer, and B. A. Frederick, Research Associate, Station Director, and Research Associate, USDA, ARS Northern Prairie Agricultural Research Lab, Sidney, MT 59270.

Abstract. Hoary cress (Brassicaceae: *Cardaria draba* (L.) Dsv.) is an important pest of rangeland, alfalfa, other field crops, and vegetable crops. Presently, it has been reported to occupy more than a quarter of a million acres on county and Forest Service land, as well as an undisclosed area on other ownerships, in six states: California, Idaho, Kansas, North Dakota, Oregon, and Utah. In North America, it is included on the noxious weed list of 15 states and one province, and it has been reported occasionally in most other states and provinces during the past century. The accuracy of these numbers depends upon the frequency of which other weeds are mistaken for hoary cress. Despite differences in silicle morphology, response to herbicides, 2n number of chromosomes, and seed viability, related mustards, including *C. chalepensis* and *C. pubescens*, are frequently mistaken for *C. draba*. Reports that herbicides are ineffective against hoary cress may reflect the frequency of which it is misidentified, resulting in inappropriate formulations applied. Inadequate knowledge of the weed's phylogeny and taxonomy is an obstacle to its sustainable management, and potential for its biological control is being assessed. Results of amplified fragment length polymorphism are anticipated to characterize interspecific variation among 130 accessions of the three species from eastern Australia or western United States. They also are anticipated to characterize intraspecific variation. Results of this study may facilitate the responsible selection of biological control age.

THE INTERACTION OF FIRE AND HERBICIDES IN THE CONTROL OF SQUARROSE KNAPWEED.
Steven A. Dewey, R. William Mace, Lillian A. Buhler, and Kimberly Andersen, Professor, Research Associate, and Research Assistants, Department of Plants, Soils, and Biometeorology, Utah State University, Logan, UT 84322-4820.

Abstract. Rangeland infested with squarrose knapweed was burned by wildfire in August of 1996. Various rates and combinations of picloram, clopyralid, and 2,4-D, were applied to burned and non-burned areas in October of 1996 or May of 1997. In one study, fall-applied picloram (0.25 to 0.5 lb/A) plus 2,4-D (0.5 lb/A) preceded by

wildfire resulted in 98 to 100% control of squarrose knapweed 32 months after treatment; whereas the same herbicides without pre-application wildfire provided only 7 to 20% control. Grass yields increased 4- to 8-fold following fall herbicide treatments preceded by fire. In a second study, fall herbicide applications following fire again generally were more effective than corresponding treatments in non-burned plots. However, there were no significant differences in effectiveness between burned and non-burned plots after 2 years if herbicides were applied in the spring. In the absence of any herbicide treatment squarrose knapweed biomass increased in burned areas by more than 120% in just one year.

SPOTTED KNAPWEED, MEADOW HAWKWEED AND YELLOW STARTHISTLE RESPONSE TO IMAZAPIC. Sandra L. Shinn and Donald C. Thill, Graduate Research Associate and Professor, Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83844-2339.

Abstract. Spotted knapweed, meadow hawkweed, and yellow starthistle currently infest about 297,000, 79,000 and 262,000 ha, respectively, of range and non-cropland in Idaho. The purpose of this study was to determine the effect of different imazapic rates and application times on control of these weeds. Experiments were established on unimproved pasture land near Lewiston (yellow starthistle), St. Maries (spotted knapweed and meadow hawkweed) and Athol, ID (spotted knapweed). Treatments were arranged as a 2 (fertilizer) by 12 or 15 (herbicide) factorial randomized complete split-block design. Imazapic was applied PRE (only yellow starthistle) and POST in fall 1997, and POST in spring 1998. Picloram and an untreated control were included in each experiment. Ammonium sulfate fertilizer was applied during spring 1998 to one half of each block, while no fertilizer was applied to the other half. Treatments were applied only during the first year of the two year study. Picloram controlled yellow starthistle, meadow hawkweed, and spotted knapweed 98 to 100%, reduced plant density 89 to 100%, and biomass 69 to 100% in 1998. In 1999, control was 77 to 100% and plant density and biomass were reduced 68 to 100% and 18 to 100%, respectively. Imazapic did not control spotted knapweed. Meadow hawkweed was controlled 14 to 68% in 1998 when imazapic was applied sequentially (fall and spring), but was not controlled in 1999. Imazapic applied PRE reduced the yellow starthistle density 62 to 83% in 1998 and 7 to 27% in 1999. Surviving yellow starthistle plants were large and produced total biomass similar to untreated plants.

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

Abstract. Diflufenzopyr is an auxin transport inhibitor (ATI) which interferes with the transport of naturally occurring auxin and synthetic auxin-like herbicides in plants. Diflufenzopyr blocks the polar transport of these compounds and disrupts the auxin balance needed for plant growth. Previous research at North Dakota State University has shown perennial weed control was increased by the addition of diflufenzopyr to dicamba and other auxin herbicides. The purpose of this research was to evaluate diflufenzopyr at various rates applied with auxin herbicides for leafy spurge, spotted knapweed, and Canada thistle control. Herbicides evaluated included dicamba, picloram, 2,4-D, picloram plus 2,4-D, quinclorac, clopyralid, clopyralid plus 2,4-D, and imazapic.

In the first study, herbicides were applied at the normal use rate for season-long leafy spurge control to determine if the addition of diflufenzopyr increased leafy spurge control compared to the herbicides alone. Herbicides were applied in the fall prior to a killing frost. Leafy spurge control with picloram was increased by 2-fold 24 MAT (months after treatment) when the herbicides were applied with diflufenzopyr compared to the herbicides alone.

The second experiment evaluated the importance of the diflufenzopyr ratio (herbicide:ATI) applied with various herbicides for leafy spurge and Canada thistle control. Leafy spurge and Canada thistle control 12 to 15 MAT was greater when herbicides were applied with diflufenzopyr compared to alone, regardless of the diflufenzopyr rate. For example, leafy spurge control increased from 38 to 92% with picloram plus 2,4-D when diflufenzopyr was added compared to picloram plus 2,4-D applied alone. Canada thistle control increased from 13 to 42% with clopyralid plus 2,4-D when diflufenzopyr was added compared to clopyralid plus 2,4-D alone. Spotted knapweed control was similar whether or not diflufenzopyr was applied regardless of the herbicide evaluated.

In summary, leafy spurge control was increased when diflufenzopyr was applied with auxin herbicides. Canada thistle control with clopyralid was improved when the herbicide was applied with diflufenzopyr. Diflufenzopyr could be used to increase long-term perennial weed control with herbicides or allow the use of reduced herbicide rates without subsequent loss in weed control.

CONTROL OF TREE-OF-HEAVEN IN RIPARIAN AREAS WITH IMAZAPYR STEM INJECTION.
Joseph M. DiTomaso and Guy B. Kyser, Cooperative Extension Specialist and Staff Research Associate, Department of Vegetable Crops, Weed Science Program, University of California, Davis, CA 95616.

Abstract. Tree-of-heaven was introduced as an ornamental to the United States from eastern Asia before 1800. It soon escaped cultivation and spread in urban, nursery, woodland, riparian, and other disturbed areas throughout the country. Because tree-of-heaven produces vigorous suckers and stump sprouts, mechanical control efforts are generally unsuccessful. Foliar herbicide treatments are difficult for control of large trees and can injury desirable vegetation. Although basal bark treatments with triclopyr and cut stump treatments with glyphosate or triclopyr are effective, stem injection technique requires less herbicide, prevents resprouting from cut stems, and provides flexibility in the timing of tree removal.

In this study, we evaluated the effectiveness of stem injection treatments with undiluted imazapyr (2 lb/gal) on tree-of-heaven clumps or trees with single stems (1.5 to 6 inches diameter). Treatments were made in October 1998. Small trees with stem diameter between 1.5 and 3 inches were given one angled hatchet mark with a hand axe and injected with 1 ml of imazapyr formulation. Medium trees with stem diameter between 3 and 6 inches received two hatchet marks and were injected with 1 ml per mark. Hatchet marks and herbicide treatments were made to clumps by adding the diameters of all stems and dividing by four or eight. This represented one herbicide injection per 6 and 12 inches of stem diameter. All treatments included 12 replicates. Trees were cut and removed with a chainsaw in February, four months after treatment, and evaluated in June for number of resprouts and crown reduction. Clumps will not be cut until June 2000. The study included a corresponding set of hacked and untreated control trees and clumps.

Eight months after treatment, no resprouts developed on both small and medium treated trees. In comparison, untreated trees had an average of 2.8 resprouts. Imazapyr treatments resulted in average crown reduction of over 97% on both small and medium trees. Average crown reduction was 84 and 76% in clumps treated with 1 ml imazapyr for every 6 and 12 inches stem diameter, respectively. These results indicate that stem injection is an effective alternative to cut stump treatment for control of tree-of heaven, particularly in sensitive riparian areas.

DETECTING YELLOW STARTHISTLE (*CENTAUREA SOLSTITIALIS*) WITH HYPERSPECTRAL REMOTE SENSING TECHNOLOGY. L. W. Lass and D. C. Thill, Research Associate and Professor, Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83844-2339.

Abstract. Early detection of small weed infestation on range and forest lands will allow for more successful weed management. Hyperspectral remote sensing technology uses a new type of sensor that better defines the reflective light spectrum when compared to older sensors, thus improving weed detection accuracy and efficiency. The objective of this research project was to develop modern remote sensing procedures to accurately and efficiently detect locations of yellow starthistle in range and forest lands with management level accuracy. The Probe 1 hyperspectral sensor, from Earth Search Sciences Inc., McCall, ID recorded images of the Snake River Canyon south of Lewiston, ID on July 19, 1998. The instrument is an imaging spectrometer that measures reflected light at wavelengths from 440 to 2,543 nm in 12 to 16 nm increments. A spectral angle mapper (SAM) algorithm was used to classify the images. SAM quantifies the image class separability based on the measures of the angle between two vectors that point to the center of known spectral values for the plant species and recorded pixel values of the image. SAM classifies the pixel as infested with yellow starthistle regardless of cover class, since the spectral values of the lower cover classes tend to decline along the vector established for high cover class populations. Infestations with 70 to 100% yellow starthistle cover and larger than 0.1 ha appear regardless of the classification angle. However, the low SAM angles (2 and 3 degrees) did not completely define the extent of the infestation regardless of cover class and the highest SAM angle tested (10 degrees) started to show new areas that were not infested. Accuracy assessment showed the overall image errors were the lowest (10 to 15%) when SAM angles were set to 5 or 6 degrees. Assessment of the yellow starthistle class in images from 5 or 6 degrees SAM angles showed a 10% and 20% omissional (not on image but on ground) and commissional (on image but not on ground) error, respectively. Higher than expected commissional error could be attributed to pixels with mixed vegetation consisting of mostly shrub-grass. SAM identified areas of the Probe 1 image as infested with as little as 1 to 30% yellow starthistle cover. Early detection of new infestations may be possible with hyperspectral sensors if some commissional error is acceptable.

WILL SURFACE STERILIZATION OF PURPLE NUTSEDGE TUBERS INFECTED WITH ROOT KNOT NEMATODE AFFECT THE ABILITY OF ROOT KNOT NEMATODE TO INFECT CHILE.
Nora McCaw White, Jill Schroeder, Stephen H. Thomas, Cheryl Fiore, and Jacki Fuchs, Undergraduate Student, Professor, Professor, Research Assistant, and Research Specialist, Department of Entomology, Plant Pathology and Weed Science, New Mexico State University, Las Cruces, NM 88003.

Abstract. Yellow (YNS) and purple nutsedge (PNS) host the plant pathogenic root knot nematode (RKN), *Meloidogyne incognita*. Infested YNS tubers serve as a source of inoculum for chile peppers. RKN associated with YNS and PNS has also survived fumigant nematicide treatments. The objective of this research was to determine if RKN infested PNS tubers serve as a source of inoculum to infect chile and if the nematode is located on the surface of the tubers. The experiment was established with a factorial treatment arrangement in a randomized complete block design with six replications. Factors included RKN infested or noninfested PNS tubers and three surface sterilization treatments. Sprouted rhizomes and shoots were removed prior to shaking the tubers with a hypocholorite solution (10% v/v) for 2 or 10 min or with tap water for 2 min. After rinsing, four tubers were planted in each pot containing a 4- to 6-leaf chile plant 'NM 64' to bioassay for the presence of RKN. After 75 days the pots were harvested to determine the level of RKN infection on the chile and PNS. Plant top and root dry weights, tuber number and weight, and RKN count by species were determined. RKN infested PNS tubers inoculated chile in all of the surface sterilization treatments. RKN does not reside on the surface of the tuber. RKN populations were higher on chile and PNS in the 10 min bleach treatment than the control. Further research is needed to determine where the RKN is located within the tuber.

HERBICIDE TESTING IN HYBRID SPINACH GROWN FOR SEED. Timothy W. Miller and Carl R. Libbey, Extension Weed Scientist and Agricultural Technologist, Washington State University, Mount Vernon Research and Extension Unit, Mount Vernon, WA 98273.

Abstract. Hybrid spinach is slow growing initially and easily overcome by early-season weed competition. It is also a very minor acreage row crop in which few herbicides are registered for use. Closely related to common lambsquarters, spinach is sensitive to many herbicides, even those registered for use in other Chenopodiaceae crops such as sugarbeet. Consequently, weed control in hybrid spinach seed has relied on expensive hand weeding within the row and rototilling between the rows. In on-going studies at WSU Mount Vernon, several herbicides and herbicide combinations have been tested for crop safety and efficacy.

Of 25 total treatments tested in 1999, only *S*-metolachlor plus dimethenamid (0.5 + 0.75 lb/A PRE) was still providing greater than 90% weed control 69 days after treatment, although it caused moderate (13%) initial crop injury. Treatments combining low (< 10%) crop injury and good (> 85%) mid-season weed control were pyrazon plus dimethenamid (1 + 0.75 lb/A PRE), *S*-metolachlor plus phenmedipham (0.5 + 0.5 lb/A PRE + POST), phenmedipham plus pyrazon (0.5 + 0.5 lb/A POST), and cycloate plus phenmedipham (1 + 0.5 lb/A PPI + POST) (87, 87, 87, and 85% control, respectively). Crop density was severely reduced by combination treatments with ethofumesate; other treatments statistically reducing the stand from the handweeded check were cycloate plus *S*-metolachlor (1 + 0.5 lb/A PPI + PRE) and pyrazon plus phenmedipham (1 + 0.5 lb/A PRE + POST). Most treatments did not statistically reduce seed yield from the handweeded check. Only cycloate plus *S*-metolachlor (1 + 0.5 lb/A PPI + PRE), ethofumesate plus dimethenamid (0.5 + 0.75 lb/A PRE), and *S*-metolachlor plus ethofumesate (0.5 + 0.75 lb/A PRE) yielded poorer than the handweeded check.

EFFECT OF ROOT-KNOT NEMATODES ON THE CONTROL OF PURPLE AND YELLOW NUTSEDGE WITH PYRITHIOBAC AND HALOSULFURON. Michael Ronquillo, Jill Schroeder, Stephen H. Thomas, Leigh Murray, and Kenneth Brown, Undergraduate student, Professor, and Professor, Department of Entomology, Plant Pathology, and Weed Science, Professor and Graduate Student, University Statistics Center, New Mexico State University, Las Cruces, NM 88003.

Abstract. Both purple and yellow nutsedge (PNS, YNS) are major weed pests in chile pepper crops grown in southern New Mexico. PNS and YNS are hosts to root-knot nematodes (RKN). RKN can increase the vigor of the YNS and PNS and may affect the efficacy of herbicides. The objective of this experiment was to evaluate PNS and YNS control with pyrithiobac and halosulfuron and to determine if root-knot nematodes affect control. These herbicides are currently being evaluated for use in chile pepper production. PNS and YNS were evaluated in separate experiments. Each experiment was established with a two by three factorial treatment arrangement in a randomized complete block design and six replications. Factors were the presence or absence of RKN and three herbicide treatments including a control. Pre-germinated PNS and YNS tubers were planted in 6 inch pots, placed on benches within a greenhouse, and inoculated one day after planting with ca. 10,000 RKN eggs. At the 4- to 5-leaf stage of growth, PNS and YNS were treated with pyrithiobac at 0.064 lb/A or halosulfuron at 0.032 lb/A. Visual evaluations were taken weekly to evaluate nutsedge damage and regrowth. The experiments were harvested 45 days after planting. The results of these experiments showed that there was no interaction between the RKN and the herbicide treatments. Root and shoot dry weight were surpressed by both herbicide treatments and neither affected the reproduction of the nematodes on the roots. The halosulfuron was more effective for both PNS and YNS control the pyrithiobac.

COWPEA COVER CROP MULCH FOR WEED CONTROL IN DESERT PEPPER PRODUCTION.
Milton E. McGiffen, Jr. and Chad Hutchinson, Department of Botany and Plant Sciences, University of California, Riverside, CA 92521-0124 and Univ. of Florida, Hastings Res. and Educ. Center, P.O. Box 728, Hastings, FL 32145.

Abstract. A two-year field project was conducted in Thermal, CA investigating cowpea (*Vigna unguiculata*) mulch (CM) as an alternative weed control option in pepper (*Capsicum annuum*) production. Treatments included bare ground production system (BG) with hand weeding, BG with no weeding, a cowpea mulch production system (CM) with hand weeding, and CM with no weeding. Cowpea was seeded in July in 76 cm beds and irrigated with buried drip line. Two weeks prior to transplanting peppers, irrigation water was turned off to dry cowpea plants. In September, cowpea was cut at the soil-line and mulch returned the bed top. Pepper plants were transplanted into mulch and fertilized through drip line. During the season at two-week intervals, number of weeds emerged and pepper plant heights were measured. Additionally, at harvest in December, fruit production, pepper plant dry weight, and weed dry weight were measured. Fewer weeds emerged in CM compared to BG. At harvest, weeds emerged in non-weeded CM were reduced 80 and 90% compared to non-weeded BG for 1997 and 1998, respectively. Weed dry weights in non-weeded CM were 67 and 90% less than weed dry weights in non-weeded BG over the same period. In 1997 and 1998, respectively, pepper plants in CM produced 202 and 156% more dry weight than in BG. Pepper plants in CM produced more fruit weight than in BG with similar fruit size. CM provided season long weed control without herbicides while promoting plant growth and fruit production compared to the BG system.

SPATIAL CHARACTERISTICS OF WEEDS IN TOMATO FIELDS. Martina Dokladalova and W. Thomas Lanini, Graduate Student and Extension Weed Specialist, Vegetable Crop Department, University of California, Davis, CA 95616.

Abstract. The current trend in agricultural production is moving towards herbicide use reduction while maintaining high levels of weed control. A selective herbicide application can be implemented after weed maps are drawn based on spatial characteristics of weed dispersal. Creating weed density maps of the dominant weeds in the processing tomato fields, and examining the use of these maps to support selective herbicide spraying is the goal of this research. Sampling techniques and data analysis are explored in their effectiveness to describe the variability of weed aggregation patterns. Kriging as a weighted average of observed weed densities gives an estimate of the weed densities and the variance at unsampled locations and is used for creating the weed maps. Weed maps are divided into zones so the variability of weed infestation within zones is minimal and between zones is maximal. Sequential sampling techniques are used as innovative approaches to minimize the sampling requirements to give accurate estimates of weed densities in each manageable zone. Black nightshade and barnyardgrass are the main dominant weeds in California processing tomato fields. The data collected suggest that the temporal stability of weed occurrence within a field exists. However the intensity and the size of weed clumpes changes from year to year. Highly aggregated weeds are spread in succeeding years, size of patches is increased by tillage while the level of weed abundance remains constant.

INVESTIGATING WILD OAT SEED DISSEMINATION USING AN INDIVIDUAL-PLANT GROWTH MODEL. William J. Price and Donald C. Thill, Graduate Student and Professor, Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83844-2339 and Bahman Shafii, Department of Statistical Programs, Division of Plant Science, College of Agriculture, University of Idaho, Moscow, ID 83844-2339.

Abstract. An individual-plant growth simulation model for quantifying plant competition between spring barley and wild oat has been developed previously. Incorporation of that model into a larger simulation framework will allow for more complex phenomena to be investigated while accounting for plant-to-plant competition. As a demonstration of this idea, the calibrated growth model is used as the basis of a simulation describing the dispersal of wild oat seed within a spring barley crop production system. This simulation can be used to explore various factors effecting seed dissemination, e.g. initial points of infestation, harvest equipment, dormancy or seed banks, basic management strategies, etc. Investigation of such factors in a sensitivity analysis system has potential applications in weed science education. Instructors or students are provided with the flexibility to setup scenarios contrasting various relevant parameters. The computing requirements of the model are relatively intense, however, the use of the model should be feasible within a research or university environment and could prove to be a valuable educational tool.

AN INTERNET RESOURCE REVIEW FOR INTRODUCTORY WEED SCIENCE COURSES IN THE 21ST CENTURY. David W. Wilson and Stephen D. Miller, Instructor and Professor, Department of Plant Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. As we head into a new millennium improving classroom integration of available Internet resources becomes paramount. Several categories of classroom materials are available online. Weed taxonomy and identification sites, research publication access, weed science extended education courses, extension bulletins and teaching help kits are just a few of the available Internet resources now available. Weed science instructors can decrease course preparation time and increase integrated computer use in their course through active student access to on-line materials. The potential for building an individual course related link site for access to the wide variety of world wide resources is easily attainable.

PROPENSITY OF WEEDS TO EVOLVE RESISTANCE TO HERBICIDES. Ian H. Heap, Weed Scientist, WeedSmart, P.O. Box 1365, Corvallis, OR 97339.

Abstract. Some weed species show a propensity to evolve resistance to a wide range of herbicides. Of the 147 weed species that have evolved resistance to one or more herbicide modes of action (MOA), 104 had evolved resistance to only one herbicide MOA, 26 species to 2 MOA, 10 species to three MOA, 2 species to four MOA, 4 species to five MOA, and 1 species (rigid ryegrass – *Lolium rigidum*) had evolved resistance to eight herbicide modes of action thus giving a total of 222 herbicide-resistant weed biotypes. Rigid ryegrass has evolved resistance to the herbicide modes of action 1, 2, 3, 5, 7, 9, 11, and 15 (letters represent the WSSA herbicide mode of action classification). Other weeds that have evolved resistance to numerous MOA's are wild-oat (*Avena fatua*) to 1, 2, 8, 15, and 25; barnyardgrass (*Echinochloa crus-galli*) to 1, 3, 5, 7, 8, and 15; goosegrass (*Eleusine indica*) to 1, 2, 3, 9, and 22; annual bluegrass (*Poa annua*) to 5, 7, 11, 16, and 22; black-grass (*Alopecurus myosuroides*) to 1, 2, 3, and 7; and horseweed (*Conyza Canadensis*) to 2, 5, 7, and 22. With the exception of horseweed these species all belong to the family Poaceae. The 147 resistant weed species belong to 29 weed families. Forty-eight species belong to Poaceae and 29 to Asteraceae, accounting for 53% of all resistant species, which reflects the large number of weeds in general from these families. Information about these resistant weeds and the WSSA herbicide groups can be found on the International Survey of Herbicide Resistant Weeds web site at http://www.weedscience.com.

VARIATION IN AMPLIFIED CHLOROPLAST GENES FROM DIFFERENT LOCOWEED VARIETIES IN NEW MEXICO. Sanjeev Kulshreshtha and Tracy M. Sterling, Research Specialist and Associate Professor, Department of Entomology, Plant Pathology and Weed Science, New Mexico State University, Las Cruces, NM 88003.

Abstract. Locoweeds [woolly locoweed (*Astragalus mollissimus*), silky crazyweed (*Oxytropis sericea*), and Lambert's locoweed (*Oxytropis lambertii*)] cause "locoism" in livestock resulting in large economic losses. As an alternative to chemical and mechanical means of controlling locoweeds, potential of biological control of these weeds has not yet been fully explored. Previously, this lab has reported differential feeding behavior of the weevil *Cleonidius trivittatus* on various woolly locoweed varieties (*A. mollissimus* var. *bigelovii, earlei, matthewsii, mollissimus, mogollonicus*, and *thompsonae*) indicating differential physio-biochemical characteristics of these varieties. Therefore, a study was initiated to evaluate phylogenetic relationships among *Astragalus mollissimus* varieties found in New Mexico. Chloroplast DNA (cpDNA) from different locoweed varieties collected from various locations in New Mexico, was used for amplification of a specific single, contiguous target gene sequence comprised of the cp genes *rpo C1* and *rpo C2*. As a negative species control, amplifications from pea (*Pisum sativum*) cpDNA were included. To deduce the phylogenetic relationships among different locoweed varieties, amplified products were subjected to a set of 12 different restriction enzymes which are polymorphic in nature for *Astragalus* species. Restriction sizing of restricted fragments was performed using various gel conditions ranging from 1 to 3% agarose. Patterns of appearance of different molecular weight (MW) fragments on gels were scored. Variation among restriction fragments was observed for only three enzymes. This result suggests that the *rpo C1* and *rpo C2* genes are relatively conserved in these locoweed varieties. These results will be used to develop a phylogenetic tree among these varieties, and to evaluate if more restriction sites should be analyzed.

GENETIC DIVERSITY OF JOINTED GOATGRASS (*AEGILOPS CYLINDRICA*) USING DNA FINGERPRINTING TECHNIQUES. Todd A. Pester[1], Sarah M. Ward[2], Philip Westra[1], and Scott J. Nissen[1], Graduate Research Assistant, Assistant Professor, Professor, and Associate Professor, [1]Department of Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523 and [2]Department of Soil and Crop Sciences, Colorado State University, Ft. Collins, CO 80523.

Abstract. The objective of this study was to determine the genetic diversity of jointed goatgrass accessions using DNA fingerprinting techniques. Eight jointed goatgrass accessions were selected, that represented a range of geographic locations, from a collection of 53 accessions currently being maintained at CSU. RAPD (Random Amplification of Polymorphic DNA) techniques were used for DNA-based genetic fingerprinting. DNA was extracted and amplified with 30 different 10-base random primers. Using agarose gels, many distinct bands were produced in each run but only two polymorphisms were detected, indicating very little genetic diversity among these eight accessions. This result is consistent with the loss of allelic variation after long distance colonization events and the limited amount of time in the new environment to increase genetic diversity by outcrossing. Fifty additional jointed goatgrass accessions from 13 different Eurasian countries were obtained from the National Small Grains Collection in Aberdeen, ID. The same 30 primers were used on the Eurasian accessions and again, few polymorphisms were detected. These results suggest either a very limited amount of genetic diversity in jointed goatgrass or the inability of RAPD techniques to detect the diversity in this species. To improve DNA fragment resolution, polyacrylamide gel electrophoresis (PAGE) and silver staining techniques were employed on 16 selected accessions; 13 Eurasian accessions, one from each country in our collection; and three U.S. accessions, one each from Washington, Colorado, and Oklahoma. The PAGE and silver staining techniques resolved several more DNA bands of various fragment size; however, very few polymorphisms were still detected.

GLUFOSINATE EFFICACY, ABSORPTION, AND TRANSLOCATION IN PIGWEED SPECIES AS AFFECTED BY RELATIVE HUMIDITY. Elmé Coetzer, Kassim Al-Khatib, and Monte D. Anderson, Graduate Student and Associate Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506 and Field Development Representative, Aventis, Gretna, NE 68028.

INTRODUCTION

Palmer amaranth (*Amaranthus palmeri*), redroot pigweed (*A. retroflexus*) and common waterhemp (*A. rudis*) are a major problem in the Midwest. The increase in triazine and acetolactate synthase inhibiting herbicide resistant biotypes has forced producers to change to different, sometimes less effective herbicides.

Glufosinate-ammonium is a nonselective postemergent herbicide that is used to control several annual and perennial grass and broadleaf weeds, including pigweeds (Ahrens 1997). The use of glufosinate might be an alternative to control these species when glufosinate resistant cropping systems are adapted. However, the efficacy of postemergent herbicides, such as glufosinate, is influenced by environmental conditions before, during, or after the time of herbicide application (Price 1983, Anderson 1993).

OBJECTIVES

Determine the effects of relative humidity (RH) on a) glufosinate efficacy, and b) absorption and translocation of glufosinate in Palmer amaranth, redroot pigweed, and common waterhemp.

MATERIALS AND METHODS

Palmer amaranth, redroot pigweed, and common waterhemp were grown in growth chambers at 35 or 90% RH and 26/21 C day/night.

Efficacy study. Glufosinate was applied to the pigweed plants at the 9-leaf stage at 0.5X, 1X, and 2X of the use rate. The use rate was 410 g/ha^{-1}. Control plants, which received no herbicide treatment, were treated with water. Visual ratings of plant injury were made 1, 4, 7, and 14 days after treatment (DAT), based on a scale from 0 to 100%.

Absorption and translocation study. Plants were grown at the temperature and relative humidity regimes described above. Eight 1 µL droplets containing 740 Bq ^{14}C-glufosinate, 2.56 µL non-labeled glufosinate, and 0.5% by volume crop oil concentrate were applied uniformly across the adaxial leaf surface of the third leaf of plants at the 6-leaf stage. Plants were harvested 6, 24, and 96 hours after treatment (HAT) and were separated into foliage above treated leaves, treated leaves, foliage below treated leaves and roots. The treated leaf was washed thoroughly with 10 ml double distilled water for 30 s to remove unabsorbed herbicide. Radioactivity was determined in the rinsate solution to account for unabsorbed herbicide. Plant parts were air dried, oxidized and trapped $^{14}CO_2$ were quantified using liquid scintillation spectrometry. Absorption was computed by comparing the radioactivity recovered in the entire plant to the total amount applied. Herbicide translocation was computed as the amount of radioactivity recovered in a given plant part as a percent of the total radioactivity in the plant.

Data analysis. The experimental designs for the temperature, relative humidity, absorption, and translocation studies were split plots with temperature or humidity as main plot. The subplot for the temperature and relative humidity studies was species by glufosinate rate, whereas the subplot for the absorption and translocation study was harvest time by species. In the translocation study an unstructured correlation model was used to allow for arbitrarily different correlations between amounts of ^{14}C-glufosinate moving into or out of each plant part. Radioactivity measurements on the different plant parts were considered as repeated measures and mixed model analysis of repeated measures were performed. (Littell et al. 1996). All treatments were replicated four times and experiments were repeated twice.

RESULTS AND DISCUSSION

Efficacy study. All three amaranthus species were controlled more at 90% RH than at 35% RH with all three glufosinate rates (Table 1). When plants were grown at 35% RH, all three rates controlled Palmer amaranth more than redroot pigweed and redroot pigweed more than common waterhemp 1 DAT. Palmer amaranth control was 35, 35, and 40% when grown under 35% RH and treated with 205, 410, and 820 g ha^{-1} glufosinate, respectively, whereas redroot pigweed control was 15, 20, and 25%, respectively, and common waterhemp control was 5, 15, and 20%, respectively. However, when plants were grown at 90% RH, redroot pigweed control 1 DAT was greater than that of Palmer amaranth and common waterhemp at all three rates. Redroot pigweed control when grown under 90% RH and treated with 205, 410, and 820 g ha^{-1} glufosinate was 57, 70, and 80%, respectively, whereas Palmer amaranth control was 52, 65, and 75%, respectively, and common waterhemp control was 52, 65, and 72%, respectively. As expected, control of all three species increased at both relative humidity regimes as the rate increased.

Redroot pigweed grown at 90% RH was controlled 100% across all three glufosinate rates 4 DAT, whereas Palmer amaranth and common waterhemp control were 88 and 81%, respectively. There were no differences in control 4 DAT among the three species when grown at 35% RH (Table 2). All three glufosinate rates resulted in control higher than 80% for all three species when grown at 90% RH, whereas only the 2X rate (820 g ha^{-1}) resulted in more than 80% control 4 DAT when plants were grown at 35% RH (data not shown).

At 14 DAT, all three glufosinate rates resulted in 100% control for all three species when grown at 90% RH, whereas the 205, 410, and 820 g ha^{-1} glufosinate applications resulted in 57, 89, and 96% control, respectively, averaged across all three species (data not shown).

This consistent phenomenon of increased control at the low RH level as rate increases, suggests that higher application rates are needed to obtain good control of these three species at lower RH levels. These results agree with those of Nalewaja et al (1975) who found that redroot pigweed control with bentazon was higher when the plants were grown in high rather than low relative humidity after treatment.

No species by humidity interaction was observed 7 DAT (data not shown) and some regrowth was observed in all three species when grown at the low relative humidity. At 14 DAT, redroot pigweed, Palmer amaranth, and common waterhemp control were controlled 93, 91, and 87%, respectively when averaged across both relative humidity regimes and all glufosinate rates (Figure 1).

Absorption and translocation study. Relative humidity did not alter glufosinate absorption and 59% was absorbed 6 HAT in all three species, whereas 83% glufosinate was absorbed 24 and 96 HAT, regardless of *Amaranthus* species (Figure 2).

More absorbed glufosinate translocated out of the treated leaf of all three species when grown at 90% RH than at 35% RH across all three sampling times. Translocation out of the treated leaf for Palmer amaranth, redroot pigweed, and common waterhemp was 31, 18, and 17%, respectively, when grown at 90% RH. Less than 6% glufosinate translocated out of the treated leaf when plants were grown at 35% RH across all species and sampling dates (Figure 3). More than 95% glufosinate remained in the treated leaf at 35% RH across all three sampling dates. Glufosinate was evenly distributed among the foliage above the treated leaf, and the foliage below the treated leaf and the roots. When grown at 90% RH, 11.3, 17.7, and 34.4% glufosinate translocated out of the treated leaf 6, 24, and 96 HAT, respectively. Translocation was favored to the foliage above the treated leaf 24 and 96 HAT, which implies mainly acropetal movement (Table 3). These results are not surprising since glufosinate has limited movement in the phloem (Bromilow et al. 1993). However, transport to the roots and crown of green foxtail, barley (Mersey et al. 1990) and giant foxtail (*Setaria faberi* Herm.) has been reported.

CONCLUSIONS

Common waterhemp control was greater than Palmer amaranth, but similar to that of redroot pigweed. All three species were controlled more at 90% H than at 35% RH. Higher glufosinate application rates are needed to achieve satisfactory control of Palmer amaranth, redroot pigweed, and common waterhemp. Absorption was not influenced by relative humidity and translocation in all three species was greater at 90% RH than at 35% RH. Since relative humidity did not influence absorption, the good control that was obtained with all three species at 90% RH, is due to greater glufosinate translocation at 90% RH.

LITERATURE CITED

Ahrens, W. H., ed. 1997. Herbicide Handbook Weed Science Society of America, Champaign, Illinois, 147-149.

Anderson, D. M., C. J. Swanton, J. C. Hall, and B. G. Mersey. 1993. The influence of temperature and relative humidity on the efficacy of glufosinate-ammonium. Weed Res. 33:139-147.

Bromilow, R. H., K. Chamberlain, and A. A. Evans. 1993. Phloem translocation of strong acids - glyphosate, substituted phosphonic and sulfonic acids - in *Ricinus communis* L. Pestic. Sci. 37:39-47.

Littell, R. C., G. A. Milliken, W. W. Stroup, and R. D. Wolfinger. 1996. SAS System for Mixed Models. SAS Institute. Cary, NC.

Mersey, B. G., J. C. Hall, D. M. Anderson, and C. J. Swanton. 1990. Factors affecting the herbicidal activity of glufosinate-ammonium: absorption, translocation, and metabolism in barley and green foxtail. Pestic. Biochem. Physiol. 37:90-98.

Nalewaja, J. D., J. Pudelko, and K. A. Adamczewski. 1975. Influence of climate and additives on bentazon (*Amaranthus retroflexus)* control. Weed Sci. 23:504-507.

Price, C. E. 1983. The effect of environment on foliage uptake and translocation of herbicides. Pages 157-169 *in* J. L. P. Van Oorshot, ed. Aspects of Applied Biology 4. Influence of environmental factors on herbicide performance and crop and weed biology. Wellesbourne, UK: Association of Applied Biologists.

Table 1. Visible injury of Palmer amaranth, redroot pigweed and common waterhemp one DAT as affected by glufosinate rate and relative humidity.

	Glufosinate rate	Visible injury	
		35% RH	90% RH
	g ha^{-1}	%	
Palmer amaranth	205	35	52
	410	35	65
	820	40	75
Redroot pigweed	205	15	57
	410	20	70
	820	25	80
Common waterhemp	205	5	52
	410	15	65
	820	20	72
LSD (0.05)[a]		4	

[a]Fisher's protected LSD comparing means within each column.

Table 2. Palmer amaranth, redroot pigweed, and common waterhemp control 4 DAT with glufosinate as affected by relative humidity. Means were averaged across species.

	Visual injury		
Glufosinate rate	35% RH	90% RH	LSD (0.05)[a]
g ha^{-1}	%		
205	55	84	10
410	76	91	10
820	83	95	10
LSD (0.05)[b]	8	8	

[a]Fisher's protected LSD comparing means within each row.
[b]Fisher's protected LSD comparing means within each column.

Table 3. Translocation of ^{14}C-glufosinate applied on Palmer amaranth, redroot pigweed, and common waterhemp. Means were averaged over species.

	Percent glufosinate						
	35% RH			90% RH			
Plant parts	6 HAT[a]	24 HAT	96 HAT	6 HAT	24 HAT	96 HAT	LSD (0.05)[b]
	%						
Treated leaf	96.3	95.2	97.0	88.7	82.3	63.4	6.2
Foliage above treated leaf	1.2	2.5	1.5	6.9	10.7	24.4	5.0
Foliage below treated leaf	1.7	1.7	1.2	3.7	6.2	11.3	2.6
Roots	0.7	0.6	0.3	0.8	0.7	1.0	0.3

[a]HAT, hours after treatment.
[b]Fisher's protected LSD comparing means within each row.

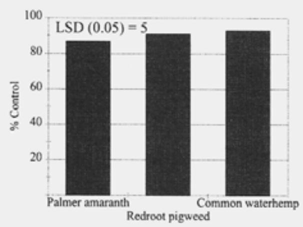


Figure 1. Visible injury of Palmer amaranth, redroot pigweed, and common waterhemp 14 DAT as affected by relative humidity. Means were averaged over relative humidity and glufosinate rates.

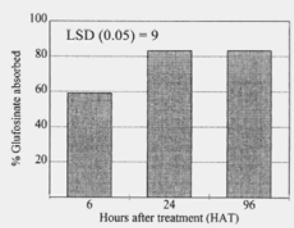


Figure 2. ^{14}C-glufosinate absorption of Palmer amaranth, redroot pigweed and common waterhemp 6, 24 and 96 HAT. Means were averaged over species and relative humidity.

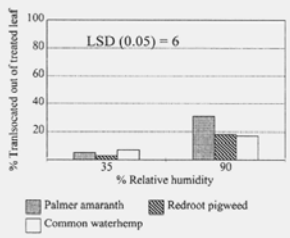


Figure 3. Percent translocation of absorbed glufosinate out of the treated leaf for Palmer amaranth, redroot pigweed and common waterhemp as affected by relative humidity. Means were harvested over sampling dates.

A SUSTAINABLE APPROACH TO NEMATODE AND NUTSEDGE MANAGEMENT IN CHILE USING NEMATODE-RESISTANT ALFALFA AS A ROTATION CROP. Cheryl Fiore[1], Leigh Murray[2], Ian Ray[3], Jill Schroeder[1], and Stephen Thomas[1], Research Assistant, Professor, Professor, and Professor, [1]Department of Entomology, Plant Pathology and Weed Science, [2]Department of Experimental Statistics, and [3]Department of Agronomy and Horticulture, New Mexico State University, Las Cruces, NM 88003.

Abstract. New Mexico harvests approximately 30,000 A of chile a year in spite of heavy losses from a variety of pests. Slow emergence and growth rate contribute to its lack of competitiveness. Southern root knot nematodes (RKN) and the perennial weeds, yellow and purple nutsedge are two of the most difficult pests to control in chile. Research indicates that tubers of both nutsedge species and traditional chile crop rotations also host RKN. However, a few semi-dormant cultivars of alfalfa are RKN resistant. The objective of this 4-year research project is to determine if RKN-resistant alfalfa in rotation with chile is an effective, sustainable approach to RKN and nutsedge management. The experiment was designed as a split-plot, randomized complete block with four replications. Alfalfa cultivars 'Magna 8' (RKN resistant) and 'Doña Ana' (RKN susceptible) were planted at a high and low seeding rate in September 1997. Cotton, the least RKN susceptible row crop, was planted as a control in the spring 1998 and again in 1999. Both years the cotton was plowed down before harvest. Alfalfa was harvested five times during 1998, and again in 1999 with no significant yield differences. Seven days after each harvest, yellow and purple nutsedge biomass was estimated by sampling 4 0.25 m quadrats in each alfalfa plot. RKN populations were estimated using soil cores from each harvested quadrat. RKN populations were below detectable levels in the alfalfa plots during 1998 and 1999 field seasons. Purple nutsedge and yellow nutsedge density in 1999 ranged from 1 to 35% of the biomass harvested in 1998 indicating that interference from alfalfa was effectively reducing the above-ground biomass. However, repeated measures analysis indicated that yellow nutsedge biomass increased in 1999 between the July and August harvests; this increase was greatest in the RKN susceptible Doña Ana plots. Overall, in 1998 and 1999, yellow nutsedge and purple nutsedge biomass was higher in the Doña Ana variety and in plots seeded at the low planting density.

EFFECT OF CROP SEEDING RATE ON CROP COMPETITIVENESS AND THE RATE OF HERBICIDE REQUIRED FOR SATISFACTORY WEED CONTROL. Ken J. Kirkland, F. A. Holm, and F. Craig Stevenson, Agriculture and Agri-Food Canada, Research Farm, Scott, SK, Canada; Dept. of Plant Sciences, University of Saskatchewan, Saskatoon, SK, Canada; and Research Scientist, Saskatoon, SK, Canada.

Abstract. A higher than recommended crop seeding rate could improve crop competitive ability and allow for the use of lower herbicide rates as part of an integrated weed management strategy. A study was conducted at three locations in Saskatchewan, Canada in 1996 and 1997 to determine if a higher than recommended seeding rate could be used to maintain crop productivity as herbicide rates were reduced. The experiment included four herbicide rates (untreated check and 0.5, 0.75, and full recommended label rate), two crop seeding rates (recommended and 1.5 times recommended), and three crops (barley, wheat, and lentil). Crop yield and net return generally were lower, and broadleaf and grassy weed fresh weight were higher, when herbicides were not applied at Saskatoon, but not at the other locations. Wheat grain yield was 16% lower at Scott and Melfort, and lentil grain yield and net return were 66% lower at Saskatoon, when herbicide rate was reduced from the full and 75% label rate to the 50% label rate. Higher weed fresh weight with the 50% label rate compared with higher herbicide rates occurred at Scott, but not at the other two locations. Grassy weed growth at all locations did not increase as much in barley sown at a rate 1.5 times recommendation when herbicides were not applied in 1996. There was no indication that increasing seeding rate to 1.5 times recommendation maintained crop yield and net returns with the greater weed pressure at the lower than recommended (50% and 75%) herbicide rates. An appropriate herbicide rate remains to be an important decision determining crop productivity and weed control, especially for poorly competitive crops such as lentil. The adoption of a higher than recommended seeding rate, as an integrated weed management tool, should not influence the decision regarding the best herbicide rate.

BARLEY VARIETY AND FERTILIZER PLACEMENT EFFECTS ON WILD OAT CONTROL WITH TRALKOXYDIM. Joan Campbell[1], Donn Thill[1], and Don Morishita[2], Research and Instructional Associate, Professor, and Associate Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, [1]Moscow, ID 83844-2339 and [2]Twin Falls, ID 83303-1827.

Abstract. Barley variety and fertilizer placement effects on wild oat control with tralkoxydim were evaluated in dryland and irrigated conditions near Moscow and Kimberly, Idaho, respectively. 'Harrington', 'Colter', 'Galena', and 'Nebula' spring barley varieties were seeded and nitrogen fertilizer was broadcast and incorporated or fertilizer was placed in a band with the drill. Tralkoxydim was applied when barley had 3 to 5 leaves and wild oat had 1 to 4 leaves. Tralkoxydim rates were 0, 0.09, and 0.18 lb/A. The experimental design was a split-split-plot with four replications at Moscow. Variety was the main plot, fertilizer placement was the subplot, and tralkoxydim rate was the sub-subplot. The experimental design at Kimberly was a two by three factorial randomized complete block, with four replications. Wild oat and barley height, tiller number, and biomass were measured after heading. Wild oat seed was collected when seed began to mature, but before seed shed. Grain was harvested at maturity.

At Moscow, barley height averaged over variety was 29 inches when fertilizer was banded compared to 28 inches when fertilizer was broadcast. Fertilizer placement did not affect any other measurement. Grain yield was best with Harrington and least with Nebula when averaged over tralkoxydim rate and fertilizer placement. Grain yield difference in varieties was correlated positively to barley height. When data were averaged over variety and fertilizer placement, the untreated control always had the most wild oat tillers and biomass, and the least barley biomass and grain yield compared to the tralkoxydim treated plots. There were no differences between the two tralkoxydim rates. Only barley tillers were not affected by tralkoxydim application. Wild oat seed is being counted to determine seed production. At Kimberly, visual wild oat control averaged 54% for Galena, Harrington, and Colter and did not differ from each other. Wild oat control was lower with Nebula, which averaged only 44%. Wild oat control averaged 0, 66, and 89% for 0, 0.09, and 0.18 lb/A tralkoxydim, respectively. Grain yield ranged from 77 to 83 bu/A for Galena, Harrington, and Colter and did not differ from each other, but grain yield was lower for Nebula which averaged 72 bu/A.

ANNUAL-WEED HOST SPECIES AFFECT *MELOIDOGYNE INCOGNITA* VIRULENCE ON CHILE PEPPERS. Brian J. Greenfield, Steven H. Thomas, Jill Schroeder, Leigh Murray, Jackie Fuchs, and Cheryl Fiore, Research Assistant, Professor, Professor, Professor, Research Specialist, and Research Assistant, Department of Entomology, New Mexico State University, Las Cruces, NM 88003.

Abstract. Studies indicate that there are differences in Root Knot Nematode (*Meloidogyne incognita*, Mi) population development on chile based on the previous plant host's species. Previous research found that Mi inoculum source affects host suitability and growth of yellow nutsedge and chile peppers. Therefore, a greenhouse experiment was conducted to determine reproduction on chile after inoculation with Mi eggs that come from one of several annual weed species. The experiment was established in a randomized complete block design with six replications. Single chile pepper plants were established in six-inch pots filled with a 2:1 sand:soil mix. At the 2- to 4-leaf stage of growth, plants were inoculated with 5000 Mi eggs plus juveniles that had been extracted from the roots of Palmer amaranth, spurred anoda, Wright's groundcherry, tomato 'Rutgers', or chile pepper 'NM-64'. Control plants were inoculated with deionized water. The chile peppers were allowed to grow for 45 days after inoculation, then harvested. The Mi were extracted from the chile pepper roots using a 10% NaOCl solution. Meloidogyne incognita obtained from the annual weed hosts produced between 300,000 and 400,000 eggs which is half the reproductive rate of Mi obtained from chile peppers. Meloidogyne incognita from tomato as the host plant produced an average of 1,140,248 plus or minus 104,556 eggs in 45 days, which was nearly 50% higher than Mi from chile as the host plant. Least significant means indicate that there are significant differences in reproduction of Mi on chile depending on the plant species of the Mi inoculum source.

CONTROL OF CLOVER BROOMRAPE IN CLOVER. Laura E. Suverly, Matthew D. Schuster, Kee-Woong Park, and Carol A. Mallory-Smith, Graduate Student, Graduate Student, Graduate Student, and Associate Professor, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331-3002.

Abstract. Clover broomrape, a federally listed noxious weed, was identified in 1998 in a red clover field in Clackamas County, OR. Clover broomrape is an obligate parasite that attaches to the roots of the host plant, in this case red clover, leading to damage and death to the host. Studies were established in 1998 and 1999 to evaluate the efficacy of herbicides for clover broomrape control and crop safety. The treatments used were imazamox, glyphosate, MCPA, pyridate, and imazethapyr. Treatments were applied to 8 by 20 foot plots arranged in a randomized complete block with four replications. The plots were evaluated visually for clover broomrape control and red clover injury. None of the treatments provided control of the clover broomrape. In September 1999, actions were taken to halt harvest operations; the field was burned, and in October 1999, an internal quarantine on clover broomrape was proposed.

WEED COMMUNITY SHIFTS ASSOCIATED WITH CONTINUOUS GLYPHOSATE APPLICATIONS IN CORN AND SOYBEAN ROTATION. Michael W. Marshall, Kassim Al-Khatib, and Larry Maddux, Research Assistant, Associate Professor, and Professor, Department of Agronomy, 2004 Throckmorton Plant Sciences Center, Kansas State University, Manhattan, KS 66506-5501.

INTRODUCTION

The impact of herbicides on weed community dynamics is a major concern with the advent of herbicide-tolerant crops such as glyphosate-resistant corn, soybean, canola, and sugarbeets. Historically, repeated use of a single mode of action has resulted in a weed community shift. For example, widespread use of 2, 4-D in wheat producing regions caused a major shift of weed community resulting in weedy grasses replacing weedy dicots as the major weed problem. In crop systems that use non-selective herbicides, such as glyphosate, weed population shifts within the crop-weed community is inevitable. For example, glyphosate tolerant species such as ivyleaf morningglory, large crabgrass, and velvetleaf could expand in total proportion in response to glyphosate treatments. Therefore, the objective of this study was to evaluate weed population changes in a corn and soybean rotation under various herbicide treatments.

MATERIALS AND METHODS

Experimental layout. Field experiments were conducted in 1998 and 1999 near Manhattan and Rossville in northeastern Kansas. Field design consisted of a randomized complete block design with four treatments and four replications with plot sizes of 7.6 m by 10.2 m in Manhattan and 7.6 m by 7.6 m in Rossville. A carrier volume of 187 L/ha, pressure of 138 kPa, and height of 48 cm was used for all spray treatments. Plots were overseeded with ivyleaf morningglory at 4.6 kg ha^{-1}, large crabgrass at 3.8 kg ha^{-1}, and velvetleaf at 1 kg ha^{-1}. Weed density counts were measured every 4 weeks with a 0.48 m^2 quadrant.

Corn. Dekalb DK 580RR corn was planted at 74,000 seeds ha^{-1} in Manhattan and Rossville. The 1998 herbicide treatments included: 1) atrazine (2.2 kg ha^{-1}) plus metolachlor (2.6 kg ha^{-1}) immediately after planting followed by atrazine (0.6 kg ha^{-1}) plus bromoxynil (0.4 kg ha^{-1}) 24 days after planting (DAP); 2) glyphosate (1.1 kg ha^{-1}) at 30 DAP; 3) glyphosate (1.1 kg ha^{-1}) 20 DAP followed by glyphosate (0.8 kg ha^{-1}) 30 DAP; 4) atrazine (2.2 kg ha^{-1}) plus metolachlor (2.8 kg ha^{-1}) immediately after planting followed by glyphosate (1.1 kg ha^{-1}) 30 DAP. The 1999 herbicide treatments included: 1) atrazine (2.2 kg ha^{-1}) plus metolachlor (2.6 kg ha^{-1}) plus flumetsulam (0.7 kg ha^{-1}) immediately after planting followed by atrazine (0.6 kg ha^{-1}) plus bromoxynil (0.4 kg ha^{-1}) 24 days after planting (DAP); 2) glyphosate (1.1 kg ha^{-1}) at 30 DAP; 3) glyphosate (1.1 kg ha^{-1}) 20 DAP followed by glyphosate (0.8 kg ha^{-1}) 30 DAP; 4) atrazine (2.2 kg ha^{-1}) plus metolachlor (2.6 kg ha^{-1}) plus flumetsulam (0.7 kg ha^{-1}) immediately after planting followed by glyphosate (1.1 kg ha^{-1}) 30 DAP.

Soybean. Dekalb CX367cRR soybean was planted at 346,000 seeds ha^{-1} in Manhattan and Rossville. Herbicide treatments in 1998 included: 1) metribuzin (0.6 kg ha^{-1}) plus metolachlor (2.8 kg ha^{-1}) immediately after planting followed by bentazon (1.1 kg ha^{-1}) plus acifluorfen (0.3 kg ha^{-1}) plus COC (1 kg ha^{-1}) 30 days after planting (DAP); 2) glyphosate (1.1 kg ha^{-1}) at 30 DAP; 3) glyphosate (1.1 kg ha^{-1}) 20 DAP followed by glyphosate (0.8 kg ha^{-1}) 30 DAP; 4) metribuzin (0.6 kg ha^{-1}) plus metolachlor (2.8 kg ha^{-1}) immediately after planting followed by glyphsate (1.1 kg ha^{-1}) 30 DAP. The 1999 herbicide treatments included: 1) sulfentrazone (0.3 kg ha^{-1}) plus chlorimuron (0.1 kg ha^{-1}) plus metolachlor (2.8kg ha^{-1}) immediately after planting followed by bentazon (1.1 kg ha^{-1}) plus acifluorfen (0.3 kg ha^{-1}) plus cloransulam (18 g ha^{-1}) plus COC (1 kg ha^{-1}) 30 days after planting (DAP); 2) glyphosate (1.1 kg ha^{-1}) at 30 DAP; 3) glyphosate (1.1 kg ha^{-1}) 20 DAP followed by glyphosate (0.8 kg ha^{-1}) 30 DAP; 4) sulfentrazone (0.3 kg ha^{-1}) plus chlorimuron (0.1 kg ha^{-1}) plus metolachlor (2.8 kg ha^{-1}) immediately after planting followed by glyphosate (1.1 kg ha^{-1}) 30 DAP.

RESULTS AND DISCUSSION

Manhattan. Ivyleaf morningglory dominated the weed community in Manhattan in both 1998 and 1999. However, all treatments were effective and reduced overall population levels. Large crabgrass and Palmer amaranth remained at low population levels throughout the study period indicating a small seed bank reserve. Overall, ivyleaf morningglory comprised the majority of the weed community in Manhattan (Figures 1 and 2).

Rossville. Ivyleaf morningglory population decreased to nearly zero across all treatments in corn to soybean rotation (Site 3). However, weed pressure was quite severe in 1999 as noted by all three species (Site 4). Ivyleaf morningglory and large crabgrass dominated the weed community and populations increased across all treatments, especially for the single glyphosate treatment (TRT 2). Large crabgrass dominated the weed community in Site 3 at the end of 1999 probably due to season long germination of this species (Figure 3). Large second year totals for Site 4 indicated a large seed bank reserve for all three species (Figure 4).

CONCLUSIONS

Overall, ivyleaf morningglory populations comprised the majority of the weed community in all locations especially under the single glyphosate applications. Large crabgrass and ivyleaf morningglory populations increased as a total percentage of the weed community under the single glyphosate applications. Species that are tolerant to glyphosate, such as ivyleaf morningglory, will comprise a larger percentage of the weed community under continuous glyphosate programs.

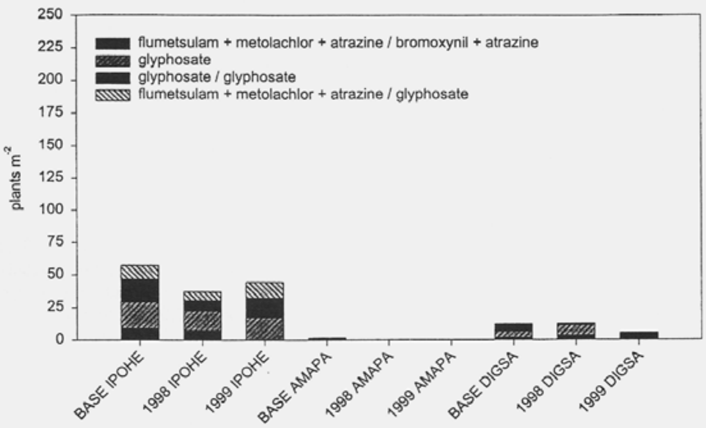


Figure 1. Ivyleaf morningglory (IPOHE), Palmer amaranth (AMAPA), and large crabgrass (DIGSA) populations in a corn to soybean rotation as affected by herbicide treatments.

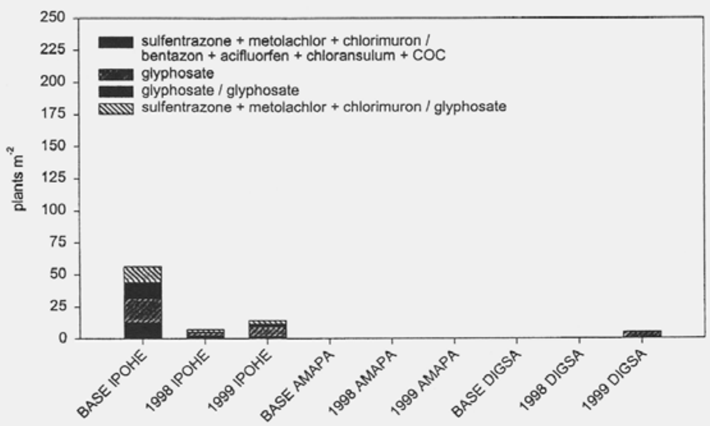


Figure 2. Ivyleaf morningglory (IPOHE), Palmer amaranth (AMAPA), and large crabgrass (DIGSA) populations in a soybean to corn rotation as affected by herbicide treatments.

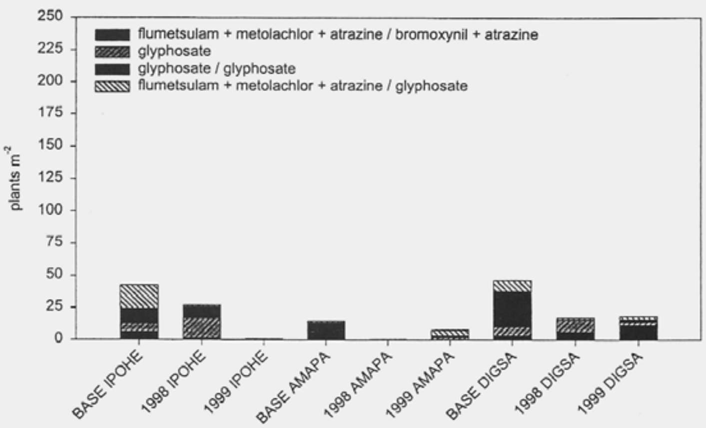


Figure 3. Ivyleaf morningglory (IPOHE), Palmer amaranth (AMAPA), and large crabgrass (DIGSA) populations in a corn to soybean rotation as affected by herbicide treatments.

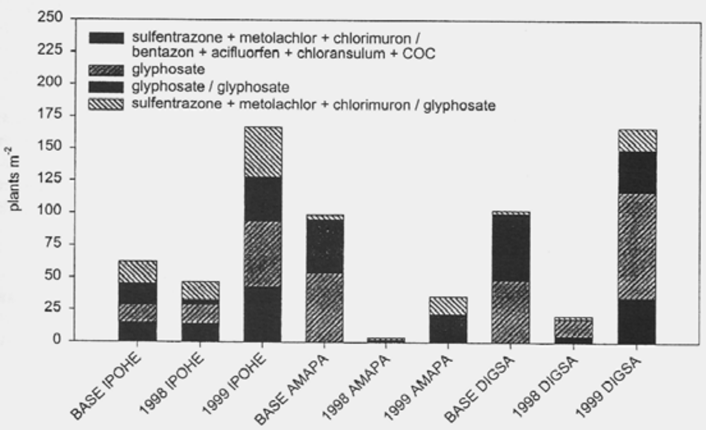


Figure 4. Ivyleaf morningglory (IPOHE), Palmer amaranth (AMAPA), and large crabgrass (DIGSA) populations in a soybean to corn rotation as affected by herbicide treatments.

WEED POPULATION DYNAMICS IN GLYPHOSATE TOLERANT READY CROPS. Sandra M. Frost and Stephen D. Miller, Graduate Student and Professor, Department of Plant Science, and David E. Legg, Associate Professor, Department of Renewable Resources, University of Wyoming, Laramie, WY 82071.

Abstract. Weed populations under a new cropping system may shift with time under continuous use of glyphosate in glyphosate tolerant crops. The objective of this six year study is to answer the question "Does the use of glyphosate in glyphosate tolerant crops cause weed shifts or development of resistence?"

Emerged weed counts in August in low and high glyphosate treatments correlate to seed bank counts for one species, *Amaranthus retroflexus* (L.). Two species, *Amaranthus retroflexus* (L.) and *Solanum sarrachoides* Sendtner, survived more often in low and high glyphosate treatments than in rotated or no glyphosate treatments. Three species, *Koschia scoparia, Salsola iberica* Sennen and *Solanum sarrachoides* Sendtner survived more often in corn/sugarbeet rotation than in continuous corn rotation.

EFFICACY OF RESIDUAL HERBICIDES IN GLYPHOSATE TOLERANT COTTON. Peter A. Dotray, J. Wayne Keeling, and John D. Everitt, Associate Professor, Department of Plant and Soil Science, Texas Tech University, Lubbock, TX 79409-2122 and Professor and Research Assistant, Texas Agricultural Experiment Station, Lubbock, TX 79401-9757.

Abstract. The use of glyphosate as a rope-wick, spot-spray, preplant, or postemergence-directed (PD) treatment has occurred in cotton since its introduction in the 1970's. The development of glyphosate resistant cotton varieties has provided new opportunities for postemergence-topical (PT) control of many troublesome weeds in-season. In weed control studies conducted from 1996 to 1999 at several locations across the Texas Southern High Plains, glyphosate was evaluated alone or as part of a weed control program that included residual herbicides. In a 1998 field experiment, pendimethalin at 1.12 kg/ha applied preplant incorporated followed by (fb) prometryn at 1.3 kg/ha applied preemergence did not control silverleaf nightshade. Pendimethalin fb prometryn fb glyphosate PT at 0.84 kg/ha controlled silverleaf nightshade at least 50%.

In a field experiment conducted in 1999, a glyphosate tolerant variety, 'Paymaster 2326 RR', was planted in mid-May. Herbicide treatments in conventional tillage cotton included pendimethalin fb prometryn, pendimethalin fb glyphosate PT, prometryn fb glyphosate PT, pendimethalin fb glyphosate PT fb glyphosate applied PD, pendimethalin fb prometryn fb glyphosate PT, and glyphosate PT fb glyphosate PD fb glyphosate PD. Pendimethalin fb two applications of glyphosate controlled Palmer amaranth 96% late season, whereas pendimethalin fb prometryn and glyphosate applied alone controlled Palmer amaranth 63% and 83%, respectively. Pendimethalin fb two glyphosate applications and glyphosate applied alone controlled devil's-claw 98%, whereas pendimethalin fb prometryn controlled devil's-claw 30%. In a second field experiment in 1999, trifluralin at 0.84 kg/ha fb prometryn controlled Palmer amaranth and devil's-claw 88% and 23%, respectively. Trifluralin fb prometryn fb glyphosate plus pyrithiobac at 0.04 kg/ha applied PT controlled Palmer amaranth and devil's-claw 100 and 83%, respectively.

The addition of residual herbicides improved Palmer amaranth and devil's-claw control in most of the glyphosate tolerant cotton weed control systems evaluated. The selection of a residual herbicide will be dictated by the weed population dynamics.

WEED MANAGEMENT IN TEXAS SOUTHERN HIGH PLAINS COTTON USING THE HERBICIDE APPLICATION DECISION SUPPORT SYSTEM (HADSS). LeAnna L. Lyon, J. Wayne Keeling, and Peter A. Dotray, Graduate Research Assistant and Professor, Texas Agricultural Experiment Station, Lubbock, TX 79401 and Associate Professor, Department of Plant and Soil Sciences, Texas Tech University, Lubbock, TX 79409.

Abstract. North Carolina State University modified a computer-based, postemergence herbicide program that makes recommendations to cotton producers based on weed density, weed competitiveness, and herbicide efficacy. Validation of the Herbicide Application Decision Support System (HADSS) program is needed for cotton production on the Texas Southern High Plains. Field experiments were established in 1999 at the Texas Agricultural Experiment Station near Lubbock to compare the HADSS program recommendations to standard producer practices. The program was evaluated in glyphosate-tolerant cotton, bromoxynil-tolerant cotton, and non-transgenic cotton. Producer standards were compared to the HADSS program and the HADSS program plus trifluralin applied preplant incorporated. Weed density and herbicide applications were made at 1- to 2-leaf, 6- to 8-leaf, and 10- to 12-leaf cotton growth stages. Palmer amaranth and devil's-claw control was evaluated two weeks after each treatment and compared to a non-treated control. In the glyphosate-tolerant cotton system, the HADSS program recommendations paralleled the standard practices at every cotton growth stage. Late season control following producer standards and control with HADSS plus trifluralin averaged 97%. HADSS alone averaged 88% weed control. Weeds in the bromoxynil-tolerant cotton system using producer practices and the HADSS plus trifluralin were controlled 93%. HADSS alone controlled these weeds 71%. In the non-transgenic cotton, producer recommendations, HADSS plus trifluralin, and HADSS alone averaged 98, 92, and 76% weed control, respectively. HADSS recommendations were different from producer standards for the bromoxynil-resistant and non-transgenic systems. These studies will continue during the 2000 growing season.

EVALUATION OF PREEMERGENCE AND POSTEMERGENCE HERBICIDES ON SUGARBEETS IN CENTRAL OREGON, 1999. Marvin D. Butler, Associate Professor, Department of Crop and Soil Science, Oregon State University, 850 NW Dogwood Lane, Madras, OR 97741.

Abstract. 1999 was the fifth year of sugarbeet production in the Madras, Culver and Prineville areas of central Oregon. Weed control methods continue to be refined as growers gain experience with the crop. Annual evaluation of preemergence and postemergence herbicide applications on sugar beets has been conducted in two commercial fields near Culver and Prineville, Oregon since 1994. During 1999 glyphosate and glufosinate resistant sugarbeet varieties were evaluated. The study compared glyphosate and glufosinate with the standard combination of preemergence and postemergence herbicides used in central Oregon. In addition, ethofumesate was evaluated at 1.5 and 1 lb/A followed by phenmedipham and desmedipham plus triflusulfuron at the labeled rate and at micro-rates (one-third label rate). Postemergence-only applications were phenmedipham and desmedipham plus triflusulfuron at the labeled rates and micro-rates. Micro-rate treatments were in combination with or without clopyralid, and with or without methylated seed oil. A late treatment first applied at the 2- to 4-leaf stage was phenmedipham and desmedipham plus triflusulfuron plus clopyralid plus methylated seed oil at 2% v/v. No differences in yield were detected between glyphosate and glufosinate resistant sugarbeets varieties treated with glyphosate and glufosinate or the standard herbicide treatment. Reducing the rate of ethofumesate slightly reduced the level of weed control. Preemergence plus postemergence treatments provided greater weed control than any of the postemergence treatments alone. Following ethofumesate applied preemergence, standard postemergence herbicide rates applied twice provided greater weed control than micro-rates applied twice or micro-rates alone applied three times. The late treatment caused significant injury to the sugarbeet plants.

ECONOMIC COMPARISON OF WEED MANAGEMENT SYSTEMS IN SUGARBEETS. Charles A. Rice and Stephen D. Miller, Graduate Assistant and Professor, Department of Plant Science, University of Wyoming, Laramie, WY 82071.

Abstract. Effective season long weed control is imperative in sugarbeet production as sugarbeets compete poorly with weeds. Currently a combination of herbicides, cultivation and hand labor are used to control weeds in sugarbeets. The development of herbicide tolerant sugarbeets by means of genetic engineering may provide additional herbicide options for effective weed control. An irrigated field study was conducted at Torrington, Wyoming in 1999 on a Bayard sandy loam (coarse, loamy, mixed, mesic Torriorthentic Haplustol) to compare weed control and economic returns between glufosinate or glyphosate tolerant to conventional sugarbeets. Sugarbeet varieties included in the study were 'MK-71' (conventional), 'HM 1605 RR' (glyphosate tolerant) and 'Beta 2012 LL' (glufosinate tolerant). Each variety had three different herbicide treatments plus an untreated and hand weeded check. The hand weeded check was included with each variety to allow for comparison of herbicide program costs with hand labor. Plots measured 10 by 20 feet and were replicated three times. Weed control was excellent with all glyphosate and conventional herbicide treatments whether applied as a standard or micro-rate program. Weed control with glufosinate treatments was fair to poor depending upon herbicide application timing and number of applications. Sugarbeet yields were different among varieties and were generally related to weed control.

BROADLEAF WEED CONTROL IN SPRING-SEEDED ALFALFA WITH POSTEMERGENCE APPLICATIONS OF AC 299,263 AND IMAZETHAPYR. Richard N. Arnold and Dan Smeal, Pest Management Specialist, and Agriculture Specialist, New Mexico State University, Agricultural Science Center at Farmington, New Mexico, Farmington, NM 87499.

Abstract. Alfalfa is New Mexico's leading cash crop, accounting for approximately 20% of the state's crop income. Weed compete vigorously with spring-seeded alfalfa for light, nutrients, and moisture. Some weeds, when harvested with alfalfa, may reduce quality. Hay quality, particularly protein content, is an important consideration in feed rations in some markets, such as the dairy and horse racing industries. A field experiment was conducted in 1999 at Farmington, NM to evaluate the response of alfalfa (var. Legend) and annual broadleaf weeds to postemergence applications of AC 299,263 and imazethapyr. Treatments were applied with a compressed air backpack sprayer calibrated to deliver 30 gpa at 30 psi. Treatments were applied on June 16 when alfalfa was in the second trifoliolate leaf stage and weeds were small. Black nightshade, redroot and prostrate pigweed, and common lambsquarters infestations were heavy and Russian thistle infestations were light throughout the experimental area. Plots were evaluated on July 15. Alfalfa was harvested on August 24, using a self-propelled plot harvester.

AC 299,263 plus buctril applied at 0.024 + 0.25 lb/A had the highest injury rating of 5. All treatments gave good to excellent control of broadleaf weeds except the check. The weedy check had significantly higher yields as compared to herbicide treatments. This is possibly attributed to the high weed content when harvested. All treatments had a significantly higher protein content than the check.

WEED MANAGEMENT IN SOLID-SEEDED DRY BEANS. Robert E. Blackshaw, Louis J. Molnar, and Henning H. Muendel, Weed Scientist, Research Associate, and Plant Breeder, Agriculture and Agri-Food Canada, Lethbridge, AB, Canada T1J 4B1.

Abstract. Growers in western Canada are adopting upright cultivars of dry bean because they are less susceptible to white mold and they can be direct-cut at harvest. However, adequate weed control in this new production system remains a concern. Field studies were conducted over 3 years to determine the combined effects of cultivar growth

habit, row spacing, plant density, and herbicides on weed management and dry bean yield. In the absence of weeds, upright and viny cultivars yielded similarly; a reduction in row spacing from 69 to 23 cm increased yield by 19% and an increase in bean density from 20 to 50 plants/m^2 increased yield by 17%. In the presence of weeds and when herbicides were used, narrow-row and high-density production practices resulted in better weed control over the entire growing season and higher dry bean yields were attained compared to a wide-row and low-density production system. In the absence of tillage, herbicide use in narrow-row dry beans did not necessarily increase. Herbicide combinations, often at reduced rates, controlled weeds as well or better than the full rate of any individual herbicide in solid-seeded dry beans. Ethalfluralin applied PPI followed by reduced rates of either POST imazethapyr or bentazon provided efficacious and economical weed control. Grower recommendations have been developed for weed management in solid-seeded dry beans.

FALLOW WEED SUPPRESSION WITH CEREAL COVER CROPS. Robert E. Blackshaw, James R. Moyer, and Raymond C. Doram, Weed Scientists and Research Associate, Agriculture and Agri-Food Canada, Lethbridge, AB, Canada T1J 4B1.

Abstract. Cropping systems in western Canada that include fallow can leave the soil exposed to erosion and require frequent weed control treatments. Cover crops may have potential for soil conservation and to suppress weed growth. Experiments were conducted under rain-fed conditions at Lethbridge, Alberta to determine the effect of short-term fall rye, winter wheat, and annual rye cover crops during fallow on weed growth and subsequent wheat yield. Fall rye was often as effective as post-harvest plus early spring tillage or herbicides for spring weed control on fallow. Spring seeded annual rye did not adequately compete with weeds. Winter wheat and fall rye residues, after growth was terminated in June, reduced weed biomass in September by 50% compared to no cover crop. Fall-seeded cover crops reduced the density of dandelion and Canada thistle but increased the density of downy brome, wild buckwheat, and thyme-leaved spurge in the following fall or spring. Killing the cover crop with a disc tended to produce lower dandelion, foxtail barley, Canada thistle, and sowthistle populations than a glyphosate killing treatment. Wild oat and redroot pigweed populations were lowest when the cover crop was killed with glyphosate. Wheat yields after fall rye and no cover crop fallow were similar but yields after spring seeded annual rye were less than after no cover crop.

GRASS CONTROL IN CANOLA, POTATO, AND SUNFLOWER WITH CLETHODIM. Alan R. Kurtz, Todd J. Mayhew, and Jeffrey Smith, Field Market Development Specialists, Valent USA Corp., Plymouth, IN 45663; Gilbert, AZ 85234; and Sioux Falls, SD 57106.

Abstract. Valent USA Corporation anticipates federal registration, permitting use of clethodim in several new crops, beginning in the 2000 growing season. Crops affected include potato, sunflower and canola as well as the minor crops cucumber and pepper (bell and non-bell). In addition, the pre-harvest interval (PHI) for clethodim products in sugarbeets will be reduced to 40 days. Registration in cucumber and pepper was made possible with the assistance of the IR-4 Project. Clethodim controls a broad spectrum of annual and perennial grasses when applied postemergence to the listed crops as well as to currently labeled crops. Research conducted or sponsored by Valent USA Corporation confirmed excellent tolerance of these crops to clethodim applications. Clethodim application rates in the new crops will be similar to those used in currently labeled crops. PHI for the new crops will be: canola (60 days); potato (30 days); sunflower (70 days); cucumber (14 days); pepper (20 days). Clethodim is formulated as an emulsifiable concentrate.

EVALUATION OF DRY PEA, LENTIL, AND CHICKPEA TOLERANCE TO SULFENTRAZONE. Kent McKay and Brian Jenks, Area Extension Specialist and Area Research Specialist, North Central Research/Extension Center, Minot, ND 58701; Neil Riveland, Agronomist, Williston Research/Extension Center, Williston, ND 58802; and Greg Endres, Area Extension Specialist, Carrington Research/Extension Center, Carrington, ND 58421.

Abstract. There are few herbicides labeled for broadleaf weed control in field pea, lentil, and chickpea. The objective of this study was to evaluate three rates of sulfentrazone applied pre-plant incorporated (PPI) and preemergence (PRE) for crop tolerance and weed control in dry pea, lentil, and chickpea. Studies were located at Minot, Williston, and Carrington, North Dakota. In previous studies in 1997 and 1998 in Minot, sulfentrazone caused minimal injury to these crops and gave excellent control of kochia.

In 1999, chickpea was the most tolerant crop at all locations with all treatments. Chickpea yield was higher with all sulfentrazone treatments compared to the untreated check. Dry pea injury varied across locations and was more severe with the PPI treatment. However, dry pea yields when combined across locations were higher for all sulfentrazone treatments compared to the check. Lentil injury was most severe with the PPI treatment. Early injury ranged from 40 to 90% at Minot, 18 to 43% at Carrington, and 35 to 86% at Williston. The PRE treatment caused less injury to lentil ranging from 45 to 85% at Minot, 2 to 18% at Carrington, and 9 to 19% at Williston. Lentil yield was significantly reduced with the PPI treatments at Williston. However, yields were 270 lb/A higher with the low rate of sulfentrazone applied PRE compared to the check. The other PRE sulfentrazone rates were similar to the untreated check. At Carrington, lentil yield was higher across all sulfentrazone treatments (PPI and PRE) compared to the check even though there was severe crop injury at any rate applied PPI. The lentil crop at Minot was damaged by hail and was not harvested.

This study showed good chickpea and field pea tolerance to sulfentrazone when applied preemergence. Lentil injury was moderate to severe at all locations. This is in contrast to previous studies in 1997 and 1998 where there was minimal injury to lentil. This study will be repeated in 2000. We will request that crops that show good tolerance to sulfentrazone be submitted to IR-4 for residue trials and development of tolerance petitions.

ANTAGONISM OF INSECTICIDE ACTIVITY IN CANOLA WITH LOW DOSES OF SULFONYLUREA HERBICIDES. Pete J. Schneider, Joseph P. Yenish, David Bragg, and John Burns, Associate in Research and Assistant Professor, Department of Crop and Soil Sciences, Washington State University, Pullman, WA 99164-6420; Area Agent, Washington State University Cooperative Extension, Pomeroy, WA 99347-0190; and Area Agent, Washington State University Cooperative Extension, Colfax, WA 99111-1894.

Abstract. Canola is a crop which is extremely sensitive to sulfonylurea herbicides. Misdirected spray drift from sulfonylurea herbicide applications to cereal grains has caused injury to canola in many instances in the Pacific Northwest and elsewhere. Additionally, field observations have lead to the suspicion that sublethal and no observable effect dosages of sulfonylurea herbicides may reduce the activity of foliar and systemic insecticides used in canola.

Field studies were initiated in 1998 and repeated in 1999 to determine if low doses of sulfonylurea herbicides antagonized the activity of imidacloprid and bifenthrin on the control of cabbage aphid and cabbage seedpod weevil in canola. In 1998, the experimental design was a three by three factorial with insecticide treatments of nontreated, a seed treatment of 0.625 lb imidacloprid/100 lb canola seed, and a foliar treatment of 0.04 lb bifenthrin/A applied at full canola bloom. Herbicide treatments included nontreated, 0.00019 lb thifensulfuron plus 0.00009 lb tribenuron/A, and 0.000019 lb thifensulfuron plus 0.000009 lb tribenuron/A. The thifensulfuron plus tribenuron rates were equivalent to 0.01 and 0.001, respectively, times the recommended rate for small grain. In 1999, the experimental design was a 3 by 4 factorial with the same insecticide and herbicide treatments plus the addition of 0.0019 lb thifensulfuron

plus 0.0009 lb tribenuron/A herbicide treatment which was equivalent to 0.1 times the recommended rate for small grains. Herbicide applications were at the rosette stage of the canola ahead of the bifenthrin applications. Insect populations were determined by counting the number of cabbage aphid colonies at set intervals following the bifenthrin application and determining the percentage of canola siliques exhibiting exit holes caused by the cabbage seedpod weevil.

Cabbage aphid counts taken 10 days after the bifenthrin application in 1998 showed greater than a five-fold increase in the number of aphid colonies within an insecticide treatment when 0.01 and 0.001 rates of sulfonylurea herbicide were applied in combination with either insecticide. Aphid populations for both insecticides were approximately one-half of the population of the nontreated insecticide treatment within the 0.01 and 0.001 rates herbicide treatment. Aphid populations were not different for any of the three herbicide treatments within the nontreated insecticide treatment. Cabbage seedpod weevil counts taken at harvest showed that within the imidacloprid treatment, populations were over 10 and 25 times greater when the insecticide was applied in combination with 0.01 and 0.001 field rates of sulfonylurea, respectively, than imidacloprid alone. For bifenthrin the differences were approximately 2 and 5 times greater, respectively. A reduction in canola seed yield of approximately 25% in comparison to the yield of the nontreated herbicide treatment was seen within both imidacloprid and bifenthrin treatments for both herbicide rates. Within the nontreated insecticide treatment, canola seed yield actually increased approximately 25% with both herbicide rates compared to the nontreated herbicide treatment. Results for 1999 are not completely summarized, but initial summary shows the same trends.

WILD PROSO MILLET (*PANICUM MILIACEUM*) RESPONSE TO IMAZAMOX: SHOOT DRY MATTER REDUCTION AND ABSORPTION. Décio Karam[1,2], Scott J. Nissen[1], and Philip Westra[1], Graduate Research Assistant, Associate Professor, and Professor, [1]Department of Bioagricultural Science and Pest Management, Colorado State University, Ft. Collins, CO 80523 and [2]Brazilian Agricultural Research Corporation.

Abstract. Imazamox control of wild proso millet, a weed problem in corn producing areas in the United States and Canada, was studied under greenhouse and laboratory conditions at Colorado State University. Twelve biotypes of wild and cultivated proso millet were grown in flats filled with commercial potting soil. Plants were treated in a spray chamber at 210 L ha^{-1} when plants had 4-leaves to 1-tiller about 10 days after planting. Imazamox was applied at 0.053, 0.027, 0.013, and 0.007 kg ha^{-1}. Shoot dry matter reduction varied by biotypes. Imazamox at 0.053 kg ha^{-1} reduced shoot dry weight from 72 to 93% depending on the biotype. Shoot dry weight reduction observed due to imazamox at 0.027 kg ha^{-1} varied from 42 to 73%. Absorption was studied in two wild proso millet biotypes selected based on differential response to imazamox. Imazamox at 0.053 kg ha^{-1} was applied alone and in combination with methylated seed oil (1% v/v), NIS (0.25% v/v), NIS (0.25% v/v) plus urea ammonium nitrate (UAN-28% 1% v/v), and UAN-28% (1% v/v). Treated leaves were washed with 10% methanol plus 0.25% NIS. Absorption was calculated by the difference of the imazamox applied and the imazamox recovered in leaf wash. No differences in absorption were observed at 24 and 48 hours. Imazamox absorption with methylated seed oil and with NIS plus UAN-28% was 89% and 94% respectively, while absorption of imazamox alone was 65% at 24 hours.

EFFECTS OF PROPICONAZOLE ON GERMINATION AND GROWTH OF BROADLEAF WEEDS. Laura A. Hanson, Bill D. Brewster, Carol A. Mallory-Smith, and Bradley D. Hanson, Graduate Student, Senior Instructor, Associate Professor, and Faculty Research Assistant, Oregon State University, Corvallis, OR 97331-3002.

Abstract. Propiconazole, a sterol biosynthesis inhibitor, is frequently employed in the control of fungal pathogens in agricultural and horticultural crops. Field studies conducted in 1998 and 1999 indicated that propiconazole inhibited germination and growth of broadleaf weeds. In a 1999 field study, propiconazole applied at a rate of

0.157 lb/A reduced Powell amaranth, common groundsel, hairy nightshade, and annual sowthistle densities by 86, 17, 49, and 53%, respectively. To further examine these observations, a greenhouse experiment was performed to determine the effects of propiconazole on germination and biomass production of redroot pigweed. Preemergence applications of 0.209 lb/A propiconazole reduced pigweed biomass by 63% as compared to an untreated control. Although applications of propiconazole at the 2- and 4-leaf stage of growth visibly injured pigweed, biomass production was not significantly reduced.

SPRAY CARRIER VOLUME AFFECTS ACTIVITY OF HERBICIDES AT LOW DOSAGES. J. Schroeder and P. A. Banks, Professor, Department of Entomology, Plant Pathology and Weed Science, New Mexico State University, and MARATHON-Agricultural & Environmental Consulting, Las Cruces, NM 88003.

Abstract. Research to determine the effect of herbicides on nontarget crops has traditionally been conducted using dose response studies where the herbicide rate of application varies but carrier volume remains constant. Spray drift, however, consists of small droplets that are made up of concentrated herbicide solution. Therefore, the objective of this research was to determine if varying carrier volume proportionally with the herbicide dosage would change crop response compared to maintaining a constant carrier volume with varying dosages. The research was conducted at two locations with a factorial treatment arrangement in a randomized complete block design and four replications. The factors were carrier volume and herbicide dose. Separate experiments were conducted at each location to evaluate sweet corn response to glyphosate and cotton response to 2,4-D applied at 0.37, 0.185, 0.092 and 0.046 kg/ha. The constant water carrier volume was 281 L/ha and the variable carrier volumes were 94, 47, 24, and 12 L/ha, respectively, for the declining rates. Treatments were compared to controls that were either non-treated or treated with a full rate of each herbicide (1.12 kg/ha). Applications were made to 25 cm tall sweet corn and pre-blooming cotton. Data included visual injury ratings 7, 14 and 21 days after treatment, plant fresh weight, and crop yield. For both crops, the variable carrier volume increased visual injury compared to the constant carrier volume. In sweet corn, the plant fresh weights and crop yield were reduced in plots treated with the variable carrier volume compared to the constant carrier volume. The cotton fresh weights were reduced similarly by all the treatments and yields were dramatically reduced by 2,4-D in all treatments. The treatments were applied at the pre-bloom stage of growth, when the cotton reproduction was most susceptible to the herbicide. At one location, however, cotton yield was reduced more by 2,4-D applied at 0.092 kg/ha in 24 L/ha carrier compared to 281 L/ha. This work suggests that when determining non-target crop response to drift amounts of herbicide, the carrier volume and timing of treatment application will affect the resulting damage. In general, using carrier volumes for each dosage that are proportional to the full dosage that would have been applied to the target field may provide more useful information concerning the potential damage a herbicide can cause to nontarget crops.

THE INFLUENCE OF APPLICATION TIME OF DAY ON GLYPHOSATE EFFICACY. Dallas E. Peterson and Kassim Al-Khatib, Extension Weed Scientist and Associate Professor, Kansas State University, Manhattan, KS 66506.

Abstract. Herbicides are often applied in the early morning or late evening hours in Kansas to avoid high wind conditions and minimize the risk for herbicide drift. However, producers and applicators often complain of poor weed control with early morning or late evening applications of glyphosate. A field experiment was conducted near Manhattan, KS to determine the influence of application time of day on glyphosate efficacy. The experiment had a randomized complete block design with a split plot arrangement of application stage as the main plot, and application time of day as the subplot. Palmer amaranth were less than 8 inches tall and velvetleaf were less than 4 inches tall with the early postemergence treatments, while Palmer amaranth were less than 12 inches tall and velvetleaf were less than 8 inches tall with the late postemergence treatments. Glyphosate at 0.56 kg/ha plus

ammonium sulfate at 1% w/w was applied at 6:00 a.m., 10:00 a.m., 1:30 p.m., 5:00 p.m., and 9:00 p.m. on both application dates. Application time of day influenced glyphosate efficacy at the late application stage, but not at the early application stage. Weed control was 95% or higher with all application times of day on the early application date. Weed control with the 10 a.m., 1:30 p.m., and 5 p.m. treatments on the late application date was greater than 96%. However, Palmer amaranth control at 6 a.m. and 9 p.m. was 88 and 85%, respectively, and control of velvetleaf at 6 a.m. and 9 p.m. was only 47%. Application time of day with glyphosate appears to be important when near the threshold level of acceptable weed control. Lower weed control with early morning or late evening applications could be due to the diurnal movement of plant leaves, presence of dew, or the effect of light on physiological interactions in plants.

RESULTS FROM QUINCLORAC APPLIED PREEMERGE AND POSTEMERGE IN GRAIN SORGHUM. Mark C. Boyles, Leo Charvat, and Gus Foster, Field Biologists, BASF Corp., Research Triangle Park, NC 27709.

Abstract. Grain sorghum requires effective grass and broadleaf weed control for successful production. However, few postemerge grass control products are available. Recently quinclorac was labeled for postemerge annual grass and broadleaf weed control in grain sorghum. Studies were conducted the last three years by BASF and university researchers in Texas, New Mexico, Oklahoma, Kansas, Colorado, and Nebraska show that quinclorac can provide acceptable grass and broadleaf weed efficacy applied both pre-emergence and postemerge.

Studies conducted over the past three years show that quinclorac applied alone both pre-emerge and postemerge at rates of 0.25 to 0.38 lb/A will provide greater than 80% control of morningglory, common sunflower, field bindweed, yellow and green foxtail, barnyardgrass, crabgrass, and velvetleaf with out sorghum injury. Postemerge applications must be made on non-tillering less than 2 inch grasses. Applications of quinclorac must be on broadleaves less than 6 inches tall. Quinclorac applied alone will not provide acceptable efficacy on pigweed species. Other labeled materials such as atrazine must be applied in a tank mix. The best overall grass and broadleaf weed efficacy was provided by quinclorac (0.25 to 0.38 lb/A) in combination with atrazine at 0.5 to 1 lb/A. All applications of quinclorac need to be applied in a combination with other labeled herbicides in grain sorghum and applied postemerge in combination with 1% MSO. Quinclorac applied preemerge in combinations with dimethenamid, atrazine or a combination of dimethenamid plus atrazine showed excellent sorghum tolerance with excellent (>90%) broadleaf and grass control. Postemerge combinations with atrazine, bromoxynil, and dicamba show good sorghum tolerance. Sorghum has excellent tolerance to quinclorac (rates up to 0.38 lbs/A) applied preemerge to 12 inches tall.

RESULTS FROM FALL FALLOW APPLICATIONS OF QUINCLORAC APPLIED ON FIELD BINDWEED PREPLANT TO WHEAT. Mark C. Boyles and Tim Culpepper, Field Biologists, BASF Corp., Research Triangle Park, NC 27709.

Abstract. Winter wheat requires effective control of field bindweed for successful production. Recently quinclorac was labeled for fallow applications on field binweed on land being planted to winter wheat. Studies conducted from 1994 to 1999 by BASF and university researchers in Texas, New Mexico, and Oklahoma, show that quinclorac provides excellent efficacy when applied postemergence in the fall to actively growing field bindweed.

Quinclorac (0.125, 0.25 lb/A) applied postemergence in combination with 0.5 lb/A of 2,4-D provided greater than 80% control of field bindweed 12 MAT. Quinclorac in combination with 2,4-D applied in a three year program approach of 0.25 lb/A of quinclorac the first fall followed by 0.125 lb/A the second and third fall provided greater than 90% field bindweed efficacy. Quinclorac plus 2,4-D applied as a one year program or a three year program provided better field bindweed efficacy than that provided by glyphosate plus 2,4-D, dicamba plus 2,4-D or glyphosate, and equal to efficacy provided by picloram plus 2,4-D. Applications of quinclorac just prior to planting winter wheat at 0.25 lb/A did not show any crop damage.

ALTERNATIVE HERBICIDES TO DIURON IN CARBON-SEEDED PERENNIAL RYEGRASS. Bradley D. Hanson, Bill D. Brewster, and Carol A. Mallory-Smith, Faculty Research Associate, Senior Instructor, and Associate Professor, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97330.

Abstract. Carbon seeding commonly is used to increase the crop safety of diuron in perennial ryegrass seed fields in western Oregon. Diuron also is used to control weeds in established perennial ryegrass. Recently, annual bluegrass (*Poa annua*) developed resistance to urea herbicides, reducing the effectiveness of this herbicide program for most growers. Field studies were initiated in 1998 and 1999 near Corvallis, OR to find alternative-site-of-action herbicides for use in newly planted and established perennial ryegrass fields. Treatments of clomazone, norflurazon, and sulfentrazone applied to fall carbon-seeded perennial ryegrass controlled annual bluegrass 89 to 100% and did not reduce seed yield. Spring-1999-carbon-seeded perennial ryegrass injury from applications of norflurazon, sulfentrazone, or azafenidin was acceptable; however, carbon seeding did not prevent crop injury from pendimethalin or flufenacet-metribuzin. This trial was not taken to yield. Injury to perennial ryegrass carbon-seeded in Fall, 1999 at three locations was acceptable with applications of norflurazon, clomazone, sulfentrazone, or azafenidin; effects on yield will be measured in 2000. Clomazone, norflurazon, and sulfentrazone, alone and in combinations with oxyfluorfen, diquat, or glufosinate, were applied to established stands of perennial ryegrass with acceptable levels of crop injury and weed control in 1998 and 1999.

ABSORPTION AND FATE OF BAY MKH 6561 BY DOWNY BROME AND JOINTED GOATGRASS. Lynn Fandrich, Sandra McDonald, Scott Nissen, and Philip Westra, Graduate Research Assistant, Extension Specialist, Associate Professor, and Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523.

Abstract. Field observations show differential response to post applications of BAY MKH 6561 by downy brome (susceptible) and jointed goatgrass (suppression). The influence of adjuvants on foliar absorption of BAY MKH 6561 by downy brome and jointed goatgrass was evaluated under growth-chamber and laboratory conditions. Radiolabeled BAY MKH 6561 absorption by downy brome and jointed goatgrass without the use of adjuvants was 49 and 44% 48 HAT, respectively. Foliar absorption reached a maximum of 95% for both species with the use of non-ionic surfactant (NIS) 24 HAT. Combinations of NIS and nitrogen did not increase absorption over NIS alone. Translocation and metabolism of BAY MKH 6561 by downy brome and jointed goatgrass were evaluated 12, 24, 48, and 96 HAT. Total ^{14}C-BAY MKH 6561 found in the treated leaves of downy brome and jointed goatgrass reached a maximum of 40 and 55% and remained at that level through 96 HAT. Downy brome and jointed goatgrass treated leaves metabolized 54 and 55% of absorbed ^{14}C-BAY MKH 6561 12 HAT and 98% metabolism occurred in both species 48 HAT. On a whole plant basis, jointed goatgrass metabolized ^{14}C-BAY MKH 6561 more rapidly than downy brome with 8 and 21% parent intact 24 HAT, but both species metabolized 99% of absorbed 96 HAT. Observed differential susceptibility is not explained by absorption, translocation and metabolism of BAY MKH 6561 by downy brome and jointed goatgrass. Research to evaluate root absorption and ALS/AHAS enzyme sensitivity to the potential contribution of differential sensitivity needs to be conducted.

LITTLESEED CANARYGRASS CONTROL IN DURUM WHEAT WITH BAY MKH 6561. Carl E. Bell, Weed Science Farm Advisor, Cooperative Extension, University of California, Holtville, CA 92250.

Abstract. Six field experiments have been conducted on durum wheat from 1996 through 1999 in the Imperial Valley of southeastern California, to evaluate littleseed canarygrass control with BAY MKH 6561. Littleseed canarygrass is an important weedy annual grass in warm temperate and subtropical cereal growing regions, such as the southwestern USA, northern Mexico, the Mediterranean, and south Asia. This grass is not adequately controlled by currently available herbicides. In addition, durum wheat is usually more easily injured by grass control herbicides that are safe to other types of wheat, which further reduces the herbicide options for littleseed canarygrass control. In these experiments, comparisons of BAR MKH 6561 were made to four herbicides; diclofop-methyl, tralkoxydim, fenoxaprop, and flucarbazone-sodium. Over the six trials, BAY MKH 6561 has provided the most consistent control of littleseed canarygrass among the herbicides tested. Crop injury has been observed in some cases, but appears to be related to stage of growth of the crop at time of application. Yield data from these trials indicates that BAY MKH 6561, at most of the tested rates and timing of application, is safe to the crop.

SULFOSULFURON METABOLISM AS AFFECTED BY TEMPERATURE AND SOIL MOISTURE IN DIFFERENT GRASS SPECIES. Brian L. S. Olson, Kassim Al-Khatib, Phillip W. Stahlman, and Paul J. Isakson, Graduate Student and Associate Professor, Department of Agronomy, Manhattan, KS 66506; Professor, Kansas State University, Agricultural Research Center-Hays, Hays, KS 67601; and Product Technical Specialist, Monsanto Co., St. Louis, MO 63198.

Abstract. Sulfosulfuron metabolism by wheat, jointed goatgrass, downy brome, and wild oat as affected by air temperature or soil moisture was evaluated in growth chamber studies. In the temperature study, air temperature was either 25/23 or 5/3 C day/night. Radiolabeled sulfosulfuron was vacuum infiltrated into the leaf tissue, and the herbicide was extracted. Wheat metabolized 87% of the sulfosulfuron within 12 h after treatment at 25/23 C, whereas no wheat metabolism of sulfosulfuron occurred at the 5/3 C temperature until 48 h after application. Delayed sulfosulfuron metabolism was also observed for jointed goatgrass at the 5/3 C temperature, whereas no herbicide transformation was detected in either wild oat or downy brome 48 h after application. At 25/23 C, wheat, jointed goatgrass, and wild oat metabolized 100, 60, and 46% , respectively, of sulfosulfuron 24 h after treatment, whereas downy brome only metabolized 7%. In the soil moisture study, soil moisture treatments were one-third pot capacity or pot capacity. Radiolabeled sulfosulfuron was applied at the three-leaf stage. Soil moisture did not affect sulfosulfuron metabolism with wheat and jointed goatgrass metabolizing more sulfosulfuron than wild oat and downy brome. In conclusion, downy brome is more susceptible to sulfosulfuron than the other grass species because of its low metabolic rate. Air temperature affected sulfosulfuron metabolism with greater metabolism occurring at 25/23 C, whereas sulfosulfuron metabolism was not altered by soil moisture.

EVOLUTION OF PRIMISULFURON RESISTANCE IN DOWNY BROME. George W. Mueller-Warrant[1], Carol A. Mallory-Smith[2], and Kee-Woong Park[2], Research Agronomist, Associate Professor, and Graduate Student, [1]USDA-ARS, National Forage Seed Production Research Center, 3450 SW Campus Way, Corvallis, OR 97331-7102 and [2]Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331-3002.

Abstract. The early stages of evolution of resistance to primisulfuron in downy brome (BROTE) were observed in long-term weed control plots in Kentucky bluegrass grown for seed in Madras and LaGrande, OR. Downy brome population density increased exponentially over the five year period of the studies (approximately 10-fold per year) in untreated checks and in some of the 14 herbicide treatments. Excellent control was achieved by combinations of primisulfuron plus terbacil in 1994 and 1995, but plot to plot variability in effectiveness of this treatment increased

greatly by 1996. Archived seed samples from the 1994 through 1996 harvests of a selected group of treatments (50 to 55 plots total) were tested for tolerance to 39 g ha^{-1} (1X rate) primisulfuron applied at the 2-leaf growth stage. Average downy brome survival was 5.9% for seed harvested in 1994, increasing to 7.7% in 1995 and 19.7% in 1996. Dose response curves were developed for seedlings of 21 accessions, including susceptible, intermediate, and resistant field plots, and survivors of primisulfuron treatment in earlier greenhouse tests. $LD_{50\%}$ for seven resistant accessions was 5 times larger than for nine susceptible accessions. Susceptible and resistant accessions were most clearly separated at the 2X treatment rate. High rate survivors (3X to 8X) of a resistant accession in an earlier greenhouse test were no more resistant than the field source itself, but 1X survivors of several partially resistant accessions did increase in resistance over their seed sources.

INTRODUCTION

Because herbicide resistance is generally recognized only after it has developed into a field-scale problem, specific details of its evolution are usually unknown. These unknown details may include the initial population size, the initial frequency of resistance genes within the population, and how resistance develops and spreads within the population in response to management practices. Long-term post-harvest residue management by herbicide treatment studies in Kentucky bluegrass grown for seed in the Pacific Northwest have provided an opportunity to observe critical details of the early stages of evolution of resistance to primisulfuron in downy brome. Grass seed stands sown in 1992 were harvested for five years. Herbicides treatments were generally applied to the same plots each year, but some treatments were modified after several years. Downy brome population density increased exponentially over time (approximately 10-fold per year) in untreated checks and in some of the 14 herbicide treatments. Excellent control was achieved by combinations of primisulfuron plus terbacil in 1994 and 1995, but plot to plot variability in effectiveness of this treatment increased greatly by 1996. Archived seed samples from the 1994 through 1996 harvests of a selected group of treatments (50 to 55 plots total) were tested for tolerance to 39 g ha^{-1} primisulfuron applied at the 2-leaf growth stage (Table). Average downy brome survival was 5.9% for seed harvested in 1994, increasing to 7.7% in 1995 and 19.7% in 1996. Dose response curves were developed for seed produced on plots showing susceptibility or resistance to primisulfuron in the field, and on survivors of primisulfuron treatment in the greenhouse in an attempt to answer such questions as: 1) what are the best combinations of herbicide rate and seedling growth stage for separating resistant from susceptible plants, 2) whether these downy brome populations have exhausted their potential to increase in resistance, and 3) what, if anything, can be inferred about the genetics of resistance.

OBJECTIVES AND TECHNIQUES

Our specific objective was to measure changes in the frequency of resistance to primisulfuron in downy brome in response to selection pressure from primisulfuron, both in the field and in the greenhouse. This was done by developing dose response curves to characterize the survival of 21 separate downy brome accessions over 12 rates of primisulfuron. Nine of the accessions derived from a single physical location (Madras plot 237) harvested in 1994, 1995, and 1996 after one, two, or three consecutive years of field treatment with primisulfuron, further subdivided on the basis of whether the seed was (a) produced in the field, (b) in the greenhouse on plants grown from seed from the field source but surviving treatment in the greenhouse with a 1X rate of primisulfuron, or (c) in the greenhouse on plants receiving no additional primisulfuron treatment. Three of the accessions were derived from the 1996 harvest of a nearby (minimum distance 16 m, average distance 25 m) plot (Madras plot 344), and included field grown seed, greenhouse 1X survivor seed, and a composite of greenhouse high rate (3X to 8X, 10 plants total) survivor seed. Four of the accessions were derived from a single physical location (LaGrande 340) in a second field test. These included 1995 field harvest seed, greenhouse 1X survivor seed (16 plants) from 1996 field source, and greenhouse untreated seed from both 1995 and 1996 field sources. The other five accessions were field harvest seed from three other plots at Madras and two at LaGrande. The logistic equation ($Y=100*10^{(A+B*X)}/(1+10^{(A+B*X)})$) was used to describe the dose response relationship between seedling survival and herbicide rate. Exponents were calculated by regression of transformed survival ($Y'=Log(0.01*Y/(1-0.01*Y))$) versus herbicide rate. Visual inspection of the raw data and preliminary regression analysis divided the 21 accessions into three categories: resistant (7 accessions), susceptible (9 accessions), and intermediate (5 accessions). Problems with uniformity of initial watering procedures lead to staggered emergence and a range in seedling growth stages when primisulfuron was applied. We recorded growth stages to the nearest 0.5 leaf for all 11,944 emerged seedlings at time of herbicide application. Most seedlings fell into the 2.5 to 3.0 or 3.5 to 4.0 leaf size groups, but those that were in the 0.5 to 2.0 leaf size group were much more sensitive to primisulfuron. The frequency of seedlings falling into each of the four leaf size groups varied among the 21 accessions and the 12 rates. Separate dose response curves for seedlings in the 0.5 to 2.0, 2.5 to 3.0, 3.5 to 4.0, and 4.0 to 8.0 leaf growth stages were calculated for the pooled resistant and susceptible groups. A transformation procedure was then developed that adjusted the herbicide rate by the square of the ratio of the logarithms of the leaf sizes in each group to the average leaf size (Figures 2 and 3). This transformation procedure did a reasonably good job of correcting for differences in tolerance to primisulfuron in the seedling size groups, although somewhat better adjustments could have been obtained by developing separate transformation procedures for the resistant and susceptible groups. However, applying separate transformation procedures to resistant and susceptible groups would have raised the difficult question of which procedure to use with any individual accession, and hence a single transformation procedure was used on all data. Data values of 0 or 100% survival were adjusted to 0.5 or 99.5% survival to enable their use in logistic regression. Data points were dropped from regression analysis in two general cases (a) high rates with no survival when somewhat lower rates were already achieving complete kill, (b) points representing small numbers of seedlings where the difference between measured percent survival and either 0 or 100% survival was based on the survival or death of only one or two seedlings. Such cases were generally handled by regrouping with neighboring points.

CONCLUSIONS

A 4- to 5-fold differences existed in response to primisulfuron between resistant and susceptible accessions. For both types of response, 2-fold increases in herbicide rate above the $LD_{50\%}$ decreased survival to under 3%, while 2-fold decreases in rate increased survival to around 84%.

The 2X treatment is the best single rate to classify individual plants at the 2.5- to 3-leaf growth stage as either almost certainly resistant (**survivors**) or probably susceptible (**dead seedlings**). Lower rates greatly increased the chance of truly susceptible individuals surviving treatment (**escapes**), while higher rates increased the chance of resistant individuals dying anyway.

High rate survivors (3X to 8X) of the most resistant accession in a previous rate response study produced seed that was no more resistant than the field source itself, whereas 1X survivors of susceptible or partially resistant accessions often increased in resistance over their parents.

Dose response relationships of these 21 accessions provide ambiguous hints regarding the genetics of resistance. The possibility that results for all 21 accessions could be explained by their seed being physical mixtures of only two phenotypes suggests that the genetics might be as simple as that for a single, dominant gene. However, the quantitative, continuous nature of these dose response functions implies the existence of multiple minor factors working together to determine the fate of individual seedlings. If the mechanism of resistance is metabolic detoxification, then the maximum degree of resistance may be set by a single genetic factor (such as the affinity of an enzyme for primisulfuron), with many other factors potentially reducing the rate at which the herbicide is metabolized and increasing the probability of death.

Further steps to take toward understanding the evolution of primisulfuron resistance in downy brome include: 1) screen 1997 harvest downy brome seed from all 180 plots at each site for frequency of resistance, defined as survival when treated with a 2X rate at a 3-leaf growth stage, 2) map the spatial distribution of resistance at both test sites, and correlate this with plot herbicide treatment history, seed dispersal patterns during swathing and combining, resistance frequency measurements on selected plots (55 out of 360) from 1994 to 1996, and downy brome density per plot from 1994 through 1997, 3) develop a computer model that describes the observed spread of resistance, and predicts the impact of alternative scenarios of management history, such as broadcast application over the field of single treatments (e.g., highly effective applications of primisulfuron plus terbacil, moderately effective applications of primisulfuron alone, or moderately effective treatments without primisulfuron), alternating use of highly effective and ineffective treatments from year to year, or side-by-side placement of effective and ineffective treatments, 4) use this computer model to develop and evaluate potential resistance management strategies.

Table. Response of archived BROTE seed to primisulfuron.

Response of BROTE at 2-leaf stage to 39 g/ha primisulfuron	Year of seed production 1993-94	1994-95	1995-96
		(no. of plots in each category)	
archived seed not viable	7	0	0
100% mortality	26	19	18
95-99% mortality	8	17	9
88-95% mortality	8	6	9
80-88% mortality	0	2	1
70-80% mortality	0	3	4
50-70% mortality	2	2	7
<50% mortality	0	1	7
Total no. of samples tested	51	50	55
Total no. of seedlings treated	1393	4303	3972
% of seedlings surviving	5.9	7.7	19.7

Primisulfuron was first applied in the 1993-94 growing season. BROTE seed was collected during cleaning of Kentucky bluegrass seed, and samples from selected treatments at Madras and LaGrande were archived in cold storage.

Field plot source regressions

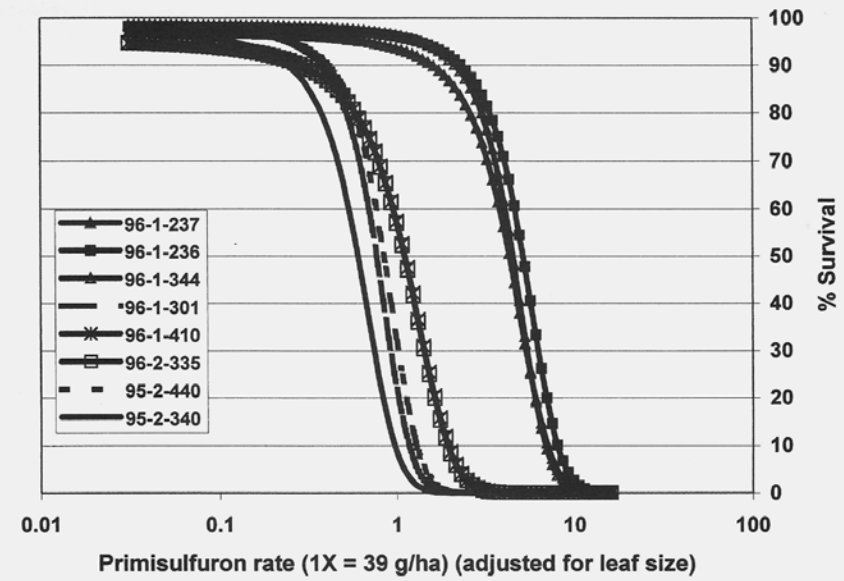
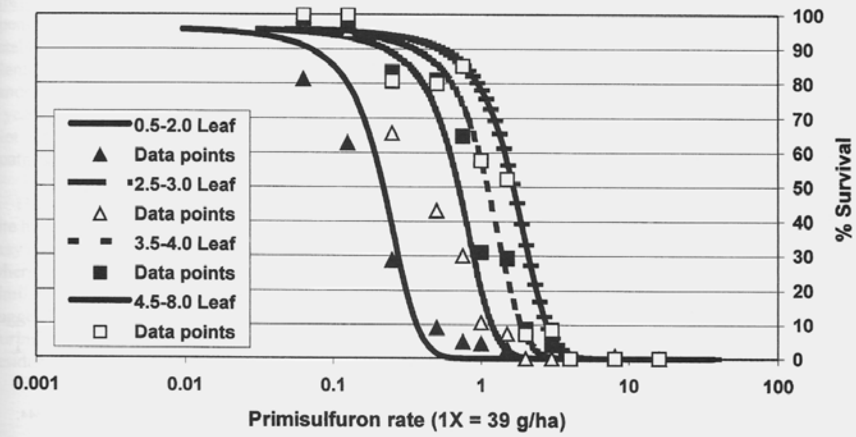
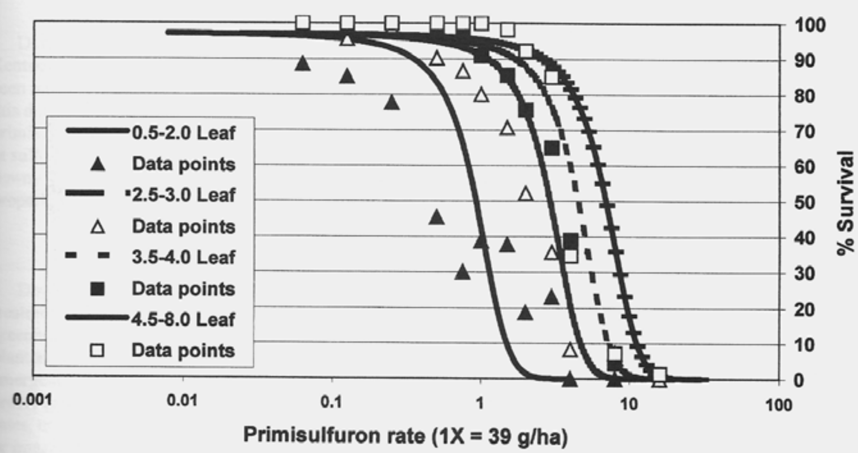


Figure 1. Dose response curves for all field plot sources. Note clear grouping into 3 resistant types and 5 susceptible types.

Leaf size effect: 9 Susceptible accessions pooled



Leaf size effect: 7 Resistant accessions pooled



Figures 2 and 3. Impact of leaf growth stage at time of treatment on dose response curves for pooled data from 9 susceptible and 7 resistant accessions. Logistic regressions based on adjusting primisulfuron rate by the square of the ratio of the logarithm of the number of leaves in each leaf stage group to the logarithm of the average number of leaves.

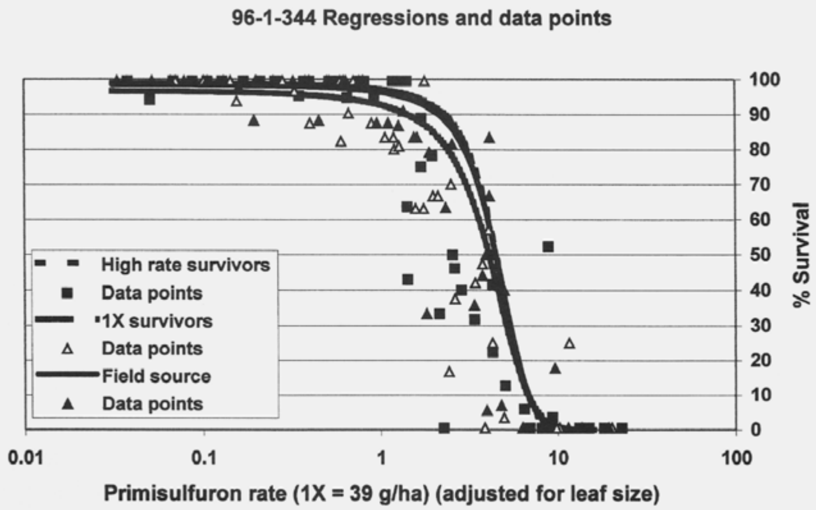


Figure 4. Dose response curves for field harvest, greenhouse 1X survivor, and greenhouse high rate survivors for 1996 harvest of Madras plot 344. Note similarity of all curves, indicating absence of further gain from selection pressure.

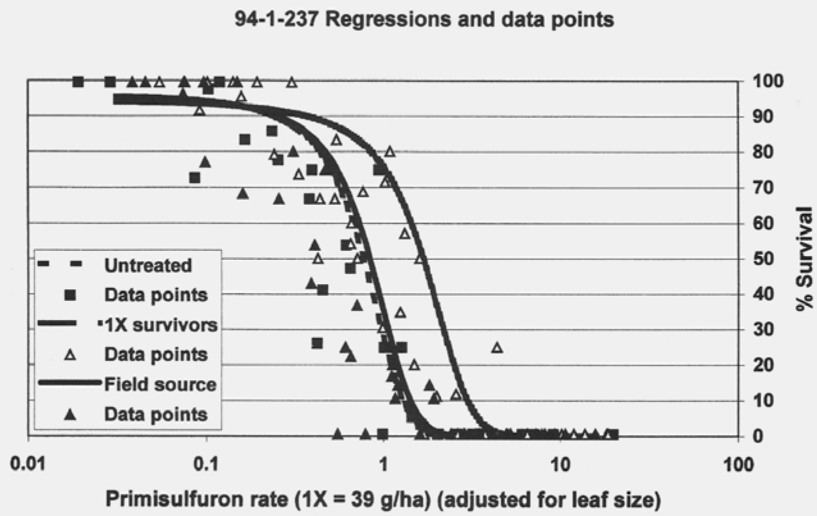


Figure 5. Dose response curves for field harvest, greenhouse 1X survivor, and greenhouse untreated for 1994 harvest of plot 237 at Madras, OR. Increase in resistance from greenhouse 1X selection was similar to increase in field from 1994 to 1995.

EFFECT OF RESIDUE AND DISTURBANCE ON JOINTED GOATGRASS ESTABLISHMENT. Shane G. Early, Eric R. Gallandt, David R. Huggins, Joseph P. Yenish, and Frank L. Young, Agricultural Project Assistant/Graduate Student, Assistant Professor/Weed Ecologist, Soil Scientist, Weed Scientist/Extension Specialist, and Research Agronomist, Department of Crop and Soil Sciences, Washington State University, Pullman, WA 99164.

Abstract. Levels of previous crop residue and soil disturbance caused by rotation sequence and various no-till drill openers affect soil surface environmental conditions and are thus potential regulators of jointed goatgrass establishment. A study was conducted to evaluate jointed goatgrass establishment and fecundity in winter wheat planted into high (spring wheat) or low (pea) residue using a high or low disturbance direct-seed drill. A randomized complete block, split-plot experimental design was used at two sites near Pullman, WA. One site had 7 years of no-till management (NT) while the other site had been managed with conservation tillage (CT). Main plot factors were residue (high or low) and disturbance (high or low), the split factor within subplots was jointed goatgrass spikelet density (0, 50, 100, 200, 400 joints/m^2).

High residue treatments decreased jointed goatgrass establishment at both sites ($P<0.003$); moreover, the NT site had 50% less established jointed goatgrass as compared to the CT site, suggesting an accumulated duff layer may reduce establishment. Greatest spikelet production occurred in low residue and low disturbance treatments whereas high residue and high disturbance treatments produced the least spikelets ($P<0.04$). Wheat yields were similar with both drills in high residue but greater in low residue and high disturbance conditions ($P<0.07$), suggesting reduced crop interference from established jointed goatgrass. First year experimentation occurred during an unusually wet and mild fall, a consideration to be taken when evaluating the strong previous crop residue effect and negligible effect of soil disturbance on jointed goatgrass establishment.

SULFONYLUREA HERBICIDE RESISTANCE IN DOWNY BROME. Daniel A. Ball and Carol Mallory-Smith, Associate Professors, Oregon State University, Columbia Basin Agricultural Research Center, Pendleton, OR 97801, and Oregon State University, Corvallis, OR 97331.

INTRODUCTION

Diminished control of downy brome (*Bromus tectorum* L.) from primisulfuron was observed in a commercial Kentucky bluegrass seed field in northeastern Oregon in August 1998. Multiple applications of primisulfuron had been made to this perennial crop each year for a 4-yr period. Greenhouse bioassays were conducted to determine if this downy brome population differed from a sulfonylurea susceptible population in its susceptibility to primisulfuron and to other acetolactate synthase (ALS) inhibitor herbicides sulfosulfuron, BAY MKH 6561 (a sulfonylaminocarbonyltriazolinone), and imazamox (an imidazolinone). These compounds effectively control downy brome in winter wheat and could stimulate renewed interest in direct-seed production of winter wheat if properly managed to delay herbicide resistance development.

METHODS

Downy brome seed was collected near Athena, OR from mature plants surviving repeated primisulfuron treatment, dry stored in paper bags for several months, then planted in 10 cm x 10 cm pots in potting soil mix under greenhouse conditions. Collections of downy brome with no history of primisulfuron treatment were similarly planted. Seed collections were from Pendleton and Imbler, OR, and LaCrosse, WA. After downy brome emergence, pots were thinned to five downy brome plants per pot. At approximately the 3-leaf stage of downy brome growth, pots were sprayed with a 40, 80, or 160 g/ha of primisulfuron, representing 1X, 2X, or 4X field use rates, or 80 g/ha primisulfuron plus chlorpyrifos. Additional treatments consisted of sulfosulfuron at 35 or 70 g/ha, or imazamox at 35 or 70 g/ha, representing 1X and 2X field use rates, and the 2X rate of either compound plus chlorpyrifos. Chlorpyrifos inhibits metabolism of sulfonylurea herbicides in treated plants (1) thereby synergizing herbicidal activity in sensitive plants. The study was arranged as a RCB with five replications. The study was repeated twice. A non-ionic surfactant at 0.5 % v/v was added to sulfosulfuron treatments and a crop oil concentate at 2.3 l/ha was added to primisulfuron and imazamox treatments. At approximately 40 days after treatment, all above-ground plant material was clipped, oven dried, and weighed. A third trial was conducted to evaluate the response of three downy brome collections to BAY MKH 6561. Treatments consisted of 45, 90, or 180 g/ha of BAY MKH 6561, representing a 1X, 2X, or 4X field use rate, or 90 g/ha BAY MKH 6561 plus chlorpyrifos. Experimental design and data collection were the same as described for the other trials, and the study has not been repeated.

RESULTS

The Athena downy brome biotype exhibited a high level of resistance to all rates of primisulfuron, sulfosulfuron, and BAY MKH 6561 compared to an untreated control. No reduction in above ground dry matter was observed after any treatment of primisulfuron, sulfosulfuron, or BAY MKH 6561. The inclusion of chlorpyrifos to treatments produced no reduction in observed tolerance to primisulfuron or sulfosulfuron in the Athena biotype, thereby suggesting an altered site of action as the mechanism for primisulfuron resistance. Analysis of isolated ALS enzyme from green downy brome plant material confirmed that the Athena biotype ALS enzyme exhibited a
1955-fold greater resistance to chlorsulfuron and a 200-fold greater resistance to BAY MKH 6561 than the sensitive biotype ALS enzyme (Bayer, personal communication). This differs from a primisulfuron-resistant downy brome biotype described earlier where enhanced metabolism of primisulfuron was the suspected herbicide resistance mechanism (2). The Athena biotype tended to exhibit a slight level of resistance to imazamox, but observed resistance was eliminated by inclusion of chlorpyrifos. These results emphasize the need for proactive resistance management plans to mitigate the onset of field level resistance in downy brome.

LITERATURE CITED

Ahrens, W. H., and W. R. Panaram. 1997. Basis for thifensulfuron-insecticide synergism in soybeans (*Glycine max*) and corn (*Zea mays*). Weed Sci. 45(5) 648-653.

Mallory-Smith, C., P. Hendrickson, and G. Mueller-Warrant. 1999. Cross-resistance of primisulfuron-resistant downy brome to sulfosulfuron. Weed Sci. 47:256-257.

ANALYSIS OF EXPERIMENTAL WHEAT X JOINTED GOATGRASS HYBRID LINES USING THE HIGH MOLECULAR WEIGHT GLUTENIN TECHNIQUE AND CHROMOSOME COUNTS. Lisèle Cremieux[1], Laura A. Morrison[1], Jeremy R. Snyder[1], Robert S. Zemetra[2], and Carol A. Mallory-Smith[1], Graduate Student, Post-doctoral Research Associate, Former Graduate Student, Professor, and Associate Professor, [1]Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331 and [2]Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83844.

Abstract. The recent discovery of fertile wheat x jointed goatgrass hybrids in infested wheat fields raises the possibility of gene flow between wheat and jointed goatgrass and the need to better understand the genetics of the hybrids. This study investigates wheat x jointed goatgrass F1 and reciprocal backcross lines produced in experimental field plantings. Electrophoresis of the high molecular weight (HMW) glutenin seed proteins was used to establish a baseline for evaluating hybrids collected in natural populations. The HMW glutenin profiles are a useful diagnostic tool because the band patterns, in the 80-120kDa molecular weight range, are species-unique (3 bands for goatgrass, 4 bands for wheat) and can be used to trace parentage in the hybrid seed on the basis of band contribution. Experimental hybrids show considerable diversity in banding profiles (17 patterns of 4 to 7 bands). As expected, diversity decreases in more advanced generations (BC2 and BC1S1). The backcrosses were not in isolation plots. Preliminary analysis suggests that most of the backcrosses were to wheat. Chromosome counts confirm the direction of the crosses and vary as follows: 35 chromosomes for F1; 36 to 57 for BC1; 28 to 49 for BC2; and 33 to 52 for BC1S1. A chromosome number of 28 suggests that jointed goatgrass was the recurrent backcross pollen donor, while numbers closer to 42 and above point to wheat as the pollen donor. This information will contribute to the development of a method for tracing population structure and parentage in hybrids collected in Oregon wheat fields.

MON 37500 APPLICATION TIMING AFFECTS DOWNY BROME AND WINTER WHEAT RESPONSE.
Phillip W. Stahlman and Patrick W. Geier, Professor and Assistant Scientist, Kansas State University Agricultural Research Center, Hays, KS 67601.

Abstract. MON 37500 (proposed name sulfosulfuron) is a newly-registered sulfonylurea herbicide for use in winter and spring wheat. Unlike other herbicides in this chemical family, MON 37500 is effective against both grass and broadleaf weeds. An experiment conducted near Hays, KS investigated the effects of MON 37500 application timing on weed control efficacy and winter wheat response. MON 37500 was applied at 0.031 lb/A PRE on September 29, or POST with non-ionic surfactant at weekly intervals thereafter through December, and from early February through March. Preemergence-applied MON 37500 provided the greatest downy brome control (97%). Control decreased with each later POST application in the fall and increased with later application in the spring. Late-December treatments of MON 37500 provided the least downy brome control (50%). Downy brome control increased from 60% with the early-February treatment to 73% with March treatments. MON 37500 caused minor wheat chlorosis beginning with late-October applications, and all subsequent fall-POST applications resulted in some wheat injury. MON 37500 applied in late-February was the only spring-POST treatment to cause chlorosis. Wheat treated with MON 37500 outyielded untreated wheat regardless of application timing (55.8 to 73.6 bu/A compared to 40.5, respectively), with the greatest yield for wheat treated PRE. A strong correlation ($r = 0.81$) existed between winter wheat yield and weed control with MON 37500. Flixweed control was 100% regardless of MON 37500 application timing. MON 37500 controlled henbit 75% or more when applied before December.

BRUSH AND NOXIOUS WEED MANAGEMENT WITH THE BURCH WET-BLADE MOWER. Tom D. Whitson, Extension Weed Specialist and Professor, Plant Sciences Dept., University of Wyoming, Laramie, WY 82071.

Abstract. The Burch Wet-Blade mower is a new innovative method of weed control that allows herbicides to be applied along the under-side of a mower blade. Herbicides are applied as concentrated solutions through a computer regulated pump. Herbicides are contained by a closed system of Flo-Thru-Cells with the use of computer monitored ground-speed sensors to keep applications uniform.

Rubber (gray) rabbitbrush, known for its ability to resprout after a fire or any other mechanical disturbance, was the first species tested with the wet-blade mower. One year after treatment, applications of picloram at 0.25 and 0.5 lb/A provided 95 and 100% control, respectively. Wild iris control was 90, 95, and 100% with triclopyr at 2 lb/A, triclopyr plus imazapyr at 2 + 0.25 lb/A, and picloram at 0.5 lb/A, respectively. On leafy spurge, applications of picloram at 0.5 lb/A achieved 99% control, while imazapic at 0.25 lb/A achieved 95% control. Dalmatian toadflax control of 100% with picloram at 0.5 lb/A.

Table. Percent control of weed species 1 year following herbicide applications through the Burch Wet-Blade mower.

Herbicide[a]	Rate	Wild iris	Leafy spurge	Rubber rabbitbrush	Dalmatian toadflax
	lb/A	% control			
Picloram	0.25	-	-	95	-
Picloram	0.5	95	95	100	100
Triclopyr + imazapyr	2 + 0.25	100	–	50	–
Triclopyr	2	90	–	50	–
Imazapic	0.25	–	99	–	–

[a]Applications of herbicides made in July and August of 1998. Evaluations: August, 1999.

INVESTIGATING THE IMPACT OF RUSSIAN KNAPWEED INVASION ON NITROGEN CYCLING IN GRASSLANDS USING COMPUTER MODELING. Harold D. Fraleigh, Jr.[1], Debra Peters[2], K. George Beck[3], and William J. Parton[4], Graduate Research Assistant, Research Scientist, Associate Professor, and Professor, [1]Ecology Program, Natural Resources Ecology Laboratory, Colorado State University, Ft. Collins CO 80523; [2]USDA-ARS Jornada Experimental Range, New Mexico State University, Las Cruces, NM, 88003; and [3]Department of BioAgricultural Sciences and Pest Management and [4]Natural Resources Ecology Laboratory, Colorado State University, Ft. Collins, CO 80523.

Abstract. Russian knapweed, a non-native perennial composite, can form monospecific stands lasting decades on western rangeland. Biological control has limited success on Russian knapweed expansion. Currently, successful restoration efforts involve three key steps: herbicide application, soil cultivation, and seeding to grass. Cultivation is thought to release volatile allelochemicals trapped in the soil; however, cultivation can change many soil characteristics including organic matter decomposition rates and nutrient availability. In order to simulate nitrogen cycles on rangeland dominated by either grass or Russian knapweed, we used the CENTURY biogeochemistry computer simulation model with appropriately adjusted C:N, lignin:N and growth parameter values. CENTURY results suggest that net nitrogen mineralization is significantly reduced in soils under Russian knapweed relative to soils under grass. After conversion from grass to Russian knapweed domination, labile soil nitrogen pools decrease rapidly within the first couple of years, while slow soil nitrogen pools gradually increase for decades. Following chemical control and cultivation, the model predicts net nitrogen mineralization rates and

labile soil nitrogen pools increase, in a pulse lasting a few years, to levels greater than that occurring in grass-dominated rangeland. An empirical study is warranted to investigate whether the expected increase in nitrogen availability is responsible for improved reclamation success associated with cultivation, and if no-till reclamation could be successful with low levels of nitrogen applications.

WEED CONTROL WITH IMAZAPIC PLUS 2,4-D IN NON-CROPLAND, PASTURE, AND RANGELAND. Kenneth L. Carlson, Joseph Vollmer, Daniel Beran, Jeffrey Birk, Todd Horton, Ted Alby, Pam Hutchinson, Cletus Youmans, and Bobby Watkins, Senior Field Research Agriculturist, Senior Technical Specialist, Technical Specialist Intern,Technical Strategic Manager, Technical Specialist, Senior Field Research Agriculturist, Field Research Agriculturist, Senior Field Research Agriculturist, and Principal Field Research Agriculturist, American Cyanamid Company, Lincoln, NE 68506 and Princeton, NJ 08543.

Abstract. Imazapic, a member of the imidazolinone herbicide family, is a broad spectrum herbicide that expresses contact, translocation, and residual activity at very low use rates with an environmentally responsible toxicological profile. Imazapic is currently sold under the tradename Plateau® herbicide, and is registered for the control of over 90 grass and broadleaf weed species, including key perennial weeds such as leafy spurge, johnsongrass, and Canada thistle in non-cropland areas, native prairiegrass renovation and restoration, wildflower establishment and maintenance, and conservation reserve program (CRP) lands. A Section 18 emergency exemption use in pasture, rangeland, and CRP for the control of leafy spurge in Nebraska was granted in the fall of 1999. Registration for pasture and rangeland uses is anticipated in late 2001. American Cyanamid Company is developing a new package mix with a 1:2 ratio of imazapic plus 2,4-D low volatile ester, tradename Oasis® herbicide, to be used for weed control in non-cropland, rangeland, pasture, and CRP. Field research trials have been conducted with the package mix of imazapic plus 2,4-D to quantify weed control achieved, and to identify weeds where additional control is achieved over imazapic alone. Initial results indicate that the package mix does provide effective weed control on a multitude of perennial, biennial, and annual weed species. Perennial weeds controlled include hoary cress, diffuse knapweed, Russian knapweed, leafy spurge, perennial pepperweed, Platte thistle, rhizome johnsongrass, and rush skeletonweed. Biennial and annual weeds controlled include baby's breath, downy brome, houndstongue, tumble mustard, musk thistle, plumeless thistle, Scotch thistle, and yellow starthistle. In these initial field research trials it has become apparent that the combination of imazapic plus 2,4-D does provide improved weed control over imazapic alone on several important weed species. These weeds include baby's breath, common bugloss, common tansy, diffuse knapweed, leafy spurge with spring applications, musk thistle, Platte thistle, plumeless thistle, and spotted knapweed. These improvements in weed control, however, were not enough in every case to provide commercially acceptable weed control. Registration for this new package mix is anticipated in late 2000 for non-cropland and CRP, with rangeland and pasture to follow at a later date.

POSSIBLE CORRELATIONS BETWEEN SITE CONDITIONS AND THE OCCURRENCE OF YELLOW TOADFLAX IN THE FLATTOPS WILDERNESS AREA OF COLORADO. Jason R. Sutton and K. George Beck, Research Associate and Associate Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523.

Abstract. Yellow toadflax is a common weed throughout the United States and Canada. It is especially prevalent in the Intermountain West, and has become a serious problem in the Flattops Wilderness on the western slope of the Colorado Rockies. Using GIS technologies, yellow toadflax infestations were mapped in the Ripple Creek drainage of the Flattops Wilderness beginning July 8, 1999 and ending August 6, 1999. Site characteristics were recorded and compared to random site characteristics obtained during the same growing season. Sixty-five plots that contained yellow toadflax and 70 random plots were mapped. Each plot consisted of a 19 m radius with three

randomly assigned transects radiating from the center of the plot. A 1 m^2 quadrat was placed at a random location along each transect. Site characteristics sampled include: slope, aspect, elevation, soil type, C/N ratio, organic matter, vegetation type, species composition, percent cover of existing species, and existence of trails or disturbances. For sites containing yellow toadflax, size of infestation, density, and percent cover of the plant were taken. The study indicates yellow toadflax occurrence in the Ripple Creek drainage correlates with parks, disturbance, aspect, and number of species per plot. Yellow toadflax patches also correlate with two grass species and seven forb species (p-values < 0.05).

THE COMPETITIVE EFFECTS OF FIVE COOL-SEASON PERENNIAL GRASSES ON FOXTAIL BARLEY. Jerry M. Langbehn and Tom D. Whitson, Extension Agent, Thermopolis, WY 82443-0962 and Dept. of Plant Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Foxtail barley is a short-lived perennial that reproduces from seed. It has increased in many hay meadows and pastures in the western United States causing hay values to decline. Herbicides have not provided consistent control because of uncertain fall moisture to activate products such as pronamide. This experiment was conducted near Thermopolis, WY to determine the competitive ability of five perennial cool-season grasses selected for vigorous growth in high pH soil conditions. Grasses selected included: 'Newhy' hybrid wheatgrass, 'Pryor' slender wheatgrass, 'Jose' tall wheatgrass, 'Shoshone' beardless wildrye, and 'Prairieland' altai wildrye. Grasses were seeded August 12, 1997 and grasses and foxtail barley were clipped, dried and weighed in July, 1999. Tall wheatgrass was well-adapted to this high pH site and became quickly established one year after seeding. The second year tall wheatgrass displaced 90% of the foxtail barley and produced 4,485 lbs of dry forage/acre, while the production of foxtail barley was only 356 lb/A. The protein and relative feed value of tall wheatgrass was at the level of the average of the five grass species.

Table. Competitive effects of five cool-season grasses with foxtail barley.

	1998	1999				
	Foxtail	Dry wt		Perennial grass[b]		Foxtail
Grass species[a]	barley control	Perennial grass	Foxtail barley	Crude protein	Relative feed value	barley control
	- % -	lb/A		%		
Hybrid wheatgrass 'Newhy'	47	1371	795	9.6	81.7	56
Slender wheatgrass 'Prior'	3	2598	1005	4.4	70.6	59
Tall wheatgrass 'Jose'	57	4485	356	8.2	80.5	90
Beardless wildrye 'Shoshone'	0	721	2014	10.5	83.1	19
Altai wildrye 'Prairieland'	2	1086	2462	8.5	91.1	27
(Average)	21.8	2052	1326	8.2	81.4	50

[a]Seeded with a Brillion Seeder, Aug. 12, 1997 at 15 lb/A PLS.
[b]All species were clipped by species 4-m^2 quadrats/rep., oven dried then weighed.

INTEGRATED MANAGEMENT STRATEGIES FOR THE ATTRITION OF YELLOW STARTHISTLE IN NORTHERN CALIFORNIA RANGELAND. Stephen F. Enloe, Joseph M. DiTomaso, Steve B. Orloff, and Daniel J. Drake, Graduate Research Assistant and Cooperative Extension Non-Crop Weed Ecologist, Department of Vegetable Crops, University of California, Davis, CA 95616 and Crops and Livestock Farm Advisors, U.C. Cooperative Extension, Siskiyou County, Yreka, CA 96097.

Abstract. Yellow starthistle is a Mediterranean invader that infests over five million ha in California. Despite several strategies for short-term control, annual grasslands in California are susceptible to reinvasion through new propagule introduction or seedbank recruitment. One current paradigm for noxious weed management in the Western United States suggests shifting disturbed annual systems to perennial grasses should reduce invasion and suppress noxious weeds. This idea is largely untested in California's annual rangelands.

A study was initiated in 1997 on degraded range dominated by *Centaurea solstitialis* near Yreka, California. Mean annual precipitation is 460 mm, with >80% occurring from October to April. The study site was established on a southern aspect (0 to 2% slope) and gravelly loam soil. Plot size was 15 by 15 m and each treatment had four replications for a total of 64 plots in a randomized complete block design. Sixteen treatments included clopyralid (0.1 kg/ha) applied for 0, 1, 2, or 3 yr in combination with seeding pubescent wheatgrass (*Thinopyrum intermedium* ssp. *barbulatum*) and or rose clover (*Trifolium hirtum*). Treatment evaluations consisted of spring vegetative cover, starthistle density, biomass, seedhead production and seedbank, and yearly soil moisture depletion.

Results indicate significant declines in the yellow starthistle seedbank with three clopyralid treatments. Clopyralid treatment alone resulted in a community shift to annual grasses and forbs, with starthistle reinvading if treatment was discontinued. Established stands of wheatgrass reduced but did not eliminate yellow starthistle invasion and seedhead production. These results suggest integrated strategies are critical for managing yellow starthistle in California.

CONSIDERATIONS FOR RESUMING FOREIGN EXPLORATION FOR NATURAL ENEMIES OF SPOTTED KNAPWEED: STATUS OF BIOLOGICAL CONTROL, PLANT IDENTIFICATION AND CLIMATE MATCHING. Lincoln Smith, Research Entomologist, USDA-ARS, Northern Plains Agricultural Research Laboratory, Sidney, MT 59270.

Abstract. Thirteen species of insect natural enemies have been introduced to North America for biological control of spotted and diffuse knapweed. *Urophora* spp., *Larinus minutus*, *Cyphocleonus achates*, *Agapeta zoegana* and *Sphenoptera jugoslavica* appear to be significantly reducing populations of diffuse knapweed. However, these insects appear to be having less impact on spotted knapweed, which occurs primarily in the interior of the continent. This suggests that many of the introduced agents may not be well adapted to the climate and/or the plant species. Climate matching techniques indicate that areas where spotted knapweed occurs in the western United States are more similar to Eurasia than Europe, from which agents have been introduced. "Spotted knapweed" in western Europe is a diploid species (*Centaurea maculosa* Lam), whereas in eastern Europe and Asia it is a tetraploid species (*Centaurea biebersteinii* DC), like the North American population. It is likely that agents adapted to the target weed species and climate will be found in the Ukraine, southern Russia and central Turkey, which have not been extensively explored for this weed.

USING HERBICIDES IN COMBINATION WITH *SPHENOPTERA JUGOSLAVICA* TO IMPROVE THE ROOT BEETLE'S CONTROL OF DIFFUSE KNAPWEED. Robert Wilson, K. George Beck, and Philip Westra, Graduate Student, Associate Professor, and Professor, Department of Bio-agricultural Science and Pest Management, Colorado State University, Fort Collins, CO 80523.

Abstract. The root beetle (*Sphenoptera jugoslavica*) negatively influences diffuse knapweed populations, but inconsistently in space and time. In the spring of 1998, a 3 yr field experiment was established to determine if low rates of picloram or clopyralid in combination with the root beetle could enhance the beetle's control of diffuse knapweed. Three sites were chosen in Colorado where the root beetle was previously established. Picloram and clopyralid were applied separately on plots at 0, 0.5, 1, and 2 oz/A during the third week of June or at the end of September. Density and cover measurements were collected three times during the growing season in permanent quadrats to determine herbicide effects on the growth of diffuse knapweed. Diffuse knapweed plants were harvested outside the permanent quadrats to determine seed production and the number of plants bearing *Sphenoptera* larvae. Density results taken during the same year as herbicide application suggest spring herbicide treatments have the potential for mimicking a mid-summer growth arrest that is necessary for beetle success. Spring treatments also thinned the total rosette population the year of herbicide application. These spring herbicide effects may help promote the insect's performance. This is indicated by an increase in the percentage of plants bearing *Sphenoptera* larvae associated with most spring treatments the year following application. Both spring and fall treatments decreased total rosette densities the year following herbicide treatment but did not mimic a mid-summer growth arrest. Sampling next spring should help in determining the long-term effect of herbicide/*Sphenoptera* combinations on controlling diffuse knapweed.

LEAFY SPURGE MANAGEMENT WITH SHEEP AND FLEA BEETLES. K. George Beck and Larry R. Rittenhouse, Associate Professor and Professor, Department of Bioag Sciences and Pest Management and Department of Rangeland Ecosystems Sciences, Colorado State University, Ft. Collins, CO 80523.

Abstract. Leafy spurge (*Euphorbia esula*) is an aggressive, perennial rangeland weed that displaces native vegetation and causes millions of dollars to be lost annually in the agricultural and non-agricultural sectors. Many cultural, chemical, and biological control methods have been evaluated, but herbicides are used primarily. Leafy spurge infests a wide array of habitats and is considered difficult to impossible to control in sensitive shelterbelts and riparian areas where herbicides are very difficult to use. An experiment was initiated in 1993 to determine an optimum sheep stocking rate and grazing duration that is compatible with flea beetle herbivory, and to determine the impact of sheep grazing alone and sheep grazing plus flea beetles on the entire plant community within a defined leafy spurge infested habitat.

The experiment was conducted in a riparian area 25 miles east of Denver, CO. The site is characterized by low organic matter, sandy, gravely soil, with primarily a leafy spurge-western wheatgrass (*Agropyron smithii* Rydb.)-Kentucky bluegrass (*Poa pratensis* L.) understory and a semi-open plains cottonwood (*Populus sargentii* Dode) overstory. A factorial design arranged as a split-plot was used. Main plots were four stocking rates (two, four, six, or eight sheep/A) by three grazing durations (10, 20, or 30 days). Each plot was 1 acre in size. In 1993, all main plots were split; 500 flea beetles (*Aphthona flava*) were randomized and released onto a single point into one-half of each main plot. There were 12 treatments and one control plot per block. Each treatment was replicated twice and all data were subjected to regression analysis.

Data collected reflect the results of treatments invoked in 1995, 1996, 1997, and 1998. These data show that 8 sheep grazing alone for 10 days were exerting biological control of leafy spurge. Leafy spurge density within this treatment was decreased 94% while smooth brome cover increased 22-fold All 30 day grazing treatments stimulated leafy spurge recovery; cover and density increased 8- and 10-fold from their lowest points where 8 sheep grazed for 10 days. The combination of 8 sheep grazing for 10 days along with flea beetles decreased leafy spurge

density to zero. A positive response from western wheatgrass and Kentucky bluegrass did not occur where leafy spurge cover or density were at their lowest, but occurred after smooth brome cover decreased. Peak western wheatgrass and Kentucky bluegrass cover occurred where 6 sheep grazed for 30 days. Smooth brome cover within this treatment combination decreased to less than 2%, but leafy spurge cover had increased from less than 3% at its lowest point (8 sheep for 10 days) to 22%, which was still less than half that in the non-grazed control. The presence of flea beetles did not substantially alter the relationship among the three major perennial grasses. These data suggest that while leafy spurge was competing with all three perennial grass species, smooth brome's influence on western wheatgrass and Kentucky bluegrass was at least that of leafy spurge because western wheatgrass and Kentucky bluegrass showed no positive response until smooth brome populations decreased, even though leafy spurge recovery from treatment ensued simultaneously.

Sheep and *Aphthona flava* flea beetles are compatible and both animals may be used to graze leafy spurge simultaneously to achieve adequate control. The management system developed from this research may be used to effectively manage leafy spurge in riparian areas or shelterbelts where herbicides may be difficult or impossible to use.

IMAZAPIC AS A TOOL FOR LEAFY SPURGE MANAGEMENT. Denise M. Markle and Rodney G. Lym, Graduate Research Assistant and Professor, Plant Sciences Department, North Dakota State University, Fargo, ND 58105.

Abstract. Imazapic is an ALS inhibiting herbicide recently labeled for leafy spurge control in non-cropland. Research at North Dakota State University has shown that occasionally imazapic will injure certain grass species. The purpose of this research was to evaluate imazapic applied alone, in rotation with picloram plus 2,4-D, or the three herbicides applied together for long-term leafy spurge control and minimal grass injury.

Imazapic applied alone or with various adjuvants injured grasses in greenhouse studies; however, imazapic did not decrease herbage production in field studies. In the greenhouse, crested, western, and pubescent wheatgrasses, and smooth bromegrass production was reduced to an average of 12, 3, 30 and 27%, respectively, compared to the control. Production from the warm season species big bluestem and blue grama was not reduced as greatly as the cool-season grasses in a separate experiment. However, imazapic at 2 oz/A applied alone reduced production of sideoats grama and switchgrass to 66 and 51%, respectively, compared to the control. Grass production following treatment by imazapic applied with a methylated seed oil (MSO) and 28% N ranged from 66%, compared to the untreated control, for big bluestem to zero production with switchgrass.

Imazapic provided similar or better leafy spurge control than the standard treatment of picloram plus 2,4-D in the field. Imazapic at 2 oz/A applied with a MSO alone or with 28% N averaged 72% leafy spurge control 12 months after treatment (MAT) compared to 40% control with picloram plus 2,4-D at 8 + 16 oz/A. Imazapic at 2 oz/A applied with a MSO in mid-September provided the best leafy spurge control 12 MAT compared to applied in August or October.

In general, imazapic applied in the fall provided better leafy spurge control than the mid-summer treatment and control was improved when the herbicide was applied with a MSO compared to imazapic applied alone. Grass injury to cool season species tended to be higher when imazapic was applied in July compared to fall-applied, but the grasses recovered by 12 MAT.

A three herbicide mixture of picloram plus 2,4-D plus imazapic applied once in the spring provided excellent long-term leafy spurge control. Control averaged across locations was 98% in September 1999, 15 MAT. This high level of control was unexpected and is similar to picloram applied alone at 32 oz/A. The same three herbicide

treatment applied in the fall only averaged 61% control 12 MAT. The best split treatments were picloram plus 2,4-D applied in the spring followed by imazapic in the fall and imazapic fall-applied followed by picloram plus 2,4-D in the spring which averaged 82 and 97% control, respectively, 12 and 3 months after the last treatment, respectively.

In general, imazapic applied with a MSO provided better long-term leafy spurge control than the present standard treatment of picloram plus 2,4-D. Imazapic occasionally stunted both cool and warm season grasses, but the grasses recovered by 12 MAT. Imazapic will be a useful addition to long-term leafy spurge management.

LEAFY SPURGE CONTROL WITH IMAZAPIC IN WYOMING. Mark A. Ferrell and Thomas D. Whitson, Extension Educator and Professor, University of Wyoming, Laramie, WY 82071-3354.

Abstract. Leafy spurge continues to be a major problem in Wyoming. Leafy spurge spread has been limited but has not decreased, and there are infestations in every county. However, major infestations occur in the northeast corner of the state. The objective of this research was to compare the efficacy of imazapic for leafy spurge control at two locations. One study was located in Crook County, Wyoming five miles south of Devils Tower. The other in Cheyenne, Wyoming on Warren Air Force Base. The studies were a randomized complete block design with four replications. Crook County leafy spurge was 16 to 24 inches tall and Cheyenne leafy spurge was approximately 20 inches tall.

In Crook County imazapic regardless of rate provided excellent leafy spurge control 297 days after treatment (DAT). Picloram at 0.5 lb/A also provided excellent control. Grass damage was sever especially at the higher rates of imazapic. The addition of methylated seed oil seemed to increase grass damage.

In Cheyenne imazapic provided little or no leafy spurge control 288 DAT; however there was considerable shoot suppression at the 0.25 lb/A applied rate. No other treatment was effective. Leafy spurge control 590 DAT found imazapic providing little or no control, or shoot suppression. Grass damage 288 DAT was severe where 0.25 lb/A of imazapic was applied. Grass damage 590 DAT was not as evident but was still very noticeable where 0.25 lb/A of imazapic had been applied. The addition of BAS-662 did not increase control. It appears that more research is needed in order to make more accurate predications for control of leafy spurge with imazapic as well as timing of application to reduce grass damage.

THE ECOLOGY OF INVASIVE ALIEN PLANTS: MECHANISMS OF INVASIVENESS OF THE EXOTIC WEED, SCOTCH BROOM *CYTISUS SCOPARIUS* (L.) LINK, IN BRITISH COLUMBIA. Raj Prasad, Research Scientist, Pacific Forestry Centre, Canadian Forest Service, Natural Resources Canada, 506 West Burnside Road, Victoria, B.C. V8Z 1M5, Canada.

Abstract. Scotch broom and gorse (*Ulex europeaus* L.) are exotic weeds which pose a serious threat to forested and other landscapes in southwestern British Columbia. These exotic weeds have several characteristics which promote their invasiveness and displacement of native plant species, e.g. reduced leaves, active stem photosynthesis, nitrogen fixation, profuse seed production, longevity of seed banks, rapid vertical growth, adaptability to various ecological niches, and lack of natural enemies. There is little data on the impact of Scotch broom and gorse on conifers in British Columbia. Therefore, two experimental sites were established on southern Vancouver Island to determine the nature and extent of invasiveness of Scotch broom in forested areas, and its impact on conifer crop trees and other plant communities. Accordingly, field experiments were carried out to measure light infiltration (PAR, photosynthetically active radiation) and effects of competition of Scotch broom on Douglas-fir (*Pseudotsuga menziesii* Mirb.) seedling growth. Results demonstrated that Scotch broom not only reduces the input of PAR but also retards the height-volume growth of conifer seedlings.

EFFECT OF SOIL SOLARIZATION, COVER CROPS, AND METHAM ON FIELD EMERGENCE AND SURVIVAL OF BURIED ANNUAL BLUEGRASS *(POA ANNUA)* SEEDS. R. E. Peachey[1], J. N. Pinkerton[2], K. L. Ivors[2], M. L. Miller[3], and L. W. Moore[3], Senior Research Assistant, Research Plant Pathologist, Research Assistant, Research Assistant and Professor, [1]Departments of Horticulture and [3]Botany and Plant Pathology, Oregon State University, Corvallis OR 97331 and [2]USDA ARS HCRL, Corvallis OR 97331.

Abstract. Field experiments were conducted on a silty-clay loam in Corvallis, OR during the summers of 1995 and 1996 to study the effects of soil solarization, spring-planted green manure cover crops, fumigation with metham, and combinations of these treatments on weed seed survival. Annual bluegrass seeds were incorporated into the soil as a bioassay species and soil samples extracted to determine seed survival to 15 cm deep in the soil. Soil solarization was applied over a 53 to 59-day period using a 0.6 mil clear polyethylene film. Maximum soil temperatures recorded at depths of 5, 10, and 20 cm were 52, 47, and 33 C in solarized soil. Soil samples were collected from four depths after the solarization period in both solarized and nonsolarized plots and surviving seeds germinated in a greenhouse.

Solarization reduced annual bluegrass seed survival from 89 to 100% in the upper 5 cm of soil but did not reduce survival below 5 cm. Solarization may have enhanced survival below 5 cm. Cover crops of barley, rapeseed and sudangrass generally increased survival of annual bluegrass seed buried 2.5 to 15 cm deep in the soil. Green manure cover crops plus solarization did not improve the efficacy of solarization alone and in some cases diminished the effectiveness of solarization. Solarization significantly improved the efficacy of 0.25 rates of metham (230 L ha^{-1}) in the top 5 cm of soil, reducing overall seed survival in the soil by 40% compared to metham alone (230 L ha^{-1}) but only 30% compared to solarization alone. The conventional rate of metham (930 L ha^{-1}) was the most effective and consistent treatment across all depths.

Table. Seed survival of annual bluegrass (average of both years) after cover cropping, fumigant or soil solarization. Values represent the average of the data from four depths in 1995 and 1996 and are presented as the percent of the check treatment.

Cover crop or fumigant	No. obs	Nonsolarized[a]	Solarized
		% of check plot	
Barley	8	193 a	89 cde
Rapeseed	8	131 abc	63 ef
Sudangrass	8	153 ab	124 abcd
Metham (230 L ha^{-1})	8	101 bcde	51 f
Metham (930 L ha^{-1})	8	8 g	-
Check	8	100 bcde	81 def
Noninoculated check[b]	8	201 a	-

[a]Means in this table followed by the same letter do not differ ($P<0.05$).
[b]Without disease organisms.

ENHANCING THE EFFECTIVENESS OF SOIL SOLARIZATION. Clyde L. Elmore, John Roncoroni, and Steve Tjosvold, Weed Specialist, Staff Research Associate, and Farm Advisor, Dept. of Vegetable Crops, University of California, Davis, CA 95616 and Santa Cruz County, Watsonville, CA 95076.

Abstract. Soil solarization is being evaluated as an potential alternative for methyl bromide in field-grown flower crops in California. In high radiation areas of the state, soil solarization has been very effective as a preplant treatment to many flower crops. There is effective annual weed control for an annual crop cycle. Increased growth of flower transplants is observed after soil solarization. Standard solarization was a single clear layer of 1.1 mil polyethylene (Climagro). An increase in soil temperature was observed when a large bubble wrap was used under a clear polyethylene tarp compared to the tarp alone or a clear polyethylene tarp over polyethylene bags filled with

water. Soil temperature at 5 cm were higher using clear tarp than a black polyethylene, embossed black polyethylene, two layers of clear polyethylene or a small bubble wrap with clear polyethylene cover. Lower temperatures were recorded within 2 miles of the coast compared to inland sites. Annual weeds (corn spurry, shepherdspurse, annual sowthistle, common groundsel, annual bluegrass, California burclover, redroot pigweed and common lambsquarter) were controlled. Common purslane was not controlled in the coastal studies. Broccoli chop (5 dry T/A) increased weed control compared to ammonia, bloodmeal, acetic acid or composted chicken manure. Metham at 50 to 100 gpa with soil solarization gave the best weed control.

ANNUAL COVER CROPS DECREASE HERBICIDE RUNOFF IN CITRUS. Timothy S. Prather and Fuhan Liu, Weed Ecologist and Postdoctoral Research Assistant, Statewide IPM Project, University of California Cooperative Extension, Kearney Agricultural Center, Parlier, CA 93648.

Abstract. New regulations from the California Environmental Protection Agency have been proposed that require use of techniques to reduce the amount of preemergent herbicide leaving orchards. Cover crops may reduce surface water runoff but use is very limited in citrus because of frost concerns. The objectives of the study were to measure surface water runoff volume and canopy temperatures from cover cropped and bare soil treatments within a hill-side citrus orchard. There were four blocks with two treatments, bare soil and cover crop, with plots measuring 6.7 by 91 m for surface water runoff measurement. Canopy temperatures were measured in cover cropped and bare soil plots 0.6 to 0.8 ha with two blocks. Runoff water was measured by diverting water using berms and furrows into containers fitted with electric pumps connected to flow meters. Canopy temperatures were measured using Hobo temperature sensors. Runoff water volume from cover cropped plots was 30% of bare soil runoff volume (5,600 L ha^{-1} versus 18,700 L ha^{-1}, respectively). Canopy temperature from three cold periods did not differ between treatments. Reducing total volume leaving citrus orchards should reduce the amount of herbicide leaving the orchards as well. Canopy temperatures of a hill-side orchard were not decreased by use of a cover crop.

EFFECTS OF PRE- AND POST-TRANSPLANT HERBICIDE APPLICATIONS TO NEWLY-PLANTED STRAWBERRY. Timothy W. Miller and Carl R. Libbey, Extension Weed Scientist and Agricultural Technologist, Washington State University, Mount Vernon Research and Extension Unit, Mount Vernon, WA 98273.

Abstract. Strawberries are typically produced in a 3-year rotation in northwestern Washington. Transplants are established during April or May the first year and berries harvested during June or July the second and third years. Weed control during the establishment year is critical to the success of the planting. Herbicide applications are currently limited to pre-transplant treatments to avoid potential crop injury, but opening a furrow in treated soil during the transplanting operation usually results in poor weed control in the row. A post-transplant application would result in a more uniform herbicide band in the transplant row, and would therefore be preferable to pre-transplant application. Two strawberry cultivars ('Totem' and 'Redcrest') were treated either pre- or post-transplant with various herbicides and herbicide combinations (eight herbicides, 25 treatments). Weed control during the growing season as well as strawberry leaf area and the number of leaves, runners, and daughter plants at the end of the growing season were measured. While most treatments resulted in excellent early-season weed control, most caused only slight crop injury; only azafenidin (0.5 lb/A) or azafenidin plus oxyfluorfen (0.5 + 0.25 lb/A) applied pre-transplant, and pendimethalin plus thiazopyr (1.5 + 0.38 lb/A) applied post-transplant caused greater than 10% injury. Still, herbicide treatment regardless of timing significantly reduced strawberry leaf area as compared to hand weeded plants. Considering both strawberry leaf area and weed control rating at the end of the summer, the top three treatment combinations were pendimethalin plus lactofen (1.5 + 0.25 lb/A), pendimethalin plus acifluorfen (1.5 + 0.25 lb/A), and pendimethalin plus thiazopyr (2 + 0.25 lb/A), applied immediately post-transplant.

EVALUATION OF LOW-RATE HERBICIDES FOR POTENTIAL USE IN VEGETABLE CROPS. Steven A. Fennimore and W. Thomas Lanini, Extension Specialists, Department of Vegetable Crops, University of California, Davis, CA 95616; Milton E. McGiffen, Extension Specialist, Department of Botany and Plant Sciences, University of California, Riverside, CA 92521; and Carl E. Bell, Farm Advisor, University of California, Imperial County, Holtville, CA 92250.

INTRODUCTION

All indications are that pesticide use cancellations as the result of the Food Quality Protection Act will have a major impact on weed management programs in vegetable crops. Therefore, we are working to develop mitigating strategies such as alternative herbicides for vegetables. The objective of these studies was to identify new potential vegetable herbicides. This work was supported by the USDA Pest Management Alternatives Program.

MATERIALS AND METHODS

Broccoli, cantaloupe, carrot, lettuce, onion, spinach, and processing tomato varieties were screened for tolerance to low-rate herbicides at four locations in California. Tests were conducted at the USDA Station in Brawley, CA, the Coachella Valley Agricultural Research Station at Indio, CA, the University of California, Davis, Vegetable Crops Unit at Davis, CA, and the USDA Station at Salinas, CA. Postplant preemergence herbicides tested at all locations were: carfentrazone at 0.05, 0.1, 0.15 and 0.2; dimethenamid at 0.938 and 1.172; flumioxazin at 0.063, 0.125 and 0.25; flufenacet at 0.525, 0.6 and 0.675; halosulfuron at 0.032 and 0.047; isoxaben at 0.25 and 0.5; rimsulfuron at 0.016 and 0.031; and sulfentrazone at 0.15 and 0.25 lb/A. Postemergence herbicides and rates tested were: carfentrazone at 0.01 and 0.03; cloransulam at 0.008 and 0.016; halosulfuron at 0.032 and 0.047; imazamox at 0.032 and 0.4; rimsulfuron at 0.031; dimethenamid at 1.5; sulfentrazone at 0.15 and 0.25; and triflusulfuron at 0.016 and 0.031. At the time of application the crop growth stages, in numbers of true leaves, were as follows: broccoli; 2, carrot; 1 to 2, lettuce; 3 to 4, onion; 1 to 3, spinach; 2 to 4, and tomato, 2. Soil textures were as follows: Brawley, clay loam; Davis and Salinas, sandy loam; Indio, loamy sand. All treatments were applied at 16 to 26 GPA and replicated three to four times at each location. The herbicides were sprinkler incorporated at all sites as soon as possible after application. Stand counts and crop phytotoxicity estimates were taken at 14 to 28 days after application and crop biomasses (dry weight) were determined at approximately 50 days after application.

RESULTS AND DISCUSSION

Preemergence results. Crop/herbicide combinations, all herbicide rates are lb/A, that resulted in acceptable levels of crop tolerance were: broccoli treated with sulfentrazone at 0.15, (Table 1), cantaloupe treated with halosulfuron at 0.032 (Table 1), carrot treated with sulfentrazone at 0.15 (Table 2), lettuce treated with carfentrazone at 0.1 (Table 2), onion treated with carfentrazone at 0.05 (Table 3), and tomato treated with sulfentrazone at 0.15, dimethenamid at 0.938, halosulfuron at 0.032, and rimsulfuron at 0.016 and 0.031 (Table 4). Spinach was not tolerant to any of the preemergence herbicides tested. All combinations not previously mentioned resulted in unacceptable crop injury.

Postemergence results. Broccoli, carrot and onion were not tolerant to any of the postemergence herbicides tested (Tables 5, 6 and 7). Crop/herbicide combinations, lb/A, with acceptable tolerance were: cantaloupe treated with halosulfuron at 0.032 and 0.047 (Table 5), lettuce treated with imazamox at 0.032 (Table 6), spinach treated with cloransulam at 0.008 and 0.016 (Table 7), and processing tomato treated with halosulfuron at 0.032 and 0.047, and rimsulfuron at 0.031 lb/A (Table 8). All combinations not previously mentioned resulted in unacceptable crop injury.

Table 1. The effect of several candidate herbicides applied preemergence on broccoli and cantaloupe stand, biomass and crop injury.

Herbicide	Rate	Broccoli			Cantaloupe		
		Stand	Biomass	Injury[a]	Stand	Biomass	Injury[a]
	lb/A	— % untreated —		0-10	— % untreated —		0-10
Untreated	--	124	84	0.1	98	77	0.0
Handweeded	--	100	100	0.4	100	100	0.4
Carfentrazone	0.050	85	79	0.8	83	74	3.7
Carfentrazone	0.100	63	62	3.0	63	56	4.7
Carfentrazone	0.150	71	69	3.5	64	46	5.5
Carfentrazone	0.200	56	57	4.5	50	22	6.2
Sulfentrazone	0.150	104	84	1.5	92	60	4.8
Sulfentrazone	0.250	81	78	3.3	60	37	6.3
Dimethenamid	0.938	94	83	3.6	70	60	2.4
Dimethenamid	1.172	65	67	3.3	52	41	3.5
Halosulfuron	0.032	15	11	8.0	130	103	2.5
Halosulfuron	0.047	21	3	8.5	90	56	3.8
Rimsulfuron	0.016	51	22	7.5	58	22	5.2
Rimsulfuron	0.031	21	3	8.5	39	8	6.4
Flumioxazin	0.063	23	16	7.2	28	36	7.1
Flumioxazin	0.125	16	14	8.3	11	15	8.0
Flumioxazin	0.250	10	6	9.1	6	8	9.3
Isoxaben	0.250	23	17	7.8	35	46	5.0
Isoxaben	0.500	17	14	8.0	19	24	7.1
Flufenacet	0.525	78	64	4.5	79	55	5.0
Flufenacet	0.600	79	54	4.5	66	55	4.6
Flufenacet	0.675	73	44	4.5	64	51	5.4

[a]0 = no injury, 10 = dead plants.

Table 2. The effect of several candidate herbicides applied preemergence on carrot and lettuce stand, biomass and crop injury.

Herbicide	Rate	Carrot			Lettuce		
		Stand	Biomass	Injury[a]	Stand	Biomass	Injury[a]
	lb/A	— % untreated —		0-10	— % untreated —		0-10
Untreated	--	99	78	0.0	118	84	0.0
Handweeded	--	99	100	0.2	100	100	0.0
Carfentrazone	0.050	90	67	0.5	62	73	1.7
Carfentrazone	0.100	78	79	1.2	93	98	1.8
Carfentrazone	0.150	67	79	1.8	64	49	3.5
Carfentrazone	0.200	58	75	2.9	66	55	3.1
Sulfentrazone	0.150	92	104	1.5	85	66	3.8
Sulfentrazone	0.250	76	58	2.9	43	21	4.9
Dimethenamid	0.938	33	35	6.2	10	8	8.9
Dimethenamid	1.172	21	18	6.9	2	15	9.8
Halosulfuron	0.032	53	41	5.7	9	3	9.2
Halosulfuron	0.047	40	38	6.1	17	12	8.7
Rimsulfuron	0.016	66	50	3.2	9	10	7.8
Rimsulfuron	0.031	57	56	4.3	11	4	9.0
Flumioxazin	0.063	62	64	2.8	1	0	8.4
Flumioxazin	0.125	42	40	3.8	11	0	9.9
Flumioxazin	0.250	27	29	5.4	11	0	10.0
Isoxaben	0.250	47	46	3.2	7	8	8.6
Isoxaben	0.500	25	29	4.6	19	4	9.7
Flufenacet	0.525	89	72	2.2	40	16	7.2
Flufenacet	0.600	69	64	2.4	13	8	7.0
Flufenacet	0.675	63	71	2.4	34	16	7.0

[a]0 = no injury, 10 = dead plants.

Table 3. The effect of several candidate herbicides applied preemergence on onion and spinach stand, biomass and crop injury.

Herbicide	Rate	Onion			Spinach		
		Stand	Biomass	Injury[a]	Stand	Biomass	Injury[a]
	lb/A	— % untreated —		0-10	— % untreated —		0-10
Untreated	--	85	65	0.0	117	85	0.2
Handweeded	--	100	100	0.1	100	141	0.0
Carfentrazone	0.050	97	136	0.6	83	62	2.5
Carfentrazone	0.100	80	80	2.4	30	25	4.8
Carfentrazone	0.150	69	71	3.0	27	31	4.6
Carfentrazone	0.200	56	65	3.6	7	5	7.7
Sulfentrazone	0.150	87	84	2.3	22	20	1.8
Sulfentrazone	0.250	66	57	3.8	8	5	5.7
Dimethenamid	0.938	76	35	3.3	75	64	1.8
Dimethenamid	1.172	74	62	4.7	59	46	3.0
Halosulfuron	0.032	28	23	6.2	27	7	2.9
Halosulfuron	0.047	32	24	7.4	24	2	3.0
Rimsulfuron	0.016	38	26	5.4	83	39	0.8
Rimsulfuron	0.031	34	28	6.4	38	30	1.7
Flumioxazin	0.063	45	41	4.3	6	13	8.9
Flumioxazin	0.125	24	26	6.5	0	1	10.0
Flumioxazin	0.250	12	10	7.0	0	0	10.0
Isoxaben	0.250	54	106	4.0	24	46	6.2
Isoxaben	0.500	42	50	5.1	16	32	7.5
Flufenacet	0.525	47	44	4.7	74	68	5.0
Flufenacet	0.600	57	58	5.0	82	70	4.4
Flufenacet	0.675	57	45	5.0	64	53	5.4

[a]0 = no injury, 10 = dead plants.

Table 4. The effect of several candidate herbicides applied preemergence on processing tomato stand, biomass and crop injury.

Herbicide	Rate	Processing tomato		
		Stand	Biomass	Injury[a]
	lb/A	— % untreated —		0-10
Untreated	--	100	68	0.1
Handweeded	--	100	100	0
Carfentrazone	0.050	115	94	1.1
Carfentrazone	0.100	78	88	2.6
Carfentrazone	0.150	64	48	4.4
Carfentrazone	0.200	48	31	6.9
Sulfentrazone	0.150	107	102	1.8
Sulfentrazone	0.250	84	69	4.2
Dimethenamid	0.938	95	89	2.1
Dimethenamid	1.172	85	53	2.9
Halosulfuron	0.032	97	81	1.8
Halosulfuron	0.047	95	73	1.9
Rimsulfuron	0.016	140	190	0.9
Rimsulfuron	0.031	121	121	1.1
Flumioxazin	0.063	3	17	9.0
Flumioxazin	0.125	0	0	10.0
Flumioxazin	0.250	0	0	10.0
Isoxaben	0.250	24	22	5.8
Isoxaben	0.500	17	11	7.5
Flufenacet	0.525	31	19	6.7
Flufenacet	0.600	24	8	7.1
Flufenacet	0.675	24	4	7.3

[a]0 = no injury, 10 = dead plants.

Table 5. The effect of several candidate herbicides applied postemergence on broccoli and cantaloupe stand, biomass and crop injury.

Herbicide	Rate	Broccoli			Cantaloupe		
		Stand	Biomass	Injury[a]	Stand	Biomass	Injury[a]
	lb/A	— % untreated —		0-10	— % untreated —		0-10
Untreated	--	95	58	0.0	30	7	0.0
Handweeded	--	100	100	0.0	100	100	0.0
Carfentrazone	0.010	43	40	4.2	23	6	7.9
Carfentrazone	0.030	32	32	5.2	17	3	8.6
Sulfentrazone	0.150	87	67	1.3	18	6	7.2
Sulfentrazone	0.250	87	69	2.0	2	0	9.8
Cloransulam	0.008	34	23	5.2	38	24	3.7
Cloransulam	0.016	16	17	6.7	27	6	6.7
Dimethenamid	1.500	65	41	4.1	46	10	4.7
Imazamox	0.032	24	13	8.1	33	5	7.8
Imazamox	0.040	14	9	7.8	10	0	8.2
Halosulfuron	0.032	5	1	9.9	90	79	0.8
Halosulfuron	0.047	2	0	9.3	86	96	1.0
Rimsulfuron	0.031	0	2	9.8	89	78	2.2
Triflusulfuron	0.016	65	53	3.9	87	64	1.5
Triflusulfuron	0.031	61	40	3.8	76	54	1.6

[a]0 = no injury, 10 = dead plants.

Table 6. The effect of several candidate herbicides applied postemergence on carrot and lettuce stand, biomass and crop injury.

Herbicide	Rate	Carrot			Lettuce		
		Stand	Biomass	Injury[a]	Stand	Biomass	Injury[a]
	lb/A	— % untreated —		0-10	— % untreated —		0-10
Untreated	--	100	58	0.0	116	13	0.0
Handweeded	--	100	100	0.0	100	100	0.0
Carfentrazone	0.010	65	94	4.6	32	18	7.0
Carfentrazone	0.030	24	32	6.4	22	13	9.2
Sulfentrazone	0.150	90	143	3.5	83	50	4.5
Sulfentrazone	0.250	81	134	4.2	59	32	8.7
Cloransulam	0.008	57	55	4.1	80	47	3.6
Cloransulam	0.016	40	23	5.2	88	51	5.1
Dimethenamid	1.500	73	49	3.1	89	35	2.3
Imazamox	0.032	42	41	6.2	102	80	1.7
Imazamox	0.040	31	33	5.7	109	66	2.6
Halosulfuron	0.032	22	8	8.8	34	7	8.0
Halosulfuron	0.047	9	1	8.6	33	2	7.1
Rimsulfuron	0.031	40	15	8.1	4	0	9.2
Triflusulfuron	0.016	58	28	4.3	98	29	3.8
Triflusulfuron	0.031	62	43	4.8	84	17	3.5

[a]0 = no injury, 10 = dead plants.

Table 7. The effect of several candidate herbicides applied postemergence on onion and spinach stand, biomass and crop injury.

Herbicide	Rate	Onion			Spinach		
		Stand	Biomass	Injury[a]	Stand	Biomass	Injury[a]
	lb/A	— % untreated —		0-10	— % untreated —		0-10
Untreated	--	89	52	0.0	97	81	0.0
Handweeded	--	100	100	0.0	100	100	0.0
Carfentrazone	0.010	80	199	1.0	25	9	6.7
Carfentrazone	0.030	40	83	3.5	1	3	9.4
Sulfentrazone	0.150	56	148	2.2	9	7	7.5
Sulfentrazone	0.250	46	109	3.9	1	3	9.5
Cloransulam	0.008	38	66	5.4	111	75	0.9
Cloransulam	0.016	22	17	8.6	96	77	0.6
Dimethenamid	1.500	82	109	2.9	130	82	2.3
Imazamox	0.032	66	79	4.8	38	5	8.7
Imazamox	0.040	54	40	4.5	8	3	8.4
Halosulfuron	0.032	12	8	7.8	3	1	8.7
Halosulfuron	0.047	8	5	8.3	0	0	9.2
Rimsulfuron	0.031	13	12	8.4	27	3	9.8
Triflusulfuron	0.016	72	46	2.4	52	29	3.6
Triflusulfuron	0.031	59	35	3.7	31	14	5.1

[a]0 = no injury, 10 = dead plants.

Table 8. The effect of several candidate herbicides applied postemergence on processing tomato stand, biomass and crop injury.

Herbicide	Rate	Processing tomato		
		Stand	Biomass	Injury[a]
	lb/A	— % untreated —		0-10
Untreated	--	82	56	0.0
Handweeded	--	100	100	0.0
Carfentrazone	0.010	13	4	9.6
Carfentrazone	0.030	3	1	9.9
Sulfentrazone	0.150	10	4	9.8
Sulfentrazone	0.250	5	1	9.4
Cloransulam	0.008	71	23	6.6
Cloransulam	0.016	24	3	8.7
Dimethenamid	1.500	126	72	2.2
Imazamox	0.032	0	0	10.0
Imazamox	0.040	3	1	8.8
Halosulfuron	0.032	158	353	0.7
Halosulfuron	0.047	130	277	0.8
Rimsulfuron	0.031	111	240	1.4
Triflusulfuron	0.016	126	95	2.8
Triflusulfuron	0.031	95	62	2.9

[a]0 = no injury, 10 = dead plants.

HERBICIDE SCREENING TESTS FOR DESERT VEGETABLE CROPS. K. Umeda, Area Extension Agent, University of Arizona Cooperative Extension, Maricopa County, Phoenix, AZ 85040.

Abstract. Most herbicides are initially discovered, developed, and registered for use in the major crops such as corn, soybeans, small grains, cotton, and sugarbeets. Very little, if any crop screening efforts are directed toward minor crops that include high value vegetable crops. In the desert southwest U.S., melons, lettuce, cole crops, onions, and carrots are produced with a limited number of herbicides and heavy reliance is placed on mechanical

tillage and cultivation and hand-hoeing. Several field tests were initiated and conducted to evaluate several newly introduced corn/soybean/small grain herbicides for potential use in minor crops. Seventeen herbicides recently gaining registrations in various major crops were evaluated in screening tests for potential use in melons (cantaloupe and watermelon), lettuces (head, romaine and red leaf), and broccoli. In a preemergence herbicide screening test, flumioxazin, dimethenamid, halosulfuron, and s-metolachlor demonstrated melon crop safety at rates higher than rates for effective weed control. In a postemergence screening test, halosulfuron and rimsulfuron gave acceptable weed control with adequate crop safety. Flumetsulam and thifensulfuron appeared to offer some acceptable weed control with a very narrow margin of crop safety. Herbicides that did not offer adequate melon crop safety or acceptable weed control in the screening tests were carfentrazone, sulfentrazone, cloransulam, flumiclorac, fluthiamide/metribuzin, imazamox, isoxaflutole, triflusulfuron, primisulfuron/prosulfuron, and clomazone. Plant-back tests are also being conducted to evaluate and determine the effect of herbicide residues on rotational crops from preemergence and postemergence applications on crops. Herbicides demonstrating crop selectivity and weed control efficacy will advance to further testing to evaluate potential use on specific crops and weeds.

FIELD DODDER (*CUSCUTA PENTAGONA*) MANAGEMENT IN TOMATOES WITH RIMSULFURON OR TOLERANT VARIETIES. W. Thomas Lanini, Extension Weed Ecologist, Department of Vegetable Crops, University of California, Davis, CA 95616.

Abstract. Field dodder is a stem parasite of many broadleaf crops, including tomatoes. A field trial was established in May, 1999 to examine field dodder control using rimsulfuron. Treatments were initiated at the preemergence, cotyledon, 1 true-leaf, and 2 true-leaf stage of tomato growth. Treatments were applied as a single treatment or as a split treatment. In addition to the timing and split treatments, all postemergence treatments were applied with silicone surfactant, crop oil concentrate, methylated seed oil (MSO), or MSO plus silicone surfactant. None of the treatments resulted in complete dodder control. Split treatments which were initiated at the cotyledon or 1 true-leaf stage, generally provided better control than did those initiated at the preemergence or 2 true-leaf stage. Crop oil concentrate provided better initial dodder suppression, but by harvest, no differences among surfactants were observed. Light measurements below the tomato canopy indicated that split applications were less injurious to tomatoes. Two tomato varieties were also evaluated for dodder resistance, 'Heinz 9492' and 'Heinz 9553', and compared to the grower variety, 'Halley 3155'. Both Heinz 9492 and Heinz 9553 were highly resistant to dodder parasitism, compared to Halley 3155. Dodder growth on the Heinz varieties was reduced by over 90% compared to the dodder growth on Haley 3155.

SWEET CORN TOLERANCE AND WEED CONTROL WITH BAS 662. Corey V. Ransom, Joey K. Ishida, and Corey J. Guza, Assistant Professor, Research Technician, and Graduate Student, Malheur Experiment Station, Oregon State University, Ontario, OR 97914.

Abstract. Weed control is important in sweet corn to reduce weed competition. Sweet corn varieties can be sensitive to herbicides and sweet corn tolerance to new herbicides needs to be evaluated. Trials were conducted in 1998 and 1999 to evaluate sweet corn tolerance and weed control with BAS 662 (dicamba plus diflufenzopyr). Tolerance and efficacy trials were conducted separately in both years. 'Jubilee' sweet corn was planted in 30-inch rows at a population of 21,500 seeds/A in 1998 and 29,000 seeds/A in 1999. Planting took place May 18 in 1998 and May 5 in 1999. Weeds were controlled in the tolerance trials with a preplant application of EPTC (3.14 lb/A) and atrazine (0.5 and 0.75 lb/A) and by handweeding. Plots were 4-rows wide and 30-feet long and were replicated three times in the efficacy trials and four times in the tolerance trials. Postemergence treatments were applied June 9, 1998 to 2-collar corn and June 1 and 4, 1999 to 3-collar corn. The predominant weeds in the

efficacy trials were redroot pigweed, common lambsquarters, and hairy nightshade. Sweet corn was evaluated for tolerance to BAS 662 (0.175 lb/A) with NIS, COC, NIS + 32% N, or bentazon in 1998 and to BAS 662 (0.132, 0.175, 0.263,0.350 lb/A) plus NIS (0.25 % v/v) with and without 32% N (1.25% v/v) in 1999. Sweet corn injury was evaluated throughout the growing season and yields were determined by harvesting the ears from the center two rows of each plot. In 1999, a subsample of 25 ears was taken from each plot, the husks were removed, and the weight recorded. The length and diameter of each ear was also measured. The weed control trials evaluated BAS 662 (0.88 to 0.175 lb/A) alone and in combination with bentazon, atrazine, bentazon plus atrazine, or bentazon plus dimethenamid. BAS 662 treatments were compared to bentazon and bentazon plus atrazine in both years. All combinations in 1998 included COC (1% v/v) while all treatments in 1999 contained NIS (0.25% v/v) and 32% N (1.25% v/v).

THE CRITICAL PERIOD OF COMPETITION BETWEEN WATERGRASS AND WATER-SEEDED RICE. K. D. Gibson[1], A. J. Fischer[2], T. C. Foin[1], J. E. Hill[1], and B. P. Caton[1,3], Postdoctoral Research Assistant, Assistant Professor, Professor, Agronomist and Chair, and Weed Ecologist, [1]Department of Agronomy and Range Science, [2]Department of Vegetable Crops, and [3]International Rice Research Institute, University of California, Davis, CA 95616.

Abstract. The timing of weed control measures can be an important factor in reducing weed escapes and minimizing the risk of weed interference with crop growth. The watergrasses (*Echinochloa phyllopogon, E. oryzoides*) are the most economically important weeds in California rice, yet no critical period of competition has been established. We conducted a field experiment in 1999 at the Rice Experiment Station near Biggs, CA to determine the critical period of competition for watergrass. A complete randomized block design with five blocks and two factors (weedy and weed-free periods) was used. Rice was aerially applied into flooded fields on May 14, 1999. Molinate was applied at 0, 15, 30, 45 and 60 days after seeding rice (DAS) to control watergrass. Treated plots were hand-weeded following herbicide application to insure plots remained weed-free. Plots sprayed with molinate at 0 DAS were hand-seeded with watergrass at 15, 30, 45, and 60 DAS at a rate of 500 seeds/m^2. Each seeding treatment was sampled 14 days later to assess determine emergence. The weed-free and weedy controls were harvested at 30, 45, and 60 DAS. All plots were harvested at crop maturity. We draw three main conclusions from the experiment. First, delaying the emergence of watergrass relative to the crop improved the suppressive ability of rice. Watergrass plants in plots seeded at 15 DAS produced significantly less biomass than plants that emerged with the crop. No watergrass emerged in plots seeded at 30 DAS or later. Second, watergrass must be controlled early in the season. When watergrass was controlled at 45 DAS or later, rice yields were reduced as much relative to the weed-free control as plots that received no weed control. Third, watergrass interferes with rice early in the season before canopy closure. Relative to weed-free plots, interference in rice growth by the weed was detectable in untreated plots as early as 30 DAS. However, rice yields were not affected by watergrass if the weed was removed by 30 DAS. Early interference is consistent with experiments that suggests competition for nitrogen may play an important role in watergrass:rice interactions.

EPTC INCORPORATION METHODS: EFFECTS OF VARYING TIMES AND QUANTITIES OF WATER. Dana Coggon and Scott Nissen, Undergraduate Student and Associate Professor, Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523.

Abstract. Chemigation is a popular method of EPTC application in potatoes even though EPTC losses due to volatilization have been documented. Ground application of EPTC to dry soil followed by water incorporation could be an acceptable alternative for many potato producers. The time period between application and incorporation is critical for EPTC activity. This was evaluated using barley (*Hordeum vulgare*) as a bioassay

species. Barley seeds were planted in 12.7 cm^2 pots containing a sandy loam soil with a 0.9% organic matter. Ten seeds were placed at two depths, 3.8 cm and 7.6 cm, to evaluate EPTC efficacy. EPTC was applied at a 0.5 kg/ha and incorporated with 1.3 cm of water 0, 12, 24, and 48 hours after herbicide treatment (HAT). Barley biomass was taken at 21 DAT. Plant growth was reduced by 100% at 0 and 12 HAT, but dropped to 24% 48 HAT for barley planted at 3.8 cm. At depth 7.6 cm, plant growth was reduced 66% 12 HAT but by 24 HAT growth reduction had dropped to only 17%. Further research is being conducted to evaluate the quantity of water needed to provide optimum distribution of EPTC within the soil profile. Information derived from these experiments will help to improve EPTC performance.

PENDIMETHALIN AND ETHOFUMESATE AS DCPA REPLACEMENTS IN DRY BULB ONIONS.

Scott J. Nissen and Mike E. Bartolo, Associate Professor and Research Scientist, Department of Bioagricultural Sciences and Pest Management and Department of Horticultural and Landscape Architecture, Colorado State University, Fort Collins, CO 80523 and Arkansas Valley Research Center, Rocky Ford, CO 81067.

Abstract. DPCA was an important herbicide in many vegetable crops because if properly activated by irrigation or rainfall it provided good pre-emergence control of many annual broadleaf weeds. The manufacture of DCPA was discontinued in 1997, leaving many onion producers without adequate weed control options. Research was conducted to establish the level of crop safety and efficacy for two products that have demonstrated some selectivity in dry bulb onions. Pendimethalin was applied pre-emergence at rates of 0.8, 1.2, 1.5, and 2 lb/A and at lower rates in combinations with bensulide. Ethofumesate was applied pre-emergence at rates of 0.3, 0.5, 1.0, and 1.5 lb/A. Research was conducted at six locations across Colorado on soils ranging from sandy loam to clay loam and organic matter contents from 1.4 to 2.1%. The spring of 1999 was wetter than normal so all locations received between two and four inches of precipitation following herbicide applications. Stand counts and yield data were collected from five of six locations, while weed control evaluations were possible at three of six locations. Based on stand counts and yield data there was no crop response to pendimethalin at any location. Under weed free conditions stand counts and onion yields were similar for handweeded checks and plots treated with ethofumesate; however, weed control was significantly better with pendimethalin as compared to ethofumesate. Combinations of bensulide with low rates of pendimethalin did not improve weed control over pendimethalin alone.

WEEDS OF AGRONOMIC CROPS

INTERACTION OF HERBICIDE AND NITROGEN FERTILIZER ON WILD OAT CONTROL IN A FIELD SCALE EXPERIMENT. Alvin J. Bussan, Lee R. Van Wychen, Ed Luschei, and Bruce D. Maxwell, Assistant Professor, Graduate Research Assistants, and Associate Professor, Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, MT 59717-3120.

Abstract. Availability of nitrogen to crops and weeds can have a dramatic impact on the competition between species. Inadequate fertilization potentially results in poor crop canopy development and allow weeds to compete for light and moisture. Likewise, excess nitrogen can benefit the development of weed canopy and increase competition with the crop. Therefore, it is likely the nitrogen fertility will impact the efficacy of herbicides. With the development of precision agriculture technologies (e.g. global positioning systems (GPS), rate controllers, and yield monitors) unique opportunities exist to conduct field scale research that investigates inputs specific to producer fields and localized regions.

The objectives of this research were to 1) determine the effect of POST applied wild oat herbicides at varying rates with different nitrogen (N) fertility rates on wild oat control (seedling survival, reproductive tiller density, and fecundity) and spring wheat yield at the field scale and 2) determine usefulness of GPS, rate controllers, and yield monitors for conducting field scale experimentation.

Research was conducted in a 30 ha producer field near Sun River, MT, during 1998 and 1999. N was broadcast applied as ammonium nitrate in strips 20 by 1400 m with custom application equipment. N rates varied from 0 to 176 kg/ha in 44 kg/ha increments. Fenoxyprop, imazamethabenz, and tralkoxydim were applied at 0.25X, 0.5X, 0.75X, and 1X the label rate in strips 20 by 220 m perpendicular to the soil fertility treatments with a spray coupe equipped with Mid-Tech rate controllers and a GPS. Wild oat were treated when they reached the 3- to 4-leaf stage. Wild oat were mapped prior to herbicide treatment and wheat harvest with a GPS backpack. Fenoxyprop and tralkoxydim at the 0.75X and 1X rate provided similar control of wild oat. Imazamethabenz at the 0.5X, 0.75X, and 1X rate provided similar wild oat control. Conditions at the time of application were hot and dry, which may have improved the performance of imazamethabenz relative to fenoxyprop or tralkoxydim. More research is required to quantify environmental effects on efficacy of herbicides at reduced rates. Use of precision agriculture equipment made this research possible, but did not reduce the labor required for data collection. Accuracy of information is of concern (especially yield data) because of the addition of spatial variation in the data. However, GPS, rate controllers, and yield monitors definitely improved the ability to conduct long-term field scale research.

FACTORS AFFECTING RYE CONTROL WITH IMAZAMOX. Chad S. Trusler, Johnny R. Roberts, Jason P. Kelley, and Thomas F. Peeper, Graduate Student, Graduate Student, Senior Agriculturist, and Professor, Plant and Soil Sciences Department, Oklahoma State University, Stillwater, OK 74078.

Abstract. Field experiments were conducted during the 1997 to 1998 and 1998 to 1999 winter wheat growing seasons to investigate the influence of application timing, tank mixtures with hormone type herbicides, and seasonal grazing with cattle on the control of rye in hard red winter wheat with imazamox. Rye control was strongly influenced by application timing. Tank mixtures of MCPA, 2,4-D and dicamba had little or no influence on rye control. Rye control with imazamox application after grazing was lower in grazed wheat at one of two sites. Interactions were found between wheat seeding rates and imazamox application rates in rye control data.

EVALUATION OF IN-CROP, PRE-HARVEST, AND POST-HARVEST APPLICATIONS FOR CANADA THISTLE AND DANDELION CONTROL. Brian M. Jenks, Kent McKay, and Gary Willoughby, Weed Scientist, Extension Agronomist, and Research Specialist, North Dakota State University, North Central Research Extension Center, Minot, ND 58701.

Abstract. Various herbicide treatments were applied either in-crop (wheat), pre-harvest, or post-harvest in 1998. Our objective was to evaluate how effectively these herbicide treatments would control Canada thistle into the 1999 growing season. For the 1998 growing season, clopyralid plus 2,4-D (94%) was the most effective in-crop treatment rated in August 1998. Canada thistle control with 2,4-D amine was better than normally expected (70%). Control with dicamba plus 2,4-D, tribenuron plus 2,4-D, and bromoxynil plus MCPA ranged from 71 to 80% (rated in August 1998). However, after harvest the Canada thistle plants were coming back very strong in the above treatments except for clopyralid plus 2,4-D. Glyphosate (1 qt/A) was applied pre-harvest (Sept 10, 1998) and post-harvest (Oct 8, 1998)

Each treatment was rated for Canada thistle and dandelion control on May 29, 1999. Pre-harvest and post-harvest glyphosate applications provided better Canada thistle and dandelion control compared to in-crop treatments. Canada thistle control with pre-harvest glyphosate ranged from 89 to 94% and dandelion control was 73 to 86%. Post-harvest glyphosate was slightly more effective on Canada thistle (90 to 99%) and dandelion (97 to 99%) compared to the pre-harvest application. Dicamba plus diflufenzopyr (2 oz prod/A) was not effective on Canada thistle or dandelion.

Following the May 1999 visual evaluation, the plot area was tilled and seeded with spring wheat. Canada thistle shoots started to emerge by the third week of June. Canada thistle densities in July 1999 were generally lower than in spring 1998 where pre-harvest or post-harvest glyphosate treatments were applied. The in-crop treatments applied in 1998 generally provided poor long-term control of Canada thistle and dandelion based on comparisons between spring 1998 and July 1999 densities. Canada thistle density (in 1999) in the untreated check increased 226% compared to the density in spring 1998. Canada thistle densities also increased in the other in-crop treatments: tribenuron plus 2,4-D (109%), dicamba plus diflufenzopyr (142%), and dicamba plus diflufenzopyr plus quinclorac (175%). Canada thistle density was much lower with the in-crop treatment of clopyralid plus 2,4-D, where the density only increased slightly (2%). Densities in pre-harvest treatments were +20%, -5%, -20%, and -69%. Densities in the post-harvest treatments were -3%, -19%, and -37%. This study clearly shows that in-crop applications in wheat may suppress Canada thistle during the growing season, but pre-harvest or post-harvest applications are necessary for long-term control.

EVALUATION OF HARD RED WINTER WHEAT CULTIVARS FOR THEIR COMPETITIVE ABILITY AGAINST JOINTED GOATGRASS USING REMOTE SENSING. Amanda E. Stone, Thomas F. Peeper, Eugene G. Krenzer, John B. Solie, and Marvin L. Stone, Graduate Student, Professor, and Professor, Department of Plant and Soil Science, Professor and Professor, Department of Biosytems and Agricultural Engineering, Oklahoma State University, Stillwater, OK 74078.

Abstract. From previous experiments, it has been established that certain hard red winter wheat cultivars compete better with jointed goatgrass than others. The characteristics that cause the cultivars to be better competitors have not been clearly defined, but may be related to biomass accumulation and the ability of a cultivar to retain photosynthetically active leaves during winter. Our research is focused on remote sensing to quantify these characteristics and to determine their relationship to competitive ability. In the 1998 to 1999 growing season, a two channel spectrometer (400 to 1100 nm) with an enclosed light source was used to measure reflectance spectra of seven hard red winter wheat cultivars. Reflectance were measured every other week from the middle of December till the middle of March. Radiance from the spectral bands centered at 670 and 780 nm were used to calculate NDVI, Normalized Difference Vegetation Index. This index is highly correlated with plant biomass and

general plant health. This growing season (1999 to 2000) we planted 24 hard red winter wheat cultivars with and without jointed goatgrass. We recorded our first spectral signatures 12 days after planting, using the Oklahoma State University two band sensor (red and near infrared). With this sensor we measured red (670 + 6 nm) and near infrared (780 + 6nm) values of incident light and light reflected from the crop canopy each week, except during inclement weather.

Results from 1998 to 1999, and this years data show that cultivars can be classified based on NDVI and classification appears to be related to the hard red winter wheat cultivars competitiveness against jointed goatgrass

---

THE WHEAT/JOINTED GOATGRASS CROP-WEED COMPLEX IN OREGON WHEAT FIELDS.
Laura A. Morrison, Lisèle Cremieux, Lori Kroiss, David Krebs, and Carol Mallory-Smith, Postdoctoral Research Associate, Graduate Research Assistant, Graduate Research Assistant, Undergraduate Research Assistant, and Associate Professor, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 57331.

Abstract. Jointed goatgrass (*Aegilops cylindrica* Host) infestations have become relatively widespread across the dry-land winter wheat region of eastern Oregon. Surveys conducted in 1998 and 1999 of 60 infested field and non-field sites across a seven-county area found 23 populations of jointed goatgrass x wheat (*Triticum aestivum* L.) hybrids. Of the 2598 spikes collected from 363 hybrid plants, 542 spikes were partially female fertile, producing an average of 1.3 seeds/fertile spike. Hybrid plants were collected from winter wheat fields and spring barley fields, along field edges, in access roads, and in fields out of wheat. In addition to collections from winter wheat fields, jointed goatgrass was found in spring wheat and spring barley fields, cattle feed lots and grazing ground, abandoned fields, roadsides, uncultivated scab and watershed areas in and adjacent to wheat fields, and waste areas near grain elevators. Although typically reported as a self-pollinating species, jointed goatgrass populations surveyed in Oregon show a high incidence of cross-pollination tendency as well as nicking with the anthesis of winter and spring wheats. Preliminary genetic analyses using SDS-PAGE of the high molecular weight glutenin seed proteins and microsatellite (SSR) markers show a low diversity in jointed goatgrass. Morphological and genetic analyses of the hybrids suggest a population of mixed generations of F1 and backcross hybrids. These data point to the development of a crop-weed complex by introgressive hybridization and call for continued study to fully characterize the problem.

JOINTED GOATGRASS SEED PRODUCTION IN SPRING WHEAT. Darrin L. Walenta[1], Joseph P. Yenish[1], Frank L. Young[1], Daniel A. Ball[2], and Eric Gallandt[1], Graduate Research Assistant, Assistant Agronomist/Extension Weed Specialist, USDA-ARS Research Agronomist/Weed Scientist, USDA-ARS Agronomist, Associate Professor, and Assistant Professor, [1]Department of Crop and Soil Sciences, Washington State University, Pullman, WA 99164 and [2]Columbia Basin Agricultural Research Center, Oregon State University, Pendleton, OR 97801.

Abstract. Jointed goatgrass is a troublesome winter annual grass weed that infests winter wheat in the Pacific Northwest. Rotating to a spring crop for three or more consecutive years is a recommendation for the management of jointed goatgrass infestations. Studies were established during the spring of 1999 near Lind, WA, Pendleton, OR, and Pullman, WA to evaluate spring emergence and spike production by jointed goatgrass grown in pure stands and in competition with spring wheat. Average annual precipitation for the study locations are 235, 420, and 560 mm/year, respectively. Two studies were established at each location. Spring wheat was seeded according to localized standards. There were four seeding dates at two week intervals, approximately, at each location. In the first study, jointed goatgrass infestations were planted by broadcasting spikelets on the soil surface at a rate of 161 spiklets/m^2 immediately prior to seeding spring wheat. The second study was located on a site with an

established or "natural" jointed goatgrass soil seed bank. The experimental design was a randomized complete block factorial arrangement with four replications. Main factors were seeding date and pure or mixed stands of jointed goatgrass and spring wheat. At all locations with planted infestations, jointed goatgrass plants established at all seeding dates. Spikes were produced in the two earliest seeding dates at each location. At Lind and Pullman, spikes were produced in the third seeding date. No spikes were produced in the final seeding date at any location. At Lind, pure stands of jointed goatgrass produced 362, 22, and 1 spikes/m^2 at the three earliest seeding dates. However, jointed goatgrass growing in competition with spring wheat produced 58, 16, and 1 spikes/m^2 at the three earliest seeding dates at Lind. In "natural" jointed goatgrass infestations, establishment was less than in planted infestations and was influenced by location. At Lind, jointed goatgrass plants established in the two earliest and final seeding dates. At Pendleton, no jointed goatgrass plants established at any seeding date. At Pullman, jointed goatgrass plants established at all seeding dates. Jointed goatgrass produced spikes at the two earliest seeding dates at Lind. Spikes were produced at all seeding dates in "natural" infestations at Pullman. In both studies at each location, spring wheat grain yield was influenced by jointed goatgrass competition and seeding date.

PROGRESS REPORT ON EFFECT OF CONTROLLING JOINTED GOATGRASS IN WHEAT ROTATIONS IN NEBRASKA. Gail A. Wicks, Gordon E. Hanson, Gary W. Manhken, and Steven D. Miller, Professor, Technician, and Technician, University of Nebraska, North Platte, NE 69101 and Professor, University of Wyoming, Laramie, WY 82071.

Abstract. After 3 yr of data collection, the effects of crop rotation, winter wheat varieties, and time of tillage are affecting jointed goatgrass (JGG) densities. Cultivation of the tillage plots occurred in the ecofallow period in the spring following wheat harvest and before corn planting. The tillage plots in the corn were cultivated once. Initially in 1996, we over-seeded JGG across all plots in 15 A of non-uniform infestation of JGG. The rotations are winter wheat-fallow, winter wheat-ecofallow corn-fallow, and winter wheat-ecofallow corn-corn-fallow. 'Pronghorn', 'Alliance', and 'Vista' winter wheat varieties were planted each fall. These varieties represent medium tall, medium, and short stature wheats that are adapted to western Nebraska. In addition, two tillage treatments were imposed on all plots. The four rotations have been in place for 3 years. In 2000, following winter wheat harvest, the effects of the three varieties will be obtained from all rotations. In 1999, JGG seed production was reduced 60% by planting a medium-tall winter wheat variety (Pronghorn) compared with the shorter varieties (Alliance or Vista). (The soil seedbank data indicate that Pronghorn wheat reduced JGG joints 88% compared with Vista since 1996.) The draw back with Pronghorn is that grain yields were about 20% less than those obtained from Alliance or Vista. Originally, grain sorghum followed corn in the 4-year rotation. After 1 yr we substituted corn for the grain sorghum because corn is more adapted to the higher elevation areas of western Nebraska, eastern Colorado, and northwestern Kansas. In addition, grain sorghum does not die until frost and therefore uses valuable soil water that could be used by the next crop. It was suspected that grain sorghum used more soil water in the late summer and fall and reduced winter wheat yields in 1999. Keeping the surface soil dry also prevents jointed goatgrass from germinating in the fall during the beginning of the fallow period following grain sorghum. Beginning tillage May 1 during the prewheat-fallow period provided conditions suitable for more JGG seeds to germinate before wheat planting than delaying initial tillage until June 29, 1998. This trend has been consistent across the three years. However, no difference could be detected in the joints in the soil seedbank between tillage and no-tillage treatments. Tillage did not affect winter wheat nor corn yields following the ecofallow period. Even with better weed control on the tilled plots in 1999, corn yields were reduced about 15% in the continuous corn plots that were tilled compared with no-till. The corn suffered from drought during late June and July.

BAY MKH 6561 - A NEW SELECTIVE HERBICIDE FOR GRASS CONTROL IN WHEAT. Hans J. Santel[1], Allen C. Scoggan[1], John D. Wollam[1], Dieter Feucht[2], and Klaus H. Mueller[2], Product Manager and Regional Development Managers, [1]Bayer Corp., Kansas City, MO 64120 and [2]Bayer AG, 51368 Leverkusen, Germany.

Abstract. BAY MKH 6561 is a new sulfonyl-amino-carbonyl-triazolinone herbicide discovered and being developed by Bayer. The product acts as an inhibitor of the enzyme acetolactate synthase (ALS). It provides excellent activity against grasses and several important broadleaf weeds when applied postemergence to wheat. In field experiments conducted between 1993 and 1999 in Europe and North America, the product has demonstrated strong and consistent activity against important grass weeds like cheatgrass, downy brome, wild oat, canarygrass, blackgrass, wind grass and the perennial grass, quackgrass. At the suggested use rates of 30 to 60 g/ha weeds were selectively controlled in wheat.

Very low toxicity of BAY MKH 6561, tested as pure active ingredient and 70 DF formulation, was observed when the product was administered orally, as dermal treatment or by inhalation to male and female rats. Dermal applications to rabbits or guinea pigs did not result in irritation or sensitization. Only slight to moderate eye irritation was observed in the respective test with rabbits. Chronic studies showed no evidence of any neurotoxic, genotoxic, teratogenic or carcinogenic potential or reproductive toxicity. No residues of toxicological significance were detected in plants or animals and dietary exposure calculations resulted with reasonable certainty, that no harm to humans will result from the use of BAY MKH 6561. The overall classification of BAY MKH 6561 technical falls in Toxicity Category III; Signal Word: CAUTION.

On the soil surface, BAY MKH 6561 is stable to photodegradation. The major routes of degradation in soil are abiotic processes and microbial breakdown to the final mineralization product, carbon dioxide. In field dissipation studies the product was well to moderately fast degradable depending on soil type. No BAY MKH 6561 degradates were found in any soil layers below 6 inch depth. On the basis of a series of studies and modelling, BAY MKH 6561 does not represent a risk to groundwater BAY MKH 6561 indicated a low potential to bioaccumulate and insignificant concentrations in drinking water were estimated from model calculations.

BAY MKH 6561 showed little toxicity for birds, fish, green algae, daphnia, honeybees and earthworms. The use of the product will result in a minimal risk for fish, birds, aquatic and terrestrial invertebrates and algae.

BAY MKH 6561: A NEW HERBICIDE FOR GRASS AND BROADLEAF WEED CONTROL IN CEREAL. Allen C. Scoggan, Hans J. Santel, John D. Wollam, and Richard D. Rudolph, Regional Development Manager, Product Manager, and Regional Development Managers, Bayer Corporation, P.O. Box 4913, Kansas City, MO 64120.

Abstract. BAY MKH 6561, or Olympus, is a sulfonylaminocarbonyl triazolinone herbicide which has been field tested on wheat throughout the United States since 1993. This compound inhibits acetolactate synthase (ALS), and has selectivity on spring, winter, and durum varieties. The spectrum of control includes several species of monocot and dicot weeds at the application rates of 30 to 45 g/ha.

Bromus control is the primary target since existing herbicides have limited timing, selectivity, and use patterns which reduce usefulness. BAY MKH 6561 applied postemergence between the 1- to 2-leaf stage and shoot elongation has provided economic control of the following *Bromus* species: *B. tectorum, B. secalinus, B. rigidus,* and *B. japonicus*. Additional grasses controlled or economically reduced included *Avena fatua, Phalaris minor* and *P. paradoxa,* and *Apera spicaventi*. Interesting side effects, and sometimes control, was also noted on *Aegilops tauschii* for which there is no selective control outside genetically altered wheat cultivars.

Broadleaf control is obtained primarily on the mustard family. BAY MKH 6561 will offer an adequate weed spectrum for economical control, however considerations of resistance management, difficult and diverse weed pressure, and extended growing seasons will sometimes necessitate the use of sequential herbicides or mix partners. BAY MKH 6561 has been tested with a wide spectrum of sequential and mix partner herbicides with no negative effects on the expected additive activity.

PERFORMANCE OF BAY MKH 6561 IN WINTER WHEAT GROWN IN THE SOUTHCENTRAL US.
Andrew T. Palrang[1], John E. Cagle[1], J. Alan Hopkins[1], Lance J. Nearman[1], and Hans J. Santel[2], [1]Field Development Representatives, and [2]Product Development Manager, Bayer Corp., Kansas City, MO 64120.

Abstract. BAY MKH 6561 has been tested in field experiments in Arkansas, Kansas, Oklahoma and Texas since 1993. The product has demonstrated strong and consistent activity against important grass weeds like cheatgrass, downy brome, japanese brome and wild oat at the suggested use rates of 30 to 45 g/ha (0.6 to 0.9 oz product/A). At the highest single rate tested (45 g/ha), or after sequential applications of 30 g/ha in fall and spring, the effect on rescuegrass was limited to suppression.

Cheatgrass control was excellent from single postemergence applications of 30 g/ha early in the fall through applications in the spring. *Bromus* control was also excellent when the product was applied to grazed wheat in the spring after removal of the cattle. This wide application window will allow growers to protect their wheat crop from brome competition in the spring if economics favor grain production.

In addition to *Bromus* control, efficacy on wild oat has successfully been demonstrated. Fall applications of BAY MKH 6561 were superior to spring applications and offered early and extended protection of the crop from weed competition. At a rate of 45 g/ha applied in the fall, BAY MKH 6561 provided better wild oat control than 93 g/ha of spring applied fenoxaprop. The use of BAY MKH 6561 for *Bromus* or wild oat control resulted in positive yield responses following either fall or spring application timing.

ROTATIONAL CROP RESPONSE TO BAY MKH 6561. Curtis R. Rainbolt, Donald C. Thill, and Daniel A. Ball, Graduate Research Assistant and Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow ID 83844 and Associate Professor, Columbia Basin Agriculture Research Center, Oregon State University, Pendleton, OR 97801.

Abstract. Winter wheat is grown in rotation with barley, pea, lentil, and mustard. Some herbicides persist in soil longer than one growing season, injuring subsequently planted crops. Studies were established in winter wheat near Moscow, ID, Pendleton, OR, and Wilcox, WA to evaluate rotational crop sensitivity to BAY MKH 6561, a new ALS inhibiting herbicide. BAY MKH 6561 at 0, 22, 45, and 90 g/ha, and sulfosulfuron at 35 g/ha were applied during fall 1997 or spring 1998. 'Baronesse' barley, 'Tilney' mustard, 'Pardina' lentil, and 'Columbia' pea were planted in spring 1999. Mustard was visually injured 8 to 19% at all locations by fall or spring-applied BAY MKH 6561 at 90 g/ha and fall-applied sulfosulfuron. At Moscow, all treatments reduced mustard biomass 30 to 46%, and at Pendleton pea biomass was reduced 20 to 30% by fall or spring applied BAY MKH 6561 at 90 g/ha. Barley, pea, and lentil seed yields were not affected by herbicide treatments at Moscow and Wilcox. Mustard yield was reduced 38 to 53% at Moscow and Wilcox by fall or spring applied BAY MKH 6561 at 90 g/ha. Spring-applied BAY MKH 6561 at 90 g/ha reduced barley yield 11% at Pendleton. A growth chamber soil bioassay was used to determine the rate of BAY MKH 6561 dissipation. Averaged over all rates the predicted half-life following fall applications ranged from 68 (Moscow) to 79 (Pendleton) days. Following spring applications, the estimated half-life ranged from 60 (Wilcox) to 69 (Moscow) days.

WINTER ANNUAL BROME CONTROL IN WINTER WHEAT AND FOLLOW CROP RESPONSE TO BAY MKH 6561. Phillip W. Stahlman and Patrick W. Geier, Professor and Assistant Scientist, Kansas State University Agricultural Research Center, Hays, KS 67601.

Abstract. Studies were conducted near Hays, Kansas to evaluate downy brome and cheat control in winter wheat with BAY MKH 6561 compared with MON 37500, and to determine the response of row crops seeded in failed winter wheat treated with each herbicide. The efficacy study consisted of BAY MKH 6561 at two rates alone and the low rate in combination with metribuzin at four times of application. Cheat was controlled 95% or more by each herbicide treatment regardless of application timing. Downy brome control with BAY MKH 6561 at 0.027 or 0.04 lb/A applied early-fall POST (EFP), late-fall POST (LFP), or early-spring POST (ESP) was 60 to 68%; late-spring (LSP) applications were less effective (48 to 55% control). MKH 6561 plus metribuzin at 0.027 + 0.014 lb/A applied EFP or LFP controlled downy brome slightly better than BAY MKH 6561 at 0.027 lb/A, but not when applied in spring or any time with the higher rate of BAY MKH 6561. Wheat treated with the low rate of BAY MKH 6561 plus metribuzin ESP yielded more than wheat receiving BAY MKH 6561 alone EFP. In one recrop study, neither grain sorghum nor sunflower seeded no-till into failed winter wheat in May were affected by treatments of BAY MKH 6561 applied the previous fall, while fall-applied MON 37500 affected both crops severely. In another recrop study, spring-applied BAY MKH 6561 stunted early season growth of regular and imidazolinone-tolerant corn by 30 and 43%, respectively, but both corns recovered and yields were not reduced. Neither plant growth nor yield of imidazolinone-resistant corn, grain sorghum, non-STS soybean, or STS soybean were affected by BAY MKH 6561.

CHEAT CONTROL WITH MON 37500 AND BAY MKH 6561 IN WINTER WHEAT. J. P. Kelley and T. F. Peeper, Senior Agriculturist and Professor, Department of Plant and Soil Sciences, Oklahoma State University, Stillwater, OK 74078.

Abstract. Field research was conducted at three locations in central Oklahoma during the 1998 to 1999 crop year to evaluate the effect of application timing of MON 37500 and BAY MKH 6561 on wheat injury, cheat control, and wheat yield. Treatments were applied at 10-day intervals, beginning with a preemergence treatment in early October and continuing with postemergence treatments until mid March. MON 37500 was applied at 0.031 lb/A and BAY MKH 6561 was applied at 0.04 lb/A. All postemergence treatments were applied with 0.25% v/v AG-98 surfactant. Wheat chlorosis was greatest from early fall postemergence applications and was similar for both herbicides. Cheat control from preemergence treatments of MON 37500 ranged from 74 to 96% and 95 to 98% for BAY MKH 6561 at three locations. Cheat control from postemergence applications ranged from 49 to 99% and 65 to 99% for MON 37500 and BAY MKH 6561 at three locations. Early postemergence applications provided more consistent cheat control. All treatments, regardless of timing or herbicide, reduced wheat dockage due to cheat. Early fall postemergence treatments gave higher yields compared to spring treatments.

A field trial was conducted in north-central Oklahoma in the 1998 to 1999 growing season to evaluate cheat control in post-grazing wheat with MON 37500 and BAY MKH 6561. Treatments evaluated included; MON 37500 at 0.023 and 0.031 lb/A and BAY MKH 6561 at 0.027, 0.04, and 0.027 plus Sencor at 0.188 lb/A. Tonkawa, hard red winter wheat was seeded in late September in 7 by 25 foot plots. Cattle began grazing cheat-infested wheat in mid November and continued through late February. Cattle were removed and two days later, treatments were applied. All treatments were applied at 20 gpa using a CO_2 backpack sprayer. Cheat control at heading ranged from 54 to 56% for MON 37500 treatments and 99 to 100% for BAY MKH 6561 treatments. Wheat in the untreated check yielded 18.4 bu/A while MON 37500 treatments yielded 27.3 and 30.9 bu/A. Wheat yield from BAY MKH 6561 treatments ranged from 29.1 to 35.1 bu/A.

PERFORMANCE OF FLUCARBAZONE SODIUM IN COMMERCIALLY GROWN WHEAT. RESULTS OF THE 1999 CANADIAN RESEARCH PERMIT TRIALS. B. A. Bowden, P. G. Bulman, V. M. Sorensen, W. B. Gibb, B. M. Tomolak, and D. E. Feindel, Development Specialists, Bayer Incorporated, Toronto, Ontario, M9W 1G6.

Abstract. Flucarbazone sodium (MKH 6562) is a new low rate, experimental grass herbicide being developed by Bayer for postemergence grass control in wheat. The product belongs to the chemical class of sulfonylaminocarbonyltriazolinones, representing a novel class of herbicides. Flucarbazone sodium has shown crop tolerance in wheat (spring, durum and winter) with activity on major annual grasses and many important broadleaf weeds, when applied postemergence. The use rate for annual grass control is 30 g/ha and the addition of a non-ionic surfactant in the spray solution is recommended. Flucarbazone sodium must be applied in combination with a broadleaf herbicide (phenoxy, sulfonylurea, benzonitrile). Flucarbazone sodium provides control of susceptible *Avena fatua* and *Setaria viridis* as well as Group 1, 3 and 8 resistant *Avena fatua* and Group 1 and 3 resistant *Setaria viridis*.

Bayer Canada received a research permit for a broad scale field trial program in March 1999 and a total of 124 fields of 40 A (16 ha) were applied by growers across the prairie provinces of Manitoba, Saskatchewan and Alberta. The results of the Research Permit suggested flucarbazone sodium provided superior *Setaria viridis* control compared to the standards and was equal to or superior to the standards for control of *Avena fatua*. Crop tolerance was acceptable across a range of broadleaf mix partners. Crop yields were not different when compared to the standards. Flucarbazone sodium performance was not affected by sprayer type, nozzle type or water volume (exception the Sprayair at 20 L/ha). Grower satisfaction level with flucarbazone sodium was high.

THE EFFICACY OF SULFOSATE AND GLYPHOSATE IN SPRING CHEMICAL FALLOW SYSTEMS. Robert N. Klein, Jeffrey A. Golus, and Brett R. Miller, Professor and Extension Research Technologist, University of Nebraska West Central Research and Extension Center, North Platte, NE 69101 and Zeneca Field Development Specialist, Lincoln, NE 68516.

Abstract. A study was conducted to evaluate downy brome control in winter wheat stubble with sulfosate and glyphosate. Treatments were applied using a 15 foot sprayer boom (six 11003XR nozzles on 30 inch spacing). Carrier volume was 10 gpa, nozzle pressure 20 psi and speed 4.2 mph. Treatments were applied on April 7, with downy brome was 3- to 5-inches tall, with some up to 7 inches tall. The plots were rated visually for percent control on May 17.

Table. Control of downy brome in winter wheat stubble.

Treatment	Rate	Downy brome
	lb/A	% Control
Sulfosate + AMS	0.375 + 17 lb/100 gal	88
Sulfosate + AMS	0.5 + 17 lb/100 gal	92
Sulfosate + AMS	0.625 + 17 lb/100 gal	94
Sulfosate + AMS	0.375 + 8.5 lb/100 gal	76
Sulfosate + AMS	0.5 + 8.5 lb/100 gal	86
Sulfosate + AMS	0.625 + 8.5 lb/100 gal	90
Sulfosate + AMS + NIS	0.375 + 8.5 lb/100 gal + 0.25%	92
Sulfosate + AMS + NIS	0.5 + 8.5 lb/100 gal + 0.25%	95
Sulfosate + AMS + NIS	0.625 + 8.5 lb/100 gal + 0.25%	97
Glyphosate + AMS	0.375 + 8.5 lb/100 gal	92
Glyphosate + AMS	0.5 + 8.5 lb/100 gal	93
Glyphosate + AMS	0.625 + 8.5 lb/100 gal	96
Sulfosate + dicamba + AMS	0.375 + 0.125 + 8.5 lb/100 gal	94
Sulfosate + dicamba + AMS	0.5 + 0.125 + 8.5 lb/100 gal	97
Sulfosate + dicamba + AMS	0.625 + 0.125 + 8.5 lb/100 gal	99
Glyphosate + dicamba + AMS	0.375 + 0.125 + 8.5 lb/100 gal	94
Sulfosate + 2,4-D Ester + AMS	0.375 + 0.5 + 8.5 lb/100 gal	96
Sulfosate + 2,4-D Ester + AMS	0.5 + 0.5 + 8.5 lb/100 gal	95
Sulfosate + 2,4-D Ester + AMS	0.625 + 0.5 + 8.5 lb/100 gal	99
Glyphosate + 2,4-D Ester + AMS	0.375 + 0.5 + 8.5 lb/100 gal	93
Check		0
LSD (0.05)		3.1

SULFOSULFURON APPLICATION TIMING AND ADDITIVES FOR DOWNY BROME CONTROL IN WINTER WHEAT. Robert N. Klein, Jeffrey A. Golus, and Jeff Tichota, Professor and Extension Research Technologist, University of Nebraska West Central Research and Extension Center, North Platte, NE 69101 and Monsanto Agronomic Research Manager, Littleton, CO 80122.

Abstract. Two studies were conducted to evaluate downy brome control in winter wheat with sulfosulfuron. One study was to determine the optimum time to apply sulfosulfuron. The second study was to evaluate sulfosulfuron when applied with various additives. Both studies were applied with a 10 foot boom (six 11002XR nozzles on 20 inch spacing). The timing study was applied with a nozzle pressure of 22 psi and gallonage of 10 gpa. The additive study was applied with a nozzle pressure of 22 psi and gallonage of 20 gpa. Fall treatments were applied on November 10,1998 and spring treatments applied on March 18, 1999. The winter wheat was planted on September 16, 1998. Both studies were rated visually for downy brome control on April 30 and May 21, 1999. The additive study was evaluated for crop injury on November 21 for fall applied treatments, and April 19 for spring applied treatments.

Table 1. Timing of sulfosulfuron in winter wheat.

Treatment	Rate	Application date	Downy brome April 30	Downy brome May 21
	—— lb/A ——		—— % Control ——	
Check			0	0
Sulfosulfuron	0.031	Sept 18, 1998	33	32
Sulfosulfuron + R-11	0.031 + 0.5%	Sept 25	70	82
Sulfosulfuron + R-11	0.031 + 0.5%	Oct 3	82	93
Sulfosulfuron + R-11	0.031 + 0.5%	Oct 10	87	94
Sulfosulfuron + R-11	0.031 + 0.5%	Oct 24	78	68
Sulfosulfuron + R-11	0.031 + 0.5%	Oct 30	23	43
Sulfosulfuron + R-11	0.031 + 0.5%	Nov 11	30	53
Sulfosulfuron + R-11	0.031 + 0.5%	Nov 20	40	57
Sulfosulfuron + R-11	0.031 + 0.5%	March 18, 1999	38	48
Sulfosulfuron + R-11	0.031 + 0.5%	March 29	62	45
LSD (0.05)			17.3	6.5

Table 2. Sulfosulfuron and additives for downy brome control.

Treatment	Rate	Timing	Injury Nov 21	Injury April 19	Downy brome April 30	Downy brome May 21
	—— lb/A ——		—— % ——		—— % Control ——	
Check			0	0	0	0
Sulfosulfuron	0.031	Fall	0	-	22	20
Sulfosulfuron + R-11	0.031 + 0.125%	Fall	0	-	38	35
Sulfosulfuron + R-11	0.031 + 0.25%	Fall	0	-	55	45
Sulfosulfuron + R-11	0.031 + 0.5%	Fall	0	-	63	57
Sulfosulfuron + 28-0	0.031 + 100%	Fall	8	-	40	32
Sulfosulfuron + 28-0 + R-11	0.031+ 100% + 0.125%	Fall	25	-	43	53
Sulfosulfuron + 28-0 + R-11	0.031+ 100% + 0.25%	Fall	27	-	52	60
Sulfosulfuron + 28-0 + R-11	0.031+ 100%+ 0.5%	Fall	30	-	77	68
Sulfosulfuron	0.031	Spring	-	0	22	10
Sulfosulfuron + R-11	0.031 + 0.125%	Spring	-	5	23	25
Sulfosulfuron + R-11	0.031 + 0.25%	Spring	-	8	33	30
Sulfosulfuron + R-11	0.031 + 0.5%	Spring	-	13	53	48
Sulfosulfuron + 2,4-D ester	0.031 + 0.5	Spring	-	8	35	13
Sulfosulfuron + 28-0	0.031 + 100%	Spring	-	12	27	17
Sulfosulfuron + 28-0 + R-11	0.031+ 100% + 0.125%	Spring	-	22	50	50
Sulfosulfuron + 28-0 + R-11	0.031+ 100% + 0.25%	Spring	-	28	53	55
Sulfosulfuron + 28-0 + R-11	0.031+ 100%+ 0.5%	Spring	-	28	67	65
Sulfosulfuron + 28-0 + 2,4-D ester	0.031+ 100% + 0.5	Spring	-	15	45	28
LSD (0.05)			2.3	3.9	10.6	7.1

BIOLOGICAL BINDWEED CONTROL INTRODUCTION. Kenneth A. Hollon, Thomas F. Peeper, Kristopher L. Giles, and Tom A. Royer, Graduate Student and Professor, Department of Plant and Soil Sciences, and Assistant Professor and Associate Professor, Department of Entomology and Plant Pathology, Oklahoma State University, Stillwater, OK 74078.

Abstract. During mid-May 1999 field bindweed foliage infested with *Aceria malherbae* was hand collected and placed into sealed plastic bags at the Texas Agricultural Experiment Station in Bushland, TX. The bags were maintained at 21 C ±5 degrees C until distribution. The following day the samples were distributed to interested Oklahoma wheat growers. The growers were instructed to release the *A. malherbae* samples in growing field

bindweed the same day and flag the release site. Each release site was visited prior to wheat harvest and mapped and recorded using a handheld GPS unit. During October and November 1999 these sites were revisited to determine whether field bindweed at the site was exhibiting symptoms of damage inflicted by *A. malherbae*. Of 115 initial release sites throughout western Oklahoma, two sites had noticeable damage caused by feeding *A. malherbae*. Efforts are currently under way to identify factors contributing to the successful introduction and efficacy of this biological control agent.

CONTROL OF SIX KOCHIA ACCESSIONS AT THREE GROWTH STAGES WITH FLUROXYPYR AND DICAMBA. David S. Belles, Philip Westra, Scott J. Nissen, and Vanelle Carrithers, Graduate Research Assistant, Professor, Associate Professor, and Senior Research Biologist, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523 and Dow AgroSciences, 28884 South Marshall Road, Mulino, OR 97042.

Abstract. The effect of fluroxypyr on dicamba tolerant kochia accessions is an important consideration for kochia management. A field study was conducted in Larimer County, Colorado to compare the efficacy of fluroxypyr and dicamba on dicamba tolerant kochia. Fluroxypyr and dicamba were applied at 20, 39, 79, 157, 314, and 471 g/ha to six accessions of susceptible, medium, and highly tolerant kochia at three plant heights (8 to 28, 29 to 38, and 39 to 61 cm). An untreated control also was included. Kochia control, biomass, and the effect on plant height were determined. Fluroxypyr at 314 g/ha controlled all kochia accessions greater than 80%. Dicamba at 314 g/ha controlled tolerant kochia 25 to 60% and susceptible kochia 74%. Averaged across rates and accessions kochia size at application did not consistently affect control. Fluroxypyr reduced kochia biomass averaged over accessions and heights greater than dicamba only at 39 and 79 g/ha. When averaged across rates and accessions, dicamba reduced kochia biomass of large, medium, and small kochia by 51, 60, and 64%, respectively and fluroxypyr reduced kochia biomass of large, medium, and small kochia by 58, 67, and 68%, respectively. Fluroxypyr reduced kochia height of each accession greater than dicamba. Averaged across accessions dicamba rates of 314 and 471 g/ha were comparable to fluroxypyr at 39 g/ha. Averaged across rates and accessions, dicamba reduced the kochia height of large, medium, and small kochia by 33, 37, and 41%, respectively and fluroxypyr reduced the kochia height of large, medium, and small kochia by 58, 59, and 59%, respectively.

ROTATIONAL CROPPING SYSTEMS TO IMPROVE HARD RED WINTER WHEAT GRAIN QUALITY. Jon C. Stone, Thomas F. Peeper, James T. Sholar, and Roger Gribble, Graduate Student, Professor, and Professor, Department of Plant and Soil Sciences, Oklahoma State University, OK 74708 and Area Agronomist, Oklahoma Cooperative Extension Service, Enid, OK 73701.

Abstract. In Oklahoma, producers of winter wheat are seeking alternative methods of controlling grass weeds and improving economic returns. Experiments were established in North Central Oklahoma at three locations to agronomically and economically compare three crop rotations, each under no tillage and conventional tillage, with eight herbicide programs in each system. The cropping systems initiated included wheat, double-crop grain sorghum; wheat, double-crop soybeans; wheat, double-crop wheat. These experiments were initiated following wheat harvest in June 1999.

Results were averaged over herbicide treatments. Yields of double-crop soybeans were similar in conventional tillage and no tillage plots at two of three sites, with higher yields in conventional tillage at the third site. Yields of double-cropped grain sorghum were greater in conventional tillage than in no tillage at all three sites when averaged over herbicide treatments. At two of the three sites, a single application of glyphosate controlled existing weeds and was adequate for season-long weed control. At the third site, fall panicum emerged after the glyphosate was applied. Conventional tillage greatly reduced the density of cheat present when the wheat was planted.

WEED POPULATION DYNAMICS IN IRRIGATED CROPS UTILIZING VARIOUS WEED MANAGEMENT SYSTEMS. Jason Miller, Philip Westra, and Scott Nissen, Graduate Research Assistant, Professor, and Associate Professor, Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523-1177.

Abstract. An irrigated and a dryland crop rotation sequence was established in 1998 to evaluate four primary weed management systems based on repeated annual herbicide applications compared to systems based on rotation of herbicide mode of action. Crops planted in 1998 were corn and soybeans; 1999 crops were corn, soybeans, and sugarbeets. Conventional herbicides provided variable weed control depending on the crop and the weed complex present. Presence of velvetleaf complicated weed control with some herbicides. Use of soil residual herbicides sometimes resulted in hard-to-manage weed flushes late in the season. Systems built on repeat, early-season weed control generally resulted in best weed control and best crop yields. Weeds that may increase in severity under multiple year treatments based on post-emergence control technology include velvetleaf, toothed spurge, wild buckwheat, and kochia. Higher crop yields generally correlated with better weed control. Georeferenced soil samples taken annually will be used to correlate seedling populations with soil cores from which weed seeds are extracted.

DEVELOPMENT OF ORGANIC MATTER MANAGEMENT ZONES FOR MORE EFFICIENT APPLICATION OF HERBICIDES. Federico Trucco[1], Dawn Wyse-Pester[1], Kim Fleming[1], Lori Wiles[2], and Philip Westra[2], Graduate Students[1] and Professors[2], Bioagricultural Sciences and Pest Management Dept., Colorado State University, Fort Collins, CO 80523.

Abstract. Soil pH, organic matter content and structure all influence herbicide efficacy. Traditional weed control systems consist of uniform herbicide treatments based on the average characteristics of the field. However, the efficacy of the selected herbicide may vary across a field due to the heterogeneity of soil features. Consequently, it could be beneficial to characterize soil features within a field into management zones for herbicide applications. The objective of this study was to evaluate whether varying herbicide rates based on organic matter (OM) affected weed control. A variable rate herbicide treatment was applied next to a uniform herbicide application in six strips in each of two fields in 1998 and 1999. Selected variable rates of metolachlor plus atrazine were applied to specific OM management zones in each variable rate strip. The grower selected and applied the uniform herbicide treatment. For each of the variable or uniform strips, weed seedlings were examined at approximately 100 foot intervals along a transect. Weed seedlings were counted in an 18-cm band over 1.5 m of crop row when the crop was at the 2-leaf stage. Weed seedlings were adequately controlled in the uniform and variable rate strips. There were no significant differences in the efficacy of control for any one weed species at different herbicide rates within the variable treatments ($P>0.4170$). In addition, no significant differences ($P=0.05$) were found for weed counts between the uniform and variable treatments.

DRY BEAN AND SUGARBEET GROWTH IN COLORADO SOILS TREATED PREVIOUSLY WITH BALANCE. Tim D'Amato and Philip Westra, Research Associate and Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523.

Abstract. Several Colorado soils with variable properties were used to evaluate the response of sugarbeet and dry beans to isoxaflutole and its primary metabolite. The soils differed in organic matter, silt, and clay content. Soils were treated with either isoxaflutole or its primary metabolite at four different levels. The crop response varied with soil type. A heavy soil with a high clay content produced crops with little or no damage, while some crop response was noted in a light-textured sandy loam soil. Sugarbeets were more sensitive than dry beans to isoxaflutole and its primary metabolite. Soil properties, herbicide rate, and the specific crop all interact to influence the response of selected crops in soils that have been treated with isoxaflutole.

WEED CONTROL AND SUGARBEET RESPONSE WITH MICRO-RATES OF POSTEMERGENCE HERBICIDES. Stephen D. Miller and Abdel O. Mesbah, Professor, Dept. of Plant Sciences, University of Wyoming, Laramie, WY 82071 and Research Scientist, Northwest Research and Extension Center, Powell, WY 82435.

Abstract. Previous research has indicated that weed control is enhanced when desmedipham and/or phenmedipham is applied in combination with triflusulfuron, clopyralid or oil additives; however, these combination treatments have increased the risk of crop injury. Recent research in North Dakota and Minnesota indicated that the injury risk with these combination treatments became minimal at low rates (micro-rates) while still maintaining acceptable weed control.

Plots were established under furrow and sprinkler irrigation at the Powell and Torrington Research Extension Centers; respectively, in 1997, 1998 and 1999 to compare weed control and sugarbeet response with standard and micro-rate postemergence herbicide programs. Herbicide rates in the micro-rate program were reduced 50 to 75% compared to the standard program and were applied with or without an oil additive (Sun-It) at 1 qt/A. All herbicide applications were made at 7 day intervals at both locations. Broadleaf weed control was slightly less (3 to 7%) and grass control slightly better (5 to 10%) with the micro-rate treatments containing oil compared to the standard rate program without oil. Micro-rate treatments without oil were generally ineffective. Sugarbeet injury was 5 to 10% less in the micro-rate compared to the standard program.

NIGHTSHADE CONTROL IN PINTO BEAN WITH HERBICIDES APPLIED AT REDUCED RATES. Chad A. Ringdahl and Calvin G. Messersmith, Graduate Research Assistant and Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Abstract. Nightshade spp. interference reduces dry edible bean production in the northern United States and Canada. Acifluorfen, fomesafen, imazamox, imazethapyr and lactofen provide good control of nightshade in soybean. Field experiments were conducted in 1999 near Oakes and Wyndmere ND, to evaluate the effectiveness of these herbicides at reduced rates for hairy nightshade control in pinto bean. The first application of two and three split treatments was applied to 2- to 4-leaf nightshade. Subsequent treatments were applied when 90% of nightshade had 2 to 4 leaves. Single application treatments were applied to 6- to 8-leaf nightshade. All treatments were applied with methylated seed oil at 1.5% v/v. Visual evaluations of nightshade control and crop injury were made 7 days after each application. All treatments except acifluorfen provided 96% or better nightshade control. Acifluorfen provided 81-90% control. Acifluorfen, fomesafen and lactofen controlled nightshade in 3- to 5-days. Imazamox and imazethapyr controlled nightshade in 7- to 10-days. Although, acifluorfen, fomesafen and lactofen also caused greater pinto bean injury. Crop injury increased with multiple applications of acifluorfen, fomesafen and lactofen, whereas less injury was observed with multiple applications of imazamox and imazethapyr. All treatments reduced the number of physiologically mature pods by 6%, but these reductions did not affect seed yield.

DRY BEAN TOLERANCE TO HERBICIDES. Scott A. Fitterer and Richard K. Zollinger, Research Specialist and Associate Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105-5051.

Abstract. Multiple experiments were conducted in eastern North Dakota to evaluate dry bean tolerance to herbicides. Dry bean varieties were planted between May 26 thru June 7, 1999. Several dry bean types and varieties were used in these studies including: 'Maverick' and 'Remington' (pinto), 'Frontier', 'Navigator', and 'Agri-1' (navy), 'T-39' and 'Shadow' (black), and 'Cal Early LRK' and 'Montcalm' (kidney). Treatments were

applied with a bicycle-type-wheel sprayer delivering 17 gpa for soil applied and 8.5 gpa for foliar applied at 40 psi through 8002 (soil) and 8001 (foliar) flat fan nozzles. Experiments were randomized complete block designs with four replicates and 10 by 40 foot plots.

Sulfentrazone rates of less than 0.25 lb/A preplant incorporated or less than 0.188 lb/A preemergence provided excellent dry bean safety. Rates of flumioxazin less than 0.047 lb/A preplant incorporated of less than 0.031 lb/A preemergence provided excellent dry bean safety. Flumetsulam plus ethalfluralin rates of less than 0.046 + 0.94 lb/A preplant incorporated were safe in 1999. Some varietal differences were found with sulfentrazone, flumioxazin, and flumetsulam plus ethalfluralin.

Rates of San582H less than 1.97 lb/A and San582H a-isomer less than 1.13 lb/A preplant incorporated and preemergence provided excellent dry bean safety. San582H at rates less than 1.97 lb/A and San582H a-isomer at less than 0.56 lb/A to unifoliate dry bean and San582H at 1.03 lb/A at 1- to 3-trifoliate dry bean stage provided excellent dry bean safety. No varietal or yield differences were found with either San582H or San582H ∝-isomer.

Fomesafen rates less than 0.25 lb/A alone or 0.188 lb/A tankmixed with imazamox or bentazon applied at 1 to 2 trifoliate dry bean stage provided excellent dry bean safety. No varietal differences were found with fomesafen. Rates of imazamox less than 0.032 lb/A at 2- to 4-trifoliate dry bean stage provided excellent dry bean safety. No varietal, bean type (navy, pinto, black and kidney) or yield differences were found with imazamox.

With proper rates and application timing of sulfentrazone, flumioxazin, San582H, San582H a-isomer, fomesafen and imazamox have excellent potential for use in dry bean. In previous years injury has been variable for flumetsulam ranging up to 35%.

EFFECT OF GLUFOSINATE, GLYPHOSATE, AND PARAQUAT HARVEST AIDS FOR DESICCATION OF WEEDS AND DRY BEAN. Robert G. Wilson, Professor, University of Nebraska, Scottsbluff, NE 69361.

Abstract. Field experiments were conducted at Scottsbluff, NE in 1997, 1998, and 1999 to compare herbicides for reducing the moisture content of weeds and dry bean. Herbicides were applied when either 5, 30, or 80% of the seed pods had turned yellow. Two dry bean market classes; great northern and light red kidney were examined. The moisture content of weeds, dry bean plants, seed pods, and seeds were monitored 0, 5, 10, and 15 days after treatment, and crop seed yields were determined at harvest. The application of glufosinate at 0.49 kg/ha, glyphosate at 0.84 kg/ha, and paraquat 0.56 kg/ha when dry bean had 5% of the seed pods yellow, reduced plant, pod, and seed moisture 15 days after treatment compared to an untreated control. However, herbicides applied when 5% of the pods were yellow interrupted the natural maturation of the plant and caused seeds to shrivel, which resulted in a reduction in seed size and yield. If herbicide application was delayed until 80% of the seed pods were yellow, seed yields were not reduced but plant desiccation was not enhanced by herbicides. Applying paraquat late in the afternoon compared to early morning or at 54 L/ha instead of 190 L/ha improved the effectiveness of the herbicide. Paraquat reduced hairy nightshade plant moisture 26% compared to the untreated control, 15 days after treatment but had no effect on hairy nightshade berry moisture or the percent berries in harvested dry beans.

INTERFERENCE OF BIENNIAL WORMWOOD IN SOYBEAN. Eric A. Nelson and George O. Kegode, Graduate Research Assistant and Assistant Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Abstract. Biennial wormwood is a weed that has recently become problematic in soybean and dry bean in the Northern Great Plains, because it is tolerant to many herbicides commonly used for weed control in these crops. A

field experiment was conducted in 1999 to evaluate the competitiveness of biennial wormwood in soybean as influenced by duration of interference. Biennial wormwood density was 8 plants m^{-1} of soybean row. The durations of interference were 0 to 10 weeks and season-long. Biennial wormwood did not reduce soybean yield until after 7 weeks of interference. The period of most rapid yield loss due to biennial wormwood interference occurred in a 2 week period from the beginning bloom (R1) soybean stage to full pod (R4) soybean stage. In this short period, soybean yield dropped from 2760 kg ha^{-1} to 1940 kg ha^{-1}. At 6 weeks of competition, biennial wormwood dry weight exceeded 2300 kg ha^{-1} and reduced soybean yield by more than 18% compared to the weed-free control. Once 2320 kg ha^{-1} of biennial wormwood biomass was produced, the soybean seed yield dropped rapidly from 2760 kg ha^{-1} to 1600 kg ha^{-1}. Therefore, biennial wormwood should be removed from soybean within the first six week 6 weeks of the crop growing season to minimize yield loss.

WEED CONTROL IN GLYPHOSATE-TOLERANT POTATOES. Pamela J. S. Hutchinson[1], Mark J. Pavek[2], Dennis J. Tonks[1], and Charlotte V. Eberlein[3], Assistant Professor, Research Agronomist, Postdoctoral Research Assistant, and Professor, [1]Department of Plant, Soil and Entomological Sciences, University of Idaho, Aberdeen, ID 83210; [2]NatureMark Potatoes, Boise, ID 83706; and [3]District III Cooperative Extension, University of Idaho, Twin Falls, ID 83303.

Abstract. Replicated field studies were conducted to evaluate weed control, crop response and tuber yield in glyphosate-tolerant potatoes at two 1999 trials located in Aberdeen, ID and Ephrata, WA. Treatments common to both locations consisted of a weedy check, a hand-weeded check, sequential applications of 0.375 + 0.375, 0.56 + 0.56 or 0.75 + 0.75 lb/A glyphosate applied early postemergence plus just prior to potato row closure, or glyphosate at 0.75 lb/A plus metribuzin at 0.38 lb/A applied early postemergence. Two additional treatments were included at the Washington location; glyphosate at 0.75 lb/A applied early postemergence, or just prior to row closure. A treatment of rimsulfuron at 0.023 lb/A plus metribuzin at 0.38 lb/A early postemergence was included at the Idaho location. All herbicide treatments included 0.25% v/v non-ionic surfactant. Weeds common to both locations were redroot pigweed, common lambsquarters, hairy nightshade, and green foxtail. Idaho broadleaf weed densities were 70 to 90 plants/m^2 and green foxtail density was 9 plants/m^2 compared to Washington location weed densities of less than 1 plant/m^2. Redroot pigweed and common lambsquarters control was not significantly different between locations or herbicide treatments, and all herbicide treatments provided 99 to100% control of these two weeds late-season.

Late-season hairy nightshade and green foxtail control was significantly different between locations, and therefore, locations were analyzed separately for these weeds. Idaho hairy nightshade control provided by sequential applications of 0.375, 0.56, or 0.75 lb/A glyphosate was 97, 96, or 100% by late season, and did not differ among treatments. Season-long Idaho hairy nightshade control resulting from glyphosate plus metribuzin or rimsulfuron plus metribuzin early postemergence was 93 and 91%, respectively, and was significantly less than control resulting from sequential glyphosate treatments. In Washington, the single application of glyphosate applied early postemergence resulted in 63% late-season hairy nightshade control, which was significantly less than the 98% control achieved with the single glyphosate application made just prior to row closure and the 100% control provided by all other herbicide treatments. All Washington herbicide treatments provided 100% green foxtail control. At the Idaho location, rimsulfuron plus metribuzin early postemergence and the three sequential glyphosate treatments resulted in 96 to 100% green foxtail control, which was significantly different than the 94% foxtail control provided by glyphosate plus metribuzin applied early postemergence.

Kochia and tame oats were present only at the Idaho location. All three sequential glyphosate treatments and the glyphosate plus metribuzin early postemergence treatment resulted in 97 to 100% kochia control, which was significantly different than the 92% control resulting from rimsulfuron plus metribuzin early postemergence. The 0.75 + 0.75 lb/A glyphosate sequential treatment provided 100% tame oat control, which was significantly different than the 94 to 97% control provided by the other herbicide treatments.

No crop injury was observed as a result of glyphosate treatments. Tuber yields were significantly different between locations. In the Idaho trial, all herbicide treatments and the hand-weeded check had higher U.S. No. 1 and total tuber yields than the weedy check. Glyphosate at 0.75 + 0.75 lb/A applied sequentially resulted in significantly greater U.S. No. 1 and total tuber yields than rimsulfuron plus metribuzin applied early postemergence. There were no significant differences in U.S. No. 1 and total tuber yields among the other herbicide treatments.

In Washington, U.S. No. 1 yields in the hand-weeded check, and in all herbicide treatments except the single glyphosate treatment applied just prior to row closure, were higher than U.S. No. 1 yields in the weedy check. Total tuber yields in the hand-weeded check and all herbicide treatments were higher than total tuber yield in the weedy check in Washington. These results suggest that even low populations of weeds allowed to grow until just before row closure may interfere with the potato crop and lower tuber yield. The hand-weeded check plots yielded significantly more U.S. No. 2 potatoes than the weedy check and the herbicide treatments in Washington, suggesting that disturbance from hoeing and hand weeding may have caused slight tuber malformations.

SULFENTRAZONE AND FLUMIOXAZIN FOR BROADLEAF CONTROL IN POTATOES. Dodi E. Kazarian, Scott J. Nissen, and Asunta L. Thompson, Graduate Student and Associate Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO, 80523, and Assistant Professor, Department of Horticulture, Colorado State University, San Luis Valley Research Center, Center, CO 81125.

Abstract. Weed control in potatoes is based primarily on tillage and pre-emergent herbicides that are applied after the last tillage operation. Nightshades are the most common weed problems and are especially difficult to control due to their close taxanomic relationship with potatoes. Sulfentrazone and flumioxazin have demonstrated activity on nightshades and preliminary research indicates some selectivity in potatoes. Two field experiments were conducted in the summer of 1999 to establish sulfentrazone and flumioxazin efficacy, potential tank-mix partner, and potato varietal response. Sulfentrazone was applied at several rates, alone and in combination with S-metolachlor and pendimethalin, while flumioxazin was applied alone and in combination with S-metolachlor. These treatments were compared to standard potato treatments. Sulfentrazone and flumioxazin both provided excellent hairy nightshade, redroot pigweed, and common mallow weed control in potatoes with no crop response. The total yields of all treatments were comparable to the handweeded controls. Low rates of sulfentrazone, flumioxazin, and metribuzin in combination with S-metolachlor performed the best with low phytotoxicity, excellent weed control, high yields, and high USDA#1 grading percentages. Sangre, Chipeta, Russet Norkotah, and Russet Nuggets were used to evaluate cultivar response. Sulfentrazone was applied at 0.14, 0.21, and 0.28 kg ha^{-1} and flumioxazin at 0.035, 0.053, and 0.07 kg ha^{-1}. Sulfentrazone treatments resulted in 35% and 13% phytotoxicity to Sangre and Chipeta varieties, respectively, however, this injury did not result in yield loss. Sulfentrazone treatments had no significant response to other cultivars and flumioxazin treatments were safe on all the cultivars.

WEED CONTROL IN POTATO. S. M. Oltmans, R. K. Zollinger, and S. A. Fitterer, Graduate Research Fellow, Associate Professor, and Research Specialist, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Abstract. Effective weed control in potato requires the use of herbicides; however, herbicides have a limited range of rates in potato. Too little herbicide results in reduced weed control, and too much herbicide may injure potatoes. This research was conducted to determine herbicide efficacy of pre- and post-emergence herbicides and reduced

rates, and to evaluate herbicide safety on potato. Among the herbicides registered for use in ND on potato, EPTC, metribuzin, pendimethalin, metolachlor, rimsulfuron, and sethoxydim, were included in this experiment. Additional herbicides, dimethenamid, clethodim, and sulfentrazone, were also included.

'Russet Burbank' potato was planted May 25, 1999 near Glyndon, MN. Visible evaluation of foxtail, kochia, redroot pigweed, common lambsquarters, and common ragweed control were taken 10 and 30 days after application. Rimsulfuron provided good foxtail control, metribuzin plus EPTC provided fair control, and sulfentrazone provided poor to fair control, while all other treatments provided excellent control. All broadleaf treatments with the exception of metribuzin and metolachlor provided excellent kochia control. Metolachlor was the only broadleaf herbicide treatment with less than excellent control in redroot pigweed and common lambsquarter. All broadleaf herbicide treatments had excellent ragweed control. Reduced rates of sulfentrazone and clethodim were effective in controlling weeds.

Crop injury ratings were taken 10 days after application. Injury occurred due to Colorado potato beetle feeding on potatoes treated with sulfentrazone. An interaction between sulfentrazone and imidacloprid inhibited imidacloprid from controlling beetles. There was decreasing effectiveness of beetle control with increasing rates of sulfentrazone causing beetle damage to the plant.

WEED CONTROL AND ECONOMICS OF GLUFOSINATE RESISTANT CORN FOR WILD PROSO MILLET MANAGEMENT. Kevin B. Kelley, John O. Evans, and R. William Mace, Graduate Research Assistant, Professor, and Research Technician, Department of Plants, Soils and Biometeorology, Utah State University, Logan, UT 84322-4820.

Abstract. Wild proso millet is a serious weed problem in corn production. It is naturally tolerant to many corn herbicides and can seriously reduce yield. The development of glufosinate resistant corn hybrids provides an alternative control option. However, the economic feasibility of glufosinate resistant corn hybrids has been questioned. To evaluate the effectiveness and economics of glufosinate resistant corn for the control of wild proso millet, field studies were conducted at locations with wild proso millet infestations. Glufosinate was applied at the 3-leaf, 5-leaf and 7-leaf stages of weed growth as well as in split applications. Other postemergence herbicides included nicosulfuron and a premix of nicosulfuron, rimsulfuron, and atrazine. Preemergence herbicides included acetochlor, isoxaflutole and metolachlor applied alone or in sequential applications followed by either nicosulfuron or glufosinate. The greatest weed control was achieved by glufosinate following any of the three preemergence herbicides, glufosinate applied at the 5-leaf stage or the 7-leaf stage or split into two applications and the premix of nicosulfuron, rimsulfuron, and atrazine. However, glufosinate applied at the 7-leaf stage resulted in a lower corn yield due to weed competition prior to treatment. Not including glufosinate applied at the 7-leaf stage, the above treatments were also the most profitable. The higher cost of glufosinate resistance technology is justified in corn with heavy wild proso millet infestations. However, in corn with lighter wild proso millet infestations, a premix of nicosulfuron, rimsulfuron and atrazine may be more appropriate due to reduced input costs.

WEED CONTROL AND COST ANALYSIS COMPARISON OF WEED MANAGEMENT SYSTEMS IN CORN. Joel S. Lee and Stephen D. Miller, Graduate Assistant and Professor, Department of Plant Science, University of Wyoming, Laramie, WY 82071.

Abstract. Development of transgenic technology has led to alternative weed control options such as the use the non-selective herbicides glyphosate and glufosinate in corn. Irrigated field trials were conducted at the Research and Extension Center, Torrington, Wyoming with five different corn varieties in 1998 ranging from 89 to 102 days

relative maturity and at Torrington and Pine Bluffs, Wyoming in 1999 with varieties ranging in relative maturity from 99 to 101 days. Varieties planted were standard, sethoxydim resistant, glyphosate resistant, imidazolinone tolerant, and glufosinate resistant. The objectives of the experiment were to compare weed control and economic returns from the five different systems. Plots were 10 by 20 feet and replicated four times. Each system was treated with chemicals having chemistry corresponding to resistance for the variety in the system. Treatments were applied as recommended by the herbicide labels. Excellent weed control was achieved in both years with the glyphosate and imidazolinone treatments. Treatments of glufosinate and standard origin were intermediate providing good control in both years. In 1998 sethoxydim resistant treatments were the least effective; however, in 1999 sethoxydim treatments, excluding sethoxydim alone, provided excellent control. All treatments had significantly higher yields than the untreated controls both years. Due to high weed pressure grain yields in 1998 were closely correlated to weed control with glyphosate treatments yielding the highest and sethoxydim treatments yielding the lowest. Less weed pressure in 1999 caused yield differences to be related more to variety differences than to weed control.

FLUROXYPYR RATES AND TIMING IN CORN. Troy M. Price, Phillip W. Stahlman, and Patrick W. Geier, Assistant Scientist, Kansas State University Northwest Research Extension Center, Colby, KS 67701 and Assistant Scientist and Professor, Kansas State University Agricultural Research Center, Hays, KS 67601.

Abstract. Experiments were conducted in 1999 at Hays to determine the effects of fluroxypyr rate and timing compared with dicamba on kochia control, corn tolerance, and grain yield. Plots were treated on April 29 with metolachlor to reduce annual grass pressure. Two weed species, kochia and puncturevine, were present in the plots and evaluated for control. Corn was planted on April 30. Herbicides were applied at three corn maturity timings; corn at 2 to 4 inch height, corn at 4 to 6 inch height, and corn at 6 to 10 inch height. Three rates of fluroxypyr; 0.125, 0.187, and 0.25 lb/A and one dicamba rate; 0.25 lb/A were used alone and also tank mixed with atrazine at 0.5 lb/A. Dicamba at 0.25 lb/A controlled kochia and puncturevine better than fluroxypyr at 0.25 lb/A and tank mixing either herbicide with atrazine at 0.5 lb/A enhanced weed control and improved corn yield. Herbicide by timing interactions occurred for kochia and puncturevine control for each evaluation. Fluroxypyr did not provide adequate control for either species at the 0.125 and 0.187 lb/A rates. Later applications also had greater weed control. Tank mixing either herbicide with atrazine improved weed control as well. Corn receiving treatments without atrazine appeared slightly stunted and mature corn plants were shorter than the plots with atrazine added probably due more to weed competition than actual herbicide effects. When averaged over application timing, which was not significant, corn treated with dicamba at 0.25 lb/A or fluroxypyr at 0.125 or 0.187 lb/A without atrazine yielded less than corn receiving other treatments.

WHY RPA 2011772 INJURED CORN IN NEBRASKA IN 1999. Gail A. Wicks, Robert G. Wilson, Robert N. Klein, Steve Knezevic, Fred W. Roeth, and Alex R. Martin, Extension Weed Specialist, North Platte, NE 69101; Extension Weed Specialist, Scottsbluff, NE 69361; Extension Cropping Systems Specialist, North Platte, NE 69101; Extension Weed Specialist, Concord, NE 68728; Extension Weed Specialist, Clay Center, NE 68933; and Extension Weed Specialist, University of Nebraska, Lincoln, NE 68516.

Abstract. RPA 2011772® is the trade name for Balance® and isoxaflutole is the proposed common name. RPA 2011772 caused corn injury to about 15% of the 850,000 Acres of corn treated preplant or preemergence in Nebraska in 1999. RPA 2011772 was applied on loamy sand to clay loam soils across Nebraska. Organic matter content ranged from 0.8 to 4% and pH from 5.6 to 8.2. Injury was associated with many factors or combinations of factors. These included rate, calibration, application errors, soil type and associations, soil condition, seed bed preparation, soil compaction, planting depth, depth of soil coverage over the seed, rainfall and/or irrigation before

and after planting, weather factors, organic matter, pH, hybrid susceptibility, water saturated soils, soil temperature, growing degree days (GDDs), corn seedling vigor, combination with other herbicides, cloudy vs. sunshine, and soil fertility. Employing better mixing and application techniques and crop management practices would have greatly reduced the RPA 2011772 complaints.

Acres and location of crop response. About 8.5 million A of corn were planted between April 10 and June 25 in Nebraska. RPA 2011772 was applied to about 850,000 A in 1999 with the most acres treated in southwest Nebraska. Fifteen percent of the fields exhibited crop response from RPA 2011772. This response included bleached corn on overlaps, starting up at the ends of fields, and any other areas affected by RPA 2011772. Actual crop loss occurred on about 5 to 6% of the acres. RPA 2011772 plus flufenacet (sold as Epic®) was also used in Nebraska. This includes all injury symptoms.

White corn plants in fields treated with RPA 2011772 began to appear in fields during the last week in May and the first 10 days of June in western, southwest, west-central, and northeastern Nebraska. Most of the acres injured by RPA 2011772 came from southwestern Nebraska. Soils in this area and in the Panhandle are lower in organic matter and higher in pH than in eastern Nebraska. Injury in center pivot fields was most noticeable on hilly ground where the hill tops were eroded exposing the clay subsoils containing low organic matter and high pH or soil was moved to level areas in the field. Corn injury in furrow-irrigated fields was greater in areas that were leveled. Fields with variable soil types often exhibited extreme differences in RPA 2011772 response. Injury generally varied from none on fine-textured soils to slight on medium-textured soils to severe on coarse-textured soils. Largely this was because one rate was used across the entire field. Injury was also visible in other fields, especially on the ends of fields and overlaps. Injury was also found on silt loams with 4% organic matter and high pH. Most corn injured by RPA 2011772 recovered quickly. By June 25, 1999 most corn recovered in color, but severely injured fields lost plants and/or corn height was variable until corn tasseled. At North Platte, it took 6 weeks for corn to recover in height after planting in one of seven experiments, however, corn stand and yield were not affected. In some fields, tasseling was delayed 1 to 3 weeks. In some years this delay in tasseling could reduce grain yields because of early frost. The opposite effect may also occur.

Factors that may have resulted in RPA 2011772 injury. One or more factors caused RPA 2011772 injury to corn in each field that had a response. These include rate, soil type, organic matter, pH, planting depth (seed coverage), seed furrow closure, hybrid susceptibility, calibration, application errors, soil condition, rainfall or irrigation, time and amount of rainfall or sprinkler irrigation, water saturated soils, cloudy vs. sunshine, soil temperature, GDD's, corn seedling vigor, combination with other herbicides, seed safeners, soil compaction, and low soil fertility. No doubt that interactions occurred among the factors. Injury in some fields was severe enough that corn was replanted.

Rainfall. Corn planting in Nebraska began about mid-April. The worst corn injury was from fields planted between May 5 and May 25. In addition, the numerous cloudy days during this period may have reduced the corn's ability to metabolize RPA 2011772. The amount of rainfall was above normal in 1999. Most of the rain was received after May 5. Some areas received 4 inches above normal and some received 12 inches in a month after planting. The GDD's for 1999 was below normal during the rainy period.

A definite pattern existed between rainfall amount and when the event occurred in relation to planting. Areas with less rain had less injury on similar soils. The corn injury symptoms appeared as follows: the first two to three leaves of the corn plant were green. Then after receiving 1.5 to 2 inches of rain in one day, then the fourth and fifth leaves turned white, and the newest leaves (six and seven) were green. The fact that the sixth and seventh leaves were green indicates that the plants were recovering from the injury. Probably new roots were below the RPA 2011772. Sometimes in other fields, the sixth and seventh leaves were white and the eighth leaf was green. By closely examining these unusual plants, one can conclude when the heavy rainfall occurred relative to the plant growth stage (hence prior to the 4-leaf stage). Plants where all leaves remain white usually died. Probably rain occurred before emergence and the seeds must have been exposed to high concentrations of RPA 2011772. This indicates that the amount of rainfall and timing plays an important role for potential injury because RPA 2011772's metabolites are highly soluble in water. Also, they may not be adsorbed to soil colloids and organic matter which would cause more problems in some soils.

On marginal soils, sprinkler irrigation should be avoided for at least 10 days after planting when rain is forecast. Water saturated soils increase the chances of RPA 2011772 injury.

Soil types. The pattern of crop response from RPA 2011772 followed Nebraska soil and long-term precipitation and GDD maps. Crop response on fine-textured soils low in pH (<7.0) and high organic matter content (>2.5%) in much of southeastern and south-central Nebraska was virtually nil compared with soils with coarser-textured and lower organic matter in southwestern Nebraska and north of the Platte River. All of these soils have well defined "A" horizons, but differ in organic matter, pH, cation exchange capacity (CEC), and percent clay, silt, and sand. Soils in southeastern and south-central Nebraska have higher organic matter and lower pH because of more precipitation over centuries. The GDD relationship probably relates to more time to produce more humus in the soil. If injury occurred on these soils, it was from application errors, planting to shallow, not covering the seed with sufficient soil, or severely eroded soils.

Fifty-two soil samples from 26 fields were taken by University of Nebraska and Rhone Poulenc personnel from fields that showed differences in crop response to RPA 2011772 as influenced by soil type. Four samples were taken in the injured and four in the uninjured areas. The sub-samples were combined and analyzed by Olsen's Agricultural Laboratory in McCook for pH, organic matter, etc. The fields were planted the same day with the same hybrid. This eliminated some of the potential factors that may influence RPA 2011772 injury, such as hybrid sensitivity, rate, rainfall, method of planting, etc.

The soil analyses' data were pooled into different ranges within each category. High r^2 values indicate those soil factors that fit closely with RPA 2011772 injury. These are as follows: CEC ($r^2 = 0.97$), organic matter ($r^2 = 0.93$), pH ($r^2 = 0.87$), percent silt ($r^2 = 0.49$), percent clay ($r^2 = 0.32$), and percent sand ($r^2 = 0.01$). It was surprising that percent sand correlation was so low. However, the crop response of RPA 2011772 from these soil characteristics is more complicated than one factor. Two or more of these factors also determine the extent of crop response. For example, corn on loamy sand had less crop response to RPA 2011772 than corn growing on a sandy loam. Normally, greater crop response is expected to corn growing on loamy sand than the sandy loam. However, in the areas we sampled, seven of nine loamy sand soil samples had pH's of 5.6 to 6.3 compared with 6.1 to 8.2 for the sandy loam soils. Four of the nine sandy loam sample sites had pH's of 7.8 to 8.2.

Seedbed preparation and planting method. A relationship of RPA 2011772 injury to corn and seedbed preparation existed. The injury complaints could be separated into two groups -- seedbed prepared by tillage or no-till. Corn in the no-till fields were planted into corn, grain sorghum, soybean, sunflower or winter wheat residues. Fields that were tilled had the most injury. This was probably because they were planted when the surface soil was wet. Many of the no-till fields were planted before the rain when soil surfaces were dry and/or RPA 2011772 was applied preplant. Some no-till fields planted and treated with RPA 2011772 after the rains began were injured because of poor soil closure over the row.

Ecofallow corn consistently had less injury than no-till planted in corn, grain sorghum, soybean, or sunflower residues. Ecofallow consists of applying herbicides after winter wheat harvest with herbicides and planting corn with a no-till planter the following spring. Herbicides were applied preplant or preemergence. Normally, more injury would have been expected in ecofallow because the soils are wetter and cooler than tilled ground. The wheat residues insulate the soil and reduce water evaporation. The wheat residues probably intercepted some of the RPA 2011772 and slowed the release of the herbicide. In 1999, many of the preplant-treated fields were planted before the rain, thus avoiding poor coverage of soil over the seed row. The extra time allowed for degradation and movement of RPA 2011772 into the soil by rainfall and/or some soil containing chemical was removed from the row during planting. Only one severe injury report was received in ecofallow corn planted in areas of a field that had sandy loam. Injury was observed in eroded areas and where soil was removed to build terraces. Experienced ecofallow farmers know that corn cannot be planted shallow or the corn will lodge. Symptoms look like corn rootworm damage. Another big factor is that fields that have been in ecofallow for a few years have lower pH because of higher nitrogen use and reduced tillage operations. This would greatly reduce the chances of RPA 2011772 injury.

Planting depth, covering depth, and seed furrow closure. Surface soil conditions varied at planting time because of rain in 1999. In many fields that had corn injury, corn was covered with less than 1.5 inches of soil. Some was as shallow as 0.5 inches. However, planting too deep was also a problem. In one field corn planted deeper than 1.5 inches was damaged more. Plants that came from seeds 1.25 inches deep were yellow, at 2.0 inches they were white and yellow stripped, and seedlings at 2.5 inches were white and almost dead. In another field, plants were dead when seeds were covered with only 0.5 inches of soil. In another field, the plants from seeds planted at 2.5 inches deep were either not damaged or were injured severely. Of three plants removed; one plant was 13-inches tall, one was 4 inches, and the other was dead. All seeds were covered with 2.5-inches of soil. This may have been due to poor seedling vigor in cold wet soil or presence of a few self-pollinated seeds.

Wet soils introduced another factor. When soils are too wet to allow good soil flow from the covering discs, planter depth and openers should be adjusted to meet the soil conditions. The planter should be checked for covering depth of seeds in each field. Injury was greater on soils that had high pH, low organic matter, and were eroded.

Weight of the tractor and planter filled to capacity of seed, fertilizer, and herbicides also was responsible for causing RPA 2011772 injury. When fully loaded the planter placed the kernels deeper into the soil, as the planting proceeded seed, fertilizer, and herbicides were used and planting depth became shallower. This resulted in more corn injury. Upon refilling the cycle was repeated. All planters may not react in this manner. Faulty hydraulic system also has caused planter to be lifted while moving and reduce planting depth. This lead to increased RPA 2011772 injury.

Planters' furrow openers also was a contributing factor as in some instances one or more rows had more injury than others as depth of corn seeds varied as much as a half an inch.On a Platte loam, corn injury occurred on one row when a corn stalk prevented the planter unit from lowering, thus reduced planting depth from 2 inches to 1 inch. In some fields more corn injury was from deeper planting depths. Planting corn into a depression created by the furrow openers could also contribute to increased injury if a heavy rain occurred after planting. It appeared that the ridges next to the row were flattened out and the additional soil containing RPA 2011772 was silted over the row by intense rain.

Mixing and application errors. More injury appeared to be associated with applications made by farmers than commercial applications. This was related to application and mixing errors. Several fields showed injury in small defined areas. These were associated with the starting and stopping the planter equipped for band or broadcast application or sprayer alone. As soon as the sprayer began to apply the herbicide severe injury occurred, then injury decreased gradually as more of the poorly suspended RPA 2011772 was applied until no injury was observed. Each time the sprayer was refilled injury occurred. This was caused by failure to get the RPA 2011772 into suspension. The reverse of this was also seen. Injury was worse as the tank was emptied. Also, some sprayer tanks do not have sufficient agitation capacity to keep RPA 2011772 in suspension; RPA 2011772 needs to be presoaked or pre-slurried well before adding to the spray tanks. A strainer should be used to intercept granules that are not dissolved. These need to then be dissolved and added to the spray solution. Another pattern was also observed. Stopping the planter when banding or reducing speed when starting or stopping the sprayer at the ends of the field also caused over application and killed corn. This was caused by overlapping when turning around, turning the sprayer on before moving the planter, not using check valves in nozzles, and compacted soil from vehicle traffic. Seed coverage with soil in compacted areas was less, thus more injury. Turning around at the ends of fields with wide booms sometimes left severely damaged plants even though booms were equipped with no-drip systems.

More chlorotic corn was observed with sprayer going uphill than traveling downhill which was the result of rate changes due to decreasing or increasing ground speed. After three weeks the corn recovered when the sprayer was going down hill, but not up hill. A week later, all corn was green. Overlaps were visible in some fields but not in others. However, corn in some fields that accidentally received a 2X rate from an error in rate calculation or double spraying was not injured.

Banding vs. broadcast applications. Properly set and calibrated banding equipment produced similar results as broadcast applications. However, banding caused more crop injury than broadcast applications in some areas because of four reasons. First, the band width was measured when the planter was out of the ground. This has caused a 20% increase in herbicide rate when planter was placed in the ground due to narrowing the band width. The second reason was using broadcast flat-fan spray tips instead of even-flow tips. The even-flow tips are used for band application because they apply the same amount over the entire spray pattern. Broadcast flat-fan nozzle tips have tapered edges and apply more herbicide solution in the center. Flat-fan tips deposit twice as much herbicide in the center of the tip compared with the outside edge. Third, worn even-flow tips also may deposit more herbicide in the center of the band. Fourth, even-flow tips may collect herbicide residues that distorts the spray pattern and gives them a pattern like a broadcast flat-fan tip. After the spray tip was cleaned with a nozzle cleaning brush the even-flow pattern returned. In a couple of fields that were banded the injury pattern was erratic. Injury symptoms would vary within and between rows. This may be due to different outputs among tips and/or different depths of soil covering the seeds. Another problem occurred when rate controllers were used. At lower pressures the pattern was reduced as much as 30% of the width of the original band. The lower pressure is a result of slowing down on ends of fields, going up hill, or the tips becoming worn which would increase the flow rate.

In some fields that were banded with RPA 2011772, the band width was wider than the original applied band width. These fields were planted with furrow openers set just deep enough to remove plant residues and clods of soil. Intense rain apparently moved the herbicide laterally and controlled weeds outside the area originally treated. The rate over the row would be decreased, thus reducing risk of herbicide injury.

Hybrids and seed safeners. Most of the corn injury was caused on high pH low in organic matter soils. Growers try and plant hybrids that are more pH tolerant on these soils. However, some hybrids that are not pH tolerant are planted on high pH soils. The question arises if injury occurs on high pH soils is the hybrid sensitive to pH or is it RPA 2011772 that causes bleaching? The RPA 2011772 rate was probably too high on many of these soils. Golden Harvest and Pioneer Hi-Bred International Inc. have RPA 2011772 tolerance information available for their hybrids.

Reduction of rates would reduce RPA 2011772 injury, but then weed control on some weed species, especially grasses and common cocklebur, may be poorer in more normal rainfall years. Combinations with other herbicides will be needed to control the entire weed spectrum in many fields.

Some farmers reported different hybrids planted the same day in the same field responded differently to RPA 2011772. Example, a farmer planted 'Pioneer 33G-26', 'AsGrow 771', and 'AsGrow 730' hybrids on the same day in the same field and treated with RPA 2011772. Seven days after planting it rained 1.5 inches and Pioneer 33G-26 was bleached and stand density was reduced while the other two hybrids were not injured. Even if RPA 2011772 was applied correctly, susceptible hybrids can sometimes be severely damaged. In another farmer's field Pioneer 33G-26 corn was bleached and reduced corn stand where herbicide overlap occurred, but 'Pioneer 3489' and 'Pioneer 34R07' were not affected by overlap of the sprayer swath. It was also observed that 'Pioneer 22A14' was also bleached in overlaps. Pioneer HiBred International suggests that all four of these hybrids require careful management to avoid injury when using RPA 2011772. This includes reducing RPA 2011772 rates and eliminating overlaps. Also one should consider not using RPA 2011772 on sensitive hybrids on some soils.

At Scottsbluff, some seed safeners reduced corn injury from RPA 2011772. In 1996, acetochlor tank-mixed with RPA 2011772 reduced corn injury compared with the metolachlor tank-mix. In 1998, acetochlor formulations tank-mixes with RPA 2011772 had less corn injury than Axiom® or metolachlor tank-mixes with

RPA 2011772. However, in 1997, no difference was observed among herbicide treatments because only 0.5 inches of rain occurred in the first 10 days after planting (DAT). The rainfall in 1996 was 1.0 inch during the first 10 DAT and in 1998 1.2 inches occurred within 10 DAT. The hybrid used in these experiments was Pioneer 3751 IR, a hybrid that Pioneer Hi-Bred International Inc. suggests that careful management is required when using herbicides that are pigment inhibitors. The seed safener in FulTime, Surpass, and Surpass 100 also appeared to reduce RPA 2011772 injury in farmer fields. Avoid using dicamba or 2,4-D with RPA 2011772 because of increased injury potential.

Seedling vigor also may have been a factor in increasing injury as weak plants probably took up more RPA 2011772. Some growers replanted their corn because of poor emergence due to the lack of cold-tolerant seed. The corn fields were not treated with RPA 2011772.

Other considerations. In 1999, yellow corn plants occurred in many fields due to iron chlorosis caused by high pH soils not treated with RPA 2011772. These symptoms are referred to as "Platte Valley Yellows" and occurred in fields treated or not treated with any herbicides each spring. Chlorotic corn in fields in the creek and river valleys was especially bad under cold, cloudy, and wet conditions that existed in 1999. Usually the same fields exhibit these symptoms every year unless planted with a more pH-tolerant corn hybrid. Some hybrids do not tolerate high pH soils.

Lasting effects of RPA 2011772 injury. By July 15, the severely injured plants still were shorter, giving the fields an uneven appearance. Crop consultants reported more western bean cutworm eggs were found on plants that were delayed in maturity by RPA 2011772. The threshold levels were high enough that the damaged areas had to be treated with an insecticide. Some injured areas also showed more damage from second and third generation corn borers. These insects prefer to lay their eggs on less mature corn plants. RPA 2011772 injury delayed silking and made the silking plants more attractive to the corn rootworm beetles which clipped off the silks. These ears were not filled out as well as corn that was not injured. One farmer that had a tank agitation problem and banded RPA 2011772 reported that yields were 10 to 20 bu/A less than the areas of the field that had no herbicide injury. In some years, an early frost before corn maturity may also reduce corn yields in fields where injury delayed maturity.

Lastly, some fields treated with RPA 2011772 had severe late-season weed problems because of corn stand losses from RPA 2011772 or corn was severely injured and recovery was delayed. Weeds took advantage of the lack of competition from the corn. Sufficient weed seeds were produced in these fields to hinder crop production in 2000. One approach is planting a glyphosate-resistant crop. This would enable the grower to get on top of the potential weed problem. One would have to check the herbicide plant-back intervals for soybean if soybean is a viable option.

Relating 1999 with previous research in Nebraska. We have examined past years RPA 2011772 experiments at North Platte and Scottsbluff and compared them with 1999 results. The soils at Scottsbluff were a sandy loam with 1% organic matter with 8 pH, while at North Platte they were on loam soils containing 1.6% organic matter with pH 6.6 during this time period.

At Scottsbluff, RPA 2011772 was more active on corn at the higher rates than North Platte. Obviously, RPA 2011772 should be reduced on this type of soil to about 0.046 or 0.059 lb/A. Rainfall amounts were 1.77 inches 4 days after planting in 1995. Similar results occurred in 1996 when 1 inch 2 days after planting in 1996. This amount would move RPA 2011772 into the soil and caused excessive injury at the high rates. Therefore, it may be unwise to sprinkle irrigate to activate RPA 2011772 on marginal soils, especially within 10 days of applying the herbicide.

At North Platte, slight yellow was observed on corn treated with RPA 2011772 at 0.094, 0.118, and 0.141 lb/A. These rates temporarily reduced 'Pioneer 3475' corn heights at North Platte. During the first 2 weeks following planting 3.45 inches of rainfall occurred. In 1999, more severe injury occurred when RPA 2011772 at 0.094 lb/A was applied preemergence to 'Asgrow RX 488RR' corn planted May 19 with a no-till planter into a previous sunflower field. The ground was moist following 0.41 inches of rain during the week before planting. This interfered with soil coverage of the kernels by the covering disks as moist soil does not flow as easily as dry soil. Plants from kernels that were covered with ≤ 1.25 inches of soil were injured more than those covered with ≥ 1.75 inches of soil. The same rate of RPA 2011772 did not injure DK561SR corn planted May 18 into winter wheat stubble with the same corn planter. The depth of planting was not checked but should have been similar to field that was injured unless soil compaction was greater where no-till sunflower was grown in 1997 and 1998. The question is what caused the increased injury? Was it depth of soil coverage, amount of rain, the hybrid, or was it the wheat stubble reducing the amount of movement of the RPA 2011772? Lateral movement water and RPA 2011772 would have been reduced in the wheat stubble compared to the lack of crop residue on the sunflower field. In this field more RPA 2011772 may have been moved to the planter groove.

The rainfall during the first 30 days after planting varied with year to year with the most coming in 1995 and 1996. High rainfall following planting did not always equate to increase corn injury. Only two of 10 fields (1995 and 1999) had injury with RPA 2011772 at 0.094 lb/A. 'Pioneer 3563' was planted the year (1996) that we had the most rain with no injury from RPA 2011772 at 0.094 lb/A. We had no injury with this hybrid during 4 years, even in 1999 when we had equal rainfall with the experiment that was planted with Asgrow RX 488RR. This leads one to believe that Asgrow RX 488RR may be more susceptible to RPA 2011772. Pioneer 3563 and 'Golden Harvest H8874RR' are sensitive to RPA 2011772 and were used in five of the 12 experiments without showing injury. Although these hybrids were not injured in our trials, RPA 2011772 rate should be reduce to 0.082 or 0.071lb/A to reduce potential injury.

WEED CONTROL AND CROP SAFETY WITH FLUFENACET PLUS METRIBUZIN PLUS ATRAZINE.
Jim E. Anderson, Allen C. Scoggan, James R. Bloomberg, and James O. Olson, Field Development Representative, Regional Development Manager, Herbicide Product Development Manager, and Biologist, Bayer Corporation, P.O. Box 4913, Kansas City, MO 64120.

Abstract. Flufenacet plus metribuzin plus atrazine (trade name Axiom® AT) is a new pre-emergence herbicide developed by Bayer Corporation for soil applied control of grass and broadleaf weeds in corn. It will be sold as a 75% water dispersible granule (DF). Flufenacet plus metribuzin plus atrazine has multiple modes of action: inhibition of protein syntheses and cell division, and inhibition of photosynthesis. Application rates of 1.1 to 1.7 lb/A are recommended to be applied preemergence or up to 14 days preplant on light soils. Application at these rates will provide excellent control of green foxtail, as well as crabgrass species, and certain non triazine-resistant broadleaf weeds including redroot pigweed, Russian thistle, common lambsquarters and kochia. Crop safety on light soils is excellent, however rates must be adjusted for soil type, soil pH, and organic matter content. Finer texture, higher organic matter, and lower pH soils require the higher rates within the recommended ranges.

To enhance control of certain difficult to control weed species, the corn grower will have the options to include adjuvants, or to tank mix or apply sequentially with additional commercial herbicides. In many fields, flufenacet plus metribuzin plus atrazine will offer corn growers an opportunity for full season, broad spectrum weed control with a single dry flowable product.

WOOLLYLEAF BURSAGE CONTROL IN GLYPHOSATE TOLERANT AND BXN COTTON ON THE TEXAS SOUTHERN HIGH PLAINS. John D. Everitt, J. Wayne Keeling, and Peter A. Dotray, Research Assistant and Professor, Texas Agricultural Experiment Station, Lubbock, TX 79401 and Associate Professor, Department of Plant and Soil Sciences, Texas Tech University, Lubbock, TX 79409.

Abstract. The introduction of transgenic cotton varieties has provided producers another tool to control troublesome weeds. Cotton producers on the Texas Southern High Plains use preplant incorporated and preemergence herbicides to control many of their annual weed species. However, these herbicides are not effective on perennial weeds such as woollyleaf bursage. The use of glyphosate and bromoxynil in transgenic cotton varieties provides new options to control many perennial weeds in-season. Field studies were established in 1998 and repeated in 1999 at the Texas Agricultural Experiment Station at Halfway, TX. Prior to cotton planting in May of 1999, woollyleaf bursage density was recorded to determine the effect of the treatments applied in 1998. During the1998 and 1999 growing seasons, glyphosate and bromoxynil were applied three times with and without cultivation. Glyphosate was applied postemergence topical (PT) and postemergence-directed (PD) at 0.84 kg/ha. Bromoxynil at 0.56 kg/ha was applied PT at the 1- to 2-leaf, 3- to 4-leaf, and first bloom stages of growth. Commercial standard weed control systems were used at each location to compare to the glyphosate tolerant and BXN systems. Weed control was recorded 14 days after all applications. Glyphosate controlled woollyleaf bursage 94% at the end of the second season, and control increased to 98% when cultivation was added. Bromoxynil controlled woollyleaf bursage 50% without cultivation, and control increased to 77% with cultivation. Cultivation alone did not provide acceptable control.

CONTROL OF HERBICIDE RESISTANT WATERGRASS IN NORTHERN CALIFORNIA RICE WITH REGIMENT™ HERBICIDE. Thomas C. DeWitt, Greg J. Rich, and Todd J. Mayhew, Development Specialists, Valent USA Corporation, Fresno, CA 93650; Germantown, TN 38138; and Gilbert, AZ 85234.

Abstract. Regiment™ 80 WP (bispyribac-sodium) is a postemergence herbicide that has excellent efficacy against certain grasses, sedges and broadleaf weeds with selectivity for rice. It inhibits the plant enzyme acetolactate synthase (ALS), thus blocking branched-chain amino acid biosynthesis.

Bispyribac has a wide application window for control of barnyardgrass and watergrass. The herbicide can be applied up to second to third tiller stages of growth. Use rates range from 10 to 18 g/A. Optimum use rates for non-resistant *Echinochloa spp.* biotypes are 10 to 12 g/A with the grass being at the 3- to 5-leaf stage. Bispyribac is not recommend on rice with less than 3 leaves or later than panicle initiation. Herbicide resistant watergrass biotypes require rates on the upper end of the scale.

Over the last 3 to 5 years, growers in the Princeton area (Glenn County, CA) have had difficulty in controlling early, *E. oryzoides* and late season watergrass, *E. phyllopogon* in their rice fields. Grass control failures have been observed with maximum rates of thiobencarb, propanil, molinate and fenoxaprop-ethyl applied alone and sequentially. A number of trials were conducted in this area to determine the efficacy of bispyribac against these species.

Best control of resistant biotypes was observed at rates of 15 and 24 g/A, which ranged from 85 to 99% control across all trials. The 10 g/A rate did not provide adequate control regardless of application timing. Application timing is important for good control. The data indicate that the 6 lb/A rate was more efficacious than the 4 lb/A rate, which did not give adequate control. Bispyribac has been found to be an effective herbicide for controlling herbicide resistant watergrass biotypes. Bispyribac will fit well into IRM schemes where alternations of different chemical classes of herbicides are necessary to maintain control.

CYHALOFOP-BUTYL, A NEW HERBICIDE FOR GRASS CONTROL IN CALIFORNIA RICE. Richard K. Mann, Roger E. Gast, and Alan E. Haack, Development Specialists, Dow Agro Sciences LLC, Indianapolis, IN 46268.

Abstract. Cyhalofop-butyl (DE-537, 2-[4-(4-cyano-2-fluorophenoxy)phenoxy]propanoic acid, butyl ester, (R), tradename Clincher*) is a new aryloxyphenoxy propionate rice herbicide being developed by Dow AgroSciences LLC for postemergence control of grass weeds in water- and direct-seeded rice. As a postemergence, foliar application in California water-seeded rice, cyhalofop-butyl at 210 g/ha provides control of up to 6-leaf, prior to tillering, early and late watergrass, sprangletop, and other annual grasses. Cyhalofop-butyl can also be used as a rescue application to control tillered grasses at rates from 280 to 310 g/ha. Rice has excellent tolerance to cyhalofop-butyl at any time of application, with no injury seen at the highest rate tested of 560 g/ha. Cyhalofop-butyl is a phloem mobile, systemic herbicide that inhibits the enzyme Acetyl-CoA carboxylase (ACCase), an important enzyme in fatty acid production in grasses. In susceptible grasses, cyhalofop-butyl efficacy is due to metabolism to the herbicidally active monoacid metabolite. In tolerant plants such as rice, cyhalofop-butyl is quickly metabolized to the inactive diacid. Broadleaf plants are completely tolerant to cyhalofop-butyl, thus cyhalofop-butyl is very safe to neighboring broadleaf crops. Microbial degradation is the primary degradation pathway for cyhalofop-butyl in the environment. The degradation half-life for cyhalofop-butyl in aerobic soil is approximately 0.1 to 0.4 days, in aerobic water/soil systems approximately 0.1 day, and in anaerobic water/soil systems from 0.2 to 1 day. Photolysis is not a major pathway of degradation. In the absence of microbes the photolytic half-life has been experimentally determined to be about 1 month. Due to rapid soil microbial degradation, sorption coefficients were determined using sterilized soil, with calculated Kd values from 45 to 77 L/kg, and Koc values from 2000 to 9600 L/kg. Thus cyhalofop-butyl is strongly adsorbed to soil and has very low mobility, with no soil residual herbicidal activity or rotational crop issues. The risk for ground water contamination from cyhalofop-butyl is negligible, due to rapid degradation, high adsorption, and low use rates. Cyhalofop-butyl has low acute toxicity, with oral and dermal LD50's > 5,000 mg/kg. Cyhalofop-butyl is not mutagenic, teratogenic, neurotoxic, carcinogenic, or a reproductive hazard. The planned commercial formulation is a 285 g/L EC formulation (2.38 lb/gal).

EARLY WATERGRASS (ECHOR) AND BEARDED SPRANGLETOP (LEFFA) CONTROL WITH CYHALOFOP-BUTYL IN CALIFORNIA WATER-SEEDED RICE. Roger E. Gast, Alan E. Haack and Richard K. Mann, Development Specialists, Dow Agro Sciences LLC, Indianapolis, IN 46268.

Abstract. Fourteen replicated field trials were conducted in the Sacramento Valley during 1997 to 1999 in water-seeded rice culture to investigate the relationship between application rate and stage of growth for control of natural populations of early watergrass and bearded sprangletop. Treatments were targeted to the early watergrass growth stage at either 2- to 3-leaf, 4- to 6-leaf, or 2- to 3-tiller stage with cyhalofop-butyl (285 g/L EC) at rates of 70, 140, 210, 280 and 560 g/ha. Bearded sprangletop was present in most trials and was usually 1- to 2-leaf stages behind early watergrass. Water was lowered or completely removed to expose foliage at the 2- to 3-leaf timing and maintained at a 5 to 10 cm level for the later timings. Commercial formulations of propanil (aqueous suspension) at 3360-6720 g/ha and fenoxaprop-ethyl (resolved isomer) at 38 and 76 g/ha were included as reference treatments.

Cyhalofop-butyl at 210 g/ha provided greater than 90% control of both 2- to 3-leaf and 4- to 6-leaf early watergrass. Propanil at 3360 to 4480 g/ha provided 81 and 70% control of 2- to 3-leaf and 4- to 6-leaf early watergrass, respectively. Fenoxaprop-ethyl at 38 g/ha provided 71 and 68% control of 2- to 3- and 4- to 6-leaf early watergrass, respectively. Bearded sprangletop control greater than 90% was achieved by cyhalofop-butyl at 140 g/ha at the 2- to 3-leaf stage and 210 g/ha at the 4- to 6-leaf stage. Fenoxaprop-ethyl at 38 g/ha provided 82 and 85% control of 2- to 3- and 4- to 6-leaf bearded sprangletop, respectively. Control of bearded sprangletop with propanil ranged from 35 to 57%, significantly less than early watergrass.

Cyhalofop-butyl at 280 g/ha, fenoxaprop-ethyl at 76 g/ha and propanil at 6720 g/ha provided equivalent initial control (86 to 90%) of 2- to 3-tiller early watergrass. Cyhalofop at 210 g/ha and fenoxaprop at 76 g/ha resulted in greater than 95% control of 1- to 3-tiller bearded sprangletop; propanil provided only 45% control.

Cyhalofop-butyl at rates up to 560 g/ha caused little or no visual rice injury (0 to 5%) in all studies. Propanil caused slight rice injury (9 to 15%) 1 to 2 weeks after treatment. Fenoxaprop-ethyl at 38 g/ha caused significant injury to rice when applied to rice in pre-tiller stage of growth.

These studies indicate that cyhalofop-butyl, at rates ranging from 140-280 g/ha, depending on grass species and growth stage, will provide equal or better annual grass control than existing foliar products with significantly less potential for rice injury.

MULTI-ORGANIZATION COLLABORATION TO REGISTER HERBICIDES ON SUNFLOWER.
Richard K. Zollinger, Associate Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105-5051.

Abstract. Sunflower is grown on approximately 4 million acres per year in the U.S., with over half of sunflower production occurring in North Dakota. Pesticides registered on low acreage crops are limited and restricts growth in acreage. Sunflower herbicides currently registered in the U.S. for in-crop use are limited and do not control many broadleaf weed species. Lack of postemergence broadleaf herbicides restricts no-till or minimum-till sunflower production.

Research was conducted in 1996 and 1997 to determine sunflower response to several experimental broadleaf herbicides. Sulfentrazone at 0.125 to 0.375 lb/A provided control of many small-seeded broadleaf weeds with adequate sunflower safety when rate was adjusted to soil type and organic matter. Sulfentrazone controlled many small-seeded broadleaf weeds found in sunflower, such as, kochia, pigweed species, Russian thistle, common lambsquarters, biennial wormwood, nightshade species, smartweed species, and suppression of foxtail and wild mustard. No sunflower injury was observed on fine textured soils with organic matter above 3% with all rates of sulfentrazone. Temporary injury was observed on light to medium textured soils at higher rates.

In 1997 the North Dakota Department of Agriculture established a fund of $350,000 for registration of pesticides in minor crops in North Dakota. In 1998, $75,000 was granted to fund eight sulfentrazone magnitude of the residue trials in sunflower as directed by the IR-4 Project, site inspections, and other research activities associated with sulfentrazone registration. Residue trials were designed and conducted in accordance with EPA's Good Laboratory Practice requirements. Residue analysis was funded and completed by FMC Corporation. In 1999, a Section 18 Emergency Exemption package for sulfentrazone for broadleaf weed control in to-till and minimum-till in sunflower was submitted and approved by EPA in several states.

Multiple organizations combined efforts to pursue registration of sulfentrazone in sunflower. These include state universities, FMC Corporation, National Sunflower Association, IR-4 Minor Project, and North Dakota Department of Agriculture. Researchers at state universities conducted research in accordance with EPA's requirements, complied data, presented data to basic manufacturer and the sunflower grower group, coordinated and conducted residue trials, developed the Section 18 package, and educated growers on sulfentrazone use. FMC, as the basic manufacturer of sulfentrazone, supported Section 18 and 3 registration, completed residue analysis, co-funded registration costs, and provided labeling and product for sulfentrazone use in sunflower. The National Sunflower Association, or grower group associated with sunflower, acted as a liaison between government and private agencies, co-funded field research studies, represented grower group support to basic manufacturer, and administered funds from the North Dakota Department of Agriculture. The IR-4 project accepted administration

of the sulfentrazone on sunflower project, developed residue trial protocols and standard operating procedures, conducted GLP site inspections, coordinated sulfentrazone registration activities with FMC, and will submit the final package to the EPA. The North Dakota Department of Agriculture established money to fund pesticide registration in minor crops, assisted in development of Section 18 package and worked with the EPA in Section 18 package submission and clearance.

In 1999, a similar sequence was initiated for flumioxazin in sunflower. Eight residue trials were established by IR-4 residue trial protocol but excessive sunflower injury at most residue sites resulted in discontinuing residue trials and cancellation of further registration activities by the manufacturer.

American Cyanamid, the basic manufacturer of imazamox, and the North Dakota Department of Agriculture has been petitioned to support development of imidazolinone resistant sunflower with the recommendation to follow the same pattern as sulfentrazone registration in sunflower. Imidazolinone resistant sunflower has been developed by scientists at USDA in Fargo, ND and germ plasm released to most sunflower breeding companies. Residue trials will be conducted in 2000 with subsequent Section 18 registration planned in 2001. Use of imazamox in imidazolinone resistant sunflower would allow postemergence weed control and expansion of reduced-till sunflower in the U.S. Another project to follow the same pattern is underway to develop sulfonylurea resistant sunflower with eventual use of tribenuron for postemergence broadleaf weed control in sunflower.

EFFECTIVENESS OF SULFENTRAZONE FOR WEED CONTROL IN NO-TILL SUNFLOWER. Curtis R. Thompson, Alan J. Schlegel, and Garrett L Gold, Associate Professor, Kansas State University, Southwest Research Extension Center, Garden City, KS 67846; Professor, Southwest Research Extension Center, Tribune Unit, Tribune, KS 67879; and County Extension Agricultural Agent, Stevens County Extension Service, Hugoton, KS 67951.

Abstract. Herbicides available for broadleaf weed control in no-till sunflower are very limited. Experiments were established on two soil types to evaluate sulfentrazone and sulfentrazone tank mixes with pendimethalin for weed control in sunflower and sunflower tolerance. One experiment was established on a silt loam soil with a pH of 7.9 and an organic matter content of 1.4%. Sulfentrazone at 0.125, 0.15, 0.188, and 0.2 lb/A alone and tank mixed with pendimethalin at 1 lb/A were applied to the soil surface approximately 2 weeks prior to planting on May 7, 1999 (EPP) and immediately after planting on May 20 (PRE). Visual evaluations of weed control and sunflower injury were made on June 15 and August 11. A second experiment was established on an irrigated sandy soil with a pH of 7.7 and an organic matter content of 1.6%. Sulfentrazone was applied at 0.125, 0.188, and 0.25 lb/A and at 0.125 lb/A tank mixed with pendimethalin at 1 lb/A. Visual evaluations of weed control and sunflower injury were made on July 29 and September 2.

Sulfentrazone at all rates alone and in tank mix with pendimethalin at both times of application injured sunflowers on the silt loam site. The herbicide by timing interaction was not significant, however both herbicide and timing were significant. Average injury was 8% more from the PRE treatments than the EPP treatments. Averaged over timings, sulfentrazone at 0.125 and 0.15 lb/A caused less injury than sulfentrazone at 0.188 to 0.25 lb/A or sulfentrazone at 0.15 lb/A and more tank mixed with pendimethalin at 1 lb/A. Pendimethalin alone did not injury sunflower. Sulfentrazone at 0.188 and 0.2 lb/A tank mixed with pendimethalin and sulfentrazone at 0.25 lb/A alone reduced seed yield compared to the untreated sunflower yield. This silt loam soil had a high pH and a high concentration of $CaCO_3$ > 5000 ppm, which apparently increases the activity of sulfentrazone. This particular field would be marginal for sulfentrazone use in sunflower.

Sulfentrazone at 0.25 lb/A injured sunflower on the sandy soil, while sulfentrazone at 0.125 or 0.188 lb/A did not injury sunflower significantly. Sunflower yields were not reduced by sulfentrazone on the sandy soil.

Sulfentrazone alone or tank mixed with pendimethalin, regardless of rate, controlled kochia 95 to 100%, Russian thistle 92 to 100%, and redroot and tumble pigweed 97 to 100% on the silt loam soil. Sulfentrazone at 0.25 lb/A alone or at 0.15 to 0.2 lb/A tank mixed with pendimethalin controlled puncturevine more consistently than sulfentrazone at 0.125 to 0.2 alone or at 0.125 lb/A tank mixed with pendimethalin. Sulfentrazone at 0.188 lb/A or more alone or all rates tank mixed with pendimethalin controlled low infestations of large crabgrass.

In the sandy soil, sulfentrazone at 0.125 to 0.25 or at 0.125 lb/A tank mixed with pendimethalin controlled Palmer amaranth 91 to 99% at a July evaluation. Sulfentrazone at 0.25 lb/A controlled Palmer amaranth 91% at the early September evaluation while 0.125 and 0.188 lb/A rates of sulfentrazone controlled Palmer amaranth 44 and 85%, respectively . Palmer amaranth infestations were 20 to 30 plants/ft^2, thus, control rating less than 90% were unacceptable. Large crabgrass was not controlled adequately on the sandy soil.

Sulfentrazone can be a very effective herbicide for weed control in sunflower. Sunflower tolerance may be marginal on soils having a high pH and a high $CaCO_3$ concentration. Sulfentrazone was an effective herbicide for weed control in a sandy soil with an organic matter content of 1.6%.

THE EFFECT OF NORFLURAZON APPLIED AT VARIOUS TIMES AFTER PLANTING ON ESTABLISHMENT OF ALFALFA. William B. McCloskey[1], Timothy Knowles[2], and Patrick Clay[3], Associate Specialist, Assistant Agent and Assistant Agent, [1]Department of Plant Sciences, University of Arizona, Tucson, AZ 85721; [2]La Paz County Cooperative Extension, University of Arizona, Parker, AZ 85344; and [3]Maricopa County Cooperative Extension, University of Arizona, Phoenix, AZ 85040.

Abstract. Purple nutsedge is difficult to control in alfalfa. EPTC granules can reduce the amount of purple nutsedge foliage in alfalfa when treatment is initiated prior to emergence of nutsedge shoots in the spring and if multiple (4 to 6) treatments are made each season. However, in many fields, the number of nutsedge shoots per unit area continue to increase. Thus, experiments were initiated with norflurazon granules in the hope that fewer applications would result in more effective long-term nutsedge control in alfalfa. An experiment conducted in 1996 to 1998 observed good nutsedge control (80 to 95%) following a two year control program using norflurazon granules (Zorial 5G) in established alfalfa. Annual norflurazon application rates of 1.5 to 2 lb/A provided good purple nutsedge suppression under light to moderate infestations (30 to 50% cover) but dense nutsedge infestations (65 to 100% cover) required annual applications of 3 to 4 lb/A to obtain 90% or better control. A study that investigated the optimum use of norflurazon when treatments were initiated in the spring following a fall alfalfa planting in a field with a low purple nutsedge density found that annual spring norflurazon applications of 1 lb/A resulted in only fair purple nutsedge control (at best 75%) that was significantly worse than higher rates of norflurazon after two years. Interestingly, during June, July and August of 1999 after two years of treatments, there were no significant differences in nutsedge control (89 to 96%) between treatments that received annual spring applications of 1.5, 2, 2.5 or 3 lb/A of norflurazon. In addition, there were no significant differences in purple nutsedge control between treatments that received 1.5 lb/A or more of norflurzon in a single spring application versus treatments that received split applications (spring + summer) of norflurazon. Thus, the split 2 lb/A norflurazon treatment (1 + 1 lb/A) and the two split 3 lb/A norflurazon treatments (1.5 + 1.5 and 2 + 1 lb/A) were not significantly different than the single spring applications of 2 and 3 lb/A, respectively, during the second year of the study. Thus, in newly planted alfalfa fields with low nutsedge density there does not appear to be any benefit in applying more than 1.5 to 2 lb/A per year if a norflurazon 5G treatment program is initiated in the spring following a fall planting. The current norflurazon label for use in alfalfa states that "Zorial 5G may be applied to healthy stands of established alfalfa at 1 lb/A no earlier than 5 months following emergence". However, there is no research data in the literature to support or disclaim either the 5 month waiting period before application or the 1 lb/A rate limitation. Thus, studies were initiated to determine the effect of various rates of norflurazon applied at various times after planting on the establishment and yield of fall planted alfalfa.

The tolerance of flood irrigated seedling alfalfa to norflurazon was evaluated in experiments conducted in Parker Valley, AZ (1997 to 1998), at the Maricopa Agricultural Center (MAC) of the University of Arizona (1998 to 1999), and in Glendale, AZ (1998 to 1999). Norflurazon was applied at various times after fall plantings of alfalfa at rates of 0, 1 (MAC and Glendale only), 1.5, 2, 3, or 4 lb/A formulated as a 5% sand granule (Zorial 5G) using a ground driven Valmar granule applicator. The herbicide was incorporated with irrigation within 1 to 4 days of application. Forage fresh weights from strips 5 feet wide by about 20 feet long in each plot were measured using a small plot forage harvester that deposited the harvested alfalfa in a weigh basket. The fresh weight of each alfalfa sample was measured immediately after cutting. In Parker Valley, the loam soil contained about 1.5% organic matter and 38, 49, and 13% sand, silt, and clay, respectively, and norflurazon granules were applied at 0, 6.4, 13.7 and 20.4 weeks after a fall planting (November 1, 1998). Norflurazon applied at planting reduced alfalfa plant stand counts by an average over all counting dates of 57 to 82% at rates ranging from 1.5 to 4 lb/A, respectively. However, norflurazon applied at rates up to 4 lb/A at 6.7, 13.7 and 20.4 weeks after planting had no effect on alfalfa populations 4 months after planting or forage fresh weights harvested on July 1, 1998 about 35 WAP. At the Maricopa Agricultural Center (MAC), the sandy loam soil contained about 0.9% organic matter and 66, 17, and 17% sand, silt, and clay, respectively, and norflurazon granules were applied at 0, 1 month, 2 months and 3 months after a fall planting (November 25, 1998). At MAC, norflurazon applied at planting reduced alfalfa plant stand counts by an average of 49 to 63% and alfalfa height from 23 to 36% at rates ranging from 1 to 4 lb/A, respectively. Alfalfa fresh weights harvested June 14, 1999 were not as affected by the rate of norflurazon applied at planting as plant populations or plant height were and were 27.1, 26.5, 24.9, 23.3, 22.4, and 20.5 lb/plot for the 0, 1, 1.5, 2, 3, and 4 lb/A norflurazon treatments, respectively. These data indicate that norflurazon applications at planting severely reduced alfalfa plant populations, alfalfa height and early yield of alfalfa although the yield effect was not as dramatic as the population effect due to the natural thinning that occurs in newly planted alfalfa fields. yields.

At MAC norflurazon applied 1 month after planting had no effect on alfalfa populations but did significantly affect plant height and to a lesser extent yield. Plant heights were 12.2, 10.5, 10.1, 8.0, 8.4 and 7 inches and fresh weights were 22.7, 21.3, 21.3, 20.1, 19.8, and 17.3 lb/plot for the 0, 1, 1.5, 2, 3, and 4 lb/A norflurazon rates applied 1 month after planting, respectively. The only significant yield depression was at the 4 lb/A norflurazon rate. At MAC, norflurazon applied at various rates 2 or 3 months after planting had no effect on plant populations or yield. Plant height was similarly unaffected except for a 29 % reduction at the 4 lb/A rate applied 2 months after planting. At the third experimental site in Glendale, AZ the soil type was also a sandy loam soil and only one set of norflurazon applications were made about 2 months after planting. The results were similar to those obtained at MAC in that plant population was not affected by norflurazon rate but plant height was affected (16.6, 14, 14.4, 13.6, 12.1, and 10.8 inches at 0, 1, 1.5, 2, 3, and 4 lb/A norflurazon, respectively). Fresh weight was significantly reduced only at the 3 (35%) and 4 (41%) lb/A norflurazon application rates. These data indicate that norflurazon can be applied to newly planted alfalfa fields 2 months after planting at rates of 2 lb/A or less without significantly affecting plant populations or forage fresh weight on loam or sandy loam soils. In addition, there is a substantial safety margin since even the 4 lb/A rate only temporarily stunted the alfalfa and did not reduce yield in fall harvests the year after planting. Applications of norflurazon 2 months after planting or later allowed initial root growth to occur in the absence of herbicide. Furthermore, 2 months allowed sufficient root growth to occur such that the alfalfa was tolerant to high herbicide concentrations suggesting that either the alfalfa roots were utilizing moisture and nutrients in the soil profile below the herbicide treated soil zone, or alfalfa is tolerant of norflurazon, or both. These studies suggest that the label restrictions on time between planting and norflurazon application (5 months) and the maximum rate of the first norflurazon treatment (1 lb/A) are conservative and can be safely modified to 2 months and 2 lb/A in fall planted alfalfa grown in Arizona.

EFFECT OF WEED MANAGEMENT ON ALFALFA QUALITY AND STAND LONGEVITY. MaryEllen R. Dietz-Holmes[1], A. J. Bussan[1], Dennis Cash[2], and David Wichman[3], Research Associate, Assistant Professor, Associate Professor, and Research Agronomist ,[1]Department of Land Resources and Environmental Sciences, [2]Department of Animal and Range Science, Montana State University, Bozeman, MT 59717, and [3]Central Agricultural Research Center, Moccasin, MT 59462.

Abstract. Successful weed management in the establishment year of alfalfa has the potential to improve forage quality and stand establishment consequently lowering future management costs. Previous experiments have indicated significant improvement in weed control by combining cutting with herbicide application. The purpose of this study was to evaluate the effect of a new weed management strategy combining herbicide (imazamox) and cutting at different stages of weed growth on forage quality and stand longevity in newly planted alfalfa. Imazamox is a member of the chemical family imidazolinones and is effective against a broad spectrum of grass and broadleaf weeds.

Alfalfa was established at two sites in 1998 (dryland, annual precipitation 30 to 38 cm, and irrigated, annual precipitation 75 cm) and at one site in 1999 (moderate rainfall, annual precipitation 45 cm). The dryland site was located at the Central Agricultural Research Center, Moccasin, MT, the irrigated site was located at Toston, MT, and the moderate rainfall site was located at the Post Agronomy Farm, Bozeman, MT. Treatments consisted of imazamox alone, imazamox plus cutting, cutting alone and untreated controls in a randomized complete block design. A single rate of imazamox at 2.88 g/ha was applied to 5 cm tall alfalfa. Three different cutting regimes were applied corresponding to the pre-boot, anthesis ,and mature stages of grass weeds in the plots.

The first alfalfa harvest in 1998 at the Toston site corresponded to the cutting treatments. The two pre-boot and two anthesis treatments had regrown enough after the first cutting to be cut a second time in mid-August. All treatments were cut a final time in late September after a killing frost. The following year, 1999, alfalfa was harvested at three times corresponding to the normal harvest regime for the area. Alfalfa was only harvested once each year in 1998 and 1999 at the Moccasin site. Plots were harvested in 1998 at the treatment cutting times and in early summer in 1999. A second cut was not possible either year due to dry conditions and poor alfalfa regrowth. Two harvests were taken at the Bozeman site with the first corresponding to the cutting treatments and the second occurring after a killing frost. The Moccasin and Toston stands were evaluated for yield, relative feed value (RFV) and crude protein in 1998. Yield, stand establishment and weed control were evaluated at both sites in 1999. The Bozeman location was evaluated for weed control, yield and samples were taken for quality analysis. Stand establishment and weed control will be evaluated in 2000.

Four broadleaf and two grass weed species were present at low densities at the Toston site in 1998. Only a few weeds could be found primarily under the canopy. First cutting yields in 1998 varied according to the time of cutting. Higher yields occurred at the later cuttings because there was more time for growth. Higher RFV occurred in the earlier cuttings and declined with later cuttings indicating that alfalfa maturity, not weed control, affected RFV. The same trend occurred with crude protein analysis of the first cut with the exception that crude protein peaked at anthesis. There were no differences observed between treatments at the final harvest in yield, RFV or crude protein indicating that treatments did not affect quantity or quality of the late season forage. The 1999 harvests did not show any differences between treatments in either yield or number of stems.

Weed densities were also light at the Moccasin location in 1998. Four broadleaf and two grass weed species were present. The following year weed densities were evaluated at cutting and found to be insignificant. The largest yield of the 1998 harvest occurred in the cutting alone treatment at the mature timing resulting from a combination of older stand age and weed biomass present in the plots. RFV and crude protein values were greatest in the combined treatment of imazamox plus cutting at the mature timing demonstrating the positive effect of good weed control with combined treatments resulting in higher forage quality. The greatest number of stems in 1999 occurred in the imazamox plus cutting at the pre-boot stage and the cutting alone at the mature time indicating that these treatments encouraged good stand regrowth. The 1999 yield data did not show any differences between treatments.

There was an extremely heavy wild oat population at the Bozeman study site. Wild oat was not controlled in any of the three cutting alone treatments but was controlled in the combined treatments. Control efficiency increased with the later combined treatments because it took some time for the imazamox to kill the wild oats present. High wild oat presence and thus increased biomass translated to higher initial yields in the three cutting alone treatments. Significant improvement in wild oat control occurred by combining imazamox with cutting.

The 1998 imazamox plus cutting at the pre-boot and cutting alone at maturity treatments at the Moccasin location had a positive effect on weed control and subsequent stand establishment as seen in 1999 evaluations. The 1998 treatments at the Toston location did not have any affects on the 1999 stand densities. There were no differences in weed pressure in 1999 at either location among any of the treatments suggesting that all treatments provided satisfactory weed management. Weed densities will continue to be evaluated at all three locations to quantify any reestablishment or reinvasion that may occur. At the Bozeman location there was significant improvement in the control of wild oat by combining cutting with imazamox.

CANADA THISTLE CONTROL IN ESTABLISHED ALFALFA FOR SEED PRODUCTION.
Abdel O. Mesbah[1] and Stephen D. Miller[2], Research Scientist and Professor, [1]Northwest Research and Extension Center, 747 Road 9, Powell, WY 82435 and [2]Dept. of Plant Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Canada thistle is considered as one of the most troublesome and difficult to control weeds in established alfalfa for seed production. Alfalfa seed losses due to Canada thistle include both reduced yields from competition and contamination. A two year study was conducted in 1998 and 1999 at Park county, Powell, Wyoming, to evaluate Canada thistle control and alfalfa tolerance to several postemergence herbicides applied alone or in combination. Alfalfa was planted in furrow irrigated 22 inch rows in a clay loam soil with 1.2% OM on April 1997. Plots were 10 by 30 feet with four replications arranged in a randomized complete block design. Herbicide treatments were applied broadcast with a CO_2 pressurized knapsack sprayer delivering 20 gpa at 40 psi. Canada thistle infestations were moderate to heavy (20 to 30 plants/yard^2) and uniform throughout the experimental sites. All treatments were compared to a weedy check.

MCPB applied alone to 6-inch Canada thistle caused severe injury to alfalfa and less Canada thistle control compared to the other treatments. However, when MCPB was tank mixed with imazethapyr, imazamox or bentazon, alfalfa injury decreased and Canada thistle control increased. Imazethapyr and imazamox applied alone to 3- and 6-inch Canada thistle did not cause any injury to alfalfa. The highest Canada thistle control was achieved with the combination imazamox plus bentazon or imazethapyr plus bentazon when applied to 10-inch Canada thistle. In general, alfalfa seed yields were higher in herbicide treated compared to weedy check plots and yields were closely related to Canada thistle control and only slightly to alfalfa injury.

SULFOSULFURON SOIL PERSISTENCE EFFECTS ON SPRING-PLANTED CANOLA AND MUSTARD. Traci A. Rauch, Donald C. Thill, and Suzanne M. Sanders, Research Support Scientist and Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83844-2339 and Graduate Assistant, Department of Biology, West Virginia University, Morgantown, WV 26506.

Abstract. Quackgrass is a perennial grass weed that is difficult to control in cereal production systems. Sulfosulfuron is the only labeled herbicide for selective control of quackgrass in wheat. Some herbicides can persist in the soil from one growing season to the next and adversely affect growth of subsequent rotational crops.

Field studies were conducted at Potlatch and Bonners Ferry, Idaho to evaluate residual quackgrass control and rotational crop injury and yield. At both locations in 1997, the experimental design was a randomized complete block factorial with four replications. Sulfosulfuron was applied in winter wheat at two quackgrass growth stages (3- to 5- and 6- to 8-leaf) and rates of 0, 4, 9, 18, 26, 36, and 72 g/ha. In 1998, the experiments were re-established at the same locations in spring wheat as split plot designs. Main plots were herbicide treatments from 1997, and subplots were no additional herbicide or herbicide applied at the same rate and growth stage as in 1997. In 1999, spring canola and spring mustard were planted at the Bonners Ferry and Potlatch sites, respectively. At Bonners Ferry, no treatment visibly injured canola. At Potlatch, mustard injury generally increased with increasing herbicide rate and ranged from 6 to 61% on June 11 and 0 to 16% on July 15, 1999. Mustard injury was 48 and 9% greater in the plots retreated in 1998 than once treated in 1997 on June 11 an July 15, 1999, respectively. At both locations, canola and mustard seed yield increased as herbicide rate increased and was 6 and 9% higher in plots retreated in 1998 than once treated in 1997 at Bonners Ferry and Potlatch, respectively. Application timing did not affect quackgrass control at either location in 1997, 1998 or 1999. Residual quackgrass control ranged from 19 to 57% and 16 to 77% at Bonners Ferry and Potlatch, respectively, and control increased with increasing sulfosulfuron rate. Quackgrass control was 22 and 36% higher in plots retreated in 1998 than once treated in 1997 at Bonners Ferry and Potlatch, respectively.

SULFONYLUREAS AFFECTING ROTATIONAL CROPS. Samuel L. Vissotto, Philip Westra and Scott J. Nissen, Graduate Student, Professor and Associate Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523.

Abstract. Among the most popular sulfonylureas for broadleaf control in wheat are metsulfuron, triasulfuron and tribenuron plus thifensulfuron. Mon 37500 (sulfosulfuron) is another sulfonylurea that provides control of broadleaf weeds, and is also effective against grasses. These herbicides are selective to wheat, but can persist in the soil affecting subsequent rotational crops. Field and greenhouse experiments were conducted to evaluate spring barley, proso millet, sorghum and sunflower sensitivity to these sulfonylureas. The field results included the level of rate effect and the rate that started to affect these crops. Using the non-linear log-logistic regression model, greenhouse dose-responses were regressed to clarify each crop's sensitivity to sulfosulfuron and the other sulfonylureas. Rates ranged from 0 to 2X the recommended. Sulfosulfuron, metsulfuron and triasulfuron affected most of the rotational crops tested. Model comparisons allowed differentiating the four crop responses to the herbicides. Sorghum and sunflower were most sensitive and are not recommended as subsequent rotational crops in wheat fields where these sulfonylureas were used. Spring barley and proso millet, however, were more tolerant. The regression model estimated the 50% inhibition rate (I50) for each herbicide and crop. Proso millet's I50 dose-response to sulfosulfuron was 17.7 g ha^{-1}. This rate also corresponds to sulfosulfuron's concentration in the soil after one half-life. Considering a sulfosulfuron's half-life that varies between 13 and 75 days, the results obtained indicate that proso millet is an appropriate rotational crop for use in wheat fields treated with the herbicide.

PRECISION FARMING TOOLS HELP EVALUATE SPATIAL DISTRIBUTION OF CORN PESTS.
Philip Westra, Dawn Wyse-Pester, and Lori Wiles, Professor and Graduate Research Assistant, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523 and Weed Ecologist, USDA-ARS-WMU, AERC-Colorado State University, Ft. Collins, CO 80523.

Abstract. Knowledge of the spatial distribution of corn pests within fields will be required if management inputs are going to be applied to selected field areas. In 1997 and 1998, two center pivot irrigated corn fields in eastern Colorado were sampled for weed seedling, triazine resistant pigweed, nematode, and western corn rootworm egg

populations. Three grid systems were established across each field. The first grid consisted of a regular square grid with 122 sample positions spaced 76 m apart covering the entire field. A second sampling grid with 110 positions was imbedded in the regular coarse grid. Also, three 7.6 m^2 grid systems were established, each with 150 sampling units, at random locations in each field. Pest composition and density differed by field, sampling time, and year. Fifteen weed seedlings were detected across both fields with the primary species being pigweed and nightshade. 70% of the samples were pest-free for individual pests. Spatial dependence was detected for selected samples of field sandbur, pigweed, nightshade, and common lambsquarters. This dependence appeared aligned with field mechanical tillage or prevailing winds. Spatial dependence was detected from 22 to 140 m between the species by direction. Field sandbur was the only species where spatial dependence was detected across years in the same field.

EVALUATION OF A UNIQUE NOZZLE-ADJUVANT SYSTEM FOR AGRICULTURAL CROP PRODUCTION SYSTEMS. P. M. McMullan and J. Thomas, Agrobiology Research, Inc., Memphis, TN and Helena Chemical Co., Memphis, TN 38120.

Abstract. Off-target deposition of agrichemicals is becoming of increasingly greater concern. Several different spray nozzles have been introduced which can reduce the driftable fraction of the spray solution (typically droplets below 100 to 150 microns in diameter). However, the reduction in the driftable fraction is produced by shifting the spray droplet range so that fewer small droplets are formed but a greater number of large droplets are produced. This may result in fewer droplets of ideal size for expression of herbicide activity are present. A new nozzle-adjuvant system has been developed which results in production of spray droplets in a narrow diameter range with very few small droplets. This allows for reduced spray volume per acre with minimal drift potential. This nozzle system requires the use of an inverse emulsion for optimum performance. To determine the potential of this nozzle system for agricultural use, research was conducted to determine the efficacy of glyphosate-isopropylamine, paraquat, and glufosinate-ammonium when applied via the nozzle system.

WETLANDS AND WILDLANDS

EFFICACY AND EFFICIENCY OF DRIZZLE HERBICIDE APPLICATIONS IN HAWAII. Philip Motooka, Extension Specialist, Department of Agronomy and Soil Science, University of Hawaii at Manoa, Kealakekua, HI 96750.

INTRODUCTION

The drizzle herbicide application method has been adopted by several agencies and individuals in Hawaii because it is an efficient and effective weed management method (Motooka et al. 1983, Motooka et al. 1998, Motooka et al. 1999, Motooka et al. 1999). In forestry for example, the drizzle method effectively suppressed weeds and reduced trail maintenance labor by 97% over mechanical methods and by 90% over conventional herbicide spraying with knapsack sprayers (Motooka et al. 1999). However, these data were collected in carefully monitored situations. In order to characterize the efficiency and efficacy of the drizzle method under "real life" situations, a brief survey was conducted of users of the drizzle method.

MATERIALS AND METHODS

A survey, kept brief to encourage responses, was sent to users of the drizzle method. The survey asked for data on: 1) acres treated per year by the drizzle method; 2) acres treated by their traditional method, mechanical or conventional herbicide spraying, either currently or in the past; 3) efficacy of the drizzle method on a 1 to 5 scale, 1 being excellent control; 4) worker-hours required to treat one acre by the drizzle method; and 5) worker-hours to treat by their traditional method. The data were collated according to weed infestation sites (Table).

RESULTS AND DISCUSSIONS

The survey form was sent to ranchers, foresters, aquatic biologists, and maintenance workers known to be using the drizzle method. Of 15 queries sent out, 13 were returned. For the sake of confidentiality, names of the respondents were omitted (Table).

Ranch. Respondent 1 was the most experienced user and he reported using the drizzle method on 20 A/yr. With conventional spraying he used to treat 20 A/yr. He rated efficacy 2 and no longer uses his power sprayer. He reported 0.5 h to drizzle an acre versus 2 h with a power orchard gun sprayer, both in spot applications. He mows 80 A/yr, primarily to promote flushing of his grass weeds so his cattle would graze them. Respondent 2 drizzled 11 acres. Although he reported good efficacy, he sprayed 59 acres traditionally. It took his workers an hour to treat an acre because they used twine to mark their swath and had to move it after drizzling each swath. He reported 3 h to spray an acre traditionally, again using twine to subdivide the pastures. It was recommend to respondent 2 that he dispense with the twine and plan instead on revisiting the pasture after missed spots become obvious, since the drizzle method is convenient to deploy and apply. Respondent 3 had just started on the drizzle method and reported very poor results. However he was not trained in the method. Two of the heaviest users of the drizzle method did not respond to the survey.

Forestry. Respondent 4, a private employee of a non-profit group, had not used conventional spraying at all. She and her crew of volunteers treated about 20 acres in spot applications in a State Park and reported excellent control. She could not provide estimates of labor. Respondent 5, a state forester, treated 15 acres of state forests in spot applications on Hawaii. He rated control as good and the time required at 2 h/A. This however probably includes travel, preparation and clean-up as state foresters are required to log all their time. Respondent 5 could not provide a labor estimate for conventional spraying because they lacked the resources to do conventional spraying. Respondent 6, a federal forester, reported a horrendous 32 h to drizzle an acre. This however was because they were using the drizzle method to clear the rims of very deep volcanic craters, an area requiring extreme caution. Knapsack spraying used to require 64 h/A. Although there was only a 100% increase in labor efficiency in this case, the amount of labor saved, 32 h/A, was significant. Respondent 7, also a state forester, used the drizzle method for trail maintenance. He reported very good control and only 0.6 h/A; applications were made at 2 mph. Mechanical clearing of trails required 115 h/A. Indicative of the efficacy of the drizzle method, the forester is now treating trails that his agency had not maintained in decades, except for hacking their way through them when they used those trails.

Aquatic: Respondent 8, a state noxious weed specialist, Hawaii Department of Agriculture, conducted a pilot project on aquatic weeds near the mouth of a stream which was adjacent to a county beach park. Clogging of the stream by the weeds often caused flooding through the park during storms. Initially, the weed density was so high as to almost cover the entire stream surface in the target area. Although the target area was small and easily cleared, heavy rains following clearing of the target area would cause rafts of paragrass down from upstream. These rafts would occupy the same area previously cleared near the mouth of the stream which was shallow because the surf and tide of the ocean caused sedimentation there. Thus respondent 8 had to keep treating the same area until the weeds upstream opened up enough for his kayak to pass and he could treat the upstream area. Otherwise, efficacy and efficiency were excellent. Moreover, it was estimated that mechanical removal and disposal of the weeds would have cost over a million dollars and this would not have included the rafts of weeds from upstream that floated downstream. Respondent 9, a state aquatic biologist, annually treated a reservoir in the dry season between the low water line and the rainy season high water line. This was to prevent weed growth that would snag hooks during the catfish season when the weeds were inundated. He reported excellent results and phenomenal improvement in labor efficiency, from 18 h/A with the traditional spraying to 0.5 hr/A with the drizzle method. Respondent 10, also a state aquatic biologist, reported excellent efficacy and efficiency to control paragrass in a large flood control–recreational pond. Originally 36 h/A were required to make one round of herbicide application by the traditional method. With the drizzle method he managed the weeds in two mornings per year by himself, 8 hr/yr. Where once fishermen complained about the paragrass snagging their hooks, they now complain that there is not enough weeds to provide shelter for the fish. Respondent 11, a state biologist, used the drizzle method to clear shrubs from a marsh to restore sea bird habitat. He cleared 15 acres in a day, not including removal of trash, which was a much easier task after they were dead. He had tried mechanical clearing and that required 4 h/A, which did not prevent resprouting.

Miscellaneous. Respondent 12 was a gardener with a botanical garden. He used the drizzle method to manage weeds on undeveloped land in a seasonally dry area. He reported mediocre control yet was satisfied with the drizzle method. He may have been under dosing given the reported 0.3 h to treat an acre. Respondent 13 was a private landscape maintenance contractor. He used the drizzle method on 175 acres of undeveloped land, pastures and orchards. He reported mediocre results which he said was because he had been under dosing. He took 1.5 h to drizzle an acre in contrast to 4 h/A with conventional spraying.

CONCLUSIONS

Even in the hands of novice users, the drizzle herbicide application method demonstrated great potential for increasing the efficiency of weed management. However a few users had problems in achieving a high level of efficacy. Training will help in the successful adoption the method.

LITERATURE CITED

Motooka, P., G. Nagai, and L. Ching. 1983. The "magic wand" method of herbicide application. Proc. Ninth Asian Pacific Weed Sci. Soc. Conf. Suppl. Vol. p. 550-553. Manila.

Motooka, P., G. Nagai, G. Kawakami, and L. Ching. 1998. A very-low volume method for vegetation management in conservation forests. Proc. West. Soc. Weed Sci. Conf. 51: 124-127. Waikoloa, HI.

Motooka, P., C. Koga, A. Kiyono, G. Kawakami, G. Nagai, L. Ching, G. Shishido, and J. Powley. 1999. Drizzle herbicide applications for vegetation management on forest trails in Hawaii. Proc. 17th Asian Pacific Weed Sci. Soc. Conf. Bangkok. (In press).

Motooka, P., J. Powley, M. DuPonte, L. Ching, G. Nagai, and G. Kawakami. 1999. Drizzle herbicide application for weed management in forests. Proc. West. Soc. Weed Sci. Conf. 52: 136-139. Colorado Springs, CO.

Table. Efficacy and efficiency of drizzle herbicide applications in Hawaii.

Respondent	Drizzle	Traditional	Drizzle efficacy[a]	Drizzle efficiency	Traditional
	(A/yr)	(A/yr)		(h/A)	(h/A)
Ranch:					
1	20	20	2	0.5	2
2	11	59	1.5	1	3
3	3	3	N/A	0.4	0.5
Forestry:					
4	20	N/A	1	N/A	N/A
5	15	N/A	2	2	N/A
6	0.5	0.5	1	32	64
7	26	11	1.5	0.6	115
Aquatic:					
8	45	N/A	1	0.5	N/A
9	4	4	1	0.5	18
10	0.6	2	1	1.6	36
11	15	4	1	0.5	4
Misc:					
12	10.5	14	3	0.3	1
13	175	50	3	1.5	4

[a]Scale 1 to 5, 1 = excellent control.

THE EFFECTS OF MOWING ON THE DISTRIBUTION OF GLYPHOSATE WITHIN THE CANOPY OF PERENNIAL PEPPERWEED. 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 is rapidly invading several sensitive habitats throughout the west. Dense infestations limit the distribution of herbicides throughout the canopy. Applications of glyphosate alone yield poor control of perennial pepperweed. However, mowing stems and applying glyphosate to resprouting shoots greatly enhanced control. This study examined the effect of early season mowing on the retention and distribution of glyphosate on resprouting shoots of perennial pepperweed.

This experiment was conducted at two sites. Plants were either mowed or not mowed at the flowerbud stage. A combination of glyphosate (3.33 kg/ha) and water soluble dye (1% v:v) were applied to mowed areas as shoots resprouted to the flowerbud stage. Unmowed areas were sprayed at the flowerbud stage.

Mowing either decreased (site 1) or did not change (site 2) the amount of dye recovered on the foliage compared to unmowed areas. Mowing also altered the distribution of dye on the vegetative canopy. The distribution of dye was 9- and 5-fold greater in the lower third of the canopy in mowed areas in site 1 and 2, respectively, compared to unmowed plots. In contrast, dye retention in the upper third of the canopy was 7- and 15-fold greater in unmowed plots from site 1 and 2, respectively, compared to mowed plots. These results indicate shoots resprouting after mowing retain a greater proportion of herbicide within the lower third of the canopy. This may enhance absorption and translocation of glyphosate into below ground perennial organs, thus accounting for increased efficacy of glyphosate in mowed plants.

CONTROL OPTIONS FOR JUBATAGRASS, A WILDLAND WEED. Jennifer J. Drewitz and Joseph M. DiTomaso, Graduate Research Assistant and Cooperative Extension Specialist, Department of Vegetable Crops, Weed Science Program, University of California, Davis, CA 95616.

Abstract. Jubatagrass (*Cortaderia jubata*) is an introduced perennial grass, native to the Andes of South America. In California, it invades disturbed areas along the coast from Humboldt to San Diego County. Jubatagrass establishes dense populations that reduce conifer seedling recruitment and displace native plant species.

Traditionally, management of jubatagrass has been limited to mechanical removal and high volume ('spray-to-wet' equivalent to 200 to 250 GPA) spot applications of glyphosate. This study was initiated to develop alternative economical control options for jubatagrass in sensitive coastal habitats. Several herbicides, rates, treatment times (spring and fall), formulations, and application methods were evaluated for jubatagrass control at Vandenberg Air Force Base in Santa Barbara County, California. Each treatment was replicated at least eight times and evaluated the summer following treatment.

Spring and fall spot applications of glyphosate at 1.5% low volume (90 GPA) resulted in approximately 80% jubatagrass control. Regrowth did occur the following summer. Rates below this did not provide acceptable control. Low volume fall applications of fluazifop at 0.5% and imazapyr at 0.5% and 1.1% gave approximately 95% jubatagrass control with no regrowth the following year. The cost of application with these alternative treatments was comparable to a conventional high volume glyphosate application. In some coastal habitats, jubatagrass co-exists with sensitive endemic broadleaf forbs and shrubs such as *Arctostaphylos* and *Ceanothus*. Under these conditions, the graminicide fluazifop provides a safer option than non-selective herbicide treatments.

RESPONSE OF THE WESTERN PRAIRIE FRINGED ORCHID TO HERBICIDES FOR LEAFY SPURGE. John J. Sterling, Donald R. Kirby, Rodney G. Lym, and Carolyn Hull-Sieg, Graduate Research Assistant and Professor, Department of Animal and Range Science, Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105 and Research Biologist, Rocky Mountain Research Station, Rapid City, SD 57701.

Abstract. Approximately 15 to 20% of the Sheyenne National Grassland in southeastern North Dakota is infested with leafy spurge (*Euphorbia esula* L.). These infestations threaten the western prairie fringed orchid (*Platanthera praeclara* Sheviak and Bowles), which is on the federal threatened and endangered species list. The purpose of this research was to develop a herbicide treatment that controls leafy spurge while sustaining western prairie fringed orchid populations. Herbicide screening trials were established on the Sheyenne National Grassland. Treatments included glyphosate plus 2,4-D at 220 plus 330 and 440 plus 670 g/ha, imazapic plus MSO plus 28% N at 70 and 140 g/ha plus 1 plus 1 L/ha and quinclorac plus MSO at 880 and 1100 g/ha plus 1 L/ha. Herbicides were applied using a hand-held sprayer delivering 8.5 gpa at 35 psi. Imazapic and quinclorac provided 95 and 98% leafy spurge control, respectively, at the highest application rates evaluated. Glyphosate plus 2,4-D did not provide satisfactory leafy spurge control. In July 1998, a population of western prairie fringed orchid was identified for herbicide efficacy evaluation. Orchids reappeared in 83, 58 and 58% of the plots treated with quinclorac, imazapic and glyphosate plus 2,4-D, respectively, compared to 50% in the untreated control. One or more orchids were present in plots where they reappeared. Imazapic and or quinclorac could be used to control leafy spurge in western prairie fringed orchid habitat without injuring the orchid.

***ARUNDO DONAX* DEMOGRAPHY AT TWO SITES IN SOUTHERN CALIFORNIA.** Joseph G. Decruyenaere and Jodie S. Holt, Graduate Student and Professor, Dept. of Botany and Plant Sciences, University of California, Riverside, CA 92521.

Abstract. *Arundo donax* is a noxious weed inhabiting riparian areas throughout the southwestern United States. Reproduction is vegetative, and horizontal growth rates at the fronts of expanding infestations have not been investigated. A demographic study was conducted on a coastal and an inland population in Southern California. Ten quadrats, measuring 1 by 2 m, were established per site at randomized points along a 100 m transect. Quadrats were situated at the periphery of existing clumps such that half of the quadrat lay inside the clump at the beginning of the study, and horizontal expansion would progress into the other half during the study. Surveys of the quadrats were made monthly from October 1998 to September 1999. Quadrats were excavated in September 1999 to reveal changes in rhizome structure over the previous year and predict the extent of next season's expansion. Data concerning transitions in morphological attributes of stems such as flowering and branching were recorded. Attrition and damage to shoots was also recorded and likely causes were estimated by visual inspection. Branching of first-year shoots occurred earlier in the coastal population. Flowering and shoot emergence were synchronous between the two sites. The inland population is expanding at a higher rate than the coastal population. This conclusion is supported both by average age of stems at the two sites, and by actual horizontal expansion of rhizomes recorded subsequent to excavation. Over both sites, *A. donax* can expand nearly 50 cm in 2 years, which can account for its rapid invasion into riparian areas.

LIPID PEROXIDATION AS AN INDEX OF PROMETRYN DAMAGE IN COTTON. Ismael Hernandez-Rios and Tracy M. Sterling, Graduate Student and Associate Professor, Department of Entomology, Plant Pathology and Weed Science, New Mexico State University, Las Cruces NM 88003.

Abstract. Although prometryn is approved as a preplant-incorporated herbicide for cotton, its application can result in injuries to susceptible varieties. 'Delta Pine 5415' (DP) is injured at the recommended rate (1.34 kg/ha) while 'Pima S7' (PS7) is not affected even at 10-fold that amount. This differential tolerance has not been explained by differences in absorption, translocation, metabolism, site of action, or sequestration of the herbicide into lysigenous glands, nor by effects on electron transport. We hypothesize that prometryn tolerance involves an enhanced ability for PS7 to protect against triazine-induced production of reactive oxygen species (ROS). Damage from ROS results in lipid peroxidation, and perhaps increased chlorophyll fluorescence, which may be detected prior to observing tissue damage. Our objective was to determine if the evaluation of these two effects can be used as a tool to detect injuries by prometryn before visual symptoms. Under growth chamber conditions, plants of DP and PS7 were subjected to preplant-incorporated prometryn rates of 0X, 0.5X, 1X, 2X, and 4x the recommended rate. Cotyledon or leaf discs were collected for lipid peroxidation at 3, 5, 7, and 11 days after emergence. Just before tissue sampling, chlorophyll fluorescence was measured. Lipid peroxidation was determined by the thiobarbituric acid reaction method and chlorophyll fluorescence was measured with a modulated pulse fluorometer. Through the sampling period and at increased prometryn rates, photosynthetic efficiency was significantly higher in PS7 than in DP, and was inversely related to lipid peroxidation. These responses will be useful for prometryn damage prior to visual symptoms and suggest that protective mechanisms against oxidative stress are greater in PS7 than DP.

MORPHOLOGICAL AND ISOZYME ANALYSIS OF TWO NUTSEDGE ECOTYPES FROM BAKERSFIELD, CALIFORNIA. Rana I. Tayyar, Jamie Nguyen, and Jodie S. Holt, Research Associate, Lab Assistant, and Professor, Department of Botany and Plant Sciences, University of California, Riverside, CA 92521.

Abstract. Two nutsedge ecotypes from Bakersfield, California, designated as CK (*Cyperus rotundus* cv. Kempen) and CR (*C. esculentus* cv. robusta), resemble purple and yellow nutsedge, respectively. However, plants from both ecotypes grew taller, were more prolific in producing rhizomes and possessed larger tubers than the more typical forms. CK, in particular, exhibited some characters found in either purple or yellow nutsedge and produced a large amount of seeds. The more aggressive growth of these ecotypes may present a threat in agricultural fields, both potentially being highly competitive with crops. New control measures may have to be developed if they do become more widespread agricultural pests.

Isozyme starch gel electrophoresis was used in conjunction with morphological analysis to help elucidate the identity of the two nutsedge ecotypes. Tubers from three populations of yellow nutsedge and four populations each of purple nutsedge, CK and CR were propagated under both cold and hot greenhouse environments in a randomized complete block design with four replications. Individual plants were evaluated for a set of 25 morphological characters that describe size and shape of floral parts, these characters previously being reliable for taxonomic classifications. Analysis of variance did not reveal any significant differences between environments and no population by environment interactions were significant. However, significant differences were found between populations with respect to a number of the investigated traits. Data were standardized to compute a matrix of distances between all pairwise combinations of populations. The unweighted pair group method with arithmetic averaging (UPGMA) was employed to construct a dendrogram illustrating population grouping.

Leaf extracts from all the plants surveyed in the morphological study were used to assay 10 enzyme systems. A low level of isozyme variation was found. Of the 14 scorable loci, only three exhibited polymorphism. Any observed variation resided between rather than within populations. Based on Nei's (1978) unbiased genetic distance values, UPGMA was employed to generate a phenogram of population clustering. Using morphometric and isozymatic characters, all populations of CR clustered with yellow nutsedge populations, indicating that CR is within the normal range of variation of yellow nutsedge. It may represent a new introduction. Populations of CK, however, were distinct from purple and yellow nutsedge populations. Considering the low genetic variation reported in purple nutsedge and its strict vegetative mode of reproduction, CK might represent a sexually reproducing ecotype of purple nutsedge. Further analysis will be conducted on the seed progeny obtained from CK plants. All the populations will be analyzed using random amplified polymorphic DNA (RAPD) analysis to further investigate the classification of CK.

GENE FLOW, GROWTH, AND COMPETITIVENESS OF IMAZETHAPYR-RESISTANT COMMON SUNFLOWER (*HELIANTHUS ANNUUS*). Michael W. Marshall and Kassim Al-Khatib, Research Assistant and Associate Professor, Department of Agronomy, Kansas State University, Manhattan, Kansas 66506-5501.

INTRODUCTION

Herbicide resistant weeds have become a major problem in many cropping systems. With the introduction of highly site-specific herbicide families, including sulfonylurea, imidazolinone, and triazolopyrimidine, the number of herbicide resistant biotypes has increased dramatically compared to the other older herbicide families. In 1996, a northeast Kansas soybean producer complained of poor imazethapyr performance on common sunflower infesting the field. Upon further investigation including review of herbicide application history and greenhouse studies of suspected plants, it was confirmed that a imazethapyr-resistant population of common sunflower had developed. Due to the self-incompatibility of common sunflower, this study was initiated to evaluate movement of imazethapyr resistance through pollen transfer and measure relative growth and competitiveness of the resistant biotype. The three objectives of this study were to quantify yearly movement of imazethapyr-resistance through pollen transfer, compare growth habits of imazethapyr-resistant (R) and susceptible (S) biotypes, and evaluate competitiveness of R and S biotypes in communities that include mixtures and monocultures.

MATERIALS AND METHODS

Gene Flow. Field studies were initiated in 1998 at Olsburg and Oskaloosa in northeast Kansas. Imazethapyr-resistant (R) and susceptible (S) biotypes were established in 0.5 L containers in the greenhouse. Susceptible biotypes were transplanted into 5.5, 7.6, 15.2, and 30.4 m circles radiating out from a center of densely planted R biotypes. At harvest, each circular location was divided into 8 pie slices with each pie slice further subdivided into five arc-slices. A 15 g arc-slice seed sub-sample was hand clipped and treated with 1 ppm gibberillic acid to hasten germination. Embryos were transferred to 13 by 23 cm rectangular containers filled with 2.5 kg of 1:1 mixture of sand and Morrill loam (mesic Typic Argiudolls) in the greenhouse with a final stand count of 10 plants per container. Design consisted of a RCB with five replications and 40 arc-slice samples. Conditions in the greenhouse were 23/20 C (day/night) with a 16-h photoperiod. Each pot was fertilized weekly with a solution containing 300 ppm N, 250 ppm P, and 220 ppm K. At the 2- to 4-leaf stage, seedlings were treated with 70 g/ha imazethapyr plus 0.25% (v/v) nonionic surfactant. Imazethapyr was applied using a bench type sprayer calibrated to deliver 187 L/ha at 138 kPa. Proportion of resistance was scored as the number of surviving plants out of the total number of plants in the container. Data were subjected to ANOVA and means were separated at the 5% level.

Biotype Growth Analysis. Resistant and S biotypes were established in the greenhouse in a RCB design with eight replications. Growth conditions were similar to the gene flow greenhouse study. Harvest measurements were conducted 10, 20, 30, 40, and 50 days after planting. Growth parameters photosynthesis, leaf area, and dry weight were measured destructively at each harvest date. Photosynthesis was measured with the LI-COR 6400 portable photosynthesis meter. Leaf area measurements were conducted with the LI-COR 3100 area meter. Data were subjected to ANOVA and means were separated at the 5% level.

Biotype Competition Analysis. A replacement series competition analysis was used to evaluate competitive differences between R and S biotypes. A RCB design was used in the greenhouse with two biotypes, four harvest times, seven proportions, and three replications. A density of six plants per pot was used in this experiment. Growth conditions were similar to the gene flow greenhouse study. Harvest measurements were taken 10, 20, 30, 40 days after planting. Growth parameters photosynthesis, leaf area, and dry weight were measured at each harvest location with the same instruments as in the growth analysis study. Data were subjected to ANOVA and means were separated at the 5% level.

RESULTS AND DISCUSSION

Gene Flow. Significant sites of resistance were found at 30.4 m, which was the limit of our study (Figure 1 and 2). In addition, there was a significant north-south wind effect on pollen movement. This indicates that wind move the pollinators more in one direction than the other. This indicates that resistance can move a large distance in one growing season.

Biotype Growth Analysis. Overall, biotype effect was not significant. In other words, there were no statistical differences between resistant and susceptible growth habits when grown under single plant conditions. With regard to the growth parameters photosynthesis, leaf area, and dry weight (data not shown), there are no differences between resistant and susceptible biotypes (Figure 3 and 4).

Biotype Competition Analysis. Biotype, proportion, and biotype x proportion effects were not significant. Resistant and susceptible biotype photosynthesis, leaf area, and dry weight (data not shown) parameters in mixture equaled R and S biotype photosynthesis, leaf area, and dry weight (data not shown) parameters in monoculture (Figure 5 and 6). In other words, R to R and S to S intra-competitive effects were equal to or similar to R to S inter-competitive effects.

CONCLUSIONS

Gene flow through pollen transfer occurs yearly with movement documented up to 30 meters. Single plant or noncompetitive conditions shows no significant differences between photosynthesis, leaf area, and dry weight parameters of R and S biotypes. Similarly, replacement series competition analysis shows no significant differences between photosynthesis, leaf area, and dry weight parameters of R and S biotypes when comparing monoculture conditions to mixture conditions. Therefore, without herbicide selection pressure, R and S biotype populations would tend to stabilize over time without any apparent fitness advantage to the R biotype.

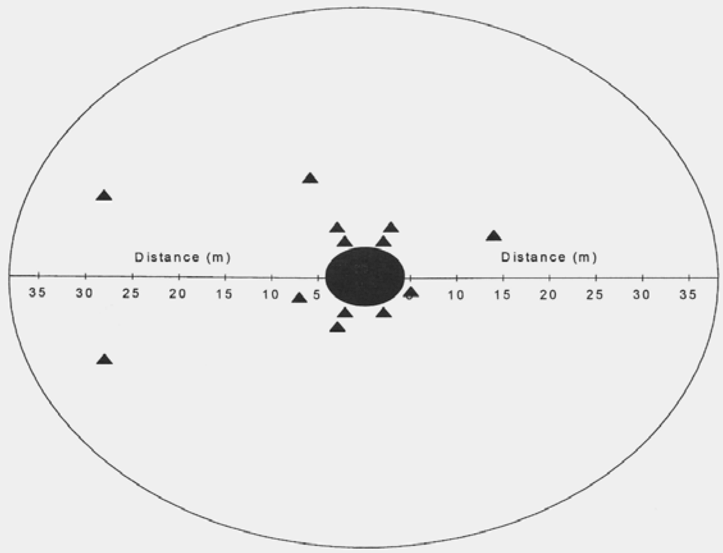


Figure 1. Significant resistance found denoted by the triangles at the Oskaloosa site in northeast Kansas in 1998. Shaded areas with the large R indicates resistance source for the entire circle.

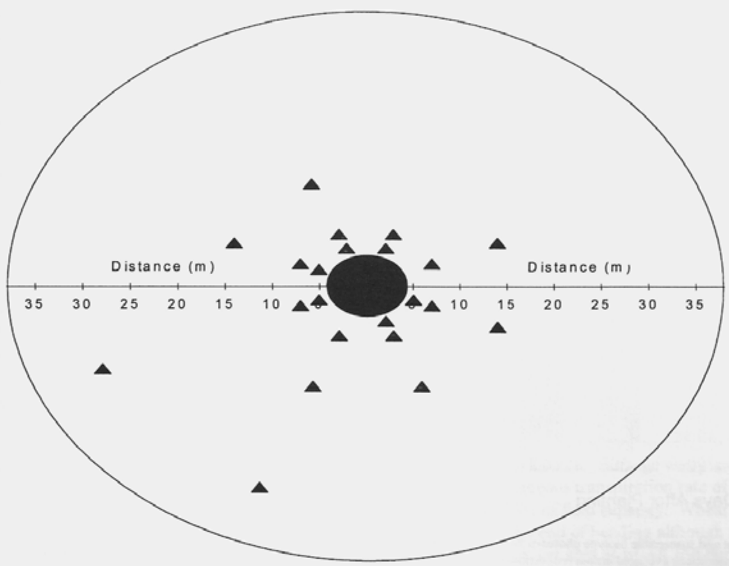


Figure 2. Significant resistance found denoted by the triangles at the Olsburg location in northeast Kansas in 1998. Shaded areas with the large R indicates resistance source for the entire circle.

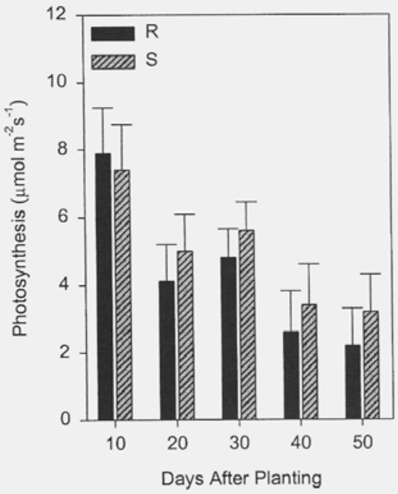


Figure 3. Resistant and susceptible biotype photosynthesis under single plant conditions.

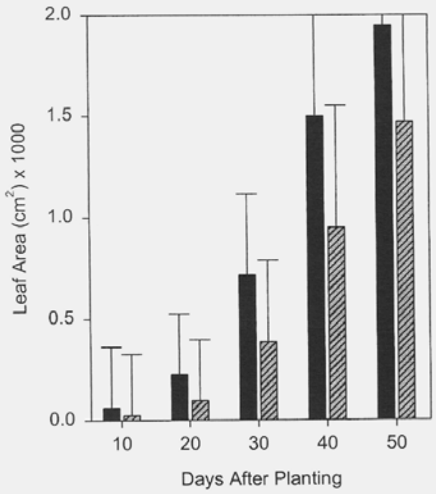


Figure 4. Resistant and susceptible biotype leaf area under single plant conditions.

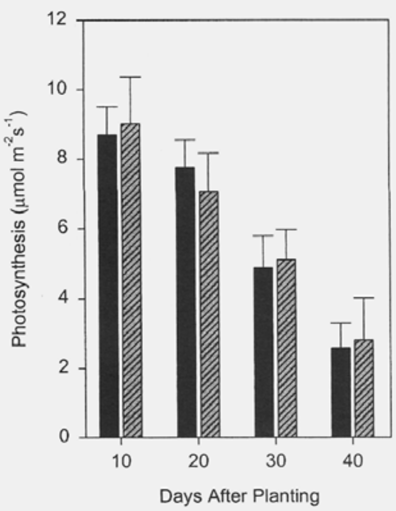


Figure 5. Resistant and susceptible biotype photosynthesis under community conditions averaged across proportions.

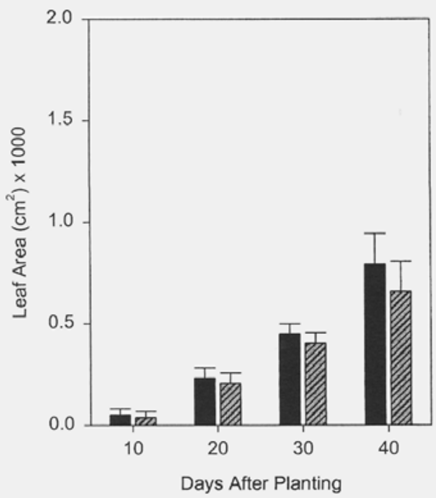


Figure 6. Resistant and susceptible biotype leaf area under community conditions averaged across proportions.

INTERFERENCE BETWEEN YELLOW MUSTARD AND WILD OAT COMPARED TO CANOLA AND WILD OAT IN GREENHOUSE EXPERIMENT. Oleg Daugovish and Donald C. Thill, Graduate Research Assistant and Professor, Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83844-2339.

Abstract. Use of alternative crops is an important tool in non-chemical suppression of wild oat in cereal grain production systems. The differential competitive ability of canola and yellow mustard with wild oat in unknown. A greenhouse experiment at the University of Idaho compared the competitive ability of 'Idagold' yellow mustard with wild oat and 'Sunrise' canola with wild oat using a replacement series design with total density of 75 plants/m². On average, yellow mustard at proportions of 33, 50 and 66% with wild oat reduced above ground biomass of the wild oat by 35% and panicle production by 60%. However, canola had little or no effect on wild oat per plant biomass and of panicle number. A single yellow mustard plant was equally competitive with two wild oat plants while a single canola plant was competitively equal to 0.8 wild oat plants. Crop development data and observations suggest that rapid germination and early growth of yellow mustard are responsible for it's greater interference with wild oat. This study indicated greater importance of intraspecific interference for yellow mustard and interspecific interference for canola with wild oat. The effects of intra- and interspecific interference for both crops are being quantified in on-going addition series field experiment.

EFFECTS OF SEED SPACIAL ARRANGEMENT ON WILD OAT COMPETITION IN SPRING WHEAT. Bob Stougaard[1], Gregg Carlson[2], and Doug Holen[1], Associate Professor, Associate Professor, and Research Associate, Montana State University,[1]Northwestern Agricultural Research Center, Kalispell, MT 59901 and [2]Northern Agricultural Research Center, Havre, MT 59501.

Abstract. A strict reliance on herbicide technology for wild oat management has not been sufficient. A preventative approach is needed that shifts focus to the crop rather than the weed with the objective of creating a more competitive cropping system. Several agronomic factors can be reconfigured to favor the crop at the expense of the weed, including seed spacial arrangements and seeding rates. In this study, spring wheat seed was placed in band widths of 10, 13, and 15 cm utilizing a Concord air drill equipped with Farmland double shoot openers. The spring wheat was seeded at 67 and 134 kg/ha. These core treatments were superimposed over wild oat densities of 0, 50, 100, and 150 plants per square meter. Wide band widths and higher seeding rates both contributed to improved wild oat suppression and greater wheat yields. Wild oat tiller number, biomass and seed yield decreased as band width and seeding rate increased. Concurrently, spring wheat tiller number, biomass, test weight and yield increased with wider seed placement and higher seeding rates.

SKELETONLEAF BURSAGE STUDIES: TRANSPIRATION RATES, WATER USE, AND INTERFERENCE. Dave Claypool, Ron Delaney, and Stephen D. Miller, Research Associate, Professor, and Professor, Department of Plant Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Skeletonleaf bursage (*Ambrosia tomentosa* Nutt.) is native to the south central Great Plains and Rocky Mountain States. It is a serious perennial weed in the wheat-growing areas of southeast Wyoming. Three studies were conducted in a growth chamber to compare skeletonleaf bursage and hard red spring wheat (*Triticum aestivum* L.) with regard to: a) transpiration rates, b) water use, and c) interference. Bursage was planted using shoots from lateral roots and wheat was planted as sprouted seeds. Instantaneous transpiration rate of bursage was higher than wheat when soil water content was 49 to 75% and less than 10% of field capacity. Wheat water use rate (kg H_2O pot^{-1} day^{-1}) exceeded that of bursage between boot stage and the end of heading although these rates were not significantly different except on one day. Both total water use and leaf area of wheat and bursage were

not significantly different. Wheat produced 74% more stem dry matter per pot than bursage. Bursage leaf dry matter production and leaf dry matter per kg water used were nearly double that of wheat. As bursage interference increased (more bursage plants per pot), wheat grain and total plant dry matter yields were significantly decreased. The number of wheat heads per pot decreased with increasing bursage interference.

BIOLOGY OF BIENNIAL WORMWOOD. Kris J. Mahoney and George O. Kegode, Graduate Research Assistant and Assistant Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Abstract. Biennial wormwood, a native weed of the Northern Great Plains, has spread throughout northern United States and southern Canada. Biennial wormwood is estimated to produce over one million seeds per plant, but additional information on biology of the species is limited. The objective of this research was to study morphology and life cycle characteristics of biennial wormwood. In 1999, an experiment was conducted to determine the influence of biennial wormwood transplanting date on flowering, biomass, and seed production. Seedlings were started in a greenhouse 2 weeks prior to nine transplanting date treatments (May 21, May 30, June 15, June 30, July 15, July 30, August 15, August 30, and September 15). Weekly destructive sampling began 2 weeks after transplanting and ended on September 29. Plants from cohorts 1 through 7 flowered between August 18 and September 15, whereas those from cohorts 8 and 9 had not flowered by September 29. Plants from cohorts 1 through 9 produced an average of 252, 514, 474, 247, 76, 16, 1, 0.3, and 0.1 grams of dry matter per plant, respectively, by September 29. Based on flower production at the first flowering date, plants from cohorts 1 through 7 produced approximately 33,000, 24,000, 19,000, 13,000, 6,000, 400, and 150 seeds per plant, respectively. On the last sampling date, plants from cohorts 1 through 7 produced approximately 80,000, 160,000, 170,000, 94,000, 37,000, 9,300, and 230 seeds per plant, respectively. Biennial wormwood exhibits an annual life cycle, and biomass production is related to seed production.

WEED SUPPRESSION IN POTATOES WITH FALL INCORPORATED NOVEL *BRASSICA* HYBRIDS.
Dennis J. Tonks[1], Charlotte V. Eberlein[2], Matthew J. Morra[3], Jack Brown[3], and Mary J. Guttieri[1], Postdoctoral Research Associate, Professor and District III Director, Professor, Associate Professor, and Support Scientist, [1]Univ. of Idaho, Aberdeen, ID 83210; [2]Univ. of Idaho, Twin Falls, ID 83303; and [3]Univ. of Idaho, Moscow, ID 83844.

Abstract. *Brassica* plants such as mustard and rapeseed contain glucosinolates, which are sulfur containing compounds that are enzymatically hydrolyzed to toxic compounds which may control weeds, soil borne diseases, and nematodes. Field experiments were conducted in southeastern Idaho to evaluate the efficacy of various *Brassica* species incorporated in the fall for weed suppression in potatoes grown the following year. The experiment consisted of a weedy control, a standard herbicide treatment (rimsulfuron at 0.026 kg/ha plus metribuzin at 0.28 kg/ha), *B. napus* L. (cv 'Helios'), *B. napus* L.(cv 'Humus'), and two novel hybrids, *B. hirta* x *B. campestris* and *B. hirta* x *B. napus*. Green manure crops were planted on August 21, 1997 and September 2, 1998 and incorporated on October 8 both years. The plot area was then planted to potatoes the following spring. In 1998, green manure treatments did not reduce weed density or biomass. In contrast, the standard herbicide treatment reduced hairy nightshade, common lambsquarters, and redroot pigweed weed density 7- to 11-fold compared to the weedy control. Total weed biomass for the standard treatment was 0.5 g/m^2 compared to 330 g/m^2 for the weedy control. In 1999, kochia density was reduced 39 to 48% by green manure treatments and biomass was reduced by 35 to 48% relative to the weedy control. However, redroot pigweed, common lambsquarters, hairy nightshade, and green foxtail were not suppressed by green manure treatments. The standard treatment reduced weed density 84 to 100% and weed biomass 29 to 100%, depending on species, relative to the weedy control. The fall incorporated *Brassica* green manure system may be of limited use for weed suppression under high elevation, short growing season conditions in southeastern Idaho.

COMPARISON OF ROUNDUP ULTRA™ AND ENGAME® (ETK-2303) FOR CONTROL OF PRICKLY SIDA, PURPLE NUTSEDGE, MORNINGGLORY AND SICKLE POD - GREENHOUSE STUDIES.
William T. Molin, USDA-ARS, Stoneville, MS 38776.

Abstract. Greenhouse experiments were conducted in 1999 at the Southern Weed Science Research Unit to evaluate the efficacy of the Roundup Ultra and Engame formulations of glyphosate for control prickly sida, morningglory, sickle pod, and purple nutsedge. Engame is a proprietary formulation of glyphosate produced by Entek Corporation. Applications were made on g ae basis. Injury from Engame was evident after 24 h and was characterized as desiccation and necrosis of the leaves. The I_{50} for inhibition of growth at three weeks after treatment by the Engame formulation was 2- to 4-times lower than that of Roundup Ultra. These results show that there are unique formulations of glyphosate with properties that likely improve uptake. Application of the formulation alone did not cause injury to the species tested.

2000-2001 WESTERN SOCIETY OF WEED SCIENCE OFFICERS AND EXECUTIVE COMMITTEE
(L to R): Donn Thill, WSSA Representative; Bob Stougaard, Member-At-Large: Richard Zollinger, Education and Regulatory Section Chair; Mark Ferrell, Secretary; Rod Lym, CAST Representative; Wanda Graves, Treasurer/Business Manager; Phil Stahlman, Research Section Chair; Jeff Tichota, Immediate Past President; Don Morishita, President; Robert Parker, President-Elect.

EDUCATION AND REGULATORY

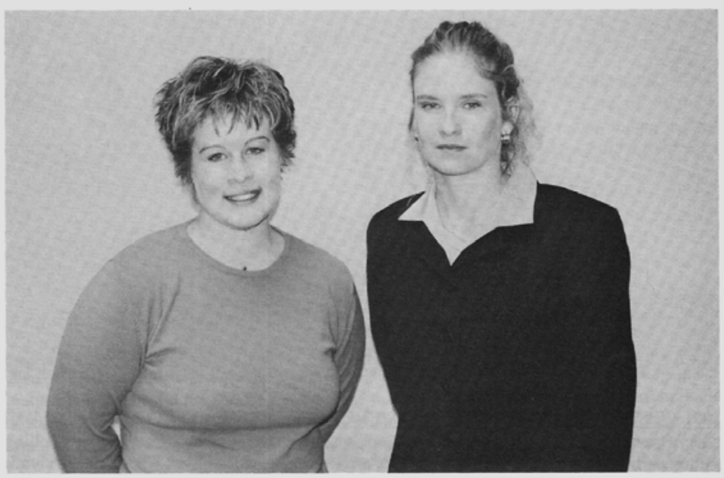
A PRIVATE RESEARCHER SHOWS HOW ELECTRONIC DEVICES CAN AID IN FIELD RESEARCH.
Mick G. Qualls and James C. Qualls, Director of Research, Qualls Agricultural Laboratory, Ephrata, WA 98823, and Computer Network Administrator, Big Bend Community College, Moses Lake, WA 98837.

Abstract. Digital cameras, scanners, and computers are now used in field studies to document and transport both visual results and numerical data instantly throughout the world. The use of e-mail to transfer digital images and numerical data simultaneously is being used in both efficacy and residue testing disciplines.

Digital cameras allow taking of both still and motion pictures, which can be printed or e-mailed. Scanners along with a computer, likewise, can scan an electronic image or photograph and transmit the scanned color images of insects or weeds over the Internet for identification purposes. The resolution of today's cameras and scanners coupled with laser printers allows top quality color images for the field researcher's use.

Several computer programs are available today that can be run on your office PC that will compile efficacy data and statistically analyze the results instantly. Residue (Good Laboratory Practices) studies can be conducted from start to finish today by capturing the raw data in real time, in the field, on computers that have been validated and verified to calculate and file the data under FIFRA GLP Regulations. EPA and FDA accept this new technology as long as their regulations are adhered to.

Field researchers today are faced with the potential of plot destruction from Environmental Activists that perceive our work to be detrimental to man and the environment. A systematic approach, using the Internet's World Wide Web, is in place to help locate research plots for potential destruction.



2000 WESTERN SOCIETY OF WEED SCIENCE STUDENT POSTER WINNERS
(L to R): Lynn Fandrich (2nd) and Elme Coetzer (1st)
Not pictured: Brian Olson (3rd)

RESEARCH PROJECT MEETINGS

PROJECT 1: WEEDS OF RANGE AND FOREST

Chairperson: Rita Beard

Subject: Invasive Species

Rita gave opening remarks and set the stage for a discussion on invasive species, where we addressed the following:

1) Where do we draw the line?
2) What is and what is not an invasive species?
3) What is a usable definition?
4) What are the biological and ecological characteristics of an invasive?
5) When, if ever, does an invasive species become naturalized?
6) Should economic value be a consideration in the classification of a plant as an invasive?

The definition of an invasive species? Eric Lane described a situation in Colorado where there is a serious question of the invasiveness of blue flax, which was included in the state's weed identification book. However, blue flax has economic value through the nursery industry. It is sold as seed, and seed companies are concerned about losing it. It has been identified as a European species. Is blue flax an invasive species? Much discourse has ensued on this issue in Colorado. Should it be pursued as a weed, and should the state instigate regulatory action in light of the industry surrounding this species?

The group struggled with the definition of an invasive species. The group acknowledged that defining invasiveness is important yet often very difficult. Many thought that there was not a single working definition of an invasive species, but that a clear, working definition is needed.

Some in the seed trade association argue that there is no process (no template) for states to decide whether a species is invasive. It was pointed out that there is a Risk Assessment process at the federal level, but not at the state level. The group agreed that a non-native species is not necessarily invasive. Furthermore, native species in one habitat may be invasive in another (i.e., across the country). Thus invasive species are not all exotic or non-indigenous(i.e., spartina, bursage). Common milkweed and poison ivy are invasive in the cropland field but not in the adjacent ditch.

What are the characteristics of an invasive species? No real set of criteria reached consensus but the following were recognized: a) plant species that have 'escaped' cultivation are not automatically invasive nor economically or ecologically threatening; b) the designation of invasive is and must be completely species dependent; c) at what plant density is invasiveness declared and we begin to take action?

What constitutes a threat? For example, does blue flax really pose a threat to Colorado rangeland? (Question to Lane) "Why was it included in the identification guide?" (Response) "Because it is non-native, and was observed to have escaped cultivation." The group generally agreed that we need data to support a supposed threat and that we need to define the scope and that our decisions need to be backed by good science. What is beyond the disruption of ecosystem processes.

Does invasion result in loss of ecosystem function? Functionality needs to be considered. Also, naturalized species probably require a different approach than new invaders. For example, does the alleged invasive species pose an ecological threat, does it pose a health risk, i.e., is it poisonous? It will take a long time to sort it out.

Should we use the protocols to determine a species invasiveness developed by Sara Reichard at University of Washington. Sarah's model and others have identified some characteristics of invasive species.

Suggested issue should be based on an ecosystem level, not restricted legal boundaries. California lists wild and a threat in addition to agricultural and a threat of specific plant behavior. Cal Epse replied "The nursery industry is not always contrary." The question is how lists are developed.

International Invasive Species Working Group. The International consortium defined plant invasion and naturalization based on ecological processes. It divided invasive plants into categories.

1) Casual invaders, naturalized (survive but without range expansion <100 m in 100 years).
2) Invasive (>100 m in 50 years).
3) Transformers, those that change or alter the ecosystem.

For example, wild oat and soft chess are transformers but are not invasive. Separate ecological species from their impacts. Moreover, the classification is location dependent. For example, yellow starthistle is naturalized in Florida but is a transformer in California and Idaho. We need to distinguish between economic and ecological species effects.

The seed trade and horitoricultural/nursery industry expects 'due process'. How will you know? Joe DiTomaso stated that there are about 1000 exotic species in California. They are all naturalized, but only some are transformers.

The question was posed, "What about the lag phase?" There can be 30 to 150 years of invasive timeline. (Response) The Working group paper defines it in 50 years.

Jack DeLoach gave an example of "wild flowers" for sale in catalogs. Jack's position was that we need to prevent introduction of exotic species in the first place. It was pointed out that this was being discussion at the World trade level, which may result in the establishment of treaties. Education is required before we expect the public to participate.

APHIS only recently became involved in regulation of interstate movement of weeds, at the federal noxious weed list. Federal noxious weed list is being re-categorized, and reorganized.

American seed trade association wants to be part of the solution. It is estimated that one in ten introduced plant species brought in by nursery industry has escaped. However, someone mentioned that 73% all weeds currently in the US were intentionally introduced.

Someone mentioned a report of survey of the acceptance of non-native species for land management. Species were deemed ok if needed to prevent erosion, or for animal feed, crested wheatgrass for example.

2001 Officers of Project 1:

Chairperson: Linda Wilson
Dept. PSES
University of Idaho
Moscow, ID 83844-2339
208-885-9489
lwilson@uidaho.edu

Chairperson elect: George Beck
Colorado State University
116 Weed Research Lab
Ft. Collins, CO 80523
907-491-7568
gbeck@lamar.colostate.edu

PROJECT 2: WEEDS OF HORTICULTURAL CROPS
Chairperson: Henry Wu

Subject 1: The Status and Traits of Transgenic Horticultural Crops

Approximately 48 people attended the Project 2 discussion session. Dr. Carlos Reyes of Monsanto and Dr. Steve Fennimore of UC Davis, Salinas, CA initiated discussion with short presentations.

Dr. Reyes began with a short presentation on Subject 1. He outlined prominent concerns such as the public acceptance of transgenic crops, and those with a lower public profile including fair and appropriate technology pricing strategies, stewardship issues of seed movement, trait performance, and resistance management, and biotechnology impacts on the agricultural products industry.

Subject 2: The Issues of Transgenics and the Alternatives to Transgenics

Dr. Fennimore spoke on "The Future of Weed Control in Vegetable Crops". Few new herbicides are expected in minor crops because of the expected costs and difficulty of development. Herbicide tolerant crops are being developed but issues of consumer and grower acceptance, weed resistance, drift, and weed shifts are concerns that may limit use. 'Non-transgenic' resistance may address public concerns. A third option is to protect old herbicide uses. The last option he proposed was development of non-chemical technologies using 'smart' cultivators, mulches, solarization, or biofumigation.

Ensuing discussion focused primarily on: 1) the potential of non-chemical technologies; 2) transgenic technology; and 3) the effect of transgenic technology on development of new or novel herbicides.

Could anything be done to eliminate weed seed dormancy by flooding the pollen pool? Genetically manipulating dormancy is very complex and not feasible at this point. Advances in digital technology may allow development of practical and 'smart' cultivators, but reliance on one technology may not be wise.

Most questions were targeted toward emerging transgenic technology. Concern was expressed that transgenics could make some favored varieties unavailable, or that transgenic crops may favor large-scale growers to the detriment of small-scale operations. The scale of crops targeted also may enhance the potential for resistance development. Limited diversity of breeder lines could be used industry wide with BT and Rup resistance, thus putting some industry segments at risk to pathogens or other pests. Monsanto has established a stewardship group within the company to address and advise on these concerns and currently are recommending that requirements for Roundup only be lifted. Developers of transgenic technology are ultimately responsible for undesirable gene flow; regulators are currently asking for hard data to justify proposed management plans to mitigate gene flow.

Would there be an advantage to a proactive labeling approach to both consumer and growers that would emphasize beneficial traits of product or seeds? Product labels are generally required if differentiating major changes in nutritional assessment. Education efforts are in progress but may be out of sync with the rate of technology development.

Herbicide resistant crops may be slowing traditional development programs for new herbicides. Another problem is that new modes of action are unknown. Resources are being diverted toward transgenic development. New herbicides tend to very active, with low use rates, that are targeted toward specific weed problems, primarily in soybean, corn, and cotton that may have limited use in horticulture systems.

2001 Officers of Project 2:

Chairperson: Ed Peachey
Horticulture Department
Oregon State University
ALS 4017
Corvallis, OR 97331
541- 737-3152
Peacheye@bcc.orst.edu

Chairperson elect: Steve Fennimore
Univ. of California
1636 East Alisal St.
Salinas CA 93905
831-755-2896
safennimore@ucdavis.edu

PROJECT 3: WEEDS OF AGRONOMIC CROPS

Chairperson: Drew Lyon

Subject 1: <u>Crop Rotation Studies - Implications for Weed Management</u>

Dr. Bob Blackshaw, with Agriculture & Agri-Food Canada made an initial presentation prior to the discussion session pertaining to crop rotation studies. Dr. Blackshaw outlined the factors to consider prior to implementing long-term rotation studies. These included the following:

- Consult with growers and industry/commodity representatives to clarify and fine-tune objectives of the study.
- Such studies require land ownership or a long-term lease.
- The site selected will typically involve 30 to 40 A and information is required with respect to land use history. Uniform cropping may be required for several years to minimize variability, to determine blocking criteria and the number of replications required. Accurate weather data is needed on site.
- Be realistic with regard to the number of treatments. Additional experiments may be needed to complement and address specific questions. Anticipate flexibility in changing treatments or one component of a treatment over time, e.g., new cultivars, new pest problems, new pesticides.
- Large plots are needed to minimize edge effects and maintain the integrity of the plots over time. You should use large, field-scale equipment which in turn may dictate plot size.
- All phases of each rotation should be present each year. Two to three cycles of a rotation are needed for the rotation effects to stabilize and to obtain meaningful results.
- Intensive soil sampling is needed to determine baseline levels of nutrients, weed seed, disease and insect populations, and to quantify soil physical and chemical properties. A portion of these samples should be archived for later comparisons. Soil seed bank sampling intensity will depend on the objectives of the study. Samples should be taken at the beginning and end of the experiment at a minimum. Samples may be included at the completion of each rotation cycle or on an annual basis.
- Weed density measurement frequency is also a function of the treatments employed and may include pre-seeding counts, prior to herbicide application, pre- and post harvest counts. More intensive counts on a small area basis provide greater accuracy than fewer counts on a large area basis.
- A multi-disciplinary team of scientists is needed with expertise to monitor diseases, insects, microbes, plant residue, soil quality, yield and crop quality. An ag-economist and statistician should be included. Co-leaders for the project are needed to provide continuity and serve as backups. A technician is needed who is specifically assigned to this single project. The technician coordinates the activities of all the participating scientists.

- Analysis should include multivariate statistics such as principle component or canonical discrimination analysis.

Discussion: Questions were raised with respect to soil seed bank sampling. Dr. Blackshaw stressed the amount of time and effort involved with such measurements. The relative attributes and procedures of flotation verses germination techniques for seed bank recovery were discussed. Flotation requires less time. The germination technique typically involves three cycles of wetting and drying or freezing in order to break dormancy.

A question was raised as to whether such studies were too fundamental and whether production recommendations could be derived. Dr. Blackshaw stated that both features could be addressed and that the outcome should not be viewed as a recipe, but as an idea for growers to consider.

Logistical considerations were then discussed. Dr. Blackshaw stressed the need for large plots and a large team of scientists. The long-term nature of these studies means that publications won't be realized for a while and that the data accumulated should be summarized and transferred from graduate student to graduate student throughout.

Subject 2: Working Together to Register Herbicides for Minor Use Rotational Crops

Sam Tutt, with FMC, and Dr. Richard Zollinger, with North Dakota State University, presented information regarding their efforts to register sulfentrazone for sunflower production.

After initial efficacy and crop tolerance trials, efforts were made to get sulfentrazone registered in sunflowers. FMC did not have the financial resources available to support the project alone. Ultimately, the project was managed under the IR-4 program with financial support from FMC and the North Dakota State Department of Agriculture. The North Dakota State Department of Agriculture obtained money from pesticide registration fees that all chemical companies are required to pay to have their products sold in the State. The National Sunflower Association (NSA) was also instrumental in providing support for this project. North Dakota State University, FMC, NSA, IR-4, and the North Dakota State Department of Agriculture were all involved in this registration.

To facilitate such registrations, an initial data package which demonstrates crop safety across environments speeds the prioritization and registration within IR-4. External funding and a network of interested parties is also necessary.

Discussion: Suggestions to speed minor crop registration were offered from the group. These included "crop grouping" which lumps related commodities together. Attaching minor crops to initial major crop labeling also speeds the process. Petitions to IR-4 will typically receive higher prioritization if they are accompanied by data supporting the registration. It was noted that it is easier to register a grass herbicide for a broadleaf crop, and vice versa, as opposed to registering a grass herbicide on a grass crop.

2001 Officers of Project 3:

Chairperson:	Bob Stougaard Montana State Univ. 4570 MT 35 Kalispell, MT 59901 p: (406) 755-4303 f: (406) 755-8951 rns@montana.edu	Chairperson-elect:	Brian Jenks NDSU 5400 HWY 83 South Minot, ND 58701 p: (701) 857-7677 f: (701) 857-7676 bjenks@ndsuext.nodak.edu

PROJECT 4: TEACHING AND TECHNOLOGY TRANSFER

Chairperson: Adrian Wadley

Subject: Ethics and Agribusiness: Precision Farming and Information Technology Developments

Discussion leaders:
Ray D. William, Oregon State University and Darin D. Oelkers, mPower3 Applied Intelligence.

This session involved a presentation from mPower3 on the access and use of information and data as generated by yield monitors, grid sampling and other information technologies (GIS/GPS), followed by an analysis of the perspectives generated by the discussion and how these various perspectives influence the development of solutions.

Ray William briefly introduced: Completing "reasoned judgement" as an everyday ethicist. He asked the group to evaluate Darin Oelkers' discussion of mPower3's "Applied Intelligence" and remote sensing program by asking the questions who *owns*, who *controls*, and who is *impacted* (either benefits or harmed) by this commercial service (i.e., how might the resulting data or information be used by different people for their benefit or harm).

Darin Oelkers described how his company, mPower3 works with processors, elevators, dealers, and growers to gather and assimilate grower data from individual fields. For example, he related one situation where a processor would work with several elevators and the elevators in turn would work with many growers to develop a data base to benefit all three. Data would include: remote sensing, ground truthing, smart soil and crop sampling, yield monitoring, field histories (crops, fertilizer, pesticides, other inputs), and weather data. In addition to monitoring weed, insect, and disease infestations, the end purpose would be to improve farming efficiencies and possibly gain competitive advantages through better information management. Growers could compare their farm practices and performance to the aggregate database compiled from all elevators, processors, and other professionals.

Questions and comments:

Who owns the data?
-Farmer owns his own information.
-Elevator/consultant can have access, if agreed by the farmer.
-All information levels are password protected.
-Aggregate data queries can only be made by subscribers.
-Subscribers may opt out of having their data in the aggregate database.

Are subscribers happy?
-Generally yes.

Is information available on field history?
-There was excellent debate on who may gain access to the historical information and how it would be used. Views varied significantly, but it was generally acknowledged that record keeping requirements will increase in the future and this type of database could provide a valuable service. The mPower3 system has - will have - this as an optional feature of the service.

Does mPower3 make recommendations?
-No – they just provide information.

Can you predict commodity outputs using the mPower3 system?
-Yes – if they decide it is ethically okay to use the data for that end.

Do growers worry that they are giving control to someone else?
-That is a predominate factor keeping some growers from working with the system, however it depends on agreements as to how data can be used by others. There is concern over confidentiality if, perhaps, courts should ask for records. Currently, growers can delete all records out of the system. Competitive companies will have to say what they plan to do with the data – it will be the key to getting customers. Participants indicated that both Safeway and Walmart have developed huge customer databases to utilize in determining buyer preferences, etc. They felt that commercial companies would be very willing to pay to have access to databases such as the one described.

Who owns information on the land – the farmer or the landowner?
-Probably the one who paid for collecting it – it may be the grower or the landowner.

When do you decide to release aggregate data and to whom? At some point would you let the Ag Statistics Service or other government agency have access to the data?
-Only as it is established in the contract. Participants felt there may be some abuses in allowing aggregate data use for other purposes other than the original intent.

Will the data be use to direct sales?
-Maybe, but base users will be reluctant to let their information go into the aggregate.

Can you fly over land and take data without authorization?
-Currently yes and is obviously being done by government and private companies using satellites and aircraft. There certainly are potential ethical issues in this area which remain unresolved.

Ray Williams followed with a short discussion on how to resolve the ethical questions raised during the session. He discussed "Ethic-based arguments or positions". As a discussion point we proposed a hypothetical situation in which a farmer and information technology company (precision ag) are considering a contractual arrangement was suggested. Darren Oelker's discussion was used as the basis for the illustration of the process of listening and understanding that Ray Williams uses to reach a "reasoned judgement". Different ethical positions were used to illustrate the sometimes intractable positions which can arise when discussing the same topic.

The process had involved completing brief questions as the group listened and discussed. A record was made of who each participant thought was impacted either positively or negatively by the ownership or control of information being proposed as described earlier.

Different ethical positions are then described such as utilitarian, environmental and rights based positions (e.g. libertarian rights and egalitarian rights). A brief discussion was held about the various ethical positions which could be and were held by members of the group about the control and ownership issues raised in the main body of the discussion. This illustrated how understanding the ethical position of a participant in a debate is crucial to reaching a reasoned judgement.

2001 Officers of Project 4:

Chairperson: Pamela J. S. Hutchinson
1693 S. 2700 W.
University of Idaho
Aberdeen, ID 83210
208-397-4181
phutch@uidaho.edu

Chairperson-elect: Rick Boydston
10401 N. 1739 PRNW
Grandview, WA 98930
509-786-9267
boydston@tricity.wsu.edu

PROJECT 5: WETLANDS AND WILDLANDS
Chairperson: Scott Stenquist

Subject 1: Executive Order 13122 – Invasive Species.

There were approximately 40 people attending this discussion session. Scott Stenquist welcomed everyone and handed out copies of the February 3, 1999 Executive Order (EO) for them to review. Participants agreed that this EO is a significant and important step in getting greater federal attention and support for the Invasive Species issue. At the same time it was noted that there are concerns about definitions especially in regards as to what constitutes an "invasive"species. The EO, in addition to creating a federal *Invasive Species Council* (led by the Secretaries of Interior, Agriculture and Commerce) provides for 1) establishing an *Invasive Species Advisory Committee*; and 2) the development of an *Invasive Species Management Plan* which is to be completed in the fall of 2000.

The Invasive Species Advisory Committee (ISAC) has been organized and is comprised of 32 non-federal participants several of which are WSWS members. It was noted that Idaho Governor Dirk Kempthorne is also a member of the ISAC. A list of the ISAC members was distributed.

The Invasive Species Management Plan will be developed by a series of workgroups coordinated by federal staff led by the Department of Interior's Gordon Brown. The workgroups will address the following:
1) communication, outreach, and education; 2) policy and regulation; 3) risk analysis and prevention;
4) management including control and restoration; 5) international activities and cooperation, and; 6) research, information sharing, documentation and monitoring.

An overview document called "Guiding Principles" will establish parameters to guide development of the Invasive Species Management Plan.

A short discussion ensued about a November 16, 1999 letter sent to the President, signed by 42 U.S. Senators encouraging the administration to make funding for programs to combat invasive species a priority in the fiscal year 2001 budget. This request was followed by a December 16, 1999 letter from the Western Governor's Association supporting the earlier letter from the 42 U.S. Senators.

Glen Secrist noted that the Western Governors Association (WGA) is also pursuing an invasive species initiative. Paul Gertler, of the WGA staff has been tasked with leading a workgroup to develop direction for the WGA's *Undesirable Non-Indigenous Species Program.* The workgroup continues to work on the recommendations for WGA direction. Major concepts emerging include the need for the states and region to develop: 1) "local capacity"; 2) statewide invasive species councils, and 3) single point of contact and rapid response teams for invasive species concerns.

Subject 2: Strengths and Weaknesses of Current Local, State, and Federal Weed Partnerships.

Scott led the discussion. Some of the concerns expressed by the group centered on the need for greater communication with and education of "middle managers". They are often key in carrying forward with conviction the budget needs of field managers and specialists. Other participants cited the need for more economic analysis of the real cost of invasive species on local environments and economies.

Other items that surfaced included the idea for regional and state demonstration areas where local groups and landowners could view the effectiveness of integrated pest management and restoration. There are many grants available from non-government organizations (NGO) which could provide resources for demonstration areas. This suggestion stimulated significant discussion from the group about the need for more proficiency in preparing grant applications. Although no consensus was reached on how to accomplish this there was agreement that state invasive species councils or even more local groups might best accomplish this.

Funding concerns were discussed at length and most participants felt this was a major deficiency in federal invasive species management efforts. There were many ideas about how to increase federal funding to match the scope of the invasive species problem. Although line-item budgeting was mentioned as an option, most felt that this would only decrease other important agency programs and that the only answer was "new" federal money. This will only happen in the short term if local and state groups can get the "facts" to, and get the support of their members of congress.

Subject 3: Use of all Integrated Weed Management Techniques.

Scott led the lengthy discussion about how the U.S. Fish and Wildlife Service participation in the USDA Technical Advisory Group on the Biological Control of Weeds (USDA-TAGBCW) could be strengthened. Specific examples were discussed including the Salt Cedar/Southwest Willow Flycatcher issue and the Giant Salvinia problem. A copy of Dr. Jim Storey's letter to Dr. Bill Brown of the U.S. Department of Interior was provided to participants. Some of the recommendations for this process included

- That USFWS maintain full support of TAGBCW.
- USFWS need "one voice" at TAGBCW.
- USFWS concerns and objections need to brought forward through petitions to TAGBCW.
- Timely decisions from APHIS.
- USFWS needs more involvement from Washington and Regional offices as well as field stations.
- Review protocols need to be developed.
- Reviews need to occur early and often.

The meeting concluded with a general discussion about what WSWS and their members could do to increase support and funding for invasive species work; especially for federal agencies which have invasive species management responsibilities. The following recommendations were received from participants:

1. Emphasize prevention and early detection and eradication.
2. Emphasize the use of "good science" with emphasis on integrated pest management and greater use of statistically sound inventory and monitoring data.
3. Always identify cost of inaction when analyzing cost of invasive species.
4. Encourage federal agencies to examine and revise if necessary, their review procedures (USFWS & Army Corp of Engineers were specifically mentioned).
5. WSWS should collaborate with other societies, and NGO's to develop a letter to the administration and agencies emphasizing the need to allocate greater resources and new funding for implementing the 1999 EO.
6. Develop information emphasizing the extensive federal land ownership in the West and comparing federal allocations compared to state and private funding on a cost per acre comparison.
7. Encourage greater involvement from related agency programs such as fire, recreation, and construction/engineering for combating invasive species.
8. Do the best with what resources you have.
9. Encourage agencies to increase participation in the "Pulling Together" initiative.
10. Focus on the need for more biocontrol research.
11. Develop more effective outreach programs so that more citizens (public) will become involved in invasive species issues.
12. Develop greater networking among individuals and agencies to provide more timely response to issues.

2001 Officers for Project 5:

Chairperson: Glen M. Secrist
Idaho Dept. of Agriculture
2270 Old Penitentiary Road
Boise, ID 83701
208-332-8536
gsecrist@agri.state.id.us

Chairperson-elect: Eric Lane
Colorado State Weed Coordinator
Colorado Dept. of Agriculture
700 Kipling St., #4000
Lakewood, CO 80215
303-239-4182
eric.lane@ag.state.co.us

PROJECT 6: BASIC SCIENCES
Chairperson: Kassim Al-Khatib

Subject: Occurrence and Distribution of Glyphosate Resistant Weeds and Mechanism of Glyphosate Resistance in Weeds.

The speakers discussed glyphosate resistance in rigid ryegrass (*Lolium rigidum*) and goosegrass (*Eleusine indica*). They also briefly outlined some investigations into control problems using glyphosate on several populations of common waterhemp (*Amaranthus rudis*) from the Midwest.

RIGID RYEGRASS (*Lolium rigidum*)
Australia: Four sites of glyphosate resistant rigid ryegrass have been confirmed in southern Australia. The first site was identified in 1996. In total the sites cover approximately 20 ha. The location and situations of the sites are Orange (Orchard), Junee (fire break), St. Arnaud (continuous cropping), and Quirindi (continuous cropping). The sites had received between 12 and 15 glyphosate applications each. Populations varied in their level of resistance, ranging from between a 2- to 10-fold increase in glyphosate resistance. There is also wide variability in levels of resistance between individuals within a single population. Cultural, agronomic and alternate herbicides have mitigated the spread of these populations.

California: In 1998 two populations of rigid ryegrass with resistance to glyphosate were confirmed from almond orchards in Northern California. The total area is approximately 5 A. The level of resistance is between 3- to 5-fold. Use of mowing the middles of the almond orchard and using oryzalin or sethoxydim have mitigated spread.

Mechanism of resistance: Monsanto has invested substantial resources and time to determine the mechanism of glyphosate resistance in rigid ryegrass. Problems faced by researchers are the high levels of variability in this species in general and the variability in levels of resistance. They had categorized levels of resistance as low (2X), medium (6X), and high (10X). Experiments ruled out uptake, translocation, and metabolism as mechanisms of resistance. Although shikimate levels are different in R and S the shikimate pathway is still impacted in both biotypes. Basal levels of EPSPS enzyme are 2 to 3X higher in R biotype. However no single factor appears to correlate to the level of observed resistance and the data suggests a more complex mechanism of resistance.

GOOSEGRASS (*Eleusine indica*)
Malaysia: Four sites of glyphosate resistant goosegrass have been confirmed in Malaysia. The populations were found in oil palm orchards and vegetable crops. There are many growers involved and approximately 150 ha infested with the R biotype. Geographically found in four different sites but all have similar levels of resistance – approximately 2- to 4-fold. Growers where this problem arose typically used backpack sprayers to apply 8 applications/year at 45-day intervals for a total of 10 years. Initially growers used 900 g/ha but as control declined they used up to 1.8 kg/ha. There is some preliminary indication that some of these populations may also have paraquat resistance.

Mechanism: Slight difference in uptake and translocation observed but not enough to impact resistance levels. No difference in metabolism between R and S. Lower shikimate levels in R plants indicates shikimate pathway only partially blocked. Glyphosate target enzyme EPSPS is approximately 5-times less sensitive to glyphosate in the R biotype. Four changes in nucleotides in EPSPS coding region, compared to susceptible, resulted in 2 amino acid changes in EPSPS protein of R biotype. Glyphosate resistance in *Eleusine* is due to insensitive EPSPS to glyphosate.

WATERHEMP (*Amaranthus rudis*)
In 1998 a complaint from one field in Iowa about poor control of waterhemp after application of glyphosate resulted in investigations by Mike Owen at Iowa State University. There does appear to be a differential response however there is not a field history of glyphosate usage on the field (first year of glyphosate produced poor results). This may suggest natural population variability in waterhemp tolerance to glyphosate. Work is ongoing at Iowa State University and also at the University of Missouri (a couple of other complaints in Southern Illinois and Missouri). Whether waterhemp is classified as "glyphosate resistant" will be determined by the results of these experiments.

General Recommendations For Product Stewardship by Monsanto:
Scouting and monitor fields.
Monsanto will test suspected cases of resistance.
Use label rates – cutting rates may have exacerbated problems in Malaysia.
Tank mixes.
Support RR crop rotations – also using acetochlor/atrazine, alachlor, halosulfuron, sulfosulfuron and triallate.

On the bright side: Mutagenesis studies in aribidopsis indicate it is highly unlikely to obtain spontaneous resistance to glyphosate.
Widespread use of glyphosate since the 70's has only resulted in these two weeds evolving resistance – it is indeed a rare event.
Only one binding region.
Modification to EPSPS enzyme often results in less fit or dead.

Discussion: Questions revolved around which species are most likely to evolve resistance – those most sensitive to glyphosate or the already marginally controlled (like buckwheat, velvetleaf, and waterhemp). No clear-cut answer to this was given, as we really don't know the answer. Naturally tolerant species are more likely to result in "species shifts" rather than resistance. As observed in the citrus industry, where glyphosate has been used for over 20 yrs continuously, species shifts have caused management changes. It is likely that we will see similar changes in the Midwest.

The session was well attended with 61 people in the audience. The two speakers gave a very comprehensive report on the distribution and mechanism of resistance of glyphosate resistant weeds.

2001Officers of Project 6:

Chairperson: Ian M. Heap
Weedsmart
P.O. Box 1365
Corvallis, OR 97339
541-929-6636
541-929-3040
heapian@pioneer.net

Chairperson-elect: Paul Isakson
Monsanto
7250 Westfield Court
St. Charles, MO 63304
636-447-1622
paul.j.isakson@monsanto

MINUTES OF THE 53rd ANNUAL BUSINESS MEETING
WESTERN SOCIETY OF WEED SCIENCE
HOLIDAY INN CITY CENTER--TUCSON, ARIZONA
MARCH 16, 2000

Call to Order - The meeting was called to order by President Jeff Tichota at 7:05 a.m.

Minutes - John Orr
It was moved (Doug Ryerson) and seconded to approve the minutes of the March 1999 business meeting as published in the proceedings. Motion passed.

Financial Report - Wanda Graves
There were 385 people in attendance at the meeting, of which 323 had pre-registered.
The WSWS is in good financial standing, with a current balance of $320,062.07. Revolving account balances account for $154,437.54 of the total capital. Revolving accounts hold funds to support Weeds of the West ($85,837.31), Noxious Weed Management Short Course ($16,415.21), and Biological Weed Control Handbook ($52,185.02). Capital is distributed as follows: mutual funds $156,273.28, certificate of deposit $10,537.60, money market savings $142, 641.15, and checking account $10,610.04. The revolving account is slightly higher than normal.

Immediate Past President's Report - Rod Lym
Three members were recognized at the Retirees' Reception and New Member Recognition on Monday night. They were Ted Warfield-FMC, Bill Miller-Dow AgroSciences, and Jack Warren-Bayer.

The video by Vermeer Production, *Life Out of Bounds: The Threat of Invasive Plants to the American Landscape,* that has been supported by the WSWS has not been completed. Vermeer is about $100,000 short to finish the project.

Rod has updated the Secretary and Student Contest section of the operating guides and posted them to the Web.

Program Committee - Don Morishita
There were 142 total presentations this year: 54 were posters (12 of which were in the student competition) and 88 were oral presentations (27 of which were entered in the student competition). Electronic submission of abstracts worked well, with a few wrinkles to iron out. Don believes this is the way to go.

Local Arrangements - Bill McCloskey
Despite problems with the sleeping rooms everything else went well with the meeting. The meeting rooms and functions came off without a hitch. Bill thanked his committee for all their efforts.

WSWS Representative - Donn Thill
The 40th meeting of the WSSA was held in Toronto, Canada, at the Westin Harbour Castle Hotel on February 6-9, 2000. There were 618 attendees. The 2001 meeting will be held on February 11-14 at the Four Seasons Holiday Inn Convention Center in Greensboro, NC. The 2002 meeting will be February 10-13 in Reno, NV. Jacksonville, FL, will be the site of the 2003 meeting. The 50th anniversary of WSSA will be in 2004 and the meeting will be in Kansas City, MO, the location of the first WSSA meeting.

Electronic submission of abstracts will move from the University of Georgia to Allen Management and Marketing (Am&M) for the 2001 meeting. The WSSA Membership Directory will be published on the WSSA web site beginning this year.

The new WSSA Director of Education is Leslie Weston. This is a three-year term; the Director of Education will be a voting member of the WSSA Board of Directors.

Am&M and WSSA signed a one-year contract with provision to renew for two more years. A three-year contract was signed with Allen Press.

An article on future research direction in weed science will be published this year in *Weed Technology*. A white paper is being prepared for use in Washington, DC.

Communication among member societies, the WSSA Washington Liaison Committee, and Rob Hedberg has improved this past year, but more improvements are needed. Member society funding for the Director of Science Policy is projected to remain static for the next four or so years. Priorities for 2000 will be as follows: Major issues--FQPA, agriculture biotechnology, and invasive weeds; minor issues--worker protection standards, USDA-ARS national weed science program, and funding for weed research and management.

WSSA currently is financially sound with about $1,054,528. However, the Society expects to lose money this next year, mostly due to higher than expected meeting costs at Toronto and lower than expected attendance.

Charlotte Eberlein is president-elect of WSSA and Carol Mallory-Smith is Treasurer. Jodie Holt and Gail Wicks were named Fellows of WSSA.

CAST Representative - Steve Miller
Steve strongly encouraged WSWS members to join CAST.

The council conducted its fall board meeting in Phoenix, AZ, Sept. 30 - Oct. 2, 1999. The spring board meeting is scheduled in Washington, DC, March 23-25, 2000. Four new reports were issued as follows: Movement and impacts of detrimental non-native plants affecting agricultural production and natural resources environments; Applications of biotechnology to crops: benefits and risks; Animal agriculture and global food supply; and Gulf of Mexico Hypoxia: land and sea interactions. Several reports are in progress.

Committee Reports

Awards - Neil Hageman
Bart Brinkman and George Beck were selected as the Outstanding Weed Scientists for the private and public sector respectively. The President's Award for service to the WSWS was presented to Gus Foster for his overall long-term efforts on behalf of the society.

Site Selection - John Orr
The 2001 meeting will be in Coeur d'Alene, ID, at the Coeur d'Alene Resort. The 2002 meeting will be in Salt Lake City, UT, at the Little America.

It has become increasingly more difficult to find adequate meeting locations while maintaining sleeping room costs under $100. John conducted a straw poll of the membership to determine if the committee would be allowed to consider rooms in the $125 range. The membership overwhelmingly voted in favor of the room increase. The committee will be looking at Hawaii sites for 2003.

Fellows and Honorary Members - Doug Ryerson
Recipients of this year's Fellows awards were Frank Young and Rod Lym. There was no Honorary Member award this year. There are no carry-over nominations for either award this year, so members were encouraged to submit nominations to the committee by May 15.

Nominations - Dave Cudney
One hundred and twenty seven members cast ballots in this year's election. The following individuals won their respective elections: Bob Parker--President; Mark Ferrell--Secretary; Scott Nissen--Research Section Chair Elect; and Phil Banks--Education and Regulatory Section Chair Elect.

Finance - Nelroy Jackson

The committee reported that the WSWS finances had been audited and accepted by the committee and that Wanda Graves continues to do excellent work in managing the society.

It was announced that the executive committee had retained Merrill Lynch to manage the society's investments. The distribution of the $320,000 account will be as follows: **Short Term Investments** (liquid operating capital accounts)--$10,000 in checking (1/3 of annual operating expenses); $104,000 in Merrill Lynch FDIC insured money market ($4000 conference expenses, $16,000 Noxious Weed Management Short Course, $20,000 (2/3 of annual operating expenses), and $64,000 balance due on Weeds of the West. **Long-Term Investments**--$206,000 in Merrill Lynch Mutual Fund Advisory Service ($10,000 CD, $40,000 excess money market savings, and $156,000 in bond mutual funds). (Copies of these documents will be on file in the secretary's notebook.)

Sustaining Membership - Vince Ulsted

Sustaining Membership letters were sent to 21 current members and four new companies. A total of 18 memberships contributed $6200. Two new memberships included United Agri Products and Sedagri. The total membership declined from 21 to 18, with a loss of $800 in contributions.

Necrology - Steve Fenimore

The committee received notification of four deaths associated with the WSWS. W. Eugene Arnold died August 25, 1999. He taught and conducted research in plant and weed science at South Dakota State University and received numerous awards and honors.

Gary A. Lee died on November 17, 1999. Dr. Lee served on the staff of the University of Wyoming and the University of Idaho in numerous teaching, research, and administrative positions. He was extremely active in the WSWS, serving as President and receiving the Fellow award for his efforts. He received many other honors and awards during his career. Dick Fosse was a long-time active member of the WSWS. He served as President and received the Fellow award. He also served as President of the California Weed Conference.

Leslie Sonder died on Feb. 8, 1999. He worked as the Extension Weed Specialist at Montana State University and, while with the California Department of Food and Agriculture, was in charge of state weed eradication programs in California for twenty years.

Two other deaths were reported during the meeting. They were Robert Higgens, a long-time extension weed specialist with the University of Idaho; and Charles Robocker, a researcher at Washington State University.

Herbicide Resistant Plants - Ian Heap

The video on herbicide resistant weeds is out of copies. Because the video is expensive to reproduce, it will not be renewed; it will be replaced by a fact sheet. There will be no summer workshop this year. The Herbicide Resistance Action Committee-North America has set three priorities: identification of weed resistance, educational tools to promote resistance management, and educational strategies.

Resolutions - Joe Yennish

No resolutions were received.

Student Educational Enhancement - Joe DiTomaso

Six students participated in last year's program. Eight are signed up for this year's program.

Legislative - Jim Olivarez

The committee and Rob Hedberg followed several issues of interest to the society which include Regional integrated pest management centers; House Bill 88; the Plant Protection Act; the Food Quality Protection Act; and Invasive Species Interagency Council and Advisory Committee.

Other continuing issues and support are needed for Ag Biotech, WPS exemption for research workers, and ARS National Weeds Program. Suggestions to strengthen to committee include scheduling periodic contacts with the Executive board member, a quarterly report, chairperson (or proxy) to attend the annual WSSA, and Washington Liaison committee--a person with a background in crops is needed on this committee.

Publications - Barbra Mullin

Weeds of the West has sold 97,000 copies and made $160,000 on the first edition. The revised edition contains 300 new seedling photos and is currently being printed. Biological Control of Weeds of the West had 3000 printed and is not sold out. It will not be reprinted. Both books are now digitized.

Placement - Jesse Richardson

There were two forms submitted for positions desired and three forms submitted for positions available.

Editorial - Kathy Christianson

The 1999 Proceedings realized income of $4575.59 with an associated cost of $4176, for a net income of $399.59. There are no copies left. There are 142 abstracts/papers submitted for publication in the 2000 Proceedings. The estimated cost for publication is $2262. Donn Thill and Joan Campbell will be the new proceedings editors. 250 copies of the 2000 Research Progress Report were printed at a cost of $10.71 each. Barb Mullin will continue as editor of the Progress Report. Four newsletters were published and posted on the Web Site. The Newsletter editor and the responsibility will return to the President of the WSWS, Don Morishita.

The WSWS web site went from 5000 to 10,000 hits this year. There were 130 online abstract submissions, but only 96 were individual papers that went into the program. Overall the program went well. Joan Campbell will remain as web site editor.

Poster - Kai Umeda

Kai reported that 54 posters were displayed at the meeting. Posters have averaged better than 50 since the Hawaii meeting in 1998. An additional four easels were donated by Valent Corp.

Student Paper Judging - Tim Miller

There were a total of 11 entrants in the Student Poster Contest and 27 entrants in the Student Paper Contest. The paper contest was divided into three sections. Winners from the 2000 Student Paper/Poster Contest were as follows:

Posters: 1st Elme Coetzer, KSU;
2nd Lynn Fandrich, CSU;
3rd Brian Olson, KSU

Paper Section #1:
1st Federico Trucco, CSU;
2nd Jennifer Drewitz, UC, Davis;
3rd Dodi Kazarian, CSU

Paper Section #2:
1st Mark Renz, UC, Davis;
2nd Curtis Rainbolt, UI;
3rd Eric Nelson, NDSU

Paper Section #3:
1st Kevin Kelley, USU;
2nd Oleg Daugovish, UI;
3rd Michael Marshall, KSU

Public Relations - Kai Umeda

Notifications of the 2000 WSWS meeting, along with the programs, were sent to various agricultural publications and regional organizations. Committee members also notified organizations in their geographical sphere of influence. The editor of the WSSA newsletter was contacted regarding the meeting. After 15 years of serving as chair of the committee, Jack Schlesselman is stepping down. Kai will be replacing Jack as committee chair.

Education - Charlotte Eberlein

Noxious Weed Management Shortcourse: Two sessions will be offered at the Sylvan Dale Guest Ranch near Loveland, CO, on April 16-19 and April 19-22. Both sessions are full.

Web-based courses: The possibility of having these types of courses in Weed Biology and Herbicide Mode of Action is slowly moving closer to reality.

Nelson Balke, University of Wisconsin, is developing a web-based Herbicide Mode of Action course that he hopes will go on line this fall.

New Business

Acceptance of new member states - Jeff Tichota

At the executive meeting on March 13, the executive committee approved the request for membership of Texas in the WSWS. Membership approval is required to change the constitution. *Doug Ryerson moved to accept Texas into the WSWS. Seconded/Passed*

President Jeff Tichota then passed the "hoe" to incoming President Don Morishita. Don presented Jeff with a plaque commemorating his tenure as WSWS President and expressing the society's appreciation for his time commitment and for a job well done.

Don invited everyone to the 2001 meeting in Coeur d'Alene, ID.

The meeting was adjourned at 8:25 a.m.

Respectively submitted,

John Orr
WSWS Secretary

WESTERN SOCIETY OF WEED SCIENCE
YEAR-END FINANCIAL STATEMENT
APRIL 1, 1999 THROUGH MARCH 31, 2000

CAPITAL	
1999-00 Balance Forward	$315,063.53
Current Income	299.33
	$315,362.86
DISTRIBUTION OF CAPITAL	
Mutual Funds	$156,273.28
Merrill Lynch Investments	50,500.00
Money Market Savings	102,925.74
Checking Account	5,663.84
	$315,362.86

INCOME	**1999**	**2000**
Registration & Membership Dues	$ 2,085.00	$21,255.00
Proceedings	1,121.59	3,837.25
Research Progress Report	716.09	2,604.75
Bio Weed Control Book	3,165.34	
Noxious Weed Control Short Course	23,872.00	
Weeds of the West Book	134,332.35	
Bank Interest	3,843.99	
Sustaining Membership		5,800.00
Promotional Hats		1,880.00
		$204,513.36
EXPENSES		
Office Supplies & Equipment	446.53	
Postage, Box Rental, Bulk Mailing	2,169.64	
Telephone	561.60	
Franchise Tax Board & Secretary of State	20.00	
Tax Accountant	210.00	
Network Solutions (Website)	500.00	
AESOP/Congressional Fellow (1998-99)	11,300.00	
CAST Membership Dues		510.00
CAST Representative Travel		250.00
Business Manager	7,200.00	
Bio Weed Control Handbook	904.88	
Weeds of the West	128,581.22	
Noxious Weed Control Short Course	31,798.21	
WSWS Promotional Hats		3,696.54
Printing		
Newsletter	1,072.39	
Proceedings	4,176.16	
Programs	975.00	
Student Awards & Plaques	539.70	1,020.00
Audio Visual Rental		2,426.93
Annual Conference Award Plaques	156.90	234.70
Conference Speaker Expense	289.19	3,352.57
Proceedings & RPR Editor Expense		621.00
Refund-Registration Fees		555.00
Executive Committee Planning Meetings	645.87	
		$204,214.03

2000 FELLOW AWARD
WESTERN SOCIETY OF WEED SCIENCE
Rodney G. Lym

Rod Lym began his college career at the West Point Academy and completed his Bachelor's Degree at the University of Wyoming. In 1979, he obtained a Ph.D. from the University of Wyoming. Rod has spent his entire professional career at North Dakota State University in Fargo, ND, beginning as a Postdoctoral Research Associate (1979-1981) and then joining the faculty as Professor of Weed Science.

Dr. Lym has been an active member of the WSWS beginning in 1979, spending 8 years on the Board of Directors. Rod has been deeply involved in various committee assignments including Chair-Project 1, Perennial Herbaceous Weeds (1983-84), Chair-Research Section 2, Weed Biology, Physiology, and Chemical Studies (1987), Finance Committee (1988 & 1989). He was the WSWS Representative to the WSSA (1992-1995), and Chair of the Research Section in 1996. Dr. Lym was the Program Chair in 1998 and was WSWS President in 1999.

Dr. Lym has presented 19 papers at WSWS meetings and has authored 68 papers published in the WSWS Research Progress Reports. His writing skills are not limited to the WSWS, since Rod has also written 34 papers in journals such as Weed Science, Weed Technology, and Journal of Range Management. Rod is also the senior author of 143 scientific papers/chapters in books and Extension publications, as well as non-WSWS Proceedings and Research Reports. Undoubtedly the greatest service to the WSWS has been Rod's serving as Editor of the WSWS Proceedings from 1989 to 1997. He incorporated some innovations that streamlined the procedures for producing the proceedings while keeping the cost to a minimum.

For his exceptional contributions to the Western Society of Weed Science, Dr. Lym was the initial recipient of the *Presidential Award of Merit* in 1994.

Rod has also been very active in the Weed Science Society of America, where he was associate editor of the 6th edition of the WSSA Herbicide Handbook, and was the Chair of the Research Section IV (1989).

Dr. Lym has also served the North Central Weed Science Society as the new herbicide editor for the NCWSS Research Report (1984-1989).

In 1998, Rod received the Society for Range Management Outstanding Achievement Award for eminently noteworthy contributions in advancing the science and art of range management.

Since 1985, Dr. Lym has been an advisor for the North Dakota Weed Control Association state noxious weed control program. Rod's research activities are almost synonymous with leafy spurge, and he was instrumental in publishing "*Leafy Spurge Control in the Great Plains*". Although Dr. Lym doesn't have an extension appointment, he fulfills that role related to rangeland, roadside, and untilled land weed control, including those areas of primary responsibility for county weed control officers. He helps lead several field days each year and makes presentations at several meeting aimed at practitioners. In many ways, Rod is acknowledged both locally and nationally as "*Dr. Leafy Spurge*".

Rod has become the epitome of a young weed scientist, rendering invaluable service to the profession while serving his clientele, university, and state, as well as the regional and national weed science societies with distinction and honor.

2000 FELLOW AWARD
WESTERN SOCIETY OF WEED SCIENCE
Frank L. Young

Dr. Frank Young is a Research Agronomist with the USDA - Agricultural Research Service in Pullman, Washington. He received his Bachelor's Degree in Wildlife Biology from South Dakota State University. Frank obtained both his Masters and Ph.D. from the University of Minnesota, majoring in Agronomy, with an emphasis on Weed Science.

Dr. Young has been very active in the WSWS since 1982 and has presented 6 papers. He was elected and served as Chair of the Research Section, as well as serving as Editor of the WSWS Research Progress Reports in 1991. One of Frank's most significant contributions to the WSWS has been his service on the Student Educational Enhancement Committee since its inception. Dr. Young's other contributions to the WSWS include Chair of the Horticulture Crops Section in 1985, and has served on various committees; such as the Graduate Student Paper Contest Committee, Nominations Committee and the Site Selection Committee.

Dr. Young has also been active in other weed societies; presenting 4 papers at the North Central Weed Control Conference, and 3 papers at Weed Science Society of America meetings. He has served as a member of the WSSA Career Brochures Committee and the Weed Loss Bibliography Committee of the WSSA. Frank has been very active in the Washington State Weed Association and has presented papers at almost every annual conference since 1982. In 1991, Dr. Young was elected an Honorary Member of the Washington State Weed Association.

Although Dr. Young has no formal teaching responsibility, he has been active in training graduate students at Washington State University and the University of Idaho. He is a member of the graduate faculty at both universities. He has served as major advisor for 5 Masters students in Weed Science at WSU, and has served on graduate committees of 7 Masters students and 10 Ph.D. students.

During his career, Dr. Young has published 31 journal articles, 4 book chapters, 5 technical bulletins, 2 extension bulletins, and many abstracts of research on weed biology, weed management, and cropping systems. In 1996, Dr. Young and co-workers received a Certificate of Excellence Award from the American Society of Agronomy for their Pacific Northwest Extension Bulletin on Russian thistle.

Currently, Dr. Young is project leader for a long-term, large-scale no-till spring cropping systems project near Ritzville, WA. This project involves the efforts of 14 scientists from ARS, WSU, UI, and OSU, with liaison members from commodity commissions and several agribusinesses.

2000 OUTSTANDING WEED SCIENTIST AWARD
PRIVATE SECTOR
Bart Brinkman

Mr. Brinkman received his Bachelor's Degree from Utah State University where he majored in Plant Science with a minor in Chemistry. He earned his Master's Degree from South Dakota State University in 1973 where he in majored in Weed Science and minored in Agronomy.

For nearly 25 years, Bart has worked in the Pacific Northwest as a Research and Development Representative. He has remained focused on his development activities even though his employer merged and evolved from Velsicol into Sandoz Agro and in 1997 into BASF Agricultural Products. Through these changes, Bart has stayed the course not only with his own research, but with his support for key university programs. Bart unselfishly works with graduate students as well as involving undergraduates as summer interns to help prepare them for the "real" world.

Bart has excelled as a weed scientist in the Pacific Northwest. He recognizes weed management issues and evaluates product resources to provide solutions that not only develop products for his company but solve weed management problems for the grower. He has been a leader at helping organize regional research projects on a variety of weed science issues. Bart's numerous accomplishments during his career with industry include: his development of perennial weed management strategies with dicamba to control field bindweed within rotational cropping systems; his key support of multi-university research projects to develop dimethenamid for use in potatoes, dry beans, sugarbeets, and grass seed; his focused development activity on dicamba in small grains evaluating reduced rates with multiple tankmix partners to provide efficacy with crop safety; and his exploratory research to identify a safener for dicamba for use in small grains.

Bart is seen as a resource for information, not only on the products he represents, but other products as well. He has an amazing understanding of crop production and pest control for the Pacific Northwest. According to one of the supporting letters, "Bart is considered 'Mr. Dicamba'. He is a walking encyclopedia on the subject."

Bart has been active as a WSWS member and was recognized as a Fellow in 1990. Additionally, he has also been active in several other state and regional societies. His contributions to weed science in the West, his loyalty to the WSWS, and his support of University programs make Bart a worthy recipient of the this award.

2000 OUTSTANDING WEED SCIENTIST AWARD
PUBLIC SECTOR
K. George Beck

George received his Bachelor's and Master's Degrees from the University of Idaho in the field of Animal Science. He earned his Ph.D. in Plant Science from the University of Idaho in 1985. He was hired by Colorado State University where he has excelled as a professor for the last 15 years.

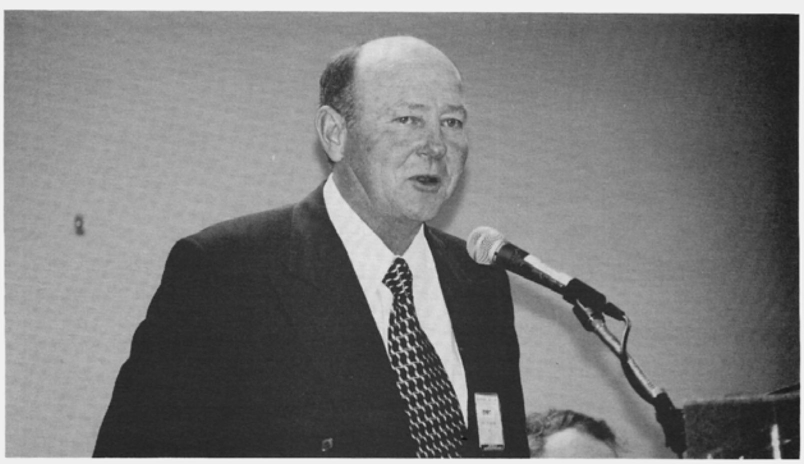
George is highly regarded in Colorado and the Western Region because of his tireless efforts to educate the public about noxious weed issues and his research efforts to develop integrated management strategies for noxious weeds. George has been instrumental in writing and supporting legislation designed to improve the management of noxious weeds on the vast areas of public land in the Western US. As chairman of the Intermountain Noxious Weed Advisory Council, George and the INWAC were instrumental in bringing the noxious weed problem to the federal government's attention. In turn, George was involved in writing Section 15 of the Federal Noxious Weed Act which requires federal agencies to manage noxious weeds in cooperation with state and local governments. In addition, George has been involved with noxious weed management in Colorado. Under his leadership, the Colorado Weed Management Association wrote the Colorado Undesirable Plant Management Act. The bill allowed Colorado to enjoy a uniform statewide weed law.

In addition to the political arena of invasive weeds, George has had many significant contributions to Weed Science through his Extension work at Colorado State University. His numerous published works include refereed journal articles, refereed chapters in books, extension publications, and technical reports. George is well known for his ability to transfer scientific information into usable and valuable information for both scientists and non-scientists alike. He has performed over 137 regional extension presentations in the last four years alone.

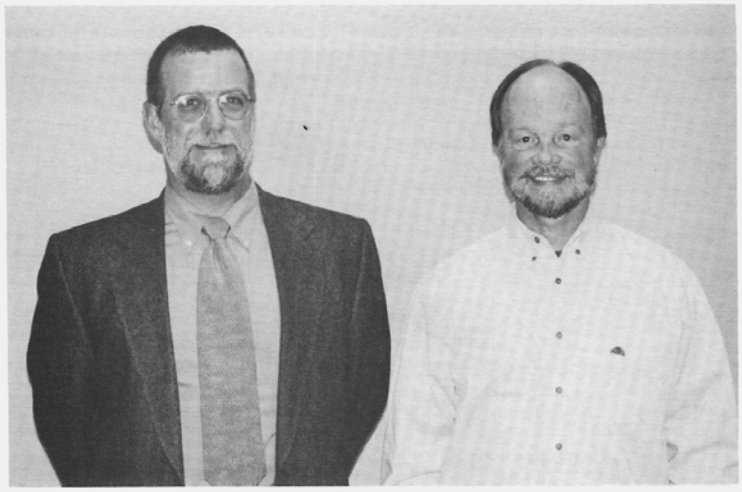
Over the past 15 years, George has been an active member of the WSWS. In addition, he has held leadership roles in several other societies, including the WSSA, Society for Range Management, International Weed Science Society, and the Colorado Weed Management Association.

George's long term support of the WSWS, his leadership roles in fighting noxious weeds at both a state and national level, his numerous professional contributions, and his tireless extension work make him a worthy recipient of this award.

2000 WESTERN SOCIETY OF WEED SCIENCE FELLOWS
(L to R): Rod Lym and Frank Young

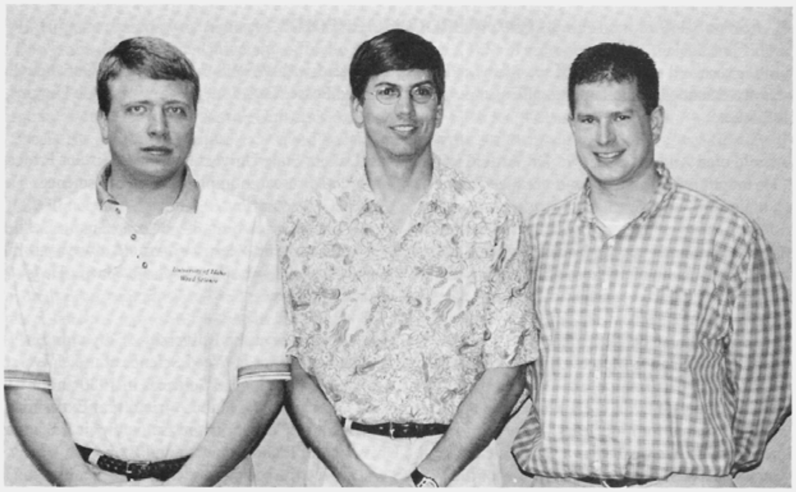


2000 WESTERN SOCIETY OF WEED SCIENCE OUTSTANDING WEED SCIENTIST
Bart Brinkman (Private Sector)

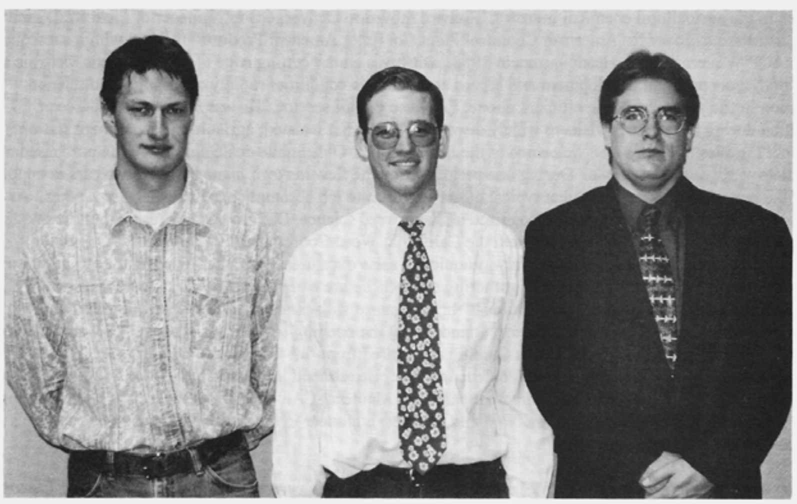


2000 WESTERN SOCIETY OF WEED SCIENCE
OUTSTANDING WEED SCIENTIST AND
PRESIDENTIAL MERIT AWARD WINNER
(L to R): George Beck (Public Sector) and Gus Foster

2000 WESTERN SOCIETY OF WEED SCIENCE STUDENT PAPER WINNERS, SECTION 1
(L to R): Jennifer Drewitz (2nd), Frederico Trucco (1st), and Dodi Kazarian (3rd)



2000 WESTERN SOCIETY OF WEED SCIENCE STUDENT PAPER WINNERS, SECTION 2
(L to R): Curtis Rainbolt (2nd), Mark Renz (1st), and Eric Nelson (3rd)



2000 WESTERN SOCIETY OF WEED SCIENCE STUDENT PAPER WINNERS, SECTION 3
(L to R): Oleg Daugovish (2nd), Kevin Kelley (1st), and Michael Marshall (3rd)

1999 NECROLOGY REPORT

The committee received notification of six deaths of friends associated with WSWS this past year. Our thoughts and prayers are extended to the families of Eugene Arnold, Richard Fosse, Gary Lee, Les Sonder, Bob Higgins and Charlie Robocker.

Eugene Arnold died August 25, 1999. Dr. Arnold joined South Dakota State University as an Assistant Professor in 1970. He taught undergraduate and graduate courses and conducted research in plant and weed science. He also was a major professor for numerous graduate degree students. Gene contributed to the completion of the Northern Plains Biostress Laboratory and received several faculty honors, including the Gamma Sigma Delta, Burlington Northern and F.O. Butler awards, plus Outstanding Teacher of the Year. Dr. Arnold always put his family first. Gene was involved in starting the Brookings Youth Soccer League and was also a coach. He is survived by his wife, Sharon, a son and daughter, five brothers and one sister.

Gary A. Lee died at home on November 17, 1999. Dr. Lee began his career at the University of Wyoming in 1965. In 1975 the family moved to Moscow, ID where Gary was appointed professor of Weed Science at the University of Idaho. Gary became Chairman of the Department of Plant, Soil and Entomological Sciences in 1980 and in 1986 was named the Associate Dean of the College of Agriculture and Director of the Idaho Agricultural Experiment Station where he served for nine years. Gary rejoined the Department of Plant, Soil and Entomological Science in 1995. Since then, he has worked as a weed scientist at the University of Idaho Research and Extension Center at Parma. Gary was a past president and Fellow of the WSWS and served the society tirelessly. He received his B.S. and M.S. degrees from the University of Wyoming and his Ph.D. at Colorado State University. He was a devoted husband, father, grandfather, and friend. He was greatly respected and loved by all who met him. He is survived by his wife, Georgia, a son and two daughters, three grandchildren, a brother and a sister.

R.A. "Dick" Fosse joined Monsanto Chemical Company in St. Louis, MO following graduation from South Dakota State University in 1952. His first assigned task was the development of one of the first herbicide screening programs in the agricultural chemical industry. Richard moved to Denver, CO as Manager of Field R&D activities west of the Missouri River for American Chemical Paint Co. (later Amchem Products) in 1956 with a subsequent move to ACP Western Region Headquarters in 1958. Dick was on the cutting edge of phenoxyacetic, benzoic acid and aminotriazole program development and served as a valuable conduit of rapidly emerging weed science information in the years preceding efficient phone, FAX and e-mail service. He was a welcomed source of information during his frequent visits to widely dispersed, somewhat isolated, agricultural experiment stations throughout the West. He was also welcomed at the Laramie, WY Oldsmobile dealership where he purchased a new vehicle at six month intervals. During one period of time he flew his own plane between two cars at opposite sides of the region which was somewhat typical of his approach to job accomplishment - whatever it takes. As a tribute to and commensurate with well recognized skills in weed science, Dick served as president of the Western Society of Weed Science (WSWS) in 1960 and the California Weed Conference (CWSS) in 1975. A vigilant monitor of Conference activities, Dick was always quick to raise questions "from the floor" relative to questionable procedures. Several learned the wisdom of gathering the facts before entering the debate. Some members will best remember Dick as the host of after hours "wildcat" bridge games with the likes of Drs. Day, Hamilton and Anderson to name a few. They were always in attendance at the opening session the next day. Richard served as Western Research Farm Manager for Union Carbide and retired from full time, active duty in weed science with the acquisition of Union Carbide by Rhone Poulenc in 1986. He retained interest in Society activities and dabbled in contract research activities from his retirement base near Manteca, CA. With the demeanor of a lion and the heart of a teddy bear, Richard A. Fosse was first and foremost a pioneer in the development of weed control as a recognized science. Thank you Dick!

Leslie W. Sonder died on February 8, 1999 at his home. Les began his career with Montana State as an Extension Weed Specialist in Bozeman. He moved to California in 1960 and began a 20 year career with the California Department of Food and Agriculture in charge of statewide weed eradication programs. Les and his wife Sally, retired in 1989 and moved to Utah in 1993. He received his B.S. and M.S. degrees from the University of Wyoming. Les is survived by his wife, two daughters and a son and four grandchildren.

Robert E. Higgins passed away January 24, 2000 at his home in Boise, ID. He was born in Boise on Sept. 19, 1916. Bob graduated from the University of Idaho in 1941 with a B.S. in Agronomy and Agricultural Education and completed an M.S. in Agronomy and Botany in 1959 at the University of Idaho. A year after completing his undergraduate degree he joined the US Navy, where he served as an aerial gunnery instructor until his honorable discharge in 1946. He worked for the University of Idaho from 1946 to 1979 as an Extension Agent and State Weed Specialist. During his tenure as a Weed Specialist he was an active member of the Western Society of Weed Science.

W.C. (Charlie) Robocker passed away in Pullman, Washington on October 12, 1999 at the age of 84.
Dr. Robocker, a native of Kalispell, Montana, received all his academic training at the University of Wisconsin, being awarded a Ph.D. in Agronomy in 1952. Charlie's entire 25 year professional career was spent with the USDA Agricultural Research Service with assignments in Reno, Nevada and Pullman, WA to develop weed management programs for range and pasture. Specific weed programs that he pioneered included studies on *Halogeton*, bracken fern, and Dalmatian toad flax. Charlie was active in the WSWS with regular attendance, as well as serving as chairman of various committees.

2000 WSWS REGISTRATION LIST

Harry Agamalian
UCCE – Emeritus
6 San Carlos Drive
Salinas CA 93901
831-758-0300

Ted Alby
American Cyanamid
12817 SE Angus Street
Vancouver WA 98683
360-896-8664
albyt@pt.cyanamid.com

Sandra Alcaraz
RDA
2345 E 16th Street
Yuma AZ 85365
520-783-3552
rdaaz@aol.com

Craig Alford
Univ of Wyoming
711 N Campbell St
Macomb IL 61455
309-836-9131
alfordcm@phibred.com

Summer Alger
Univ of Wyoming
4810 Sherman Hills #A
Laramie WY 83070
307-742-1583
summerpoole@hotmail.com

Shaffeek Ali
Alberta Agriculture
304, 7000-113 Street
Edmonton Alberta CN
780-422-4909
shaffeek.al@agric.gov.ab.ca

Kassim Al-Khatib
Agronomy Dept
Kansas State Univ
Manhatten KS 66506
785-532-5155
khatib@ksu.edu

Jim Anderson
Bayer Corp
2223 27th Ave Ct.
Greeley CO 80631
970-339-5148

Kim Anderson
Utah State University
4820 Old Main Hill
Logan UT 84322
435-797-2255
sloc9@cc.usu.edu

Monte Andersen
Aventis
22455 Capehart Road
Gretna NE 68028
402-332-5420
monte.anderson@aventis

Randy Anderson
40335 County Road GG
Akron CO 80720
970-345-2259
rlander@lamarcolostate.edu

Arnold Appleby
Crop Science Department
Oregon State University
Corvallis OR 97331
541-737-5894
arnold.p.appleby@orst.edu

Gigi Arino
Zeneca
1200 S 47th Street
Richmond CA 94707
510-231-0000
gigi.arino@agna.zeneca.com

Rick Arnold
NMSU Ag Science Center
P O Box 1018
Farmington NM 87499
505-327-7757
farmingt@nmsu.edu

Motoaki Asai
National Ag Research Center
Upland Weed Lab, NARC
Isukaba JAPAN 305-8666
+81-298-38-8426
masai@narc.attrc.go.jp

David Austin
PBI/Gordon Corp
P O Box 014090
Kansas City MO 64101
816-421-4070
daustin@pbigordon.com

Al Baber
Gowan Company
673 Rosecrans St
San Diego, CA 92106
619-222-8110

Dan Ball
Oregon State University
P O Box 370
Pendleton OR 97801
541-278-4394
daniel.ball@orst.edu

Phil Banks
Marathon Consulting
2649 Navajo Road
Las Cruces NM 88005
505-527-8853
marathanag@zianet.com

Rita Beard
USDA Forest Service
2150 Centre Ave
Ft Collins CO 80526
970-295-5745
Rbeard/wo_ftcol@fs.fed.us

George Beck
Colorado State University
116 Weed Research Lab
Ft Collins CO 80523
970-491-7568
gbeck@lamar.colostate.edu

Carl Bell
UC Cooperative Extension
11080 W Ocean Air Drive
San Diego CA 92130
858-792-5127
cebell@ucdavis.edu

David Belles
Bioagriculture Science
Colorado State University
Ft Collins CO 80523
970-491-5667
dbelles@lamar.colostate.edu

Warren Bendixen
UCCE
624 West Foster Road
Santa Maria CA 93455
805-934-6240

Benjamin Begay
BIA-Natural Resources
P O Box 7-H
Chinle AZ 86503
520-674-5163
benjaminbegay@bia.com

Brent Beutler
Utah State University
4820 Old Main Hill
Logan UT 84322
435-797-2244
bbeut@hotmail.com

Jeff Birk
Cyanamid
P O Box 400
Princeton NJ 08543
6-9-716-3134
birkj@cyanamid.com

Bob Blackshaw
Agriculture & Agri-Food
Box 3000
Lethbridge AB Canada
403-317-2268
blackshaw@em.agr.ca

Sheldon Blank
Monsanto
3805 S Dennis
Kennewick WA 99337
509-586-9060
sheldon.e.blank@monsanto

Jim Bloomberg
Bayer Corp
Box 4913 Hawthorn Rd
Kansas City MO 64120
916-242-2268
jim.bloomberg.b@bayer.com

Bob Bolton
BLM
HC 10 Box 337
Lakeview OR 97630
541-947-6114
rbolton@or.blm.gov

A Bosnic
Zeneca
303-105 Conroy Cresc
Guelph ON Canada
403-219-5417

Bryan Bowden
Bayer Inc
4A-3421 Portage Ave
Winnipeg Manitoba CN
204-985-1564
bryan.bowden.b@bayer.com

Mark Boyles
BASF Corp
RR1 Box 2140
Ripley OK 74062
918-372-4688
boyles@basf.com

Rick Boydston
USDA-ARS
24106 N Bunn Road
Prosser WA 99350
509-786-9367
boydston@tricity.wsu.edu

Luke Bozeman
Monanto
2410 Lake Ridge Circle
Wichita KS 67205
316-721-7750
luke.l.bozeman@monsanto

Ron Brenchley
Bayer Inc.
3841 E 1400 N
Ashton ID 83420
208-652-3911

Bill Brewster
107 Crop Science Bldg
Oregon State University
Corvallis OR 97331
541-737-5884
bill.d.brewster@orst.edu

Bart Brinkman
BASF
5130 2nd Ave SE
Salem OR 97306
503-363-1934
brinkmb@basf_corp.com

John Brock
Arizona State Univ
7001 E Williams Road
Mesa AZ 85212
480-727-1240
john.brock@asu.edu

Dain Bruns
Novartis
2811 Parkview Drive
Fargo ND 58103
701-293-9412
dain.bruns@cp.novartis.com

Mark Brunson
Utah State University
2246 E Grant Road
Tucson AZ 85719
520-326-8890
brunsonm@cc.usu.edu

Carl Buchholz
Novartis
12413 Wide Hollow Rd
Yakima WA 98908
509-966-5740

Lillian Buhler
PSB Dept
Utah State University
Logan UT 84322
435-797-2256
slc8x@cc.usu.edu

Bruce Burdick
BASF
797 NW 305th
Plattsburg MO 64477
816-930-2997
burdicb@basf.com

Stephen Burningham
Utah Dept of Ag
350 N Redwood Rd
Salt Lake City UT 84114
801-538-7183
agmain.sburning@email.state

Alvin Bussan
Montana State University
P O Box 173120
Bozeman MT 59717
Abussan@montana.edu

Steve Busse
American Cyanamid
7469 70th Avenue South
Sabin MN 56580
218-287-2841

Marvin Butler
Oregon State University
34 SE D Street
Madras OR 97741
541-475-3808
marvin.butler@orst.edu

Joan Campbell
University of Idaho
P O Box 442339
Moscow ID 83844
208-885-7730
jcampbel@uidaho.edu

Ken Carlson
American Cyanamid
8040 Cooper Ave
Lincoln NE 68506
402-489-9131
carlsonk@pt.cyanamid.com

Vanelle Carrithers
Dow AgroSciences
28884 S Marshall
Mulino OR 97042
503-829-4933
vfcarrithers@dowagro.com

Kathy Christianson
NDSU Plant Sciences
Loftsgard 460A
Fargo ND 58105
701-231-8132
kchristi@badlands.nodak.edu

Patrick Clay
University of Arizona
4341 E Broadway Rd
Phoenix AZ
602-470-8086
pclay@ag.arizona.edu

Dave Claypool
University of Wyoming
P O Box 3354
Laramie WY 82071
307-766-4151
claypool@uwyo.edu

Bill Cobb
Cobb Consulting Services
815 S Kellogg
Kennewick WA 99336
509-783-3429
wtcobb42@aol.com

Elme' Coetzer
Plant Science Center
Kansas State University
Manhattan KS 66506
785-532-7802
eco4172@ksu.edu

Dana Coggon
Colorado State University
2701 Chaparral Drive
Ft Collins CO 80526
970-225-9215
coggon@holly.colostate.edu

Don Colbert
American Cyanamid
2133 Jackson Street
Lodi CA 95242
209-369-1102
colbert@pt.cyanamid.com

Mark Collins
CSU Weed Science
1718 Cedar Street
Ft Collins CO 80524
970-482-5487
mcol@lamar.colostate.edu

Gil Cook
Dupont
303 S Barker Road
Greenacres WA 99016
509-922-4433
gilbert.e.cook@usa.dupont

Chris Cornwell
Oregon State University
15210 NE Miley Road
Aurora OR 97002
503-678-1264
chris.cornwell@orst.edu

Lisele Cremieux
Crop Science Dept
Oregon State University
Corvallis OR 97331
541-737-7542
lisele.cremieux@orst.edu

Ron Crockett
Monsanto
17004 NE 37th Circle
Vancouver WA 98682
360-892-9884
ron.p.crockett@monsanto.

Lori Crumley
University of Idaho
806 S Jefferson #4
Moscow ID 83843
708-885-6236

Dave Cudney
University of CA
4106 Batchelor Hall Ext
Riverside CA 92521
909-787-5823
dcudney@ucracl.ucr.edu

Randall Currie
Kansas State University
4500 E Mary Street
Garden City KS 67846
316-276-8286
rcurrie@oz.oznet.ksu.edu

Tim D'Amato
113 Weed Lab
Colorado State University
Ft Collins CO 80523
970-491-5667
tdam@lamar.colostate.edu

Mark Dahmer
American Cyanamid
20232 E Lake Avenue
Aurora CO 80016
303-617-8314
mark_dahmer@py.cyanamid

Jim Daniel
UAP
P O Box 1190
Johnstown CO 80534
970-532-2154
jdaniel@uap.com

Oleg Daugovish
PSES Department
University of Idaho
Moscow ID 83844
208-885-6236
daug6527@uidaho.edu

Jean Dawson
Retired-USDA
9103 S Moore Rd
Prosser WA 99350
509-786-3956

Frannie Decker
NM Dept of Agriculture
Box 30005
Las Cruces NM 88005
505-646-8005
fdecker@nmda-bubba.nmsu

Joe Decruyenaere
Botan & Plant Science Dept
University of CA
Riverside CA 92521
909-787-2541
jose@citrus.ucr.edu

Ron Delaney
Plant Sciences
University of Wyoming
Laramie WY 82071
307-766-3103
rdelaney@uwyo.edu

Jack DeLoach
ARS
808 E Blackland Road
Temple TX 76502
254-770-6531

Steve Dewey
PSB Department
Utah State University
Logan UT 84322
435-797-2256
steved@ext.usu.edu

Joe DiTomaso
Weed Science Program
University of CA
Davis CA 95616
530-754-8715
Ditomaso@vegmail.ucdavis

Martina Dokladalova
Veg Crops Department
University of CA
Davis CA 95616
530-752-8200
mava@ucdavis.edu

Jennifer Drewitz
UC – Davis
730 Miller Drive
Davis CA 95616
530-757-6774
jjdrewitz@ucdavis.edu

Celestine Duncan
Weed Management Services
P O Box 1385
Helena MT 59624
406-443-1469
weeeds1@ixi.net

Keith Duncan
NMSU-CES
67 E Four Dinkus Rd
Artesia CA 88210
505-748-1228
erbc@nmsu.edu

Shane Early
Washington State University
255 SW Arbor
Prosser WA
509-332-8082
searly@wsu.edu

Charlotte Eberlein
U of I R & E Center
P O Box 1827
Twin Falls ID 83303
208-736-3600
ceberl@uidaho.edu

Mike Edwards
Dupont
14611 Pecos St
Broomfield CO 80020
303-280-3830

Matt Ehlhardt
Aventis
363 Picholine Way
Chico CA 95928
530-891-0651
matt.ehlhardt@aventis.com

Clyde Elmore
Weed Science Program
University of CA
Davis CA 95616
530-752-9978
clelmore@ucdavis.edu

Stephen Enloe
Vegetable Crops Dept
University of CA
Davis CA 95616
530-752-8284
sfenloe@ucdavis.edu

Jim Enyart
West Coast Beet Seed Co
P O Box 7717
Salem OR 97303
503-393-4600
jj@wcbeet.com

Tracy Ertz-Berger
ADOT Natural Resources
2650 Castleview Drive
Prescott Valley AZ 86314
520-772-0906
tertzberger@dot.state.as.us

Steven Eskelsen
Monsanto
3603 S Quincy Place
Kennewick WA 99337
509-539-8807
steven.r.eskelsen@monsanto

John Evans
Utah State University
4820 Old Main Hill
Logan UT 84322
435-797-2242
jevans@mendel.usa.edu

John Everitt
Texas Ag Expt Station
Route 3, Box 219
Lubbock TX 79403
806-746-6101
jd-everitt@tamu.edu

Chad Fabrizius
American Cyanamid
210 E Plum Street
Colby KS 67701
785-462-3397
chad_fabrizius@py.cyanamid

Lynn Fandrich
Dept of BSPM
Colorado State University
Ft Collins CO 80523
970-482-0717
fandrich@lamar.colostate.

John Fenderson
Monsanto
P O Box 47
Kiowa KS 67070
316-825-4315
john.m.fenderson@monsanto

Steve Fennimore
UCCE
1636 East Alisal Street
Salinas CA 93905
831-755-2896
safennimore@ucdavis.edu

Mark Ferrell
University of Wyoming
P O Box 3354
Laramie WY 82071
307-766-5381
ferrell@uwyo.edu

Cheryl Fiore
NMSU
652 W Union Ave
Las Cruces NM 88005
505-646-1627
cfiore@nmsu.edu

Vernon Fischer
Columbia Ag Research Inc
5601 Binns Hill Road
Hood River OR 97031
541-387-3052
bigpears@gorge.net

Scott Fitterer
North Dakota State Univ
Loftsgard Hall
Fargo ND 58105
701-231-6220
sfittere@ndsuext.nodak.edu

April Fletcher
US Fish & Wildlife Service
P O Box 1306
Albuquerque NM 87103
505-248-6632
April_Fletcher@fws.gov

Peter Forster
Novartis
P O Box 158
Sanger CA 93657
559-875-6075

Gus Foster
BASF Corporation
812 E Elizabeth
Ft Collins CO 80524
970-484-8925
fosterj1@basf.com

Harold Fraleigh
Natural Resouces Ecology
Colorado State University
Ft Collins CO 80523
970-491-1604
haroldf@nrel.colostate.edu

James Freeman
Cascade County
521 1st Ave NW
Great Falls MT 59404
406-454-6920
weedandmosquito@mcn.net

Sandra Frost
University of Wyoming
P O Box 657
Laramie WY 82073
307-755-1387
frost47@uwyo.edu

Jay Gehrett
Spray Tech
Rt 3 Box 27
Walla Walla WA 99362
509-525-0146
gehretja@wwics.com

Todd Geselius
Dow AgroSciences
3240 36th Avenue SW
Fargo ND 58104
701-271-8479
tcgeselius@dowagro.com

Kevin Gibson
Department of Agronomy
University of CA
Davis CA 95616
530-752-9778
kdgibson@ucdavis.edu

Les Glasgow
Zeneca Ag Products
1200 S 47th Street
Richmond CA 94707-1112
510-231-5001
les.glasgow@agna.zeneca

Gaylan Goddard
American Cyanamid
1101 Parkside Circle
Lawrence KS 66049
785-331-3039
goddardg@pt.cyanamid.com

Wanda Graves
WSWS
P O Box 963
Newark CA 94560
510-790-1252
WGraves431@aol.com

John Green
3411 S Camino Seco #44
Tucson AZ 85730

Brian Greenfield
New Mexico State Univ
P O Box 328
Mesilla Park NM 88047
505-646-1627
brianjames@zianet.com

Alan Haack
Dow AgroSciences
103 Moorland Ct
Roseville CA 95661
916-797-7595
aehaack@dowagro.com

Lloyd Haderlie
AgraServ Inc
3243 JoAnna Ct
American Falls ID 83211
208-226-2602
lloyd@agraserv.com

Neal Hageman
Monsanto Company
17754 W Hampton Woods
Wildwood MO 63005-6333
314-694-2465
neal.r.hageman@monsanto

Brad Hanson
107 Crop Science Bldg
Oregon State University
Corvallis OR 97331
541-757-8446
bradley.hanson@orst.edu

Laura Hanson
109 Crop Science Bldg
Oregon State University
Corvallis OR 97331-2002
541-737-7542
laura.hanson@orst.edu

Ian Heap
Weedsmart
P O Box 1365
Corvallis OR 97339
541-929-6636
ianheap@weedsmart.com

Jerry Hensley
Novartis
1380 Lead Hill Dr #201
Roseville CA 95661
916-783-1834
jerry.hensley@cp.novartis

Ismael Hernandez-Rios
NMSU
101 Gregg Street
Las Cruces NM 88003-0003
505-646-1014
ihernand@nmsu.edu

Jeff Herrman
Monsanto
3478 North 2983 East
Twin Falls ID 83301
208-736-7294
jeffrey.c.herrman@monsanto

Charlie Hicks
Aventis Crop Science
105 Mt Moriah Road
Livermore CO 80536
970-490-2993
charlie.hicks.@aventis.com

George Hittle
IAF
P O Box 1901
Cheyenne WY 82003
Ghittle@wyoming.com

Tom Hoban IV
North Carolina State Univ
Box 8107
Raleigh NC 27695

Ken Hollon
Oklahoma State University
413 S Burdick
Stillwater OK 74074
405-624-1492
andyhollon@netscape.net

Rick Holm
Univ of Saskatchewan
51 Campus Drive
Saskatoon SK Canada
306-966-5015
holm@sask.usask.ca

Jodie Holt
Botany & Plant Sciences
University of CA
Riverside CA 92521
909-787-3801
jodie.holt@ucr.edu

Tom Holt
BASF
5045 Sunset Fairway Dr
Research Triangle Park NC
919-547-2178
holtt@basf.com

Marc Hoobler
Aventis Crop Science
1711 Leavenworth St
Manhattan KS 66502
785-770-9973
marc.hoobler@aventis.com

Stott Howard
Zeneca
1200 S 47th St
Richmond CA 94707
510-231-5059
stott.howard@agna.zeneca

Pamela Hutchinson
U of Idaho
Aberdeen R&E Center
Aberdeen ID 83210
208-397-4181
phutch@uidaho.edu

Paul Isakson
Monsanto
7250 Westfield Court
St Charles MO 63304
636-447-1622
paul.j.isakson@monsanto

Kimihiro Ishikawa
Nissan Chemical America
1291 Cumberland Ave
W Lafayette IN 47906
765-497-1161
ishikawa@nissan.wintek

Jim Jackson
UC Davis
36604 County Road 12
Woodland CA 95695
530-752-2173

Nelroy Jackson
Monsanto
400 S Ramona Ave #212
Corona CA 92879
909-279-7787
nelroy.e.jackson@monsanto

Marie Jasieniuk
Dept of Land Res & Env Sci
Montana State University
Bozeman MT 59717
406-994-6589
mariej@montana.edu

Brian Jenks
NDSU
5400 Hwy 83 South
Minot ND 58701
701-857-7677
bjenks@ndsuext.nodak.edu

Darryl Jewett
USDA-ARS
1500 N Central Ave
Sidney MT 59270
406-482-9481
djewett@sidney.ars.usda.gov

Curt Johnson
Forest Service
324 25th Street
Ogden UT 84401
801-625-5600
cjohnson/r4@fs.fed.us

Susan Johnson
USDA-Forest Service
740 Simms Street
Golden CO 80401
303-275-5065
sjohnson/r2@fs.fed.us

Herbert Jones
BIA
P O Box 7H
Chinle AZ 86503
520-674-5100
herbert_jones@doi.gov

Kurt Jones
Novartis
10715 Ottawa
Bakersfield CA 93312
661-587-9064

Larry Justesen
Carbon County
P O Box 1126
Rawlins WY 82301
307-324-6584
larryks@trib.com

Decio Karam
Colorado State University
1600 W Plum #26C
Ft Collins CO 80521
970-491-5667
karam@lamar.colostate.edu

Dodi Kazarian
CSU
3501 S Stover #6-133
Ft Collins CO 80525
970-204-6613
dodi@lamar.colostate.edu

George Kegode
North Dakota State Univ
166 Loftsgard Hall
Fargo ND 58105-5051
701-231-6420
george_kegode@ndsu.nodak

Jason Kelley
272 Ag Hall
Oklahoma State University
Stillwater OK 74078
405-624-7063
jkelley@mail.pss.okstate.edu

Kevin Kelley
Utah State University
4820 University Blvd
Logan UT 84322
435-787-1725
kevin.kelley@usu.edu

Dan Kidder
Novartis
8901 Larchwood Drive
Kernersville NC 27284
336-992-0196
dan.kidder@cp.novartis.com

Don Kirby
Animal & Range Science
North Dakato State Univ
Fargo ND 58105
701-231-8386
dkirby@ndsuext.nodak.edu

Ken Kirkland
Agriculture & Agri-Food
P O Box 10
Scott SK Canada SOK 4A0
306-247-2011
kirklandk@em.agr.co

Robert Klein
University of Nebraska
Rt 4 Box 46A
North Platte NE 69101
308-532-3611
Rklein@unl.edu

Jeff Klundt
FMC Corp
P O Box 278
College Place WA 99324
509-526-5279
jeff_klundt@fmc.com

Jeff Koscelny
Monsanto
1707 Wheatland Ave
Hays KS 67601
785-625-9661
jeffrey.koscelny@monsanto

Bill Kral
Dupont Ag Products
1739 Julie Lane
Twin Falls ID 83301
208-734-9726
c-william.kral@usa.dupont

Lori Kroiss
107 Crop Science Bldg
Oregon State University
Corvallis OR 97331
541-737-7542
lori.kroiss@orst.edu

Sanjeev Kulshreshiha
NMSU
MSC 3BE
Las Cruces NM 88003
505-646-1014

Guy Kyser
UC Davis
1 Shields Ave
Davis CA 95695
530-752-8284
gbkyser@ucdavis.edu

Richard LaCasse
BLM
1800 Marquess St
Las Cruces NM 88005
505-525-4408
rich_lacasse@nm.blm.gov

Eric Lane
Colorado Dept of Ag
700 Kipling St #4000
Lakewood CO 80215
303-239-4182
eric.lane@ag.state.co.us

Jerry Langbehn
University of Wyoming
Box 962
Thermopolis WY 82443
307-864-3421

Art Lange
Herbicide Research
9400 S Lac Jac
Reedley CA 93654
559-638-3084

Tom Lanini
Dept of Vegetable Crops
University of CA
Davis CA 95616
530-752-4476
wtlanini@ucdavis.edu

Larry Lass
PSES Dept
University of Idaho
Moscow ID 83844
208-885-7802
llass@uidaho.edu

Homer LeBaron
1230 N Cottonwood Circle
Heber UT 84032
435-654-5821
homerlebaron@shadowlink

John Leffel
JL Agricultural Cons
1260 NE Oleander
Hillsboro OR 97124
503-648-2742

Jackie LeNoble
AZ Dept of Transportation
2104 South 22nd Ave
Phoenix AZ 85009
602-712-6700
jlenoble@dot.state.az.us

Carl Libbey
WSU
16650 SR 536
Mt Vernon WA 98273
360-848-6139
libbey@coopext.wsu.edu

Kelly Luff
Aventis Crop Science
3554 East 4000 North
Kimberly ID 83341
208-423-6371
kelly.luff@aventis.com

Earl Lukkes
Big Horn Co Weed & Pest
355 East 5th Street
Lovell WY 82431
307-548-7261

Rod Lym
Plant Science Department
North Dakota State University
Fargo ND 58105
701-231-8996
lym@plains.nodak.edu

Drew Lyon
University of Nebraska
4502 Avenue I
Scottsbluff NE 69361
308-632-1266
dlyon2@unl.edu

LeAnna Lyon
Texas Agric Expt Station
Rt 3 Box 219
Lubbock TX 79401
806-746-6101
bollweevil_98@yahoo.com

Bill Mace
Utah State University
140 N 100 East
Hyde Park UT 84318
435-563-6157
bmace@mendel.usu.edu

Kris Mahoney
NDSU
480D Loftsgard Hall
Fargo ND 58105
701-231-8130
kmahoney@prairie.nodak

Najib Malik
Health Canada
2250 Riverside
Ottawa Ontario Canada
613-736-3636
najib_malik@hc-sc.gc.ca

Carol Mallory-Smith
107 Crop Science Bldg
Oregon State University
Corvallis OR 97331
541-737-5883
carol.mallorysmith@orst.edu

Richard Mann
Dow AgroSciences
9330 Zionsvillle Rd
Indianapolis IN 46268
317-337-4180
rkmann@dowagro.com

Mike Marshall
Kansas State University
2004 Throckmorton Center
Manhattan KS 66502
785-532-7241
marsw@ksu.edu

Suellen May
Larimer Co Weed District
P O Box 1190
Ft Collins CO 80522
970-498-5768

John Mayfield
Patchen
1147 N State Street
Ukiah CA 95482

Todd Mayhew
Valent
459 N Gilbert Road
Gilbert AZ 85234
480-503-2918
todd.mayhew@valent

Larry Maxfield
BLM
7875 S 3850 West
West Jordan UT 84088
801-539-4059
Lmaxfiel@ut.blm.gov

Brian Meese
Monsanto
1203A Airport Rd
Ames IA 50010
515-956-3084
brian.g.meese@monsanto

Abdel Mesbah
University of Wyoming
747 road 9
Powell WY 82435
302-754-2223
amesbah@wyoming.com

Mick Mickelson
MSU Southern Res Center
748 Railroad Hwy
Huntley MT 59037
406-348-3400
jmickelson@montana.edu

Jason Miller
CSU Dept of BSPM
609 ½ Smith Street
Ft Collins CO 80524
970-491-5667
jnmiller@lamar.colostate.edu

Steve Miller
Dept Plant Sciences
University of Wyoming
Laramie WY 82071
307-766-3112
sdmiller@uwyo.edu

Tim Miller
WSU
16650 State Route 536
Mt Vernon WA 98273
360-848-6138
twmiller@wsu.edu

Bill Molin
USDA-ARS
141 Experiment Station Road
Stoneville MS 38776
662-686-5245
wmolin@ag.gov

Don Morishita
University of Idaho
P O Box 1827
Twin Falls ID 83302
208-736-3616
don@uidaho.edu

Ed Morris
Marathon Consulting
2649 Navajo Rd
Las Cruces NM 88005
505-527-8853

Laura Morrison
Crop & Soil Science Dept
Oregon State University
Corvallis OR 97331
541-737-5421
laura.morrison@orst.edu

Dean Mosdell
Novartis
3043 218th Avenue SE
Issaquah WA 98029
425-837-9213
dean.mosdell@cp.novartis

Phil Motooka
University of Hawaii
P O Box 208
Kealakekua HI 96750
808-322-4896
pmotooka@hawaii.edu

George Mueller-Warrant
USDA-ARS
3450 SW Campus Way
Corvallis OR 97331
541-750-8738
muellerg@ucs.orst.edu

Jim Mullen
Entek
6835 Deerpath Road Ste E
Elkridge MD 21075
410-579-1622
jmullen@entekcorp.com

Barb Mullen
Montana Dept of Agric
920 No Benton
Helena MT 59601
406-444-3140
bmullin@state.mt.us

Glen Mundt
UAP
311 Evans
Caldwell ID 83605
208-455-2620
mundte@global.net

Phil Munger
BASF
800 N Lovers Lane #107
Visalia CA 93292
559-732-1785

Doug Munier
UCCE
P O Box 697
Orland CA 95963
530-865-1107
djmunier@ucdavis.edu

Martina Murray
NMSU
1805 New Mexico Avenue
Las Cruces NM 88001
505-523-2960
marmurra@nmsu.edu

Bill McCloskey
Dept of Plant Sciences
University of Arizona
Tucson AZ 85721
520-621-7613
wmcclosk@ag.arizona.edu

Kirk McDaniel
NMSU
Dept of Range Science
Las Cruces NM
505-646-1191
kmcdanie@nmsu.edu

Sandra McDonald
BSPM Dept
Colorado State University
Ft Collins CO 80523
970-491-6027
smcdonal@lamar.edu

Milt McGiffen
Dept Botany & Plant Science
University of CA
Riverside CA 92521
909-787-2430
milt@ucrac1.ucr.edu

Kent McKay
NDSU
5400 Highway 83 South
Minot ND 58701
701-857-7682
kmckay@ndsuext.nodak.edu

Patrick McMullan
Agrobiology Research
7777 Walnut Grove Road
Memphis TN 38120
901-357-2730
agrobio@earthlink.net

Hank McNeel
BLM
5001 Southgate Drive
Billings MT 59107
406-896-5043
hmcneel@mt.blm.gov

Bob McReynolds
Oregon State University
15210 NE Miley Rd
Aurora OR 97002
503-675-1264
bob.mcreynolds@orst.edu

Jerry Nachtman
University of Wyoming
Rt 1 Box 374
Torrington WY 82240
307-532-7126
nachtman@uwyo.edu

Eric Nelson
NDSU
460D Loftgard Hall
Fargo ND 58105
701-231-8164
ericnell@prairie.nodak.edu

Jeff Nelson
Dow AgroSciences
1804 Warwick Cove
Cedar Park TX 78613
512-260-2224
janelson@dowagro.com

Scott Nield
Lincoln County Weed & Pest
P O Box 1117
Afton WY 83110
307-886-3394
spurge@silverstar.com

Scott Nissen
Colorado State University
115 Weed Research lab
Ft Collins CO 80523
970-491-3489
snisssen@lamar.colostate.edu

Wesley Noel
Ag Innovations
P O Box 3852
Bozeman MT 59772
406-388-6555
aginovations@imt.net

Darin Oelkers
Mpower3
3250 W Hollyhock
Belgrade MT 59714
406-388-7024
doelkers@mpower3.com

Alex Ogg
WSU
P O Box 53
Ten Sleep WY 82442
307-366-2444
ogg@tctwest.net

Paul Ogg
Cyanamid
3619 Mountain View Ave
Longmont CO 80503
303-772-0843
oggp@pt.cyanamid.com

Jim Olivarex
UDSA-FS
P O Box 7669
Misoula MT 59803
406-329-3621
joliv1@aol.com

Brian Olson
Kansas State University
Throckmorton Hall 3706
Manhattan KS 66506
785-532-7802
holson@bear.agron.ksu.edu

Jim Olsen
Bayer Corp
P O Box 4913
Kansas City MO 64120
816-242-2303
jim.olson.b@bayer.com

Shannon Oltmans
NDSU
Loftsgard Hall
Fargo ND 58105
701-231-8167
oltmans@prairie.nodak.edu

Gene Onken
USDA-FS
4237 Sundance St
Santa Fe NM 87505
505-842-3227
gonkan/r3@fs.fed.us

Byron Orr
Agro Distribution
37540 Crescent Hill Road
Osawatomie KS 66064
913-755-4818
borr@agrodist.com

John Orr
Zeneca Ag Products
251 N Longhorn Ave
Eagle ID 83616
208-286-9300
john.orr@agna.zeneca.com

Drew Palrang
Bayer Corp
6552 Needham Lane
Austin TX 78739
512-301-1274
drew.palrang.b@bayer.com

Robert Park
Dupont Ag Products
1202 Spaich Drive
San Jose CA 95117
408-249-1225
robert.h.park@usa.dupont

Robert Parker
Wshington State University
24106 N Bunn Road
Prosser WA 99350
509-786-9234
rparker@wsu.edu

Scott Parrish
UAP
16417 N Napa Lane
Spokane WA 99208
509-467-2167
sparrish@uap.com

Matt Pauli
Monsanto
202 13th Avenue N
Fargo ND 58102
701-239-8329
matthew@pauli@monsanto

Ed Peachey
Oregon State University
2713 NW Arnold Way
Corvallis OR 97330
541-737-3152
peacheye@bcc.orst.edu

Tom Peeper
Oklahoma State Univ
Plant & Soil Science Dept
Stillwater OK 74078
405-744-9589
trp@mail.okstate.edu

Todd Pester
Plant Science Dept
Colorado State University
Ft Collins CO 80525
970-491-5667
tpester@lamar.colostate.edu

Adrianne Peterson
Box 729
Pinedale WY 82941
307-367-4728
subcowp@wyoming.com

Dallas Peterson
Kansas State University
2014 Throckmorton Hall
Manhattan KS 6506
785-532-5776
dpeterso@oznet.ksu.edu

Tim Playford
Dow AgroSciences
10521 Balroyal Ct
Fishers IN 46038
317-596-8930
tplayford@dowagro.com

Alan Pomeroy
Big Horn Co Weed & Pest
P O Box 601
Basin WY 82410
307-568-2281
weedman@tctwest.net

Raj Prasad
PFC Forestry
506 W Burnside Road
Victoria BC Canada
250-363-0600
rprasad@pfc.forestry.ca

Tim Prather
UCCE
9240 S Riverbend
Parlier CA 93648
559-646-6534
prather@uckac.edu

Troy Price
KSU-NWREC
105 Experiment Farm Road
Colby KS 67701
785-462-6281
tprice@oz.oznet.ksu.edu

William Price
College of Agriculture
University of Idaho
Moscow ID 83844
208-885-5930
bprice@uidaho.edu

Jim Qualls
Big Bend Com College
7662 Chanute Street NE
Moses Lake WA 98837
509-762-5351
jamesq@bbcc.ctc.edu

Mick Qualls
Qualls Ag Labs
3759 Dodson Road
Ephrata WA 98823
509-787-4210
mqualls@qa-lab.com

Curtis Rainbolt
PSES Department
University of Idaho
Moscow ID 83844
208-885-6236
crainbolt@turbonet.com

Gina Ramos
BLM
222 N Central Ave
Phoenix AZ 85004
602-417-9246
gina_ramos@blm.gov

Hank Ramsey
Bayer Ag
2880 N Wenas Road
Selah WA 98942
509-697-5575

Corey Ransom
OSU Malheur Exp Station
595 Onion Ave
Ontario OR 97914
541-889-2174
corey.ransom@orst.edu

Traci Rauch
PSES Department
University of Idaho
Moscow ID 83843
208-885-7730
trauch@uidaho.edu

Roy Reichenbach
Wyoming Dept of Ag
2219 Carey Ave
Cheyenne WY 82002
307-377-6585
rreich@state.wy.us

Bill Reische
Dupont
390 Union Blvd #500
Lakewood CO 80228
303-716-3906

Mark Renz
UC Davis
335 East 7th Street #6
Davis CA 95616
530-757-7821
mjrenz@ucdavis.edu

Carlos Reyes
Monsanto
800 N Lindbergh Blvd
Indianapolis IN
314-694-2695
carlos.c.reyes@monsanto

Charles Rice
University of Wyoming
1407 Grafton Apt B
Laramie WY 82072
307-742-7588
chuck_rice@hotmail.com

Wendell Rich
Agraserv
P O Box 561
Ashton ID 83420
208-652-7860
wendell@fremontnet.com

Jesse Richardson
Dow AgroSciences
9330 10th Ave
Hesperia CA 92345
760-949-2565
jmrichardson@dowagro.com

Bruce Riggle
UAP
419 18th Street
Greeley CO 80632
970-346-6257
briggle@uap.com

Chad Ringdahl
NDSU
460D Loftsgard Hall
Fargo ND 58105
701-231-8164
cringdah@prairie.nodak.edu

Michael Ronquillo
NMSU
2545 E Espina
Las Cruces NM 88001
505-522-6020
mronquil@nmsu.edu

Claude Ross
FMC Corporation
4343 Redbird Ct
Loveland CO 80537
970-669-3622
claude_ross@fmc.com

Lou Russo
BASF Corporation
186 Post Avenue
Sanger CA 93657
559-876-3182

Doug Ryerson
Monsanto
408 Deer Drive
Great Falls MT 59504
406-771-1920
douglas.k.ryerson@monsanto

Craig Rystedt
Monsanto
308 1st Avenue West
Powers Lake ND 58773
701-464-5133
craig.m.rystedt@monsanto

Fred Salzman
IR-4 Project
681 US Hwy #1 South
N Brunswick NJ 08902
732-932-9575
salzman@aesop.rutgers.edu

Craig Sandoski
Zeneca
44828 Mineral King Road
Three Rivers CA 93271
559-735-2200
craig.sandoski@agna.zeneca

Hans Santel
Bayer Corp
8400 Hawthorn Road
Kansas City KS 64120
816-242-2448
hans.santel.b@bayer.com

Lance Santo
HARC
99-193 Aiea Heights Dr
Aiea HI 96701
808-486-5355
lsanto@harc_hspa.com

Roland Schirman
WSU
202 South 2nd Street
Dayton WA 99328
509-383-4741
ce6107@coopext.cahe.wsu

Jack Schlesselman
Rohm and Haas Company
726 E Kip Patrick
Reedley CA 93654
559-638-7003
rhajts@rohmhaas.com

Steve Schoenig
CDFA
1220 N Street A357
Sacramento CA 95814
916-654-0768
sschoenig@cdfa.ca.gov

Jill Schroeder
NMSU
Box 30003 MSC 3BE
Las Cruces NM 88003
505-646-2328
jischroe@nmsu.edu

Ursula Schuch
Plant Science Department
University of Arizona
Tucson AZ 85721
520-621-1060
ukschuch@ag.arizona.edu

Joe Schuh
American Cyanamid
9879 Citrine Court
Parker CO 80134
720-851-8639
schuhj@pt.cyanamid.com

Rob Schwehr
Aventis Crop Science
401 Zamzow Ct
Roseville CA 95747
916-771-3303
rob.schwehr@aventis.com

Allen Scoggan
Bayer Inc
Box 4913
Kansas City MO 64120
816-242-4779
al.scoggan@bayer.com

Jim Sebastian
Colorado State University
2306 Durango Drive
Loveland CO 80538
970-663-0649
jseb@lamar.colostate.edu

Glen Secrist
Idaho State Dept of Agric
P O Box 7249
Boise ID 83707
208-332-8500
gsecrist@agri.state.id.us

Simone Seifert
Monsanto Company
700 Chesterfield Pkwy
St Louis MO 63198
636-737-5840
simone.seifert@monsanto

David Shields
BASF Corp
10181 Avenue 416
Dinuba CA 93618
559-591-2548
shieldd@basf-corp.com

Sandra Shinn
PSES Dept
University of Idaho
Moscow ID 83844
208-885-6236
shin0545@uidaho.edu

Devesh Singh
Oregon State University
P O Box 370
Pendleton OR 97801
541-278-4186
devesh.singh@orst.edu

Link Smith
USDA-ARS
1500 N Central Ave
Sidney MT 59270
406-482-9439
lsmith@sidney.ars.usda.gov

Randy Smith
Rohm & Haas Company
1520 E Shaw Ave #119
Fresno CA 93710
559-224-0158

Phil Stahlman
Kansas State University
1232 240th Avenue
Hays KS 67601
785-625-3425
pstahlma@oznet.ksu.edu

Bob Starke
Monsanto
364 18th Street SW
Watertown SD 57201
605-886-4844
robert.j.starke@monsanto

Scott Stenquist
US Fish & Wildlife Service
911 NE 11th Ave
Portland OR 97232
503-231-6172
scott_stenquist@fws.gov

Tom Stephens
Oklahoma Wheat Com
Rt 1 Box 29
Guymon OK 73942
580-338-7977
stephens@ptsi.net

John Sterling
NDSU
5200 Desert Lane
Prescott Valley AZ 86314
520-759-3380
jsterlin@prairie.nodak.edu

Tracy Sterling
NMSU
MSC 3BE Box 30003
Las Cruces NM 88003
505-646-6177
tsterlin@nmsu.edu

Amanda Stone
Oklahoma State University
33 N University Place #1
Stillwater, OK 74075
405-744-1991
solie@okstate.edu

Caleb Stone
Oklahoma State University
33 N University Place #1
Stillwater OK 74075
405-744-1991
stonejr@okstate.edu

Bob Stougaard
Montana State University
4570 MT 35
Kalispell MT 59901
406-755-4303
ms@montana.edu

Shay Sunderland
Monsanto
P O Box 6544
Englewood CO 80155
303-768-7327
shay.l.sunderland@monsanto

Jason Sutton
Colorado State University
2034 W Plum Street
Ft Collins CO 80521
970-491-5667
jasonsut@lamar.colostate.edu

Laura Suverly
Crop Science Office 107
Oregon State University
Corvallis OR 97331
541-737-7542
laura.suverly@orst.edu

Alan Tasker
USDA-APHIS
4700 River road
Riverdale MD 20787
301-734-5708
alan.v.tasker@usda.gov

Fred Taylor
American Cyanamid
P O Box 400
Princeton NJ 08543
609-716-2073
taylorf@pt.cyanamid.com

Rana Tayyar
Botany & Plant Sciences
University of CA
Riverside CA 92521
909-787-2541
rana@ucrac1.ucr.edu

Donn Thill
PSES Dept
University of Idaho
Moscow ID 83844
208-885-6214
dthill@uidaho.edu

David Thomas
USDA Forest Service
P O Box 96090
Washington DC 20090
202-205-0889
dthomas/wo@fs.fed.us

Curtis Thompson
Kansas State University
2510 John Street
Garden City KS 67846
316-275-9164
cthompso@oznet.ksu.edu

Mack Thompson
Dept Bio Ag Sciences
Colorado State University
Ft Collins CO 80523
970-491-7524
mthompsn@lamar.colostate

Tom Threewitt
Novartis
RR 3 Box 123
Larned KS 6750
316-285-6606
tom.threewitt@cp.novartis

Jeff Tichota
Monsanto
3018 E Nichols Circle
Litleton CO 80122
303-221-4795
jeffrey.m.tichota@monsanto

Barry Tickes
U of Arizona Coop Extension
2200 W 28th Street Ste 102
Yuma AZ 85364
520-726-3904
btickes@ag.arizona.edu

Dennis Tonks
University of Idaho
P O Box AA
Aberdeen ID 83210
208-397-4181
dtonks@uidaho.edu

Frederico Trucco
Colorado State University
915 E Drake Apt 194
Ft Collins CO 80525
970-491-5667
fedetrucco@yahoo.com

Chad Trusler
Oklahoma State University
3301 S West Street
Stillwater OK 74074
405-372-6654
truslec@okstate.edu

Ronnie Turner
Dupont
5808 Ryan Taylor Drive
Rocklin CA 95677
916-632-8665
ronnie.g.turner@usa.dupont

Sam Tutt
FMC Corporation
2029 US Hwy 14
Balaton MN 56115
507-734-3271
samuel_tutt@fmc.com

Vince Ulstad
BASF Corporation
4120 15th Street South
Fargo ND 58104
701-588-4542
ulstadv@basf.com

Kai Umeda
University of Arizona
4341 East Broadway
Phoenix AZ 85040
602-470-8086
kumeda@ag.arizona.edu

Stephen Valenti
Monsanto
4517 Quail Run Avenue
Sioux Falls SD
605-334-3350
stephen.a.valenti@monsanto

Jim Vandecoevering
American Cyanamid
771 W Blue Downs Street
Meridian ID 83642
208-888-7846
jim_vandecoevering@py.cy

Joe Vandepeute
Cal EPA
3415 Morro Bay Avenue
Davis CA 95616
916-324-3951
jvandepeute@cdpr.ca.gov

Mike Vondergeest
Zeneca
1200 S 47th Street
Richmond CA 94707
510-231-1203

Steve VanVleet
American Cyanamid
P O Box 57
Potlatch ID 83855
208-875-8756
vanvleets@pt.cyanamid.com

Sam Vissotto
Colorado State University
7600 E Caley Avenue #825
Englewood CO 80111
720-482-1382
svissotto@yahoo.com

Jennifer Vollmer
American Cyanamid
2166 N 15th Street
Laramie WY 82072
207-755-5218
jennifer_vollmer@py.cy

Joe Vollmer
American Cyanamid
2166 North 15th Street
Laramie WY 82072
207-755-5375
joseph_vollmer@py.cy

Adrian Wadley
Zeneca
1200 South 47th St
Richmond CA 94707
510-231-5006
adrian.wadley@agna.zeneca

Darrin Walenta
WSU
215 NW Anthony Apt 4
Pullman WA 99163
509-335-7817
dwalenta@wsu.edu

Ted Warfield
Warfield & Associates
2707 West 44th St
Kearney NE 68845
308-234-5195
trwarf@gbc.net

Steve Watkins
Zeneca Ag Products
P O Box 4817
Yuma AZ 85366
520-726-1509
steve.watkins@agna.zeneca

Brenda Waters
University of Idaho
29603 U of I Lane
Parma ID 83605
208-722-6701
Bwaters@uidaho.edu

Len Welch
Valent
P O Box 300
Hood River OR 97031
541-386-4557
len.welch@valent.com

Jennifer Wells
Zeneca Ag Products
498 North Mariposa
Visalia CA 93631
559-735-2211
jennifer.wells.agna.zeneca

Vincent Weng
Botany & Plant Sciences
University of California
Riverside CA 92521
909-787-2541
vincent.weng@ucr.edu

Doug West
Rohm and Haas Company
4000 Meder Road
Shingle Springs CA
530-677-6886
rhaldw@rohmhaas.com

Steve West
RDA
2345 East 16th Street
Yuma AZ 85365
520-783-3552
rdaaz@aol.com

Phil Westra
112 Weed Science Lab
Colorado State University
Ft Collins CO 80523
803-491-5219
pwestra@lamar.colostate.edu

Nora White
NMSU
P O Box 3786
Las Cruces NM 88003
505-522-7425
hmccan@nmsu.edu

Virginia White
Dept Botany & Plant Science
University of CA
Riverside CA 92521
909-787-2541
whiteva@ucrac1.ucr.edu

Tom Whitson
University of Wyoming
Box 3354
Laramie WY 82071
307-766-3113
twhitson@uwyo.edu

Rex Wichert
Zeneca
1200 South 47th Street
Richmond CA 94804
301-231-5013

Gail Wicks
University of Nebraska
Rt 4 Box 46A
North Platte NE 69101
308-532-3611
gwicks1@unl.edu

Dee Wilde
Lincoln County Weed & Pest
P O Box 1117
Afton WY 83110
307-849-0513

Michael Wille
University of Idaho
P O Box 1827
Twin Falls ID 83303
208-736-3614
mwille@uidaho.edu

Ray William
Hort Dept ALS 4017
Oregon State University
Corvallis OR 97331
541-737-5441
williamr@bcc.orst.edu

Dave Wilson
University of Wyoming
P O Box 3354
Laramie WY 82073
307-766-3329
dwwilson@uwyo.edu

Linda Wilson
PSES Department
University of Idaho
Moscow ID 83844
208-885-9489
lwilson@uidaho.edu

Rob Wilson
Bio Ag Sciences
Colorado State University
Ft Collins CO 80523
970-491-5667

Bob Wilson
University of Nebraska
4502 Avenue I
Scottsbluff NE 69361
308-632-1263
rwilson1@unl.edu

Barry Wingfield
UAP
240 22nd Street
Greeley CO 80631
970-352-4750
cbarrywing@aol.com

Sandra Wingfield
Agrisan Inc
14192 WCR 80
Eaton CO 80615
970-834-2607
agrisan@aol.com

Randall Wittie
Novartis
938 Corral Place
Galt CA 95632
209-745-6839
randall.wittie@cp.novartis

Steve Wright
UCCE
2500 West Burrel Ave
Visalia CA 93291
559-733-6482
sdwright@ucdavis.edu

Henry Wu
Monsanto
1320 East Everglade
Fresno CA 93720
559-261-0480

Yazzie Olsen
BIA
P O Box 1371
Chinle AZ 86503
520-674-5162
olsenyazzie@bia.com

Joe Yenish
WSU
465 NW Thomas Street
Pullman WA 99163
509-335-2961
yenish@wsu.edu

Frank Young
USDA-ARS
Washington State University
Pullman WA 99164
509-335-4196
youngfl@wsu.edu

Barry Younkin
BASF Corp
10181 Avenue 416
Dinuba CA 93618
559-591-2548
younkin@basf.com

David Zamora
WA State Dept of Ag
1505 N Miller #140
Wenatchee WA 98801
509-663-9616
dzamora@agr.wa.gov

Richard Zollinger
Dept of Plant Sciences
NDSU
Fargo ND 58105
701-231-8157
rzolling@ndsuext.nodak.edu

AUTHOR INDEX

CROP INDEX

Common and Botanical Name **Page**

WEED INDEX

Common and Botanical Name	Page

HERBICIDE INDEX

Common name or Code designation,
Trade name and Chemical name **Page**

WESTERN SOCIETY WEED SCIENCE
2000 - 2001 SUSTAINING MEMBERS

AgrEvo USA Company

American Cyanamid

Aventis CropScience

Ball Research, Inc.

BASF Corporation

Bayer Agricultural Division

Dow Agro Sciences

DuPont Agricultural Products

Marathon-Agricultural & Environmental Consulting

Monsanto Company

Novartis Crop Protection

Patchen, Inc.

PBI/Gordon Corporation

R&D Sprayers, Inc.

Rohm and Haas Company

Valent USA Corporation

Zeneca Agricultural Products

WESTERN SOCIETY OF WEED SCIENCE
STANDING AND AD-HOC COMMITTEES
2000-2001

STANDING COMMITTEES

AWARDS
Harry Agamalian, Chair (2002)
Phil Westra (2003)
Neal Hageman (2001)

FELLOWS AND HONORARY MEMBERS
Doug Ryerson, Chair (2002)
John Orr (2003)
Jack Schlesselman (2001)

FINANCE
Nelroy Jackson, Chair (2002)
Drew Lyon (2003)
Rick Boydston (2001)

HERBICIDE RESISTANT PLANTS
Ian Heap, Chair (2001)
Donn Thill (2002)
Dan Ball (2003)
Phil Banks (2003)
Mike Edwards (2001)
Rich Zollinger (2001)

LEGISLATIVE
Jim Olivarez, Chair (2001)
Celestine Duncan (2002)
Roy Reichenbach (2003)
Barbra Mullin, Chair (2001)

LOCAL ARRANGEMENTS
Gil Cook, Chair (2002)
Steve Dewey (2003)
Bill McCloskey (2001)

NECROLOGY
Steve Fennimore, Chair (2002)
Dennis Tonks (2003)
Doug West (2001)

NOMINATIONS
Bob Wilson, Chair (2002)
Roland Schirman (2003)
Dave Cudney (2001)
Immediate Past
President-Jeff Tichota

PLACEMENT
Doug West, Chair (2002)
Mick Mickelson (2003)
Todd Mayhew (2001)

POSTER
Jay Gehrett, Chair (2002)
Marvin Butler (2003)
Kai Umeda (2001)

PROGRAM
Bob Parker, Chair (2001)
Phil Stahlman (2001)
Rich Zollinger (2001)

PUBLIC RELATIONS
Kai Umeda, Chair
Mark Ferrell
Milt McGiffen
Brad Hanson

PUBLICATIONS
Rich Zollinger, Chair (2002)
Barbra Mullin (2002)
Curt Thompson (2003)
Ray William (2003)
Dave Cudney (2001)
Bob Parker (2001)

RESOLUTIONS
George Beck, Chair (2002)
Jeff Herman (2003)
Joe Yennish (2001)

SITE SELECTION
Mick Canavari, Chair (2002)
Corey Ransom (2003)
John Orr (2001)
Keith Duncan *ex officio*

STUDENT EDUCATIONAL ENHANCEMENT
John Fenderson, co-Chair (2002)
Jill Schroeder, co-Chair (2002)
Kirk Howatt (2003)
Linda Wilson (2003)
Joe DiTomaso (2001)
Vince Ulstad (2001)

STUDENT PAPER JUDGING
Mack Thompson, Chair (2002)
Peter Dotray (2003)
Tim Miller (2001)

SUSTAINING MEMBERSHIP
Vince Ulstad, Chair (2002)
Traci Rauch (2003)
Mick Canaveri (2001)

AD HOC COMMITTEES

EDITORIAL
Donn Thill, Proceedings
Barbra Mullin, Progress Report
Don Morishita, Newsletter
Joan Campbell, Homepage

EDUCATION
Carol Mallory-Smith, Distance Education
Scott Nissen, Distance Education
Celestine Duncan, Shortcourse