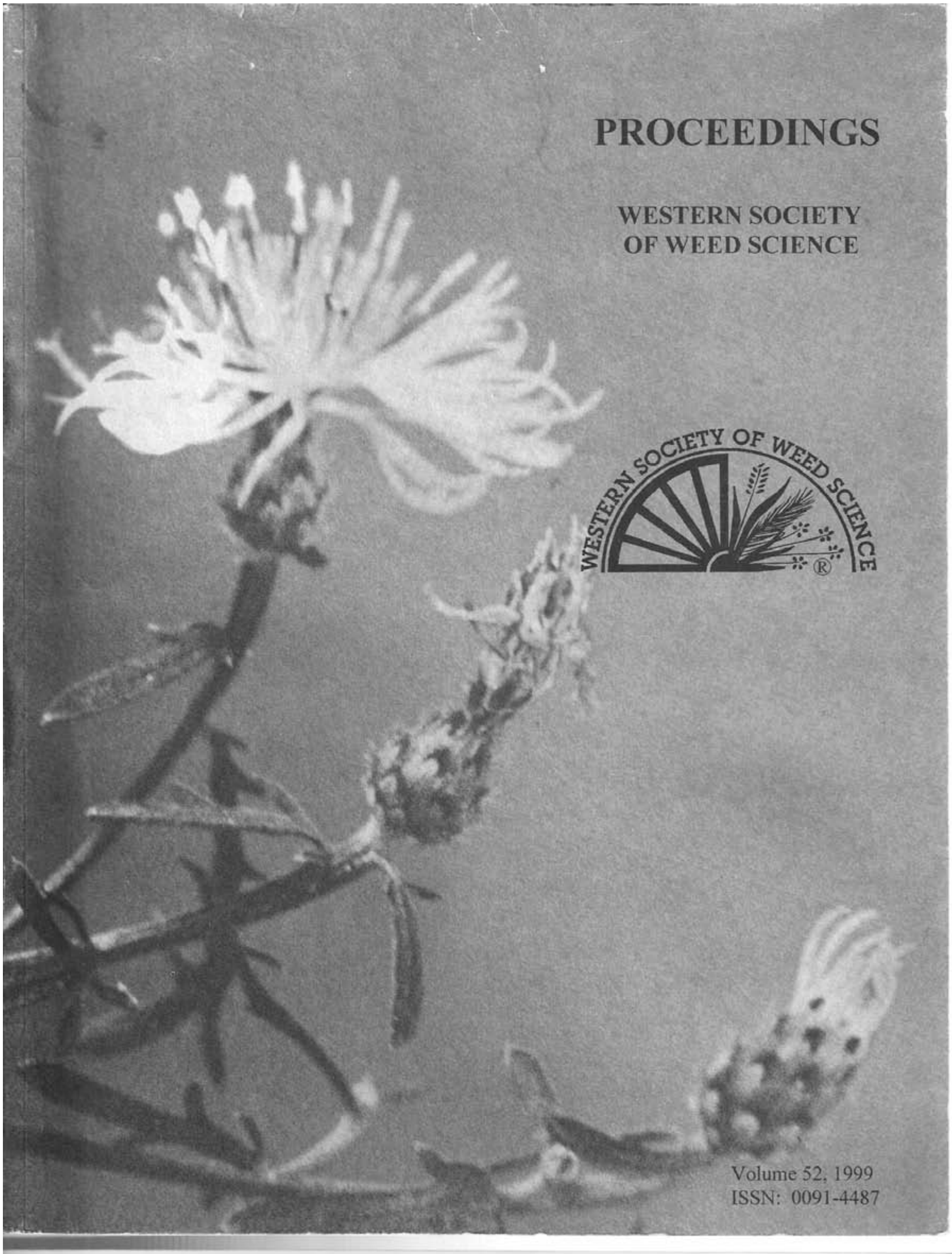

PROCEEDINGS

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1999 - 2000

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1999

PROCEEDINGS

OF

THE WESTERN SOCIETY OF WEED SCIENCE

VOLUME 52

PAPERS PRESENTED AT THE ANNUAL MEETING
MARCH 8 TO 11, 1999
THE DOUBLE TREE WORLD ARENA
COLORADO SPRINGS, COLORADO

PREFACE

The Proceedings contain the written summary of the papers presented at the 1999 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: Spotted knapweed (*Centaurea maculosa* Lam.). Cover photograph by Rodney G. Lym, North Dakota State University. All other photographs are courtesy of Jack Schlesselman.

Proceedings Editor: Kathy Christianson

TABLE OF CONTENTS

GENERAL SESSION

POSTER SESSION

RESEARCH SECTION I (Weeds of Range and Forest)

RESEARCH SECTION II (Weeds of Horticultural Crops)

RESEARCH SECTION III (Weeds of Agronomic Crops)

RESEARCH SECTION IV (Teaching and Technology Transfer)

RESEARCH SECTION V (Wetland and Wildlands)

RESEARCH SECTION VI (Basic Sciences)

EDUCATION AND REGULATORY

JOINTED GOATGRASS SYMPOSIUM

RESEARCH PROJECT MEETINGS

GENERAL SESSION

PRESIDENTIAL ADDRESS

Rod Lym, Weed Scientist
North Dakota State University
Fargo, North Dakota

When I was a graduate student at the University of Wyoming, Harold Alley once told me I should join and become active in the Westerns. He told me I would further my knowledge of weed science and form friendships that would last long after the last sprayer was put away. He was more correct than he could ever have known. The Western meetings are always the best meetings I go to both for the knowledge given and the comradery of the membership. I will always be grateful to Harold for helping me get started in the Westerns.

I work for and represent North Dakota State University and am the first WSWS President elected from that state. Contrary to popular thought, North Dakota is neither completely flat, nor completely ice. It has a rich diversity of agriculture and a large infestation of leafy spurge which has helped keep me employed since 1979.

The Badlands are probably the most famous of the tourist attractions and Theodore Roosevelt National Park is its highlight. Teddy spent several years in North Dakota and was always very fond of the state. It was in North Dakota that he overcame much of his problems with asthma and other childhood ailments. In many ways Teddy still guides us. In North Dakota we do not put milage numbers on our highway posts as most do, we instead use Teddy Heads. If you follow the Teddy Heads you will be going in the right direction. But how do you know if you are going in the wrong direction? Simple, instead of Teddy Heads you get Gus Heads! You know when you see these you are headed in the wrong and very bad direction.

Like Theodore Roosevelt, I have been fortunate to serve during a time of growth in our Society. At this years annual business meeting we will discuss the addition of two Canadian Provinces and one more state. Saskatchewan and Alberta, Canada and the state of Oklahoma. These are the first states or Provinces to be added since North Dakota, Nebraska, and Kansas became members in 1992. Of course, this is the first time we will have Canadian provinces as members.

Why does WSWS continue to grow when many Societies are suffering from declining membership? I believe it is because WSWS serves its members and many of its members in turn serve the Society. I would like to outline some of the ways that WSWS benefits its members and update you on current works in progress.

The WSWS substantially increased its recognition not only regionally, but nationally with the publication of *Weeds of the West.* Beginning in 1989 a group of seven members toiled away in Jackson Hole Wyoming to bring this book to press. Tom Whitson took the lead and pre-sold 20,000 copies at $10.50 each which covered the cost of the initial printing in 1991. *WOW* is now in its seventh printing for a total of 97,000 copies. You can now buy *WOW* on-line at amazon.com and barnesandnoble.com. You simply go to their home page, type in the title and order! Note that the same book costs less at amazon than at Barnes and Noble. Also, *WOW* is listed as the 34,252 best seller at amazon, which is quite comparable to popular novels such as *People of Darkness* by Tony Hillerman which is listed at 33,470.

The publication committee met in Salt Lake City under the leadership of Don Morishita in December to begin a major revision of *Weeds of the West*. The second edition will include many new plants as well as improved photographs of plants presently in the book. While no one knows exactly what the second edition will look like, it has already been given the nick-name "The Millennium Edition".

The publication committee also finished the WSWS brochure project. This effort was led by Shafeek Ali and Dave Cudney. The brochure is printed on one page which folds out into six sections that discuss WSWS membership, objectives, publications and educational efforts, organization, history, and membership application. The design was finished by Deb Tanner of North Dakota State University who also helped us design the logo. The colors used in the publication were taken from the WSWS logo which gives it a uniformity in design. Please pick one up at the registration desk. If you would like to send the brochure to interested parties, Wanda Graves can supply copies.

WSWS has also gained recognition from other publications such as *Biological Control of Weeds in The West* and the *Resistance Weeds* video. The video is out of print and the biological weed book will soon need to be reprinted. While these productions have not sold nearly the number of copies as the *Weeds of the West*, they have served very important segments of the Society.

We have also gained membership from the noxious weed school that WSWS sponsors and is coordinated by Celestine Duncan. The school started in 1991 and has gone from one course per year to two which are always sold out months in advanced. This school has trained 340 people from many Federal, State, and local agencies on noxious weed identification, prevention and control. We have had many BLM and Forest Service employees attend, but we also have gotten military personnel, tribal officials, and even the man who manages Ted Tuners many acres in Montana.

We have gained membership from various outreach efforts such as the affiliations work led by Tom Whitson. Because of his efforts WWCC (Western Weed Coordinating Committee) now meets immediately following WSWS and many member attend both meetings. All research section chairs have been told to spend a portion of their time to discern if their particular research section such as Agronomy has any groups that would make a natural fit. An example of this is horticulture. This year the American Society for Horticultural Science - Western Region will be meeting with us. The President is Robert Call who attended last years meeting in Kona.

So as we grow and add new members how can we expect the Society to change? Well, one thing I have heard many members say over the years is that WSWS is strong because it is a small closely knit group. Obviously, that will change as the Society increases in membership. Several members commented to me that while Hawaii meetings are always fun, there are so many people there, they miss talking with many people they normally visit with at the meeting. There are just too many people, sessions, and papers. So what is too big? Our current membership is 503 with an average of 350 attending a non-Hawaii meeting. When we go to Hawaii, attendance is well over 400. WSWS has always been an inclusive Society, not exclusive. We must continue to welcome new members to our Society, but also we must realize that as the Society grows, some of the intimacy so many enjoy about WSWS will be lost.

In February, President Clinton signed an Executive Order Concerning Invasive Weeds. A lot of people worked to get noxious weeds recognized in Washington, including Tom Whitson, Steve Dewey, those serving on the legislative committee, and George Beck who has served on INWAC for many years. This is an important step in bringing noxious weed control to the vast number of federally managed lands in the West.

However, the number of Weed Scientists working full-time on invasive weeds can be counted on one hand and you may not need all the fingers of that hand. I believe the control of invasive weed species is a major "growth area" in Weed Science. Biologists, ecologists, and entomologists are making major decisions on how to manage invasive species. Weed Scientists are the ones trained to provide a complete package of weed control methods including herbicides, biocontrol agents, seeding of competitive species, etc. This growth area must not be allowed to slip from our grasp. When given the opportunity to conduct research on invasive species jump in with both feet.

Financially the Society continues to prosper. Wanda will give you a complete report on Thursday morning. For now, I would like to discuss one portion of our monies, specifically those invested in mutual funds. Dan Ball asked how these funds were doing at the summer Board meeting and no one seemed to know, so I have done some investigation. In 1992, Peter Fay invested money that would have otherwise gone into CD's into two mutual funds. They are both Government bond funds, a short-term fund with American Century and an intermediate fund with Fidelity. Both are low risk funds. For the past five years the funds have returned an average of 5.2 and 6.2% for the short and intermediate funds, respectively. The short-term fund has been ranked in the top 10% for its type and the intermediate fund has been ranked as average. The funds have grown from the original investment of approximately $55,000 to over $72,000 and $83,000, for the short and intermediate bond funds, respectively.

In this age of double digit increases in stocks, the yields seem low. The original investment of over $55,000 that went into each of the bond funds would be worth over $120,000 at an average annual increase of 12% since 1992. The question is how should we invest our money and do we have the desire as a Society to "make money". I can tell you that our current membership fee of $15 is only enough to cover the expense WSWS sends to WSSA for our Washington liaison. The remainder of our annual budget comes from sales of publications and from Sustaining Members. We must be good stewards of our finances. However, we also have an obligation to our members to use their money for their benefit. We must begin to plan for the use of these funds to benefit the WSWS membership in the future.

I have directed the financial committee and Wanda Graves, our Business Manager to formulate a plan to use a portion of the interest from these funds to further our Society. I do not mean WSWS should start funding first-class travel for the Executive Board. Rather, I think it is time WSWS start sponsoring seminars, short-courses, and other educational efforts to update our members in their area of Science. The money belongs to the Society and should be used to benefit its members.

Another area of concern I have is the great difficulty the nominations committee has each year filling out the ballot. Many potential leaders turn them down as being too busy or uninterested. To this, I turn once again to Teddy Roosevelt who said "Every man owes a part of his time and money to the business or industry in which he is engaged. No man has a moral right to withhold his support from an organization that is striving to improve conditions within his sphere".

I am sure he would be more politically correct these days, but the point remains you cannot just take from the Society you must also give. It is the most talented and dedicated among our membership who must lead us. Thus, I would like to introduce the present Executive Board, Barbra Mullin - Immediate Past President, Jeff Tichota - Program Chair and President-elect, Jill Schroeder - Secretary, Carol Mallory-Smith - Research Section Chair, Dan Ball - Education and Regulatory Chair, Donn Thill - WSSA Representative, Steve Miller - Cast Representative, and Rick Arnold - Member-at-Large. Incoming officers include Jesse Richardson as Research Section Chair and Gil Cook as Education and Regulatory Chair. Newly elected officers are Don Morishita - President-elect, John Orr - Secretary, Phil Stahlman - Research Chair-elect, and Richard Zollinger - Education and Regulatory Chair-elect.

I am confident that these people will be strong leaders for our Society. However, if the trend of declining a nomination continues, we may be forced to recycle officers. While that may not be all bad, after all, experience is the best teacher, who among us wants to listen to Gus Foster's nonsense again? Or get chewed out by Steve Miller for a year again? So if asked, take it as the honor and a privilege to represent the Society and say yes.

It has been an honor and a pleasure to serve the Society as your President. I am very grateful for all the people that helped this year. We have overcome the copyright infringement of *Weeds of the West*, voted to add a state and two Canadian Provinces to our membership, and added a WSWS homepage on the Web. It has and will continue to be a year of growth. So as members of the Society, enjoy its benefits and participate in the Society's many activities.

HERBICIDE-RESISTANT CROPS: ISSUES, IMPACTS, AND IMPLICATIONS. Carol Mallory-Smith and George R. Hyslop, Assistant Professor and Professor, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331.

Herbicide-resistant crops, developed through traditional breeding and the newer biotechnological techniques, are a reality. They are being planted on millions of acres of crop land and the number of acres will increase dramatically over the next 5 years. Growers have embraced the technology and industry has set its course to develop more crop species to be resistant to more herbicides. As herbicide-resistant crops are introduced, some of the questions that need to be asked are: Who pays? What price? Who benefits? Who loses?

Critical issues surrounding the introduction and commercialization of herbicide-resistant crops have not been fully explored. Researchers in the public and private sector must begin to address these issues as well as the impacts and implications herbicide-resistant crops have for society, agriculture, and ecological systems. The challenge is to identify those issues with immediate importance versus those to be addressed in the long-term. Likewise, we must set up a system by which to evaluate the impacts, and interpret the implications. We must ask the right questions and design the right studies.

We cannot and should not separate societal issues from agricultural and environmental issues. We must change our view of the public as the nonagricultural community and see ourselves as part of that public. As weed scientists, we are not trained to deal with societal issues. However, the fast- growing development of herbicide-resistant crops requires that weed scientists address the complex issues embodied in public concerns. Since our discipline has been largely based on herbicides, we are obligated to this societal and scientific responsibility.

Societal issues, impacts, and implications: Society is questioning the safety of transgenic crops, the labeling and containment of the crop, the need for herbicide-resistant crops, the ethics of producing transgenic crops, and corporate control of seed and herbicides. It is important to respect the opinions held by others. Many of us may not share the ideas that it is unethical to produce transgenic crops or that there are safety issues but these views are held by others. Rather than discount them, we must address them.

If food is not labeled as transgenic, the public loses the right to know and choose what it consumes. The public fears that science can not accurately predict the long term affects of the release of transgenic crops into the environment nor the fate of inserted genes. There are concerns that herbicide-resistant crops will increase herbicide use and will move agriculture away from more sustainable systems that use integrated weed management.

In cropping systems that use herbicide-resistant crops, biological trespass may become a larger issue than chemical trespass. Who will be responsible for the genes that move from one site to another? This issue could become important as one grower chooses to grow a particular herbicide-resistant crop while another chooses to grow the same crop with a different resistance or not to grow herbicide-resistant crops at all. The movement of the herbicide-resistant gene either by pollen or seed from one grower's property to another could potentially cause serious rifts within the agricultural community.

Agronomic issues, impacts, and implications: Agronomic issues that are being raised are the effect of herbicide-resistant crops on sustainable agricultural systems and integrated weed management practices. We must keep in mind that just as one management strategy will not work for all herbicides or for all crops, herbicide-resistant crops will not solve every weed management problem. The herbicide-resistant crop must be incorporated into the overall crop production system and into the weed management plan for that system. The introduction of each new herbicide-resistant crop should include specific management strategies for the crop, use of the herbicide, and prevention of herbicide-resistant weeds. Management strategies will depend on the crop species, the herbicide or herbicides to which it is resistant, the crop rotations that are possible in a particular region, and on the weed complex that is present.

We must consider the risk of over dependence on one or two classes of herbicides. One of the most important factors in the selection of herbicide-resistant weed species is monoculture cropping. Another factor is monoherbicide cropping, i.e., the repeated use of one or several herbicides with the same site of action. Herbicide-resistant crops have the potential to create a larger monoculture/ monoherbicide system than ever before. For example, corn and soybean are typical rotation crops grown over vast acreages in the Midwest region of North America. Millions of acres of glyphosate resistant soybeans have been planted in the United States. These acres often are treated with glyphosate more than once during a growing season. The following year glyphosate resistant corn could be planted on many of those same acres and glyphosate applied again. It is inevitable that glyphosate-resistant weeds will be selected under this intensive herbicide usage.

Another component of this issue is the control of volunteer herbicide-resistant crops in subsequent crops. This is particularly important if the resistance is to a herbicide that would be used for control of the volunteer crop. This is more important if the herbicide was the herbicide of choice and there is not another option as effective or economical. For example, glyphosate resistant cereals could become a major control issue in fallow and no-tillage systems where glyphosate is regularly used for volunteer crop control. Herbicide-resistant corn could be difficult to control if soybeans with the same resistance are planted in the subsequent year. It is possible that growers may have to make additional herbicide applications to control a volunteer crop that would have been controlled under the previous weed management system. As crops are produced that carry resistance to more than one herbicide, volunteer crop control will become more complex for growers. Growers will need to understand that they may have trouble controlling the volunteer crop in the subsequent crop. They will need to know if the resistance is specific to one herbicide or if cross-resistance or multiple-resistance occurs.

Management of the seed bank also will be critical. Control of herbicide-resistant volunteers will by necessity vary for the crop and the rotation system. For example, mustard seeds are known to persist for several years in the soil so volunteers of a crop such as canola could occur for some time while wheat seed would likely not persist for more than one year.

The use of one herbicide or production practice already is known to lead to weed species shifts. For example, the introduction of broadleaf herbicides led to an increase in competition from grass weeds. Perennial weeds and some grass weeds have increased in the no-tillage systems which are being used today. Even herbicides classified as nonselective do not control all weed species. Thus, weed species shifts which can occur in herbicide-resistant cropping systems will present potentially difficult problems for control.

Ecological issues, impacts, and implications: Some of the ecological issues that must be addressed are gene movement from the resistant crop to related weed or crop species, species composition on the landscape level, and global biodiversity.

Resistance genes can move with pollen or seed. The opportunity for seed movement of a plant species is almost unlimited. The movement of crop seed by agriculture production is especially important. One hundred percent of the seed in a crop field is never harvested. Seed is lost from the time of seeding through final processing.

Resistance genes can move by cross-pollination either into a field planted with the same crop without resistance or into a closely related weed species or native plant. Many crops have weedy relatives with which they can hybridize, some of which are listed in the Table. For gene flow via pollen movement, the resistant crop must have synchronous flowering with the susceptible crop or with the weed species, the trait must be carried in the pollen, and pollination must occur. A fertile hybrid must be produced if the gene is to be incorporated into the genome from a single cross-pollination event. Otherwise, the sterile hybrid can backcross with either the crop or weed to incorporate the resistance gene into its genome. Any of these progeny might carry the herbicide resistance gene which could potentially develop into a new weed management problem. Obviously, the chance of gene movement between resistant and susceptible crops which outcross is high.

Table. Crops and their related weed species.

Crop	Weed species
Barley	Wild barleys
Canola	Wild mustards
Carrot	Wild carrot
Corn	Teosinte
Foxtail millet	Green foxtail
Poplar	Wild poplars / cottonwoods
Lettuce	Prickly lettuce
Oat	Wild oat
Radish	Wild radish
Rice	Red rice
Sorghum	Johnsongrass
Squash/pumpkin	Wild gourd
Sugarbeet	Wild beet
Sunflower	Wild sunflower species
Wheat	Jointed goatgrass

Beyond the opportunity for gene flow, the consequence of that gene flow must be evaluated. Hybrids are known to occur between crops and weed species; however, depending on the particular species, hybrids may or may not be fertile. Gene expression varies with genetic background so it is difficult to predict the effect a resistance gene may have when it is incorporated into a genome of a non-crop species. Questions remain as to how to assess risk of gene flow from the herbicide-resistant crop to susceptible crops or to weed species.

The introduction of a herbicide-resistant crop into its original region of origin should be carefully evaluated since there likely will be more wild relatives present there. Ecological and botanical surveys may be necessary in many parts of the world in order to be able to assess the risk of hybridization. However, many of these areas will be in developing countries that may not have the resources to conduct these types of assessments.

The loss of biodiversity is an increasing concern on a global scale. It is critical to preserve land races and wild relatives. The introduction of herbicide-resistant crops into the native regions of our major crop species may potentially contaminate the gene pool and create difficult problems for tomorrow's breeders who depend on this material for new and novel traits. The deployment of herbicide-resistant crops on millions of acres means that we must ask the right questions, now.

RISK ASSESSMENT OF GENETICALLY MODIFIED PLANT PRODUCTS. Thomas E. Nickson and Michael J. McKee, Ecological Technology Center, Monsanto Company, 700 Chesterfield Parkway, North, St. Louis, MO 63198.

INTRODUCTION

Modern biotechnology affords the opportunity to improve agricultural practices in many ways. Crop plants possessing tolerance to broad spectrum herbicides possessing superior environmental properties will provide several benefits in addition to potentially simpler weed management programs. For example, higher yields have been realized as well as the potential for better land stewardship. Similarly, agricultural systems using crops genetically protected from insect predation will reduce the dependence on chemicals that are less selective. The environmental benefits resulting from these two types of products include reduced use of fuels for field preparation, cultivation, weed and insect control as well as the farmer's time to perform these operations. These benefits afforded by several genetically modified crops are being realized by farmers in North America.

Food production in the future will be more intensive, requiring greater production from fixed areas of land. With the population expected to increase significantly over the next 30 years, the need for more sustainable food production practices on this fixed area of arable land is critical. New agricultural production tools must be developed to ensure that we will have abundant food and a healthy environment. Biotechnology is one of several tools that has the potential to improve the sustainability of agricultural systems. Other technologies include integrated pest management (IPM), improved farm equipment and satellite positioning systems, and development of alternate cropping systems. Tomorrow's farmers will have to have as many environmentally and economically sound and socially acceptable options to enhance his ability to effectively produce food.

Plants derived through modern biotechnology, genetic engineering specifically, are regulated until such time that enough is known about the risks they present to the environment. In the United States, the United States Department of Agriculture (USDA), Animal Health Inspection Service (APHIS) has the responsibility under law (the Plant Pest Act) to regulate genetically modified plants. Based on the information submitted, they make a Determination of Nonregulated Status allowing the modified plant to be used in agricultural production systems without restrictions. A genetically modified plant (GMP) must be shown to pose no increased plant pest risk before a determination can be made. Likewise, the US Environmental Protection Agency (EPA) has the responsibility given to them under two laws, the Federal Insecticide, Fungicide and Rodenticide Act and the Federal Food, Drug and Cosmetic Act, to regulate pesticides in the environment and their residues in foods. The safety of GMPs expressing a pesticidal protein or a pesticide used in conjunction with a GMP, e.g. herbicide tolerant crops, would be evaluated by the EPA. Lastly, the Food and Drug Agency has the responsibility to ensure the safety and wholesomeness of foods and feeds derived from genetically modified crops. Thus, an assessment of the risks to foods and feeds would have to be completed prior to marketing the GMP. This paper will focus only on the environmental risk assessment of Monsanto's GMP products.

RISK ASSESSMENT MODEL

We have organized the environmental risk assessment of GMPs into three distinct components as shown in Figure 1. A detailed, science-based assessment of the risks present from the GMP, the trait, and potential for toxic effects will provide sufficient information to make a decision as to the environmental acceptability or unacceptability of a product. Furthermore, the risk assessment will serve as a platform for appropriate environmental stewardship.

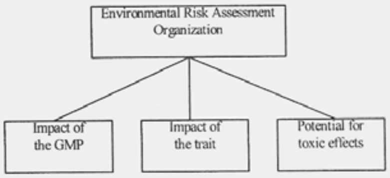

Figure 1. Environmental risk assessment organization.

Firstly, every environmental risk assessment must address the potential ecological impact of the modified plant relative to the impact of the traditional crop. The fundamental question is: has the genetic modification changed the plant in some way such that its ecological impact is altered? The scientifically determined endpoint indicating manageable risk is a conclusion of "biological equivalence". The concept of biological equivalence is similar to that of substantial equivalence used to assess the safety of foods and feeds derived from GMPs allowing for the presence of the novel trait. Experimental data are collected to ensure that the GMP product is biologically equivalent to the traditional product. This requires clearly identifying the biological properties necessary to make this assessment such as: germination, dormancy, fecundity, growth rates, volunteer potential and susceptibility to pests. In the case where the novel trait changes the fundamental fitness and potential invasiveness (e.g. drought tolerance) of the plant, the risk assessment should focus on the impact of the trait, potential toxic effects and development of appropriate risk management procedures.

Secondly, a thorough assessment of the ecological impact of the trait must be completed separate from the potential for toxicity. Because the potential exists for the transfer and persistence of the novel trait in the environment, an ecological risk is present. The scientific question to be addressed is, does the novel trait confer a selective advantage or negatively affect biodiversity? Thus, an environmental risk assessment assesses the potential for any plant (same species or compatible relative) to obtain the trait (gene flow) and to have altered ecological impact (e.g. weediness). In this context, the trait, the intended phenotype, and the other genetic elements (selectable markers, truncated genes, etc.) present in the GMP product are examined. For traits with a history of use (e.g. agronomic traits), it is recommended to thoroughly review the literature for information concerning ecological impact. Several good sources of information are available such as biology documents available from OECD, USDA APHIS, and Agriculture Canada. Because the ecological impact of the trait will be difficult to assess experimentally in small confined plots over a few seasons, an approach to consider involves developing appropriate post-commercial environmental monitoring.

The third component of an environmental risk assessment of a GMP product is the potential for a toxic effect. This has been specifically separated because the nature of some products is to confer a toxic phenotype to specific organisms such as insects and fungi. As such this intended toxic effect must be examined in a scientific framework that demonstrates acceptable levels of risk to non-target organisms (NTOs). In addition scientific evidence must be produced that demonstrates that the GMP product is not altered in its toxic potential. Use of literature reports on mode of action and compositional data showing no meaningful differences in the levels of normally occurring toxic components is a valid strategy. When insecticidal or fungicidal activity are expected, the risk assessment should contain experimental data showing the specificity of the activity toward target organism(s) and safety toward relevant NTOs.

It is recommended that a tiered experimental approach to assessing the environmental impact and potential toxicity be taken. Knowledge of the biology of the plant, agronomic practices and mode of action of the trait is used to determine the priority of experiments, the properties that should be measured and the acceptable ranges of results. Furthermore, a multidisciplinary team including expertise in regulatory requirements is an effective approach to the ascertain the appropriate amount of data to include in an environmental regulatory submission.

ENVIRONMENTAL RISK ASSESSMENT PROCESS FOR REGULATORY SUBMISSIONS

We have developed a process framework for conducting an environmental risk assessment based on a model developed by the EPA which is summarized in Figure 2. The first step in the procedure is to assign responsibility of coordinating the environmental risk assessment to an individual who will be the Risk Manager for the GMP product. The risk manager should then proceed by following an iterative four-phase process including problem formulation, risk analysis, risk characterization, and risk management (verification monitoring).

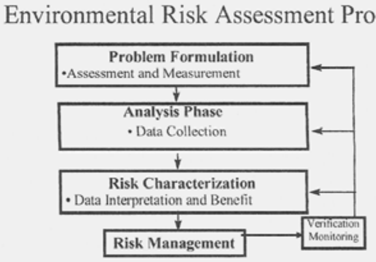

Figure 2. Environmental risk assessment process model.

Firstly, the process involves formulating or assessing the problem (risk) using the existing information about the plant, the trait and phenotype, and the potential for toxicity. Much of this information will serve as background in the risk assessment submitted. Furthermore, it establishes the baseline for a determination of relative environmental risk. For the purpose of designing experiments, emphasis should be given to scientific factors that limit the weediness/invasiveness of the traditional crop, potential impacts on biodiversity, as well as key aspects of its biology and use in agriculture. Depending on the nature of the trait, much knowledge may exist concerning the intended phenotype and the ecological risks presented by the other genetic elements in the vectors used. Similarly, a firm scientific basis to assess the risk of potential toxicity must be developed from literature precedent and knowledge of the intended genetic modification. An extensive and thorough review and analysis of the literature is the first step in defining the environmental risk. This information is can be used to obtain approval for the first field confined field trials in many world areas. In the US, the USDA APHIS allows for contained release of crops where there is a history of experience (see the USDA APHIS Notification procedure). Again, knowledge gained in the problem formulation step is important to establish appropriate experimental endpoints, evaluate for possible data gaps as well as gaps in the available experimental methodology. Lastly and very importantly, consideration must be given to regional and cultural issues existent in the region in which the product will be released. Our experiences in Europe and other world areas have shown that cultural attitudes toward the risks presented by GMP products have a powerful affect on approvals and they must not be neglected.

After conducting a thorough review of the problem, analysis of the potential risks, and delineation of appropriate experimental endpoints, we develop and implement appropriate plans to analyze the risk. One of the key challenges in data collection is the use of suitable protocols for both field and laboratory experiment as well as field surveys. It is recommend that pilot experiments be conducted to address uncertainties regarding experimental methods and establishing clearly interpretable endpoints prior to collecting data. Furthermore, third party experts should be consulted and used where practical. Independent collaborators can provide valuable insights into the region-specific environmental concerns. It is critical that the scientists involved be very familiar with the competencies of cooperators chosen to collect much of the data. The quality of any study is directly related to the quality of the people involved.

After collection, the data are analyzed in order to characterize the ecological risks. Based on the information gathered, the risk is characterized and the likelihood of an effect assessed in all three organizational elements of the risk assessment. Possible conclusions include: "no significant risk", "significant risk", and "insufficient data to conclude". In the last two cases, the Risk Manager must reiterate the first two steps of the risk assessment at a level of greater refinement. All conclusions of risk characterization should be reviewed by peers and independent experts if practical, including a conclusion of "no significant risk". Lastly, complete risk characterization may need data from multi-year experiments.

Once a science-based conclusion concerning the risk is made and the cultural aspects weighed, consideration is given to appropriate risk management; the conditions the must be imposed in order to release the product into the environment. The process is repeated until all relevant factors have been satisfactorily considered. For herbicide tolerance traits, management and monitoring practices could be proposed to assess the development of resistance. In the case of agronomic traits such as disease and herbicide resistance and insect protection, resistance management strategies should be in place prior to commercialization. It is also important to note that the risk assessment process does not stop after a product has gained regulatory approval or commercial acceptance. The risk assessment is repeated in light of any new information concerning the ecological impact of the product.

GENE FLOW OF TRANSGENES FROM CROPS TO THEIR WILD RELATIVES. THE ECOLOGICAL POTENTIAL OF TRANSGENIC CROPS TODAY AND IN THE FUTURE. Klaus Amman, Director of the Botanical Garden, University of Bern, Switzerland. (Guest speaker, no abstract submitted)

POSTER SESSION

A SUSTAINABLE APPROACH TO NEMATODE AND NUTSEDGE MANAGEMENT IN CHILE USING NEMATODE-RESISTANT ALFALFA AS A ROTATION CROP.

Cheryl Fiore[1], Ian Ray[2], Jill Schroeder[1] and Stephen Thomas[1], Research Assistant, Assistant Professor, Associate Professor and Professor, [1]Department of Entomology, Plant Pathology and Weed Science, [2]Department of Agronomy and Horticulture, New Mexico State University, Las Cruces, NM 88003.

Abstract. Each year southern root knot nematodes (RKN) and the perennial weeds, yellow and purple nutsedge, significantly reduce New Mexico chile yields. Chile emergence and growth rate is slow, making it a poor competitor with weeds. Research indicates the tubers of both nutsedge species and traditional chile crop rotations also host RKN. However, a few semi-dormant cultivars of alfalfa are RKN resistant. Our research objective, therefore, is to determine if RKN-resistant alfalfa in rotation with chile is an effective, sustainable approach to RKN and nutsedge management. 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. The experiment was designed as a split-plot, randomized complete block with four replications. Alfalfa was harvested six times during 1998, without significant yield differences. Seven days after each harvest, yellow and purple nutsedge biomass was estimated by sampling four 0.25 m^2 quadrats in each alfalfa plot. RKN populations were estimated using soil cores from each harvested quadrat. RKN populations were below detectable levels during 1998. Yellow nutsedge biomass was reduced, but purple nutsedge biomass was higher in the low density plantings in the Doña Ana alfalfa. The experiment will continue for 2 years, then chile will be planted in the plots.

EFFECT OF SOIL MOISTURE ON EPTC VOLATILITY.

Dana Coggon, Galen Brunk, and Scott Nissen, Undergraduate Bioagricultural Sciences and Pest Management, Research Associate and Associate Professor, Plant Sciences Building, Colorado State University, CO 80523.

Abstract. EPTC is commonly applied by chemigation to control grasses and some small seeded broadleaf weeds in potatoes. Field studies have demonstrated that soil moisture levels at application can influence EPTC volatility from soil. This process was evaluated under controlled conditions using a sandy loam soil with 0.9% organic matter maintained at three moisture levels, air-dry (1.94% water), field capacity (11.26% water), and saturated (22.56% water). EPTC (1 mg/ml) was applied to the surface of each soil moisture sample as 5 2μl droplets to provide a final soil concentration of 1 μg/g. Samples were placed in a growth chamber and maintained at 25 C and 50% RH under moderate light intensity provided by incandescent and fluorescent lights. Soil samples were removed at 0, 1, 2, and 4 hours, extracted, and analyzed using the gas chromatography mass spectrometry (GC/MS). There was no significant loss of EPTC from the air-dry soil; however, notable losses occurred from the field capacity and the saturated samples. Field capacity soil lost 33% of the applied EPTC during the first hour, while the saturated soil showed a loss of 59%. No significant loss was detected after the first hour. It appears that significant losses could occur under field conditions if the soil is at or above field capacity during EPTC application. This and further research should help provide information to avoid unnecessary EPTC losses that could result in significant reductions in weed control.

CONTROL OF WILD PROSO MILLET BIOTYPES WITH DIFFERENT HERBICIDES UNDER GREENHOUSE CONDITIONS.

Decio Karam[1,2], Philip Westra[1], and Scott J. Nissen[1], Graduate Research Assistant, Professor, and Associate Professor, [1]Department of Bioagricultural Science and Pest Management, Colorado State University, Ft. Collins, CO 80523 and [2]Brazilian Agricultural Research Corporation (EMBRAPA).

Abstract. Wild proso millet is a troublesome weed in the United States and Canada, where corn yield losses due to wild proso millet have been estimated at more than $50 million annually. A greenhouse experiment was conducted to examine the response of wild and cultivated proso millet to four herbicides. Flats filled with commercial potting soil were used, with 10 proso millet plants per flat. The herbicides and rates used were: imazamox at 0.053, 0.027, 0.013, and 0.007 kg/ha; glufosinate at 0.303, 0.151, 0.076, and 0.038 kg/ha; sethoxydim at 0.213, 0.107, 0.053, and 0.027 kg/ha; and glyphosate at 1.124, 0.561, 0.282, and 0.141 kg/ha. The study included a set of flats of non-treated plants. Plants were treated in a spray chamber with 204 L/ha of water when plants were 4-leaf to 1-tiller (depending on the biotype) at 10 days after planting. Percent control was recorded 7 and 21 days after treatment. Dry matter accumulation was recorded 21 days after treatment. The result obtained showed differing proso millet sensitivity to the herbicides. Different susceptibility in the biotypes was observed at the lower rates for imazamox, sethoxydim, and glyphosate. In contrast, glufosinate showed differential responses at all rates. Dry matter 21 days after treatment followed the same trend as percent control observed at 21 days.

KOCHIA AND RUSSIAN THISTLE CONTROL IN FALLOW WITH FLUROXYPYR.

Patrick W. Geier, Phillip W. Stahlman, and Douglas A. Schneweis, Assistant Scientist, Professor, and former Agricultural Technician, Kansas State University Agricultural Research Center, Hays, KS 67601.

Abstract. Fluroxypyr is a newly-registered herbicide for selective annual and perennial weed control in small grains and fallow. Kochia and Russian thistle are common difficult to control broadleaf weeds in fallow fields throughout semi-arid regions. Field experiments were conducted in 1998 at the Kansas State University Northwest Research and Extension Center near Colby to evaluate the efficacy of fluroxypyr alone and in combination with other herbicides on kochia and Russian thistle at two growth stages in spring fallow, and to compare the effects of several adjuvants on fluroxypyr efficacy. Herbicide treatments were applied when weeds were 15- to 30-cm or 30- to 45-cm tall. Kochia control 6 to 7 weeks after treatment (WAT) increased from 53 to 77% regardless of growth stage, as fluroxypyr rate increased from 0.1 to 0.2 kg/ha. Dicamba alone at 0.3 kg/ha controlled kochia 70 to 73%. Neither herbicide controlled Russian thistle more than 50%. Tank mixing fluroxypyr with glyphosate plus NIS or 2,4-D enhanced control of both species. Six of eight adjuvants tested enhanced kochia control over fluroxypyr alone at 7 WAT; Activator 90 and R-11 did not. Only Phase, Silwet L-77, and Cide-Kick II enhanced Russian thistle control over fluroxypyr alone, but none resulted in more than 53% Russian thistle control.

EFFECT OF ADJUVANTS AND TIME OF RAINFALL AFTER APPLICATION ON QUINCLORAC EFFICACY.

Thomas McDaniel[1], Jill Schroeder[1], Gus Foster[2], and Cheryl Fiore[1], Undergraduate Student, Associate Professor, BASF Field Biologist, and Research Assistant, [1]New Mexico State University, Las Cruces, NM 88003 and [2]BASF Corporation, Fort Collins, CO 80524.

Abstract. In the summer of 1998, a field study was conducted in Yuma, Colorado to determine the influence of adjuvants on quinclorac efficacy for controlling annual broadleaf and grass weeds in field sorghum. Ninety minutes after treatment application the study received 0.1 inches of precipitation. The result was little to no weed control with quinclorac regardless of adjuvant. Limited information is available regarding the time required between quinclorac application and rainfall to achieve effective weed control. Therefore, a greenhouse study was conducted to determine the effect of adjuvants and precipitation after application on quinclorac efficacy. The experiment was

established with a factorial treatment arrangement in a randomized complete block design with four replications. Barnyardgrass seeds were planted 40 seeds/cup, in a loamy soil and sub-irrigated to initiate germination. After emergence, plants were thinned to 10 plants/cup. Quinclorac plus crop oil concentrate, quinclorac plus methylated seed oil, quinclorac plus UAN, quinclorac plus Dynamic, and quinclorac with no adjuvant were applied as postemergence treatments when the plants were 2 inches tall. One-tenth inch precipitation was applied using a rainfall simulator at 1.5, 3, 6, 12 hours, or no precipitation after treatment. Plants were visually evaluated 2 and 4 weeks after application to determine injury on a scale of 0 to 100 where 0 = no injury and 100 = total plant death. Plants were harvested and top dry weight per cup was measured.

COMMON SUNFLOWER RESISTANCE TO IMAZETHAPYR AND CHLORIMURON IN NORTHEAST KANSAS.

Jolene R. Baumgartner, Kassim Al-Khatib, and Randall S. Currie, Graduate Research Assistant and Associate Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506 and Associate Professor, Southwest Research-Extension Center, Kansas State University, Garden City, KS 67846.

INTRODUCTION

The ALS-inhibiting herbicides are major components in weed management programs in Kansas. In 1996 and 1997, they were applied to approximately 58% of Kansas soybean and 29% of Kansas corn acres. Common sunflower is native to Kansas, often it is found in disturbed areas, and can tolerate dry and moist conditions. These characteristics and its large stature help make common sunflower a troublesome weed. Imazethapyr-resistant common sunflower was observed first near Rossville, Kansas in 1996. The cause of resistance was determined to be a less sensitive ALS-enzyme.

The objectives of this study were to determine: 1) if ALS-resistance has spread from the site where it was first observed into sunflower in surrounding roadsides, 2) if ALS-resistant common sunflower has appeared in additional areas in northeast Kansas, and 3) if ALS-resistant common sunflowers from these areas were resistant to imazethapyr, chlorimuron, or both.

MATERIALS AND METHODS

Seeds were collected from 14 soybean fields, one corn field, and 11 roadsides in three Kansas Counties (Figure). Seeds were collected on the Konza Prairie Research Natural Area near Manhattan, Kansas, where no herbicides had been applied in the past 25 years, to serve as a susceptible control. Common sunflower seed was also collected from a field with confirmed resistance. Sampling was conducted within a 20 km vicinity in which common sunflower resistance to imazethapyr was confirmed. Herbicide use and cropping histories from the previous three years were obtained from producers whose fields were surveyed.

One common sunflower head from each of 100 plants per site were collected. The sunflower heads were dried in a greenhouse and threshed to obtain seed. Seeds were germinated, then transplanted into each of 3 13 by 23 cm containers filled with 2.5 kg of soil. Sunflower were thinned to 10 plants per pot when 4 true leaves had expanded.

Sunflower from each site were treated with 71 and 11 g/ha of imazethapyr or chlorimuron, respectively. Herbicides were applied with a bench-type sprayer calibrated to deliver 187 L/ha at 138 kPa with 0.25% (v/v) nonionic surfactant. The control plants were treated with water and nonionic surfactant. Experiments were arranged as split plots within randomized complete blocks. Experiments were repeated three times. Visible plant injury was determined 14 days after herbicide application, with 0 = no injury and 100 = mortality. Plants were considered resistant when injury was 10% or less. Plants were considered susceptible when injury was 90% or greater. Plants were considered having intermediate response if visible injury was between 10 and 90%, respectively. Statistical analysis was performed using standard analysis of variance, and means were separated by using an LSD at 0.05.

RESULTS AND DISCUSSION

At least 1% of common sunflowers sampled from each field exhibited intermediate responses to imazethapyr and chlorimuron (data not shown). In addition, at least 1% of plants from each of 13 fields were resistant to imazethapyr, and at least 1% of plants from all 15 fields were resistant to chlorimuron (Table 1). Sunflowers from the known susceptible population were killed by imazethapyr and chlorimuron.

Less than 15% of common sunflower plants from fields 1, 2, and 3 (Table 1) were resistant to imazethapyr or chlorimuron. A sample taken from the site in which imazethapyr-resistant common sunflower was first identified (Figure, field 5) had the highest percentage (70%) of resistant plants. This field had been continuously cropped with soybean, and imazethapyr had been applied in the previous 7 years. Field 8 (Table 1), also exhibited a high level of resistance to imazethapyr. This field was managed by the same producer as field 5 and had a similar cropping and herbicide use history (Table 2). Chlorimuron resistance from these two locations was similar (Table 1).

Fields 4, 6, and 9 (Figure) were managed by another producer. Fields 4 and 6 were almost directly north of field 5 at a distance of 1 and 2 kilometers, respectively. The percentages of imazethapyr- and chlorimuron-resistant common sunflower were similar among these three fields. The producer knew that imazethapyr had been applied in these fields previously, but an accurate herbicide and cropping history was not available.

The sample from field 7, which is adjacent to field 5, (Figure) had the second highest percentage (70%) of imazethapyr-resistant common sunflower. Field 11, the only corn field from which common sunflower was collected, also was managed by the same producer as field 7. Both fields 7 and 11 were in corn-soybean-corn rotations with ALS-inhibitors being used in the soybean years only (Table 2). A similar rotation, with ALS-inhibitors applied only in the soybean year, was used by another producer in field 10. In fields 10 and 11, less than 3% of common sunflower was resistant to imazethapyr or chlorimuron.

An increase in the percentage of chlorimuron-resistant common sunflower was observed as the survey proceeded eastward. Fields 12 and 14 showed a higher percentage of plants resistant to chlorimuron than to imazethapyr (Table 1). Fields 12, 13, and 14 were owned by the same producer. Herbicide histories were not available for these four fields.

Common sunflower resistance to imazethapyr was found in roadsides neighboring the field in which resistance had been confirmed. Vegetation management programs for the roadsides included mowing and applications of picloram, 2,4-D, fluazifop plus fenoxaprop, and glyphosate. Imazapyr was used only as spot treatments for control of johnsongrass (*Sorghum halapense*). Ten roadside samples had at least 1% common sunflower plants that showed intermediate response to imazethapyr or chlorimuron (data not shown). At least 1% of common sunflower from each of seven roadside samples were resistant to imazethapyr or chlorimuron (Table 1).

Roadside A had the highest percentage (85%) of sampled common sunflower resistant to imazethapyr. No common sunflower occurred in surrounding fields, so seed samples for comparison were not available. As roadside sampling moved closer to field 5 (Figure), the percentage of imazethapyr resistance increased (Table 1). All the roadsides had less than 3% common sunflower resistant to chlorimuron (Table 1).

The percentage of resistant common sunflower in each field sample may not reflect the true resistance level. Because the seed collection took place in the fall, susceptible common sunflower may have been removed from many of the fields by known applications of ALS inhibitors. Therefore, only common sunflowers that did not receive herbicide treatment or that survived treatment were available for sampling.

An important result is the observation of common sunflower resistance to imazethapyr or chlorimuron in fields in addition tot he site where imazethapyr-resistant common sunflower was first observed. All but one of the sampled fields were within a 20 km radius of the location where common sunflower resistance to imazethapyr was confirmed. Physical movement of seed could have been facilitated by custom applications of herbicides or fertilizers, water movement by the Kansas River, or animal dispersal. Pollen movement by insects is very likely, because common sunflower is a cross-pollinated species.

Common sunflower collected from fields with repeated applications of imazethapyr showed more resistance to imazethapyr than chlorimuron (Table 1). Rotating crops and herbicide mode of action will eliminate repeated selection of resistant plants. Lower occurrences of imazethapyr- and chlorimuron-resistant common sunflower were observed in fields 10 and 11 where crop and herbicide rotations were used compared to fields 5 and 8 where soybean was grown continuously and herbicides with the same mode of action were used for several years (Tables 1 and 2).

Machinery should be weed free when it moves from field to field to minimize the spread of ALS-resistant common sunflower. In Shawnee County, measures have been taken to remove roadside populations of common sunflower to prevent harboring of ALS-resistance.

Table 1. Percent of field-collected and roadside-collected common sunflower resistant to imazethapyr and chlorimuron. Numbers designate fields and letters designate roadsides (Figure).

	Resistant common sunflower			Resistant common sunflower	
Field location	Imazethapyr	Chlorimuron	Roadside location	Imazethapyr	Chlorimuron
	%	%		%	%
1	1	8	A	85	2
2	0	1	B	0	0
3	12	2	C	1	2
4	52	10	D	9	1
5[a]	79	18	E	15	0
6	59	16	F	54	1
7	70	12	G	39	3
8	51	12	H	0	0
9	19	6	I	0	2
10	1	2	J	0	0
11	0	2	K	0	0
12	8	34	L[b]	0	0
13	8	8			
14	12	6			
15	11	22			
LSD (0.05)	14	14		14	14

[a] Location with confirmed imazethapyr-resistant common sunflower.

[b] Location with known imazethapyr-susceptible common sunflower.

Table 2. Crop and herbicide use history of fields from which common sunflower was collected.

Field location	Year	Crop history	Herbicide application history[a]
1	1997	soybean	NA
2	1997	soybean	NA
3	1997	soybean	NA
4	1997	soybean	NA
5	1997	soybean	glyphosate
	1996	soybean	alachlor, trifluralin, imazethapyr
	1995	soybean	alachlor, trifluralin, imazethapyr
6	1997	soybean	imazethapyr, others
	1996	soybean	NA
	1995	soybean	NA
7	1997	soybean	quizalofop, thifensulfuron+chlorimuron, acifluorfen
	1996	corn	atrazine, metolachlor+atrazine, bromoxynil
	1995	soybean	lactofen, imazethapyr, glyphosate-wipe
8	1997	soybean	glyphosate
	1996	soybean	alachlor, trifluralin, imazethapyr, chlorimuron
	1995	soybean	alachlor, trifluralin, imazethapyr
9	1997	soybean	NA
10	1997	soybean	imazethapyr
	1996	corn	atrazine, 2,4-D
	1995	soybean	imazethapyr
11	1997	corn	atrazine, metolachlor+atrazine, bromoxynil
	1996	soybean	quizalofop, lactofen, thifensulfuron+chlorimuron, glyphosate-wipe
	1995	corn	bromoxynil, atrazine
12	1997	soybean	NA
13	1997	soybean	NA
14	1997	soybean	NA
15	1997	soybean	NA

[a] NA=information not available.

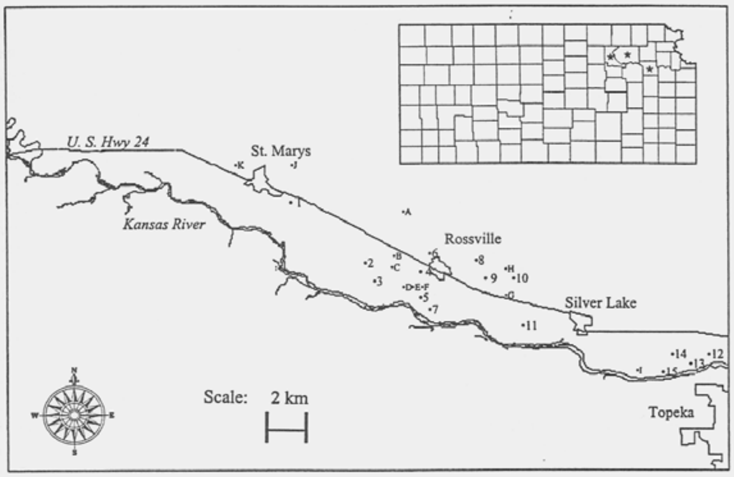

Figure. Sites where common sunflower was collected. Numbers designate fields and letters designate roadside locations (the Konza Prairie Research Natural Area is not shown). Stars designate Kansas counties where common sunflower was collected.

ROLE OF OXIDATIVE STRESS RESPONSE IN COTTON TOLERANCE TO PROMETRYN. Ismael Hernández-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. Prometryn is a photosynthetic inhibitor herbicide used as a preplant incorporated treatment for cotton production; however, its application can result in crop injury. Differential tolerance to this herbicide has been observed among cotton cultivars. Delta Pine-5415 (DP) is injured at the recommended rate, while Pima S-7 (PS7) is tolerant to rates as high as 10-fold the recommended rate. Previous studies have shown that rates of absorption, translocation, metabolism, or photosynthetic electron transport nor differential sequestration into lysigenous glands are not the mechanisms of differential tolerance between these cotton cultivars. Since prometryn is a photosynthetic inhibitor that increases the production of reactive oxygen species (ROS), such as hydrogen peroxide (H_2O_2), and hydroxyl ($^{\cdot}OH$) and superoxide ($O_2^{\cdot}$) radicals, we hypothesize that tolerance may involve an enhanced activity of protective enzymes or increased levels of antioxidant compounds. Under greenhouse conditions, DP and PS7 were subjected to prometryn rates of 0X, 0.5X, 1X, and 2X the recommended rate. Leaves were harvested 3 weeks after emergence and leaf discs collected and frozen in liquid N_2 for analysis. Although prometryn had a differential effect on DP and PS7, as evidenced by growth reduction and visual symptoms, lipid peroxidation and catalase levels were not different between both varieties. It seems that leaf samples were not taken at the appropriate time to target maximum response expression. Also, protective systems other than catalase could be involved.

PRIMISULFURON RESISTANCE IN DOWNY BROME. George W. Mueller-Warrant[1], Carol A. Mallory-Smith[2], and Paul E. Hendrickson[2], Research Agronomist, Assistant Professor, and Faculty Research Assistant, [1]USDA-ARS, National Forage Seed Production Research Center, 3450 SW Campus Way, Corvallis, OR 97331 and [2]Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331-3002.

Abstract. Downy brome is a major weed of Kentucky bluegrass grown for seed in the Pacific Northwest, and reductions in field burning are likely to exacerbate problems with this species. Tank mixes and sequential applications of primisulfuron plus terbacil generally provided 98 to 100% control of downy brome in long-term residue management by herbicide treatment studies with Kentucky bluegrass in central and eastern Oregon. However, by 1996 downy brome control in a few plots that had been treated with primisulfuron plus terbacil for 3 consecutive years was noticeably poorer than it had been in previous years. Whether downy brome survival in those plots was due to sprayer skips, different weather patterns, or increased resistance to herbicides was not clear. For the 1996 to 1997 growing season, uniform herbicide treatments were imposed on most of the existing plots, leaving three out of 15 plots in each residue management block as untreated checks. The other 12 plots received early fall treatment with primisulfuron plus terbacil followed by late fall treatment of either primisulfuron plus terbacil or primisulfuron alone where stands were thin. Samples of downy brome seed had been collected and archived during cleaning of Kentucky bluegrass seed harvested from 1994 to 1997, and a 55 plot subset of these samples was screened in the greenhouse for resistance to 39 g ha^{-1} primisulfuron applied at the 2-leaf growth stage. Average downy brome survival increased from 6% for seed harvested in 1994, to 8% for 1995, and to 20% for 1996. Dose response curves were generated for seed harvested from three plots at Madras in 1996, and the $LD_{98\%}$ for the most resistant type was 7-fold greater than for the most susceptible type. Primisulfuron-resistant types were cross resistant to sulfosulfuron and imazamox at roughly similar levels of increased resistance. Acetolactate synthase activity in all three biotypes plus another known susceptible was similarly inhibited by imazapyr and chlorsulfuron (Dale Shaner, pers. comm.), implying that resistance was not target-site based. Phytotoxicity of sulfosulfuron on the resistant types was dramatically increased by tank-mixing with an organophosphate insecticide, implying that resistance was based on metabolic degradation of sulfonylurea herbicides. Progression of symptoms on primisulfuron-treated downy brome included a rapid cessation of growth and a gradual discoloration of the treated leaves, followed by the appearance of new tillers at the base of the plant within two weeks on the resistant biotypes.

A TECHNIQUE FOR THE CHARACTERIZATION OF CARBOHYDRATES IN THE ROOTS OF BIENNIAL AND PERENNIAL WEEDS. Lori Howlett, Patricia Nielsen, and Robert G. Wilson, Research Assistants and Professor, University of Nebraska, Scottsbluff, NE 69361.

Abstract. Laboratory experiments were conducted in 1997 and 1998 to develop methods for the characterization of carbohydrates in the roots of biennial and perennial weeds. Weed roots were cleaned with water and either processed with a juicer or cut into small gratings for carbohydrate extraction with hot water. Both juice and water extracts were filtered through a 0.45 μM nylon filter before analysis. Carbohydrates were characterized using high-performance anion exchange chromatography combined with pulsed amperometric detection in a Dionex DX 500 ion chromatography system. Carbohydrates glucose, fructose, sucrose, and fructan polymers (inulin) were separated in a PA-100 column with a PA-100 guard column utilizing eluents of sodium hydroxide and a combination of sodium hydroxide and sodium acetate. Detection was with triple-pulsed amperometry using a gold working electrode.

Extraction of carbohydrates with the juicer was effective for plants with fleshy roots (chicory, common dandelion, salisfy, Canada thistle, curly dock, field bindweed, and ground cherry) while hot water extraction was more effective for woodier roots (common milkweed, diffuse knapweed, and hemp dogbane). Carbohydrates could be separated into glucose, fructose, sucrose, and fructans. Fructans could be further divided into individual polymers ranging from Dp 3 to Dp 80.

DETERMINATION OF SOUTHERN ROOT-KNOT NEMATODE INFECTION SITES IN PURPLE AND YELLOW NUTSEDGES. Patrick Mauk, Stephen Thomas, Jill Schroeder, and Liz Higgins, Undergraduate Research Assistant, Professor, Associate Professor, and Research Specialist, Department of Entomology, Plant Pathology and Weed Science, New Mexico State University, Las Cruces, NM 88003.

Abstract. Both Southern root-knot nematodes (RKN) and the perennial weeds, yellow and purple nutsedge are responsible for a substantial decline in New Mexico chile yields. Currently it is not known which subterranean structures of yellow and purple nutsedge can serve as sites for RKN infection. Due to the dark color of the subterranean structures of nutsedges and inconsistent galling it is difficult to determine sites where egg masses occur. Our research goal is to determine the possible sites of RKN infection in nutsedge species by dying the RKN egg masses with a red dye, phloxine B. Yellow and purple nutsedge tubers were harvested and sprouted in sterilized soil. After shoot emergence the pots were inoculated with 5,000 eggs of RKN. The inoculated weeds were allowed to grow for 28, 35, and 42 days. The nutsedge plants were then washed free of soil and stained with phloxine B (0.10g/L) for 15 minutes. The RKN egg masses on roots, rhizomes, and tubers were then determined, using a slight magnification. The dried nutsedge above ground and subterranean biomasses were then calculated. RKN egg masses were found on roots of both yellow and purple nutsedge, but not on rhizomes or tubers. The RKN density increased with time. Past research has concluded that tubers harvested from RKN infected nutsedge species can produce RKN infected crop seedlings. More research is needed to determine if roots are the only possible sites of RKN egg masses.

COMPUTERIZED SEED VIABILITY OF TEN WEED SPECIES FROM A BURIAL STUDY. David W. Wilson, Stephen D. Miller, and Patrick S. Mees, Research Scientist/Instructor, Professor of Weed Science and Programming Technician, Department of Plant Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Development of a tool to standardize tetrazolium viability analysis and archive data over several years is needed for seed burial studies. Human errors in viability assessment commonly include miscounts, recounts and variability in an individuals interpretation of color or live embryo characteristics. Software was written for the

Windows 95 platform with a visual interface programming package, IMAQ ImagePro 5 and the ImagePro TWAIN interface toolkit. Using a multivariant, edge detection program code, the software program, TZScan 1 was developed to use a single pass, 24-bit, flatbed color scanner connected to an IBM compatible computer to count and determine the viability of seed embryos. A 24 hour tetrazolium chloride soak in petri dishes was used for the embryos of 10 weed species from a seed burial study. Seeds were analyzed by an experienced seed test technician using visual analysis through a stereomicroscope. The seeds and black cotton cloth backing were placed on a clear acetate sheet for scanning. Scans were archived on a removable 100 Mb zip disk. Analysis using the computer viability beta version software, TZScan 1, was done and compared to the human analyzed samples. All samples were re-analyzed for error comparison of lot size and viability verification.

There were no significant differences in the computer versus the human counts, when compared to the verification count. The computer counts differed from the human counts by less than one half of one percent. Viability analysis also showed no significant differences between the TZScan program and the human analysis when compared to a second visual verification analysis. Both techniques varied by less than 0.16 of 1%.

Table. Comparison of seed counts and viability analysis of ten weed species from a Wyoming burial study, 1997.

Weed species	Computer vs human	Human vs actual	Computer vs actual
		(differences in counts)[a]	
Field bindweed	0	0	0
Cutleaf nightshade	3	2	0
Spotted knapweed	2	1	1
Jointed goatgrass	0	0	0
Leafy spurge	1	1	0
Canada thistle	0	0	0
Wild oat	0	0	0
Green foxtail	0	0	1
Kochia	0	0	0
Downy brome	0	0	0
Percent total error	0.44%	0.19%	0.25%
		(differences in viability)[b]	
Field bindweed	1	0	1
Cutleaf nightshade	0	0	1
Spotted knapweed	0	0	0
Jointed goatgrass	0	0	0
Leafy spurge	0	0	0
Canada thistle	0	0	0
Wild oat	0	0	0
Green foxtail	0	1	0
Kochia	0	0	0
Downy brome	0	0	0
Percent total error	0.17%	0.09%	0.16%

[a] Means expressed as a whole number representing an individual seed error.

[b] Means expressed as a whole number representing a difference of one live embryo.

CONTROL OF WOOLLYLEAF BURSAGE WITH *PSEUDOMONAS SYRINGAE* PV. TAGETIS

Tehmina Sheikh[1], Peter A. Dotray[1,3], Terry A. Wheeler[3], and John C. Zak[2], Graduate Research Assistant, Assistant Professor, Plant Pathologist, Professor, [1]Department of Plant and Soil Sciences, [2]Department of Biological Sciences, Texas Tech University, Lubbock, TX 79409 and [3]Texas Agricultural Experiment Station, Rt. 3, Box 219, Lubbock, TX 79401.

Abstract. Woollyleaf bursage is a native weed of western Texas and New Mexico. Control of woollyleaf bursage, which is limited to preplant herbicide applications, spot spraying, and cultivation, has been unacceptable.

Therefore, an alternative approach to control woollyleaf bursage was investigated. A plant pathogenic bacteria, *Pseudomonas syringae* pv. tagetis, was shown to be a pathogen of woollyleaf bursage in greenhouse studies. Field studies were conducted in 1997 and 1998 to determine optimum conditions that lead to infection. These experiments examined optimum *Pseudomonas* infection when applications were made during different times of the day, various times of the year, and at concentrations between 10^4 and 10^8 (full concentration). The effect of frequent applications also was examined. Early-season applications in 1997 and noon applications in 1998 showed optimum infection and provided greater infection then those made late in the season. There was no significant difference in the amount of infection when comparing the frequency of *Pseudomonas* applications.

WEEDS OF THE NORTHERN GREAT PLAINS. Brenda A. Deckard, Edward L. Deckard, and Calvin G. Messersmith, Student Services Coordinator and Professors, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Abstract. Weeds of the Northern Great Plains is a quickly accessible computer program for identifying weeds growing in the field. The program features 57 weeds species, detailed in more than 200 photos, including several growth stages of most weeds. The CD includes differentiating characteristics of weeds, such as for similar species like green and yellow foxtail. Weeds of the Northern Great Plains sells for $100, which includes shipping and handling. The CD operates on a Windows platform (either Windows 95 or 3.1) and will run on computers equipped with a CD-ROM drive and no less than a 386 processor.

WEED CONTROL AND ECONOMIC YIELD COMPARISON IN CORN. Joel S. Lee and Stephen D. Miller, Graduate Assistant and Professor, Department of Plant Science, University of Wyoming, Laramie, WY 82071.

Abstract. Conventional breeding techniques and development of transgenic technology have led to integration of herbicide resistance to non-selective herbicides such as glyphosate and produced alternative weed control options. Irrigated field trials were conducted at the Research and Extension Center, Torrington, Wyoming with five different corn varieties. Varieties included Northrop King 4640 (conventional), Dekalb 493 SR (sethoxydim resistant), Dekalb 493 RR (glyphosate resistance), Garst 8972 IT (imidazolinone tolerant), and Pioneer 38B22 (glyphosate resistance). In 1998 the study was established to determine weed control and to compare economic feasibility of 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 with the glyphosate and imidazolinone treatments. Treatments of glufosinate and standard origin were intermediate providing good control. Sethoxydim resistant treatments were the least effective providing fair control. All treatments had significantly better weed control than the controls. Grain yield was closely correlated to weed control with glyphosate treatments yielding the highest and sethoxydim treatments yielding the lowest.

THE SPATIAL DISTRIBUTION OF WEED SEED BANKS IN TWO PIVOT-IRRIGATED CORN FIELDS. Lori J. Wiles and Philip Westra, Weed Ecologist, USDA-ARS-WMU, Fort Collins, CO 80523 and Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523.

Abstract. Trials of site-specific weed management indicate herbicide use may be reduced by 40 to 60% or more in comparison to a uniform herbicide application. Maps of weed seed banks may be useful for site-specific weed management as a predictor of the composition and distribution of future weed populations. Weed seed banks were sampled in 1997 and 1998 in two eastern Colorado corn fields (130 and 175 A) to characterize the spatial distributions. In each field, the seed bank was sampled on a 250-ft square grid and on three 25-ft square grids. At each location, two soil cores were collected (2226 cores/yr). Seeds were extracted with elutriation and manually identified and counted. Samples collected in 1998 are being processed. In 1997, seeds of 13 species were detected in one field and 20 in the other, although just four species were detected in 5% or more of the cores from a field. Seed of various pigweed species was the most dense and widespread in both fields. Distributions of some species reflected seed dispersal characteristics while others reflected management of the field. In comparison to seed bank studies of small fields or areas, our results suggest patches may be more challenging to detect, but directed sampling based on past management could be a valuable. This data will be used in simulation studies to investigate cost-effective sampling strategies for weed seed banks, evaluate the benefit of site-specific, soil-applied weed management, and assess the value of the seed bank for predicting future weed populations.

CHLOROACETAMIDE HERBICIDE EFFECTS ON EARLY-PLANTED GRAIN SORGHUM.

Shannon W. Claborn, David L. Regehr, Mark M. Claassen, and Keith A. Janssen, Graduate Research Assistant and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506; Associate Professor, Harvey County Experiment Field, Hesston, KS 67062; and Associate Professor, East Central Experiment Field, Ottawa, KS 66067.

INTRODUCTION

Grain sorghum and corn are both warm-season crops, but compared to corn, grain sorghum has a reputation for slower germination and reduced early vigor in cool, wet soils. Previous research has shown differences in cold tolerance among various grain sorghum hybrids.

Some Kansas producers are planting grain sorghum in early to mid-April, about the same time as early-planted corn, to spread weather risks, utilize soil moisture more efficiently, reduce pre-plant weed control costs, and ease crop rotation to winter wheat.

Grass control in grain sorghum depends heavily on chloroacetamide herbicides, most of which require the use of a seed safener to prevent crop injury. We hypothesize that some grain sorghum hybrids will be highly susceptible to chloroacetamide injury under cool, wet conditions.

OBJECTIVE

To determine stand establishment and growth in early-planted grain sorghum in cool soil temperatures as influenced by: 1) chloroacetamide herbicides at normal and double-use rates; 2) grain sorghum hybrids differing in cold tolerance.

MATERIALS AND METHODS

Dryland field studies were conducted near Hesston, Manhattan, and Ottawa, KS. *S*-metolachlor, alachlor, propachlor, dimethenamid, and acetochlor CR (Controlled Released) were applied at the normal- and double-use rates of 1.4 and 2.8, 2.8 and 5.6, 4.5 and 9, 1.4 and 2.8, and 2 and 4 kg/ha, respectively. These treatments were applied to various early-planted grain sorghum hybrids. The high cold tolerant grain sorghum hybrids included: DeKalb DK-35, Mycogen 1506, NC+ 6B50, and Pioneer 8500. The low cold tolerant grain sorghum hybrids include: DeKalb Dk-40y, Mycogen 1482, Northrup King KS 710, and Pioneer 8699.

Atrazine at 1.12 kg/ha was applied to all treatments including the control. The experimental design was a randomized complete block design with split plots. Herbicide treatments were main plot factors, while grain sorghum hybrids were subplot factors. Each main plot was 6 by 7.6 m (8 rows), and each subplot was 0.76 by 7.6 m. The study was replicated four times. The grain sorghum hybrids were planted at a depth of 3.8 cm and at a rate of 129,200 seeds/ha. All treatments were applied pre-emergence to the grain sorghum in a chisel-disk tillage system. Soil temperature was monitored at seed depth from planting to full emergence or until the absence of cool temperatures. Initial plant stand counts and visual injury ratings were taken 18 days after planting (DAP) at approximately 75% emergence. Final plant stand counts and visual injury ratings were taken 32 DAP. Half-bloom dates were recorded when half or more of the heads in the subplot were at the half-bloom stage. Grain yield was taken at harvest (Table).

RESULTS AND DISCUSSION

The Hesston site incurred the most stressful environmental conditions, where the planting and herbicide applications on April 24, 1998 were followed by a week of cold, rainy weather (Figure). Normal-use rates did not affect the rate of seedling emergence, plant injury, or half-bloom dates. The double-use rate of *S*-metolachlor affected plant injury and increased the number of days to half-bloom. The double-use rate of dimethenamid had a significant effect on the rate of seedling emergence, plant injury, and caused the longest delay of half-bloom (Table 1). Some treatment by hybrid interactions did occur with the double-use rate of dimethenamid with several of the low cold tolerant hybrids in the rate of emergence and half-bloom dates (Data not shown).

CONCLUSIONS

The double-use rate of *S*-metolachlor caused significant plant injury and a delay in flowering. Grain sorghum development and injury was most sensitive to the double-use rate of dimethenamid in stand establishment in cool soil temperatures. Early-planted grain sorghum yields were not limited by these chloroacetamide herbicide treatments.

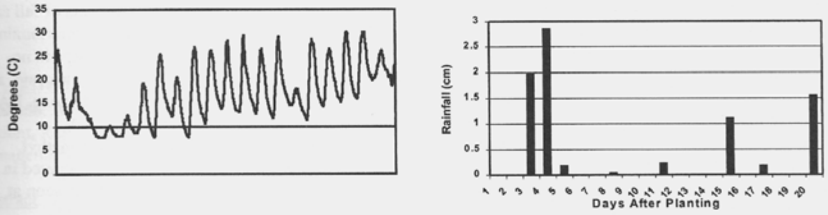

Figure. Daily soil temperatures at seed depth and rainfall during the 20 DAP at Hesston.

Table. Herbicide treatment effects on stand, injury, half-bloom, and yield at Hessston.

		Stand plants/ha				Half-bloom	
Treatment[a]	Rate	18 DAP[b]	32 DAP	Increase	Injury	DAP	Yield
	kg/ha			%			kg/ha
Metolachlor	1.4	98,020	103,060	5.5	0.8	74.6	4,390
Metolachlor	2.8	95,920	102,580	7.7	3.2	75.1	4,880
Alachlor	2.8	95,210	100,780	6.4	1.5	74.5	4,920
Alachlor	5.6	95,270	102,230	8.3	2.6	74.7	4,780
Propachlor	4.5	96,700	101,890	5.8	0.8	73.7	4,750
Propachlor	9	94,100	102,050	9.1	0.4	73.6	4,410
Dithenamid	1.4	94,250	99,430	5.9	2.1	74.8	4,990
Dithenamid	2.8	89,940	101,000	13.4	8.0	76.2	4,680
Acetochlor	2	93,150	99,810	7.8	1.0	74.7	4,700
Acetochlor	4	95,410	100,410	5.7	2.5	75.9	5,090
Control		94,550	100,180	7.1	0.6	73.9	4,970
LSD (0.05)		NS	NS	3.9	2.3	1.1	NS

[a] 1.12 kg/ha atrazine added to all treatments.

[b] Days after planting DAP.

WEED CONTROL IN DRY PEAS AND LENTILS. Nichole A. Eaton and Joseph P. Yenish, Agricultural Research Technician and Extension Weed Scientist, Department of Crop and Soil Sciences, Washington State University, Pullman, WA 99163.

Abstract. Dry peas and lentils are important crops in the Pacific Northwest. However, herbicide weed control options are limited on these commodities. Trials were established near Walla Walla and Pullman, WA to evaluate crop safety and weed control in peas and lentils under conventional and no-tillage systems. Treatments of fall and spring preplant applications of 0.047 lb/A imazethapyr and PRE sulfentrazone, BAY FOE-5043 plus metribuzin, flumetsulam, and chloransulam methyl at 0.375, 0.5, 0.055, and 0.032 lb/A, respectively, were evaluated in no-tillage peas and lentils. PPI treatments of imazethapyr, acetochlor, dimethenamid, flumetsulam, sulfentrazone, and BAY FOE-5043 plus metribuzin, at 0.047, 2, 1, 0.055, 0.375, 0.5 lb/A, respectively, and PRE sulfentrazone, BAY FOE-5043 plus metribuzin, flumetsulam, and chloransulam methyl at 0.375, 0.5, 0.055, and 0.032 lb/A, respectively, in conventionally tilled peas and lentils. POST applications of imazamox, chloransulam methyl, flumichlorac, fomesafen, and bentazon at 0.03, 0.016, 0.027, 0.25, and 0.5 lb/A, respectively, were evaluated in both conventional and no-tillage peas. POST applications of chloransulam methyl, fomesafen, and bentazon at 0.016, 0.25, and 0.5 lb/A, respectively, were evaluated in both conventional and no-tillage lentils. Weed populations were inconsistent in species makeup and density between locations, crops, and tillage systems. Thus, the information presented will focus only on crop injury and crop yield.

None of the PPI or PRE treatments caused pea crop injury that was statistically greater than the weedy check at either location in both tillage systems except for 2 lb/A acetochlor which caused 13% injury to peas at the Walla Walla location. In conventionally tilled peas, 0.03 lb/A imazamox caused 8 to 24% crop injury at Pullman and Walla Walla , respectively. Flumichlorac at 0.027 lb/A POST did not cause significant crop injury at either location or tillage system with the exception of the conventional tillage at Pullman where 41% injury was observed. Pea crop injury with 0.25 lb/A fomesafen applied POST ranged from 7 to 43% while injury with POST applications of 0.016 lbs/A chloransulam methyl ranged from 61 to 80% across locations and tillage systems. No significant injury was noted for 0.5 lb/A bentazon POST at either location in either tillage system.

Lentil injury in PPI and PRE treatments which were significantly greater than the weedy check were somewhat inconsistent across locations and tillage systems but included 20 and 24% injury at Walla Walla and Pullman, respectively, with 2 lb/A acetochlor PPI in conventional tillage, 40 and 60% injury in no-tillage and conventional tillage, respectively, at Pullman with PRE applications of 0.032 lb/A chloransulam methyl, and 15% injury with 0.375 lb/A sulfentrazone PRE at Walla Walla in no-tillage. Each of the POST applications evaluated in lentils caused significant crop injury in lentils. Lentil injury ratings across locations and tillage systems ranged from 62 to 84%, 10 to 53%, and 37 to 97% for 0.016 lb/A chloransulam methyl, 0.25 lb/A fomesafen, and 0.5 lb/A bentazon, respectively.

Crop yields were low at three of the four research sites due to insect injury. The following discussion concerns only the conventional tillage site at Walla Walla. At this site, yield differences were more greatly affected by crop injury than by weed control efficacy of the individual treatments.

Pea yields were significantly greater than the weedy check for PPI treatments of imazethapyr, sulfentrazone, BAY FOE-5043 plus metribuzin, at 0.047, 0.375, and 0.5 lb/A, respectively, and PPI and PRE flumetsulam at 0.055 lb/A, with yields ranging from 2,388 and 2,601 lb/A. The only POST treatment with yield significantly greater than the weedy check was 0.5 lb/A bentazon. No other treatment had pea yields significantly less than the weedy check except 0.03 lb/A imazamox and 0.016 lb/A chloransulam methyl applied POST.

In lentils, no PPI or PRE treatments yielded significantly different from the weedy check, with yields ranging from 830 to 1,082 lb/A, with the exception of 2 lb/A acetochlor PPI which had significantly lower yield than the weedy check. All POST treatments in lentils yielded significantly lower than the weedy check. Again, yield differences in lentils were due more to crop injury than weed control efficacy.

DRY EDIBLE BEAN RESPONSE TO SHOOT AND FOLIAR APPLICATIONS OF DIMETHENAMID, BAS 656, AND METOLACHLOR. Dodi Kazarian, Patrick Miller, Scott Nissen, and Philip Westra, Graduate Student, Research Associate, Associate Professor, and Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523.

Abstract. Field studies suggest that dry beans vary in response to PRE dimethenamid applications and this variation appears related to market class. Greenhouse studies were conducted to determine growth response of three dry bean market class varieties (pinto, black, and navy) to simulated "at cracking" (hypocotyl exposed) and four additional growth stages. In the first experiment, dry beans were evaluated for the effect of hypocotyl exposure to solutions of formulated metolachlor and formulated, technical, and formulation blanks of dimethenamid and BAS 656. The formulated and technical dimethenamid and BAS 656 inhibited the growth of all three bean market classes by 34 to 85% when hypocotyls' were exposed to a 1000 ppm solution. Black beans were most sensitive and pintos the most tolerant. Formulation blanks had no effect on any market class. Navy and black beans showed sensitivity to formulated metolachlor at a 1000 ppm, with growth reductions of 61 and 51%. In the second experiment, market classes were evaluated at the following growth stages: hypocotyl; cotyledon; unifolate; and first expanded trifoliate. Formulated dimethenamid, BAS 656, and metolachlor were studied at rates of 1.2, 0.66, and 2 kg ha^{-1}, respectively at 117 L ha^{-1}. The three bean market classes were the most sensitive to herbicides at hypocotyl and cotyledon growth stages and showed increased tolerance at unifoliate and first trifoliate stages. Navy and black beans showed the highest sensitivities to dimethenamid, BAS 656, and metolachlor with growth reductions of 80 to 90% at the hypocotyl stage, while pintos had 55%. Dry edible beans appear to express varying sensitivity to these herbicides based on market class and growth stage.

HERBICIDE INJURY IN PROSO AND FOXTAIL MILLETS. Drew J. Lyon and Stephen D. Miller, Associate Professor, Panhandle Research and Extension Center, 4502 Avenue I, Scottsbluff, NE 69361 and Professor, Department of Plant Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Herbicides labeled for use in proso millet are often used to control weeds in foxtail millet. Proso millet belongs to the genus *Panicum*, while foxtail millet belongs to the genus *Setaria*. Field studies were conducted in 1997 and 1998 at Sidney, NE and in 1998 at Archer, WY to determine if these two species differ in their response to several different herbicide treatments. In 1997, proso and foxtail millets responded similarly to the different herbicide treatments, although proso exhibited an overall greater relative reduction in yield compared to its check than foxtail millet. Plants were showing signs of drought stress in 1997 when POST treatments were applied. All POST treatments contained 2,4-D and resulted in visible crop injury and yield loss relative to the check. Injured plants of both species had poor root development, were stunted and often prostrate after treatment.

In 1998, no relative yield differences were observed for any herbicide treatment with either species at Sidney or Archer (Table), although at Sidney, proso exhibited an overall lower relative yield than foxtail millet when compared to their respective checks. Mid-season biomass was reduced, relative to the check, in proso and foxtail millets with several POST herbicide treatments at Sidney. At Archer, mid-season foxtail biomass was reduced with the atrazine treatment No mid-season biomass reductions were observed for proso millet at Archer. Heat and moisture stress appear to increase the likelihood of injury from POST applications containing 2,4-D. An abundance of early season moisture increased atrazine injury in foxtail millet. With the exception of the PRE atrazine treatment at Archer, proso and foxtail millets appeared to respond similarly to the herbicides used in this study.

Table. Mid-season biomass and yield, relative to the nontreated check, for proso and foxtail millets treated with several PRE and POST herbicide treatments at Archer, WY and Sidney, NE in 1998.

			Archer, WY			Sidney, NE	
	Application		Relative biomass				
Treatment	timing	Rate	Foxtail	Proso	Relative yield	Relative biomass	Relative yield
		lb/A	%			%	
Atrazine	PRE	0.5	45	94	94	85	97
Propazine	PRE	0.5	104	91	104	98	103
2,4-D ester	POST	0.38	93	97	103	80	95
2,4-D amine	POST	0.5	95	84	99	79	92
Dicamba + 2,4-D amine	POST	0.125+0.38	99	93	104	81	101
Prosulfuron +2,4-D amine	POST	0.018+0.38	101	94	104	85	96
LSD (0.05)			29	NS	NS	17	NS

ANNUAL GRASS AND BROADLEAF WEED CONTROL IN DRY BEANS WITH EARLY PREEMERGENCE AND PREEMERGENCE BAND APPLICATIONS OF DIMETHENAMID, BAS 656 AND METOLACHLOR II MAG FOLLOWED BY CULTIVATION AND POSTEMERGENCE APPLICATIONS OF AC 299-263 AND IMAZETHAPYR IN COMBINATION WITH BENTAZON. Richard N. Arnold and Daniel Smeal, Pest Management Specialist and Agricultural Specialist, New Mexico State University Agricultural Science Center at Farmington, Farmington, NM 87499.

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

compete vigorously with dry beans and yield reductions exceeding 70% have been recorded. A field experiment was conducted in 1998 at Farmington, NM to evaluate the response of pinto beans (var. Flint), annual grass and broadleaf weeds to early preemergence, preemergence and preemergence band applications of dimethenamid, BAS 656 and metolachlor II Mag followed by cultivation and postemergence applications of AC 299-263 and imazethapyr in combination with bentazon. Individual treatments were applied with a compressed air backpack sprayer calibrated to deliver 30 gpa at 30 psi. Soil type was a Wall sandy loam with a pH of 7.8 and an organic matter content of less than 1%. Early preemergence, and preemergence band treatments were applied on May 14, 19 and 20. Postemergence treatments were applied after cultivation on June 24 when dry beans were in the 4-trifoliolate leaf stage. Treatments were evaluated for crop injury on July 23 and weed control on August 24. The 2 center rows of each plot were thrashed on September 8.

No crop injury was observed in any of the treatments. All treatments gave good to excellent control of annual grass and broadleaf weeds. Yields were 2460 to 3074 lb/A higher in the herbicide treated plots as compared to the check. (Published with the approval of the New Mexico State University Agricultural Experiment Station.)

WEED CONTROL IN DAHLIAS WITH ISOXABEN, ORYZALIN AND PRODIAMINE. Jerry L. Maul, Extension Horticulture Agent and Assistant Professor, Department of Horticulture, Oregon State University, Corvallis, OR 97331.

INTRODUCTION

The value of Oregon's number one agricultural product - nursery and greenhouse crops, reached a record 470 million dollars in 1997. This large industry is also the most diverse, representing over 1500 cultivars of herbaceous and woody ornamentals. This diversity represents a challenge for growers when considering chemical weed control. Selectivity to herbicides, can vary considerably between genera, species and even cultivars. Dahlias are currently being grown for the sale of their tuberous roots and as cut flowers for the fresh floral market. In Douglas County, the primary weed pests of dahlias are: common groundsel, common purslane, large crabgrass, barnyardgrass and hairy nightshade. These summer annuals proliferate in cultivated soils and are often encouraged by the frequent irrigations that dahlias require during the summer months. Mechanical cultivations can eliminate weeds between the rows but not within the rows. Hand hoeing within the row is possible, but always laborious and seldom economical. Crabgrass and purslane will often reroot if not removed from the field after cultivation and common groundsel will germinate over the entire growing season. Constant cultivation is required for its control. Post emergent herbicide applications using sethoxydim or fluazifop-p-butyl to control the annual grasses is cost prohibitive because of the multiple applications required to achieve acceptable suppression.

Herbicides applied as post-plant to the dahlia "tubers" (tuberous roots) but preemergent to the weeds, have provided the most satisfactory weed control. Oryzalin at the rate of 2 qt/A (44 ml/1000 ft^2) has provided satisfactory control for annual summer grasses but is weak on broadleaf weeds such as common groundsel, common purslane and hairy nightshade. There are several preemergent herbicides that are commercially available for ornamental weed control in nursery production but few list dahlias on their label. The large and diverse number of herbaceous ornamental species and cultivars prevents the manufacturer from testing its herbicide on every ornamental crop. Furthermore, the limited acreage of these diverse ornamental crops offers little incentive for the manufacturer to secure a label for them. Some ornamental labels allow growers to test their herbicide on plants not listed on the label. Growers are hesitant to experiment with a new herbicide because of the possible damage that could occur to their crops. The grower's fear of crop damage is accentuated by the limited acreage of many ornamental crops coupled with their high value. The objective of this trial was to find a selective herbicide for dahlias that could provide suitable weed control by itself or in combination with another herbicide.

MATERIALS AND METHODS

This dahlia herbicide trial was conducted at the OSU Douglas County Demonstration Farm near Roseburg, Oregon. The soil type is a Packard gravelly loam. Prior to planting, the plot was rototilled three times. The first rototilling incorporated the winter covercrop of crimson clover, the second was to incorporate the fertilizer and the final pass prepared the bed for planting. Due to adequate amounts of phosphorous (55 ppm) and potassium (>400 ppm), Sulfur Coated Urea (37% N) was applied to the plot at a rate of 2.7 lb/1000 ft^2. Rooted cuttings and dormant roots were planted into the plot on May 7, 1998. The plot size measured 32 by 150 feet. The spacing between rows was 8 feet. The in-row spacing was 3 feet with 3 dahlias centered in each of the 48 replicated plots (12.5 by 8 ft) in each of the 4 rows.

There were a total of 12 treatments: oryzalin (44, 66.5 and 88.7 ml /1000 ft^2), isoxaben (7, 10.5 and 14 g/1000 ft^2), prodiamine (10.4, 17.3 and 23.8 g/1000 ft^2), combination treatments of oryzalin plus isoxaben (44 ml + 7 g/1000 ft^2), oryzalin plus prodiamine (44 ml + 10.4 g/1000 ft^2) and a control with no herbicide treatment. The 12 treatments were replicated four times, each plot was 12.5 by 8 feet. One quart of water was used as the carrier for the designated amount of herbicide for each plot. The control plot received water only. Immediately after application, the herbicides were incorporated with 0.5 inch of water from overhead sprinklers. Due to a record amount of rain after the May 7 planting (6 inch), the herbicides were not applied until June 3, 1998. Prior to the herbicide applications, the plot was rototilled with a walk-behind powered rototiller between the rows and hoed within the rows to remove weeds that had emerged after planting. After the plot was rototilled, a lawn roller weighted with water was pulled between the rows to flatten clods and smooth the surface for the herbicide treatments. Irrigation was applied by overhead sprinklers. During June, one irrigation per week provide 1.5 inch of water. During July and August the plots received two irrigations per week and approximately 3 inches of water. Treatment performance was measured by weed germination. Weed counts were recorded on June 30 and August 3. A quadrant measuring 2 by 10 feet was placed in each plot at the same location for the June 30 and August 3 weed counts. The weeds within each quadrant were removed by hand pulling or shallow hoeing after the June 30 count to minimize soil disturbance. Since all weeds within the sample quadrants were removed on the June 30 sample date, the August 3 values (Table 2) are a measure of cultivation (hand hoeing) and the residual effects of the herbicides. Weeds were removed from the August 3 sampling in the same manner as the June 30 sampling. Weeds outside of the sample quadrants but within the treatment plots were left to mature.

RESULTS AND DISCUSSION

Tables 1 and 2 show the actual weed counts per treatment. Mean separation was determined by LSD at the 95% confidence level. The average weed count among the herbicide treatments, during the first sampling ranged from a high of 43.3 weeds per 20 sq feet for the low rate of prodiamine, to 2.3 weeds per 20 sq feet for the combined low treatment rates of oryzalin and isoxaben. Despite this wide range, there was no significant difference among the herbicide treatments on the first sampling date of June 30 (Table 1). Weed counts from the second sampling (Table 2) showed a significant difference between the control and the herbicide treatments and a significant difference among the herbicide treatments. The combined low rate of oryzalin and isoxaben was significantly better than the rest of the herbicide treatments (Table 2). After the existing weeds were removed from the sample quadrants on June 30, no new weeds had emerged in the oryzalin plus isoxaben treated plots on the August 3 sample date.

No phytotoxicity or abnormal growth affects were observed on the dahlias in herbicide treated plots. It is important to note that the herbicides were applied to the surface of the soil after the dahlia "tubers" (tuberous roots) or stem cuttings had been planted. Firming the soil above the "tubers" and around the stem cuttings with a lawn roller and controlling the depth of incorporation of the herbicide by a light irrigation (0.5 inch), prevents the herbicides from leaching downward into the soil and stunting the dahlia roots.

SUMMARY

All of the herbicides tested in this experiment significantly reduced weed populations when combined with a mechanical practice (hoeing). Several factors should be considered when selecting a herbicide for dahlia culture. The types of weeds (grasses or broadleaf) that need to be controlled, their lifecycle, the size of the area to be treated, and the availability and cost of the herbicides.

Table 1. Weed populations - June 30 sample date.

Treatment Amt/1000 ft^2	Replication number	Total weeds	Common groundsel	Common purslane	Hairy nightshade	Other broadleaf	Large crabgrass	Other grasses	Mean[a]
					No.				
Control	17	64	28	5	2	9	20	0	
No herbicide	20	155	103	24	11	7	10	0	
	41	80	8	24	40	7	1	0	
	47	287	15	248	8	9	6	1	
Total		586	154	301	61	32	37	1	146.5a
Prodiamine	10	28	27	0	1	0	0	0	
10.4 g	23	103	74	0	16	13	0	0	
	39	17	12	0	4	1	0	0	
	43	25	21	1	2	1	0	0	
Total		173	134	1	23	15	0	0	43.3a
Prodiamine	13	4	1	0	2	1	0	0	
17.3 g	15	41	29	0	10	2	0	0	
	19	47	33	0	14	0	0	0	
	48	5	0	2	0	0	3	0	
Total		97	63	2	26	3	3	0	24.3b
Prodiamine	25	1	1	0	0	0	0	0	
23.8 g	29	10	7	0	2	1	0	0	
	32	7	4	0	3	0	0	0	
	44	4	4	0	0	0	0	0	
Total		22	16	0	5	1	0	0	5.5b
Isoxaben	1	32	0	0	2	0	30	0	
7 g	26	2	0	0	0	1	1	0	
	40	0	0	0	0	0	0	0	
	46	89	2	9	5	0	73	0	
Total		123	2	9	7	1	104	0	30.8b
Isoxaben	2	15	0	0	3	0	12	0	
10.5 g	12	6	0	0	0	0	8	0	
	34	3	0	0	2	1	0	0	
	38	5	2	0	2	0	1	0	
Total		29	2	0	7	1	19	0	7.3b
Isoxaben	3	14	0	0	5	0	8	1	
14 g	11	8	1	0	3	0	4	0	
	21	9	0	0	0	0	9	0	
	35	7	0	1	4	0	2	0	
Total		38	1	1	12	0	23	1	9.5b
Oryzalin	4	12	0	0	9	2	1	0	
44 ml	22	27	21	0	5	0	1	0	
	30	28	7	3	3	15	0	0	
	45	66	2	48	9	3	4	0	
Total		133	30	51	26	20	6	0	33.3b
Oryzalin	6	22	0	1	4	12	5	0	
66.5 ml	8	14	2	5	7	0	0	0	
	16	40	10	6	23	0	1	0	
	37	5	0	0	4	0	1	0	
Total		81	12	12	38	12	7	0	20.3b

Table 1. (Cont.)

Treatment Amt/1000 ft²	Replication number	Total weeds	Common groundsel	Common purslane	Hairy nightshade	Other broadleaf	Large crabgrass	Other grasses	Mean[a]
					No.				
Oryzalin	9	0	0	0	0	0	0	0	
88.7 ml	14	5	2	0	2	1	0	0	
	24	12	0	0	8	4	0	0	
	36	7	0	3	3	1	0	0	
Total		24	2	3	13	6	0	0	6b
Oryzalin 44 ml	7	89	0	0	89	0	0	0	
+	18	5	3	0	1	0	0	1	
Prodiamine 10.4g	27	8	4	0	4	0	0	0	
	33	15	1	5	5	4	0	0	
Total		117	8	5	99	4	0	1	29.3b
Oryzalin 44 ml	5	0	0	0	0	0	0	0	
+	28	0	0	0	0	0	0	0	
Isoxaben 7 g	31	5	0	0	5	0	0	0	
	42	4	0	0	2	1	1	0	
Total		9	0	0	7	1	1	0	2.3b

[a]Means followed by the same letter are not significantly different.

Table 2. Weed populations - August 3 sample date.

Treatment Amt/1000 ft²	Replication number	Total weeds	Common groundsel	Common purslane	Hairy nightshade	Other broadleaf	Large crabgrass	Other grasses	Mean[a]
					No.				
Control	17	23	13	1	0	8	1	0	
No herbicide	20	11	5	3	0	2	0	1	
	41	19	3	3	4	9	0	0	
	47	54	6	23	0	9	16	0	
Total		107	27	30	4	28	17	1	26.8a
Prodiamine	10	6	6	0	0	0	0	0	
10.4 g	23	7	2	0	0	5	0	0	
	39	1	0	0	0	1	0	0	
	43	5	5	0	0	0	0	0	
Total		19	13	0	0	6	0	0	4.8b
Prodiamine	13	1	1	0	0	0	0	0	
17.3 g	15	0	0	0	0	0	0	0	
	19	4	4	0	0	0	0	0	
	48	1	0	0	0	0	1	0	
Total		6	5	0	0	0	1	0	1.5b
Prodiamine 3	25	0	0	0	0	0	0	0	
23.8 g	29	3	2	0	0	1	0	0	
	32	3	3	0	0	0	0	0	
	44	1	1	0	0	0	0	0	
Total		7	6	0	0	1	0	0	1.8b
Isoxaben 1	1	0	0	0	0	0	0	0	
7 g	26	2	0	0	0	2	0	0	
	40	0	0	0	0	0	0	0	
	46	12	0	0	0	4	8	0	
Total		14	0	0	0	6	8	0	3.5b

Table 2. (Cont.)

Treatment Amt/1000 ft^2	Replication number	Total weeds	Common groundsel	Common purslane	Hairy nightshade	Other broadleaf	Large crabgrass	Other grasses	Mean[a]
		No.							
Isoxaben 2	2	1	0	1	0	0	0	0	
10.5 g	12	0	0	0	0	0	0	0	
	34	2	0	0	0	2	0	0	
	38	2	1	0	0	1	0	0	
Total		5	1	1	0	3	0	0	1.3b
Isoxaben 3	3	1	0	0	0	0	0	1	
14 g	11	0	0	0	0	0	0	0	
	21	0	0	0	0	0	0	0	
	35	1	0	0	0	1	0	0	
Total		2	0	0	0	1	0	1	0.5b
Oryzalin 1	4	2	0	0	0	1	1	0	
44 ml	22	5	5	0	0	0	0	0	
	30	24	1	1	4	18	0	0	
	45	8	0	1	3	2	2	0	
Total		39	6	2	7	21	3	0	9.8b
Oryzalin 2	6	2	1	0	0	1	0	0	
66.5 ml	8	0	0	0	0	0	0	0	
	16	6	4	0	0	1	1	0	
	37	1	0	0	1	0	0	0	
Table		9	5	0	1	2	1	0	2.3b
Oryzalin 3	9	3	2	0	0	1	0	0	
88.7 ml	14	6	4	0	1	1	0	0	
	24	15	0	0	0	15	0	0	
	36	1	1	0	0	0	0	0	
Total		25	7	0	1	17	0	0	6.3b
Oryzalin 44 ml	7	0	0	0	0	0	0	0	
+	18	2	2	0	0	0	0	0	
Prodiamine 10.4g	27	3	1	0	1	1	0	0	
	33	3	1	0	0	2	0	0	
Total		8	4	0	1	3	0	0	2b
Oryzalin 44 ml	5	0	0	0	0	0	0	0	
+	28	0	0	0	0	0	0	0	
Isoxaben 7 g	31	0	0	0	0	0	0	0	
	42	0	0	0	0	0	0	0	
Total		0	0	0	0	0	0	0	0c

[a]Means followed by the same letter are not significantly different.

VARIETAL TOLERANCE OF SEEDLING KENTUCKY BLUEGRASS TO PRIMISULFURON AND TRIBENURON.

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INTRODUCTION

Kentucky bluegrass seed crop production has steadily increased in the Columbia Basin and lower Umatilla Basin areas of northeastern Oregon and southeastern Washington. The crop is grown under irrigated conditions on sandy, low organic matter soils. In newly seeded Kentucky bluegrass stands, management of grassy weeds is a major concern. Herbicide primisulfuron is currently registered for use in seedling and established Kentucky bluegrass under Oregon Special Local Needs registration (24C) for control of downy brome. Primisulfuron provides excellent control of downy brome if application is properly timed (Ball and Walenta, 1996). Crop tolerance of seedling Kentucky bluegrass to primisulfuron has been variable and is dependent on application timing and rates (Ball and Singh, 1998). Herbicide tribenuron is registered for use in seedling and established Kentucky bluegrass for control of certain broadleaf weeds. The objective of this study was to evaluate the crop tolerance of different Kentucky bluegrass varieties to primisulfuron and tribenuron.

MATERIAL AND METHODS

The experiment was initiated on an irrigated circle at the Hermiston Agricultural Research and Extension Center in northeastern Oregon. The soil at the center is representative of the sandy, low organic matter soils prevalent in the region. Eight Varieties of Kentucky bluegrass (Adelphi, Baron, Barblue, Blacksburg, Nu-Glade, Midnight, Shamrock and Wildwood) were seeded on August 29, 1997 with a plot drill at 12-inch row spacing. The plots were 6 by 20 feet in a strip plot design with four replications. Soil at the site is sandy loam (72% sand, 22% silt, 5% clay) with 1.2% organic matter, pH 7.1 and CEC of 7.9 meq/100 gm. Herbicide treatments were applied with a handheld $C0_2$ backpack sprayer with 15 gpa water at 30 psi. Primisulfuron was applied with crop oil concentrate, MorAct at 1.7% v/v. Tribenuron was applied with nonionic surfactant, R-11 at 0.25% v/v. Kentucky bluegrass was swathed with a plot swather (variety Shamrock on June 9, 1998; varieties Adelphi, Baron, Barblue, Wildwood and Blacksburg on June 12, 1998; and varieties Nu-Glade and Midnight on June 16, 1998). Kentucky bluegrass was harvested with a plot combine (variety Shamrock on June 17, 1998; variety Adelphi on June 22, 1998; remaining varieties on June 23, 1998). Seed was oven dried, rethreshed and cleaned with a three sieve cleaner. Percent reduction in plant height and clean seed yield, compared to untreated was calculated for each replicate separately.

RESULTS AND DISCUSSION

During visual evaluations made in late fall and early spring (data not shown), the early application of primisulfuron (October 16) and the split application of caused slight injury to all varieties of Kentucky bluegrass. On April 28, 1998 evaluation, split application of primisulfuron showed slightly higher injury than other primisulfuron treatments in most varieties (Table 1). The mid-spring application (March 14, 1998) of tribenuron produced slight injury in all varieties of Kentucky bluegrass. Nu-Glade and Midnight varieties were more susceptible to injury from herbicide treatments, which may be partly due to an interaction with a severe infection of leaf rust and mildew. Primisulfuron application in fall resulted in reduction in plant height compared to untreated control (Table 2). Split fall application of primisulfuron produced greater reduction in plant height of varieties Blacksburg, Nu-Glade, Midnight and Wildwood. Mid-spring (March 14, 1998) application of tribenuron also reduced plant height in variety Nu-Glade. Treatments with early spring application of primisulfuron and tribenuron produced highest yields of Kentucky bluegrass (Table 3). Shamrock was the highest yielding Kentucky bluegrass variety. All fall applications of primisulfuron reduced the seed yield compared to untreated control (Table 4). Variety Blacksburg showed the greatest reduction in seed yields from both fall applications of primisulfuron and late spring applications of tribenuron. Except for Blacksburg, spring application of primisulfuron and tribenuron produced clean seed yields higher than untreated control. An effort was made to maintain plots in a weed free condition with hand removal of weeds. Early weed control and negligible crop injury from the spring applications of primisulfuron and tribenuron led to increase in clean seed yields from those treatments. In fall 1998, a visual evaluation showed lack in regrowth of Kentucky bluegrass following harvest and residue burn in treatments with fall applications of primisulfuron (Table 5). Herbicide treatments did not effect the germination of harvested clean seed (Table 6).

CONCLUSIONS

Herbicide tolerance was primarily related to herbicide application timing. Variety Blacksburg tended to be least tolerant followed by Nu-Glade, Midnight and Wildwood but varieties did not greatly differ in their tolerance to primisulfuron and tribenuron.

Table 1. Percent visible injury in Kentucky bluegrass, April 28, 1998.

			Spring 1998 injury of Kentucky bluegrass varieties[a]								
Herbicide	Rate	Timing	Adelphi	Baron	Barblue	Blacksburg	Nu-Glade	Midnight	Shamrock	Wildwood	Mean
	gm/ha		%								
Primisulfuron	40	Oct. 16, 1997	5	9	8	6	14	11	6	8	8
Primisulfuron	40	Nov. 13, 1997	3	8	3	6	9	10	4	3	6
Primisulfuron	40	Feb. 17, 1998	10	8	4	3	4	6	3	4	5
Primisulfuron/primisulfuron	20/20	Oct. 16/ Nov. 13, 1997	9	11	6	11	16	11	9	9	10
Tribenuron	14	Feb. 17, 1998	1	0	0	0	0	1	0	0	0
Tribenuron	14	Mar. 14, 1998	4	9	6	4	8	10	5	4	6
Tribenuron	14	Apr. 17, 1998	0	0	0	0	3	0	0	0	0
Untreated			0	0	0	0	0	0	0	0	0
Mean			4	6	3	4	7	6	3	3	

[a] LSD (0.05) value for comparing two herbicide treatments within the same variety is 5%.
LSD (0.05) value for comparing two varieties within the same herbicide treatment is 4%.

Table 2. Percent reduction in plant height of Kentucky bluegrass compared to untreated control, June 2, 1998.

Herbicide	Rate	Timing	Height reduction[a]								
			Adelphi	Baron	Barblue	Blacksburg	Nu-Glade	Midnight	Shamrock	Wildwood	Mean
	gm/ha		%								
Primisulfuron	40	Oct. 16, 1997	18	16	14	17	14	14	13	10	14
Primisulfuron	40	Nov. 13, 1997	16	13	11	11	17	10	8	6	12
Primisulfuron	40	Feb. 17, 1998	2	5	3	7	2	-2	1	-1	2
Primisulfuron/primisulfuron	20/20	Oct. 16/Nov. 13, 1997	11	12	11	20	20	19	12	17	15
Tribenuron	14	Feb. 17, 1998	0	-4	-4	-3	-10	-4	-6	-7	-5
Tribenuron	14	Mar. 14, 1998	-3	1	-8	-3	8	4	2	3	1
Tribenuron	14	Apr. 17, 1998	-3	-3	-3	0	1	-12	-3	-6	-4
Untreated			0	0	0	0	0	0	0	0	0
Mean			5	5	3	6	7	4	3	3	

[a]LSD (0.10) value for comparing two herbicide treatments within same variety is 8%
LSD (0.10) value for comparing two varieties within same herbicide treatment is 9%.

Table 3. Clean seed yield (lb/A) of Kentucky bluegrass.

Herbicide	Rate	Timing	Yield[a]								
			Adelphi	Baron	Barblue	Blacksburg	Nu-Glade	Midnight	Shamrock	Wildwood	Mean
	gm/ha		lb/A								
Primisulfuron	40	Nov. 13, 1997	332	585	538	215	173	236	869	497	431
Primisulfuron	40	Feb. 17, 1998	602	913	928	323	299	391	1180	633	659
Primisulfuron/primisulfuron	20/20	Oct. 16/Nov. 13, 1997	323	597	568	141	176	271	849	390	414
Tribenuron	14	Feb. 17, 1998	521	905	872	320	294	364	1238	648	645
Tribenuron	14	Mar. 14, 1998	471	822	853	241	241	316	1074	551	571
Tribenuron	14	Apr. 17, 1998	483	839	783	258	249	379	1161	629	597
Untreated			466	749	722	309	241	305	1004	583	547
Mean			440	741	714	251	237	316	1018	548	

[a]LSD (0.05) value for comparing two herbicide treatments within same variety is 140 lb/A.
LSD (0.05) value for comparing two varieties within same herbicide treatment is 142 lb/A.

Table 4. Percent reduction in clean seed yield of Kentucky bluegrass compared to untreated control.

Herbicide	Rate	Timing	Yield reduction[a]								
			Adelphi	Baron	Barblue	Blacksburg	Nu-Glade	Midnight	Shamrock	Wildwood	Mean
	gm/ha		%								
Primisulfuron	40	Nov. 13, 1997	27	21	25	31	26	23	10	10	22
Primisulfuron	40	Feb. 17, 1998	-33	-23	-27	-4	-24	-28	-19	-14	-21
Primisulfuron/primisulfuron	20/20	Oct. 16/Nov. 13, 1997	32	19	21	57	26	12	15	30	26
Tribenuron	14	Feb. 17, 1998	-11	-21	-20	-1	-21	-19	-24	-14	-16
Tribenuron	14	Mar. 14, 1998	-2	-10	-20	21	-2	-4	-11	5	-3
Tribenuron	14	Apr. 17, 19 98	-4	-12	-7	16	-7	-25	-17	-9	-8
Untreated			0	0	0	0	0	0	0	0	0
Mean			5	1	1	20	1	-4	-3	4	

[a]LSD (0.05) value for comparing two herbicide treatments averaged over all varieties is 18%.

Table 5. Percent visible injury (lack of regrowth compared to untreated control), Sept 4, 1998.

			Injury[a]								
Herbicide	Rate	Timing	Adelphi	Baron	Barblue	Blacksburg	Nu-Glade	Midnight	Shamrock	Wildwood	Mean
	gm/ha		%								
Primisulfuron	40	Nov. 13, 1997	61	71	70	70	70	56	50	65	64
Primisulfuron	40	Feb. 17, 1998	0	0	0	0	0	0		0	0
Primisulfuron/primisulfuron	20/20	Oct. 16/Nov. 13, 1997	76	75	76	70	75	73	65	74	73
Tribenuron	14	Feb. 17, 1998	0	0	0	0	0	0	0	0	0
Tribenuron	14	Mar. 14, 1998	0	0	0	0	0	0	0	0	0
Tribenuron	14	Apr. 17, 1998	0	0	0	0	0	0	0	0	0
Untreated			0	0	0	0	0	0	0	0	0
Mean			26	27	28	27	28	24	22	26	

[a] LSD (0.05) value for comparing two herbicide treatments averaged over all varieties is 11%.
LSD (0.05) value for comparing two varieties averaged over all herbicide treatments is 5%.

Table 6. Percent germination of Kentucky bluegrass harvested seed, 21 days after incubation.

			Germination[a]								
Herbicide	Rate	Timing	Adelphi	Baron	Barblue	Blacksburg	Nu-Glade	Midnight	Shamrock	Wildwood	Mean
	gm/ha		%								
Primisulfuron	40	Nov. 13, 1997	73	82	69	78	82	82	84	80	79
Primisulfuron	40	Feb. 17, 1998	69	78	73	76	85	79	82	85	78
Primisulfuron/primisulfuron	20/20	Oct. 16/Nov. 13, 1997	68	86	72	79	81	86	86	82	80
Tribenuron	14	Feb. 17, 1998	76	82	75	74	80	83	81	82	79
Tribenuron	14	Mar. 14, 1998	74	89	61	74	82	81	85	85	79
Tribenuron	14	Apr. 17, 1998	77	85	65	73	87	82	86	84	80
Untreated			73	82	68	75	78	81	82	81	77
Mean			72	83	69	76	82	82	82	82	

[a] LSD (0.05) value for comparing two varieties averaged over all herbicide treatments is 3%.

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DCPA ALTERNATIVE PREEMERGENCE HERBICIDES FOR DRY BULB ONIONS. Carl E. Bell and Brent Boutwell, Weed Science Farm Advisor and Staff Research Associate II, University of California Cooperative Extension, Holtville, CA 92250-9615.

Abstract. Metolachlor, bensulide, propachlor, pendimethalin, dimethenamid, and ethofumasate were evaluated in 6 field trials as possible alternatives to DCPA for preemergence weed control in dry bulb onion. Data collected from all trials included visual evaluation of weed control and crop injury along with stand counts. In four of the trials, yield data were also taken. Metolachlor and dimethenamid both caused significant crop injury to the onions and reduced yield in most of the trials. Propachlor and ethofumasate were safe to the crop, but did not control weeds

adequately. Bensulide applied alone at 4.4 kg/ha did not injure the crop, but also did not control weeds as well as DCPA. A higher rate of bensulide (6.6 kg/ha) was more effective, but there was some crop injury observed. A combination of bensulide at 4.4 kg/ha plus pendimethalin at 0.28 kg/ha was as effective on the control of a variety of annual weeds as DCPA without causing crop injury or any yield reduction.

ANNUAL BLUEGRASS INTERFERENCE IN MEADOWFOAM. Bill D. Brewster, Carol A. Mallory-Smith, and Paul E. Hendrickson, Senior Instructor, Assistant Professor, and Faculty Research Assistant, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331-3002.

Abstract. Meadowfoam is an oil-seed crop that was developed by Oregon State University to be grown in the wet soils of the Willamette Valley. These soils have been used for several decades to produce seed of annual and perennial ryegrass and tall fescue. The lack of crop rotation and a restriction on field burning has resulted in dense populations of herbicide-resistant annual bluegrass. Meadowfoam could be an important alternative crop for Willamette Valley grass seed growers. Field trials were conducted in 1994 to 1995, 1995 to 1996, 1996 to 1997, and 1997 to 1998 to evaluate the effect of annual bluegrass on meadowfoam seed yield. Annual bluegrass was seeded at eight densities in each trial prior to drilling the meadowfoam seed. The annual bluegrass stand densities ranged from zero each year to as high as 826/ft^2 in 1997 to 1998. Annual bluegrass did not greatly affect meadowfoam seed yield in any year except 1996 to 1997, when meadowfoam seed yield increased as annual bluegrass stand density increased. This increase may have been related to an infestation of *Scaptomyza* sp. fly which seemed to parasitize meadowfoam that was growing without annual bluegrass to a greater extent than meadowfoam that was growing in a stand of annual bluegrass. These studies show that meadowfoam can be a successful crop in western Oregon grass seed fields even without an annual bluegrass control program.

DEVELOPING NEW REMOTE SENSING TECHNOLOGY FOR MORE ECONOMICAL WEED CONTROL. Lawrence Lass and Donn Thill, Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83844-2339.

Abstract. Advances in selective chemical weed control and application technology provide more opportunity for "smart" precision management with herbicides during crop rotations. To take full advantage of new application systems, accurate digital mapping of weed positions will be necessary. Digital maps generated from images using multispectral and hyperspectral remote sensors offer a rapid method of surveying the weeds in the field. The objective of this project is to develop modern remote sensing procedures to identify, define, and record the locations and spatial distribution of weed infestations in wheat and pea fields with management level accuracy. The Probe 1 hyperspectral sensor, from Earth Search Sciences Inc., McCall, ID recorded images of four farms near Moscow, ID on July 19, 1998. The hyperspectral sensor has 128 bands and a spatial resolution of about 5 m. Images were georectified using both flight line correction and quadratic rectification algorithms. Images are currently being processed to develop spectral signatures for the training sites. Preliminary classification of the interrupted windgrass spectral signature indicates hyperspectral signature analysis enhanced the detection when compared to a multispectral image. The multispectral image showed a few interrupted windgrass infestations with a cover class 70 to 100%, but mistakenly classified most of the pea fields as interrupted windgrass. Hyperspectral signature analysis of interrupted windgrass generated an image with an omissional error of 29% and a commissional error of 1%. Hyperspectral signature analysis allowed us to refine the images and increase detection accuracy.

MULTI STATE EVALUATION OF JOINTED GOATGRASS BIOECONOMIC MODEL. William S. Rigby and John O. Evans, Graduate Research Assistant and Professor, Department of Plant, Soils, and Biometeorology, Utah State University, Logan, UT 84322-4820.

Abstract. Jointed goatgrass is a serious pest weed of winter wheat, it reduces yields and decreases values due to dockage. A bioeconomic model has been developed to assist growers in making management decisions. To be effective it must accurately predict jointed goatgrass and winter wheat population dynamics and yield. This study was established to validate the effectiveness of the model at predicting winter wheat yields with varied infestations of jointed goatgrass. Sites in Blue Creek, Utah and Platner, Colorado were selected to assess the models accuracy with respect to geographic locations. Soil samples to determine seedbank, fall and spring seedling counts, and reproductive tiller counts were taken during the growing season, 1998, for use in model evaluation. Data was fitted to four state functions of the bioeconomic model. These were tillers at harvest, % yield loss, yield loss model A and B.

Parameter estimates for 1998 data were compared with parameter estimates for other years and other sites. Variation in parameter estimates differed between years and sites, some significantly. Differences between years were not as great as between sites. Some parameters such as Ymax in yield model B did not differ significantly, others did. Parameter estimates do vary over years and between sites. Bioeconomic model may require more data to be accurate, not only between sites but within sites over years.

JOINTED GOATGRASS SEED PRODUCTION IN SPRING SEEDED WHEAT. Darrin L. Walenta[1], Joseph P. Yenish[1], Frank L. Young[2], Steven Seefeldt[2], Daniel A. Ball[3], and Eric Gallandt[1], Graduate Research Assistant, Assistant Agronomist/Extension Weed Specialist, USDA-ARS Research Agronomist/Weed Scientist, USDA-ARS Agronomist, Associate Professor, Assistant Professor, [1,2]Department of Crop and Soil Sciences, Washington State University, Pullman, WA 99164 and [3]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. However, research scientists and growers have observed jointed goatgrass emergence and seed production in spring cereal crops. A study was established during the spring of 1998 near Lind, WA, Pendleton, OR, and Pullman, WA to evaluate the potential for spring emergence and seed production by jointed goatgrass grown in pure stands and in competition with spring wheat. The experimental design was a randomized complete block factorial arrangement with four replications. Main factors were planting date and pure or mixed stands of jointed goatgrass and spring wheat. At each location, spring wheat and jointed goatgrass was planted on four different dates at approximately two week intervals. Jointed goatgrass was seeded at 161 spiklets/m^2. Planting date influence on jointed goatgrass plant populations was significant only at the Lind site where 38 plants/m^2 established in the earliest planting date of March 1, compared to 24 plants/m^2 (March 15), 16 plants/m^2 (March 30), and 26 plants/m^2 (April 15). Jointed goatgrass spike production was greatest at Lind where 77 spikes/m^2 were produced in the earliest planting date. At all sites, spike production was not statistically different than zero at any planting date other than the initiation date. Further tests will determine seed viability from collections made at each site.

JOINTED GOATGRASS X WHEAT HYBRIDS--FACT OR FICTION: EVIDENCE FROM OREGON WHEAT FIELDS.

Laura A. Morrison and Carol A. Mallory-Smith, Research Scientist and Assistant Professor, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331-3002.

Abstract. Hybrids between jointed goatgrass and wheat have traditionally caused little concern due to a male-sterility genetic system introduced by the jointed goatgrass parent. However, recent evidence of fertile hybrids (Zemetra, R.S., J. Hansen, and C.A. Mallory-Smith. 1998. Weed Sci. 46:313-317.) suggests the need for a more careful examination of jointed goatgrass hybridization in field conditions. This study reports the evidence for hybridization in samples collected in 1998 from four wheat fields located across the major wheat-growing region of Eastern Oregon. In an infested section of each field, 25 samples, spaced approximately 1 meter apart, were randomly collected from 2 jointed goatgrass plants (2 spikes/plant) and an adjacent hybrid plant (all spikes). An additional bulk collection of all spikes from hybrid plants located throughout the sample area was also made. Of the total 1716 F_1 hybrid spikes (combined single-plant and bulk material) collected, 369 contained 1 or more seeds. In the single-plant hybrid collection, the proportion of fertile spikes ranged from 5 to 57%, with an overall average of 1.3 seeds/fertile spike; in the bulk collection, the proportion of fertile spikes ranged from 1 to 41%, with an overall average of 1.1 seeds/fertile spike. We used SDS-PAGE of the high molecular weight (HMW) glutenin seed proteins to check for active hybridization events. HMW glutenin profiles serve as a useful screening tool for identifying hybrids because wheat and jointed goatgrass each has a unique profile which remains distinctive in the combined banding pattern formed in a hybrid seed. The seed protein analysis verifies that jointed goatgrass and wheat are actively hybridizing in the field. Analysis of the jointed goatgrass material has revealed hybrid seed whose glutenin profiles match those of the seed harvested from F_1 plants. Presence of combined jointed goatgrass/wheat glutenin profiles in seed collected from suspect backcross hybrid material supports the natural occurrence of gene flow between jointed goatgrass and wheat.

FIT OF TWO CROP YIELD FUNCTIONS TO DATA FROM WINTER WHEAT-JOINTED GOATGRASS (*AEGILOPS CYLINDRICA*) INTERFERENCE EXPERIMENTS.

Marie Jasieniuk[1], Bruce D. Maxwell[1], Randy L. Anderson[2], John O. Evans[3], Drew J. Lyon[4], Stephen D. Miller[5], Don W. Morishita[6], Alex G. Ogg, Jr.[7], Steven Seefeldt[8], Phillip W. Stahlman[9], Philip Westra[10], and Gail A. Wicks[11], [1]Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, MT 59717; [2]Central Plains Research Center, USDA ARS, Akron, CO 80720; [3]Department of Plant, Soils and Biometeorology, Utah State University, Logan, Utah 84322; [4]Panhandle Research and Extension Center, University of Nebraska, Scotsbluff, NE 69361; [5]Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY 82071; [6]Twin Falls Research and Extension Center, University of Idaho, Twin Falls, ID 83303; [7]National Jointed Goatgrass Research Program, P.O. Box 53, Ten Sleep, WY 82442; [8]USDA ARS, Washington State University, Pullman, WA 99164; [9]Agricultural Research Center, Kansas State University, Hays, KS 67601; [10]Department of Bioagricultural Science and Pest Management, Colorado State University, Fort Collins, CO 80523; [11]West Central Research and Extension Center, University of Nebraska, North Platte, NE 69101.

Abstract. Two crop yield models: (1) Yield (kg/ha)$=((j*D_c)/(1+j*D_c/Y_{max}))*(1-(i*D_w)/(1+i*D_w/a))$ and (2) Yield (kg/ha)$=(a*D_c)/(1+b*D_c+f*D_w)$, where D_c = crop density, D_w = weed density, Y_{max} = maximum crop yield, and j, i, a, b, and f are estimated parameters, were compared for their fit to 25 data sets from multi-year winter wheat-jointed goatgrass competition experiments conducted at CO, ID, KS, MT, NE, UT, WA, and WY. Three criteria were used to assess fit of the models to the data. Model 1 was superior to model 2 in terms of biological interpretability of parameters. Model 2 was superior in terms of the smallest residual sum of squares (RSS). Model 2 gave the smaller RSS for 15 of the 25 data sets analyzed. Model 2 was also superior to model 1 in terms of randomness of the residuals. Runs tests indicated residuals from fitting model 2 were randomly distributed above and below the regression curve for all 25 data sets. Residuals from fitting model 1 were random for 20, and nonrandom for 5, of the 25 data sets. Clearly, model 2 provided the best fit to the competition data. Despite model 2's superior fit, model 1 may be preferred over model 2 when yield relationships are highly variable among years and locations. Its biologically meaningful parameters could help identify the abiotic and biotic factors influencing crop yields.

FLOWERING VARIATION AMONG DIFFERENT BROOM AND THREADLEAF SNAKEWEED POPULATIONS. Evelin R. Eichler and Tracy M. Sterling, Undergraduate Student and Associate Professor, Department of Entomology, Plant Pathology and Weed Science and Leigh W. Murray, Professor, University Statistics Center, New Mexico State University, Las Cruces, NM 88003.

Abstract. Broom and threadleaf snakeweed are very common problem rangeland weeds throughout the western United States. Snakeweed is a perennial half-shrub and its adaptiveness and invasive growing pattern makes it very competitive resulting in decreased desirable forage for livestock. Chemical and biological methods have been investigated to manage snakeweed. A greater understanding of this plant's physiological and morphological processes should aid in finding more effective methods for managing this weed. Therefore, a snakeweed garden was established in 1992 in Las Cruces, NM with cuttings of plants obtained from locations across NM, AZ and TX. Broom snakeweed plants were collected from eight locations throughout NM and one in TX. Threadleaf snakeweed plants were collected from a Las Cruces, NM and a Sasabe, AZ population. The garden, located at the Leyendecker Plant Science Farm, contained five blocks each consisting of 200 plants arranged randomly in a grid pattern of 20 genotypes from 10 different populations. Flowering dates, when each plant first had a visual measure of 50% of its flowers in bloom, were recorded weekly in 1992 to 1995, 1997 and 1998. Variation in flowering dates was observed with the northernmost population of broom snakeweed (Des Moines) flowering earliest each year and the southernmost population (Texas) flowering latest. Other populations followed a similar trend. No difference was observed for the two species collected from the Las Cruces location. These data suggest that time of flowering is independent of growing location and that photoperiod does not play a role in flowering.

MONTANA'S STATEWIDE NOXIOUS WEED AWARENESS AND EDUCATION CAMPAIGN. Roger L. Sheley and Carla Hoopes, Extension Noxious Weed Specialist and Program Coordinator, Department of Land Resources and Environmental Sciences, and the Statewide Noxious Weed Awareness and Education Campaign Working Group, P.O. Box 173120, Montana State University, Bozeman, MT 59717-3120.

Abstract. Montana's natural resources are at risk from noxious weed invasion. We have approached the problem from a regional perspective collaborating with federal agencies, local organizations, and individuals to achieve successful programs that protect our natural resources. We recognize that it will take continuous participation by every state citizen to maintain a proactive and aggressive program designed to keep Montana's lands free from destruction caused by noxious weeds. Without awareness and education, we do as much to spread noxious weeds as we do to control them. Montana's statewide noxious weed awareness and education group has developed a new statewide campaign structured to reach every Montanan. The strategic campaign is designed to work for all state and federal agencies, local organizations, and individuals in a coordinated effort to generate leaders and workers to protect our native wildlife and plant populations. The benefit of the campaign to all state and federal agencies is the effective use of combined dollars to reach a broader audience at less cost. Some agencies have already come forward with funding for implementation of pieces of the campaign.

Benefit to Agencies, Organizations, and Individials. The potential for protecting Montana's heritage, our healthy environment, is strengthened as all Montanans pull together to support noxious weed efforts. It is less costly to stop the spread before it gets out of control than to allow it to take over our pristine mountains and undeveloped public lands. Without everyone's support, our lush meadows and rangelands will be replaced with monocultures of noxious weeds and we will experience the beginning of desertification of Montana's lands. Native wildlife will disappear along with hunting and recreation opportunities that our citizens and tourists find meaningful. The economic impact to every Montana citizen will be realized as more and more dollars go into management of noxious weed infestations that are out of control. Our rivers and streams will be buried by soil erosion and sediment from runoff in areas where noxious weeds have destroyed the native ground cover, depleted the soil of its nutrients, and out-competed itself turning our land into a barren wasteland. The eminent destruction of our natural heritage can be curtailed when we all pull together, understand the problem, and support noxious weed efforts.

Campaign Strategy. The Statewide Noxious Weed Awareness and Education Campaign Group is progressively developing an integrated, cohesive education and awareness campaign strategy for the state of Montana. The group has succeeded in creating a sound campaign and the beginning stages of implementation are in place. Volunteers are in key positions with new communication channels being opened to efficiently and effectively spread awareness and education to all communities throughout the state.

Past and Current Efforts. As a result of meetings over the past few years, the Montana Weed Control Association Education and Integrated Weed Management committee as well as the 20/20 Vision Meeting participants concluded that the highest priority in Montana is to educate the general public about noxious weeds.

Since 1982, a heightened concern over noxious weed issues by many agencies and organizations has prompted dissemination of diverse and helpful information to the general public in the form of videos, PSAs, media campaigns, and direct mail. Recognizing the need to continue the development and distribution of educational materials about noxious weeds, the "Statewide Noxious Weed Awareness and Education Campaign Partners" formed in early 1996. Participants in the weed awareness group are from the following agencies, organizations, and individuals:

Statewide Noxious Weed Awareness and Education Campaign Partners

Montana Departments of Agriculture and Transportation
Bureau of Indian Affairs
Public Utilities
United States Bureau of Land Management
Western Society of Weed Science
Fish, Wildlife, and Parks
Vegetation Management Corporations
Association of Range Science; Headwaters RC&D, Inc.
Natural Resource Conservation Services
Montana Weed Districts
Farm Bureau
National Park Headquarters
Montana Stock Growers
Montana Association of Counties
Wildlife Refuges
County Extension Offices
Environmental Protection Agencies
United States Forest Service
USDA/Agricultural Research Service
Montana State University System, Plant, Soil and Environmental Sciences.

Mission Statement. After a series of meetings beginning in October 1996, the weed awareness group developed a Mission Statement: *For the people of Montana to realize the economic and environmental impacts of noxious weeds and to become supportive of all aspects of noxious weed efforts.*

Messages. The group focused on seven concise messages to be delivered to the general public: 1) Explanation of noxious weed--identification of individual plants and infestations; 2) How people are affected by noxious weeds; 3) How the environment is affected by noxious weeds; 4) Why the general public needs to support all aspects of noxious weed efforts (including the Noxious Weed Trust Fund); 5) What the general public can do; 6) Successful weed management programs in Montana; and 7) There are many ways to manage weeds.

Target Audiences. The weed awareness group developed channels for communicating these messages to identified target audiences: 1) Government groups; 2) Utilities/Transportation Groups; 3) Public At Large; 4) Producers; 5) Environmental Groups; 6) Youth; 7) Small Landowners, Developers, Realtors; and 8) Recreationists, Sportsmen, Tourists.

Communication Channels. Within each target audience, direct contact channels were established and tasks identified. Members of the group and their respective agencies and associations have come forward to implement some specific tasks. Consistency and follow-through are key elements to the success of the campaign. The campaign is comprised of many tasks that are still to be addressed by the group. Opportunities and communication channels are dynamic as members of the group change employment positions. The weed awareness group concludes that a full-time coordinator is necessary to manage the complexity of the noxious weed awareness campaign, establish statewide consistency, and maintain perseverance in the program.

Conclusion. Montana is being invaded by noxious weeds, which are spreading like a biological wildfire. Throughout the west, and especially in Montana, these weeds are spreading at an alarming rate. For example, spotted knapweed has been spreading from west to east at an estimated 27% per year since 1920. Today, there is about 5 million acres of this weed in Montana alone. Leafy spurge, another noxious weed, is attacking Montana from the east. Based on the current rate of spread, the natural ecosystem on which Montanans depend for their lifestyle and livelihood will be eliminated in the near future.

Noxious weeds degrade our ecosystems by displacing diverse plant and animal populations that are essential to the ecological and economic stability of our state. Noxious weeds out-compete native plants for space, water, sunlight, and nutrients, turning once lush and productive fields and meadows into near-monocultures of useless desert. Noxious weeds increase surface runoff and soil sedimentation impacting our streams and rivers. Loss of wildlife and livestock forage, native plant diversity, endangered species, recreational opportunities and value, and the health of the ecosystem occur with the invasion of noxious weeds.

If we are going to preserve the natural heritage of Montana, it has become clear that Montanans must dramatically increase our efforts toward preventing the further invasion of noxious weeds and developing and implementing sustainable noxious weed management strategies. In order to achieve an adequate level of weed management, all Montanans must support noxious weed efforts. Therefore, it is critical that we all become aware of the threat of noxious weeds and how we and our ecosystem will be impacted in the future. Together, we can create enough awareness and support for noxious weed efforts to strengthen our healthy environments against devastation caused by noxious weeds.

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 83344-2339.

Abstract. Yellow starthistle presently infests about 200,000 ha of range and non-croplands in Idaho, accounting for about 13% of the total yellow starthistle infestations in the U.S. The purpose of this study was to determine the effect of different rates and applications times of imazapic on yellow starthistle control and annual grass injury. Experiments were established at two locations on unimproved pasture land near Lewiston, ID. Herbicide treatments were arranged as a two (fertilizer) by 15 (herbicide) factorial randomized complete-split block design with four replications. Imazapic was applied PRE and POST in fall, 1997 and POST in spring, 1998. Picloram and an untreated control were included in the experiment. Ammonium sulfate fertilizer was applied during spring 1998 to one half of each block, while no fertilizer was applied to the other half. Imazapic applied PRE increased grass plant density 45 to 51% and reduced the yellow starthistle density 62 to 83%. However, surviving yellow starthistle plants were large and produced total biomass similar to untreated plants. Imazapic applied in the spring reduced yellow starthistle density 24 to 68% and biomass 40 to 87% compared to the untreated control. Sequential applications of Imazapic applied in the fall and spring controlled yellow starthistle 83%, and reduced plant density 83% and biomass 95%. However, grass density was reduced 90%. Picloram applied in the fall or spring controlled yellow starthistle 99 to 100%, reduced plant density 89 to 99%, reduced biomass 88 to 100%, and increased grass plant density 29 to 55%.

PHOTOSYNTHETIC RATES AMONG BROOM AND THREADLEAF SNAKEWEED POPULATIONS.

Marie C. Campanella, Tracy M. Sterling, Leigh Murray, and Amrita de Soyza, Research Assistant and Associate Professor, Department of Entomology, Plant Pathology and Weed Science, Professor, University Statistics Center, and Science Specialist, USDA Jornada Experimental Range, New Mexico State University, Las Cruces, NM 88003.

Abstract. Broom and threadleaf snakeweed are highly variable perennials growing abundantly on rangelands across the western and southwestern United States. The competitiveness of these half-shrubs has partially been attributed to their ability to extract water from the soil efficiently and therefore, out-compete more desirable grasses. Snakeweed may also be able to maintain higher photosynthetic rates during periods of drought which would contribute to its competitive advantage and may help each population maintain its distinctive morphology. Determining the variability in physiological processes among snakeweed populations and between species will improve our understanding of their relative success. Therefore, photosynthetic rates were compared among nine broom and two threadleaf populations growing in the same environment. Cuttings from snakeweed originally collected from nine locations in NM, one location in AZ, and one in TX were planted in a common garden in 1992 in Las Cruces, NM. Each of the five plots in the garden contained 240 plants. Four plants from each of the 11 populations in the garden were used for photosynthesis measurements throughout the 1998 season. Morning and afternoon measurements were obtained once a week from April through June, 1998 and then once a month from July through September. A LI6200 Portable Photosynthesis System was used to measure photosynthesis on 2 stems (3 to 5 cm long) per plant. Following photosynthesis, stem tissue was collected and leaf areas were determined for the green tissue on each stem. Additional stem tissue from each plant was collected to determine water potential of each plant using a pressure bomb. Photosynthesis measurements were also taken in a time series on two days in April, one in May, and one in July. This was done to determine the photosynthetic patterns of the two species throughout the day over a season. Measurements were taken 6 to 10 times each day on one threadleaf and two broom snakeweed populations. For all the dates, photosynthesis generally decreased throughout the day. Photosynthetic rates for all times throughout the day were similar between the dates and did not differ between species or broom snakeweed populations. For weekly measurements, there was no population by time of day interaction on any date; however, photosynthetic rates were greatest in the morning regardless of population. Snakeweed photosynthetic rates for all populations were greatest in April and May and then decreased in the summer and fall.

FITNESS OF A SPECIALIST LEAFHOPPER FEEDING ON NEW MEXICO SALTCEDARS.

Peixin Sun and David C. Thompson, Graduate Research Assistant and Associate Professor, New Mexico State University, Las Cruces, NM 88003.

Abstract. *Tamarix* (saltcedar) is one of four genera of *Tamaricaceae,* represented by 90 species worldwide. In the southwestern United States saltcedar has become widely naturalized, occupying large acreages in many riparian areas and associated drainages, and completely replacing the native vegetation along many western rivers and lakes. Presently, it is considered the worst weed of southwestern riparian areas. Cultural, mechanical, and chemical controls are used in attempts to manage saltcedar. Exotic biological control agents from China and the Middle East have been found, tested, and will be released after final USFWS approval. The influence genetic diversity in NM saltcedar will have on the fitness of new biological control agents is unknown.

The object of this study is to determine whether different saltcedar accessions influence the fitness of a naturalized leafhopper (*Opsius stoctogalus*) that is monophagous on saltcedar. The experiment was set up as a randomized complete block design. Saltcedar stems were collected from six sites in New Mexico, cloned and grown in the greenhouse. Five replicates containing identical clones were established. Two nylon mesh cages were tied on each plant. Ten male and ten female adults were put into each cage. The experiment was repeated five times with a new starting date about every 7 days, each of these was considered a block. After 42 days, the population of leafhoppers in each cage was counted and compared between different accessions.

The leafhopper population was significantly influenced by date, which is not very surprising due to variable weather conditions. The population was also significantly influenced by different accessions. Populations on the plants from Rio Grande, Bosque, Artesia and Silver City were significantly larger than those on the stems collected from Dam and Athel. The interaction of date and accessions was not significant.

THE INTERACTION OF PICLORAM AND CLOPYRALID WITH *SPHENOPTERA JUGOSLAVICA* ON DIFFUSE KNAPWEED POPULATION DYNAMICS. Robert Wilson[1], K. George Beck[1], Philip Westra[1], and Mary Halstvedt[2], Graduate Student, Associate Professor, Professor, and Senior Research Biologist, [1]Department of Bioagricultural Science and Pest Management, Colorado State University, Fort Collins, CO 80523 and [2]Dow AgroSciences LLC, 3311 Horton Smith Lane, Billings, MT 59106.

Abstract. The root beetle (*Sphenoptera jugoslavica*) negatively influences diffuse knapweed populations, but inconsistently in space and time. A 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. The experiment is being conducted at two sites in Colorado where the root beetle is already established. The experimental design is a two (herbicides) by two (application timings) by four (herbicide rates) factorial arranged as a randomized complete block with four replications. Each plot is 30 by 30 feet with nine permanently marked quadrats located within each plot. Picloram and clopyralid were applied separately on plots at 0, 0.5, 1, and 2 oz/A. Herbicides were applied the third week of June and the end of September. Non-destructive samples were collected in the permanent quadrats to determine herbicide effects on growth of diffuse knapweed. These data included cover, density, and life cycle transitions of diffuse knapweed. Ten diffuse knapweed plants per treatment were harvested in the fall to determine seed production, germination, and viability. In the spring of 1999, additional plants will be harvested to determine the number of plants damaged by the *Sphenoptera*, and number of plants bearing *Sphenoptera* larvae. At one of the sites, the high rate of picloram and clopyralid applied in the spring decreased total diffuse knapweed density by over 50%, and reduced rosette densities by over 70%. The experiment will be repeated at two additional sites in 1999.

THE INFLUENCE OF VARIOUS CONTROL METHODS ON DIFFUSE KNAPWEED ON COLORADO RANGELAND. James R. Sebastian and K. G. Beck, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523 and Mary Halstvedt, Dow AgroSciences, Billings, MT 59106.

INTRODUCTION

Diffuse knapweed is an invasive, biennial, or occasionally an annual or semelparous perennial. It reproduces and spreads from seed. Diffuse knapweed grows in numerous environmental settings in Colorado where it displaces native plants and other desirable vegetation. Diffuse knapweed is very troublesome in pastures and non-crop situations along the Front Range. Environmental disturbance and degradation promote its invasion. Control and eradication of diffuse knapweed with cultural or chemical means has been studied for years, however, only recently have integrated approaches to diffuse knapweed management been studied.

OBJECTIVES

The objective of this study was to evaluate mechanical and chemical methods, invoked singly or in combination, to control diffuse knapweed. Handpulling and mowing have been used as chemical alternatives to control diffuse knapweed, but few data are available to document their effectiveness. More information is needed concerning the combination of mechanical and chemical strategies to control diffuse knapweed in pastures and non-crop areas.

MATERIALS AND METHODS

The experiment was designed as a split block. Treatments (main plots) were applied to control diffuse knapweed and they were applied for 1 year (1997), or 2 years (1997 plus 1998) split plots. Treatments were replicated 4 times. Permanent transects were established such that diffuse knapweed density and cover, and collective grass cover were determined in 5 by 0.1 m^2 quadrats per plot.

Handpull. The first diffuse knapweed handpull was conducted at the bolting growth stage and all plants were pulled. The second handpull was done four weeks later. Diffuse knapweed foliage and the top 0 to 1 inch of root were removed. Roots tended to break off near the soil surface, leaving most of the root system intact.

Mowing only. A lawn mower was used to mow diffuse knapweed three times per year. The first mowing operation took place when diffuse knapweed shoots were bolting. This was followed by two successive mowings, each invoked at 4-week intervals. The mower cut all vegetation to a 3 inch height.

Mowing plus herbicide. Two mowing operations were made as described above followed by herbicides applied in fall. Diffuse knapweed mowed plants were green and growing at fall application while non-mowed plants were senescent.

Herbicide only. All herbicide treatments were applied with a CO_2 pressurized backpack sprayer using 11003LP flat fan nozzles at 21 gpa and 14 psi. Herbicide-only treatments were applied in spring when diffuse knapweed was in the rosette to early bolt growth stage.

RESULTS

The table reflects data gathered in fall of 1998. These data represent results from 1 year of treatment and two seasons of treatments; however, data from plots assigned to receive mowing plus herbicides for 2 consecutive years were collected in fall 1998 before herbicides were applied.

Handpull. Diffuse knapweed cover did not decrease or grass cover increase in 1998 after diffuse knapweed was handpulled. After 2 years of handpulling, diffuse knapweed density nearly doubled compared to nontreated controls. This increase may have been caused by excessive disturbance and/or decreased canopy cover, which stimulated recruitment from the soil seed reserve.

Mowing only. Mowing nearly doubled the density of diffuse knapweed. Control was not achieved by mowing diffuse knapweed and grass cover did not increase because of this treatment.

Mowing plus herbicide. Mowing plus picloram outperformed mowing plus clopyralid on diffuse knapweed rosettes. Although both treatments controlled 100% of bolted diffuse knapweed, mowing plus clopyralid controlled about 50% fewer rosettes than mowing plus picloram. Mowing plus picloram decreased diffuse knapweed density to 0 whether done for 1 or 2 years. Grass cover increased 1.5-times compared to control plots with both treatments.

Herbicide only. Picloram applied alone controlled 74 to 100% of diffuse knapweed and increased grass cover 1.5-times. Most diffuse knapweed plants initially killed by dicamba plus 2,4-D or clopyralid treatments were replaced by diffuse knapweed seedlings after the initial treatments were applied in spring 1997. This is reflected in 0 to 8% control of diffuse knapweed rosettes and 89 to 94% control of bolted plants. Grass cover increased approximately 1.5-times where picloram or clopyralid were applied and from 1.2 to 1.5-times where dicamba plus 2,4-D was used.

DISCUSSION

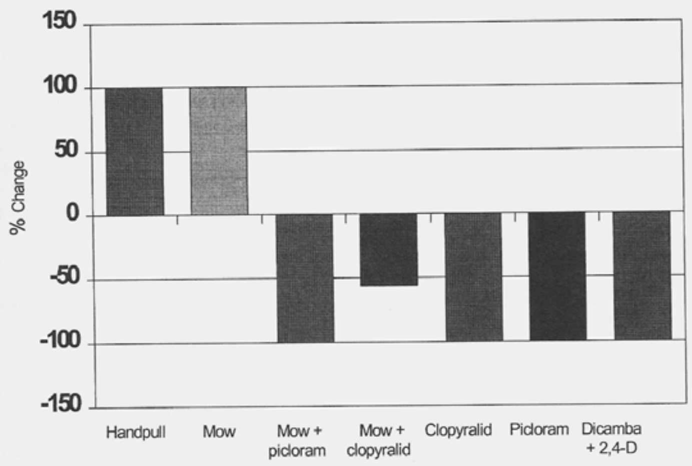
Handpulling or mowing were labor intensive, failed to control diffuse knapweed, and increased its density. First year treated plots with picloram (3 oz/A) plus mowing or picloram (4 oz/A) alone controlled diffuse knapweed similarly. All herbicide treatments controlled diffuse knapweed sufficiently to stimulate increased perennial grass cover. Long term diffuse knapweed control may require several years of these inputs to exhaust the soil seed reserve and obtain satisfactory results.

Table.

		Diffuse knapweed[a]							
		Rosette control		Bolted control		Cover		Grass cover[a]	
Treatment	Rate	Yr 1	Yr 2	Yr 1	Yr 2	Yr 1	Yr 2	Yr 1	Yr 2
	oz/A	%							
Handpull	2 times	0c A	0c A	0d B	93b A	61a A	54a A	53de A	55cd A
Mowing	3 times	0c A	0c A	0d A	0c A	66a A	62a A	48e A	51cd A
Mowing+picloram[b]	2 times + 3	84a A	90a A	100a A	100a A	1d A	3bc A	77a A	67b A
Mowing+clopyralid[b]	2 times + 3	43b A	55b A	100a A	100a A	22c B	11bc A	65bc A	60bc A
Clopyralid	4	8c B	84a A	94bc B	100a A	45b B	1bc A	72ab A	80a A
Picloram	4	74a B	100a A	96b A	100a A	3d A	0c A	77a A	83a A
Dicamba+2,4-D	8 + 16	0c A	100a A	89c B	100a A	58a B	0c A	61bcd B	80a A
Control		0c A	0c A	0d A	0c A	61a A	58a A	49e A	48d A

[a] Use lower case letters to compare means within a column and upper case letter to compare means within a row. Only compare means between adjacent columns under a data type heading (eg. 1 and 2 years of treatment under density). Means followed by the same letter are not different (LSD P< 0.05).

[b] Herbicides had not been applied to 2 year treatments at this evaluation date.



Percent Change in Diffuse Knapweed Density After Two Years of Treatment[a]

[a] Data were collected immediately before the 2nd year of fall applied herbicides were sprayed

WEED FREE WINTER WHEAT AND ROTATIONAL CROP RESPONSE TO MON 37500. Robert E. Baumgartner and Stephen D. Miller, Graduate Assistant and Professor, Department of Plant Science, University of Wyoming, Laramie, WY 82071.

Abstract. MON 37500, is an experimental grass herbicide being developed for grass control in both winter and spring wheat. Trials were established in the fall of 1997 at two Wyoming locations. The first trial established under dryland conditions at the Research and Extension Center, Archer, was designed to evaluate weed free wheat response to MON 37500 the first year and carryover, to rotational crops in subsequent seasons. The second trial established under sprinkler irrigation at the Research and Extension Center, Torrington, was designed to evaluate tolerance of corn, IR-corn, soybeans, STS soybeans, and millet when spring planted into killed wheat residue that had been fall treated with MON 37500. The plots were 18 by 50 ft and were replicated four to six times depending on location. MON 37500 had no effect on weed-free wheat yield, tillers, kernels/spike or protein. The sulfonyl]urea tolerant varieties of corn and soybean exhibited less injury from MON 37500 carryover 6 months following application than the standard varieties especially at the higher rates. Millet showed no injury to MON 37500 at any rate.

PRIMISULFURON EFFECTS ON ROTATIONAL CROPS. Paul E. Hendrickson[1], Devish Singh[2], Daniel A. Ball[2], and Carol A. Mallory-Smith[1], Faculty Research Assistant, Faculty Research Assistant, Associate Professor, and Assistant Professor, [1]Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331-3002 and [2]Columbia Basin Agricultural Research Center, Oregon State University, Pendleton, OR 97801.

Abstract. Primisulfuron is registered in the Pacific Northwest for use in Kentucky bluegrass. Primisulfuron is a sulfonylurea herbicide that is particularly effective on downy brome. Since sulfonylurea herbicides often have soil residuals that can injure subsequent rotational crops, studies were established to determine which crops might be injured after use of primisulfuron. Primisulfuron was applied at 40, 80 and a split application of 20/20 g/ha to either seedling or established Kentucky bluegrass.

Primisulfuron was applied to seedling Kentucky bluegrass at the Central Oregon Agricultural Research Center near Madras, OR. Kentucky bluegrass was planted in 1996, Trial 1, and in 1997, Trial 2 (Table). The soil was a Madras sandy loam with a pH of 6.8 and an organic matter content of 1.4%. During the winter of 1996-1997, Trial 1 was flooded with 4 inches of water for about 2 months. The seedling Kentucky bluegrass was sprayed with glyphosate in early spring to simulate the loss of the seedling Kentucky bluegrass stand. The trials were replanted in the spring of 1997 (Trial 1) and 1998 (Trial 2) to alfalfa, canola, spring wheat, and sugarbeets. In Trial 1, above ground biomass was reduced by an average of 7, 25, 33, and 75% for alfalfa, spring wheat, canola, and sugarbeets, respectively. In Trial 2, above ground biomass was reduced by an average of 70% or greater for all crops planted.

In a second set of studies, primisulfuron was applied to established grass seed crops in the Lower Umatilla Basin and Grande Ronde Valley of OR, and the Columbia Basin of WA in 1996. The established grass seed crops were harvested and replanted to sweet corn, onions, potatoes, winter wheat, peppermint, or sugarbeets during the next growing season. Carry-over effects of primisulfuron were detected on potato, winter wheat, and sugarbeets.

Table. Application data for primisulfuron carryover effects on spring planted crops..

	Application time		
	Seedling Kentucky bluegrass		
Primisulfuron rate	Trial[a] 1	Trial[a] 2	Established Kentucky bluegrass
g/ha			
40	Nov. 1, 1996	Nov. 5, 1997	Oct. 8, 1996
80	Nov. 1, 1996	Nov. 5, 1997	Oct. 8, 1996
20/20	Nov. 1, 1996/Mar. 27, 1997	Nov. 5, 1997/Apr. 8, 1998	Oct. 8, 1996/Nov. 11, 1996

[a]Trial 1 1998, Trial 2 1998.

SENSITIVITY OF ROTATION CROPS TO CLOMAZONE AND SULFENTRAZONE RESIDUALS AT TWO OREGON LOCATIONS. Matthew D. Schuster, Bill D. Brewster, Paul E. Hendrickson and Carol A. Mallory-Smith, Graduate Student, Senior Instructor, Faculty Research Assistant, and Assistant Professor, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331-3002.

Abstract. Clomazone and sulfentrazone may be labeled for use on peppermint in Oregon therefore, their residual effects on possible rotation crops were assessed. In 1997, two field trials were established, one in central Oregon at the Madras Experiment Station, and one in the Willamette Valley at the Hyslop Research Farm at Corvallis. The soil at Madras was a Madras sandy loam with a pH of 6.1 and an organic matter content of 1.6%. The soil at Corvallis was a Woodburn silt loam with a pH of 5.4 and an organic matter content of 2.6%. Both trials were sprinkler irrigated. On February 15 in Corvallis, and on March 10 in Madras, clomazone and sulfentrazone were applied to the plots at the anticipated label rate, and at twice that amount: 0.5 and 1 lb/A and 0.375 and 0.75 lb/A, respectively. Crop biomass as a percentage of untreated checks was used to quantify injury for each trial

Alfalfa, canola, tall fescue, Colonial bentgrass, perennial ryegrass, red clover, field corn, Kentucky bluegrass, orchardgrass, sugarbeets, table beets and spring wheat were planted at Corvallis on May 15 and harvested on June 25. All crops except canola, bentgrass, and sugarbeets were injured by clomazone. The trial area was reseeded with alfalfa, barley, canola, crimson clover, red clover, perennial ryegrass, sugarbeets, and spring wheat on August 27 and harvested on October 7. Only sugarbeets exhibited severe sulfentrazone injury. Spring wheat was injured with both rates of clomazone. Spring barley, crimson clover, red clover, perennial ryegrass, sugarbeets, and spring wheat, were planted on May 15, 1998 and harvested on June 30. Alfalfa, barley, canola, red clover, Kentucky bluegrass, perennial ryegrass, sugarbeets, and spring wheat were planted on August 22, and harvested on September 29. For both periods, injury was similar to that observed the second planting of 1997.

Crops planted on June 10, 1997, in Madras were: spring wheat, sugarbeets, alfalfa, canola, red clover, field corn, Kentucky bluegrass, and orchardgrass. The plots were harvested on July 2. Severe injury was prevalent. Although fairly tolerant to clomazone, sugarbeets were eliminated by sulfentrazone. Alfalfa, canola, and sugarbeets were planted August 25. Severe sugarbeet injury from the sulfentrazone residuals was still evident at the October 9 sampling. Alfalfa, was planted on June 10, 1998 and canola, sweet corn, sugarbeets, and spring wheat were planted on June 12. Again, sugarbeet injury in the sulfentrazone plots was severe. Biomass sampling was conducted on July 27. On August 20, 1998 the same crops were planted as were in the June 1997 plantings, with the exception that barley was seeded instead of orchardgrass. Biomass was sampled on October 1. In addition to sugarbeet injury from the sulfentrazone, injury from clomazone occurred at the high rate in spring wheat, and at both rates in Kentucky bluegrass.

Injury tended to be higher at Madras than at Corvallis. Because injury is still occurring, the trials will be continued until the most sensitive crops can be grown without detriment.

WILD PROSO MILLET CONTROL IN TRANSGENIC CORN. 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.

INTRODUCTION

Wild proso millet (*Panicum miliaceum* L., PANMI), a weedy biotype of the annual grass proso millet that has invaded many fields in corn producing areas across North America, is highly competitive with row crops such as corn and soybeans and can devastate crop yields if left unchecked. In recent years, it has invaded many states of the Intermountain northwestern United States including Utah and control strategies have proven difficult to develop. Genetically engineered herbicide resistant corn hybrids have recently been developed and provide a promising alternative to currently used chemical control options for wild proso millet control in corn.

Wild proso millet is tolerant to many conventional herbicides used in corn and there is currently no satisfactory method of control for this pernicious weed in corn. It is a prolific seed producer with as many as 1.35 billion seeds/ha recovered from soil samples (Harvey et al., 1990). Many crops compete well with wild proso millet and others have satisfactory chemical control options. However, seeds remain dormant in the seed bank for several years indicating crop rotation is not a satisfactory method of control (Luellen, 1982). Several herbicides have recently become available that provide varying levels of early season control, but the weed continues to germinate throughout the season and the available herbicides cannot provide season long control (Harvey et al., 1990). Also, some have toxicity and environmental limitations that would make another management system more desirable.

The properties of some broad spectrum herbicides make them particularly desirable for wild proso millet management in field corn. Glufosinate and glyphosate are postemergence, broad spectrum herbicides that have very low toxicity to mammals, no soil residual activity and low potential of moving to ground water giving them a high degree of environmental safety (Duke, 1990). Glyphosate is also readily translocated throughout the plant, providing increased control of perennial weeds. There is no reported crop injury from the application of these herbicides in transgenic varieties providing an increased margin of safety compared to some soil applied herbicides that often can lower crop yields. Also, an increased window of application, allowing application from the time of emergence up to a 24 inch crop height. These properties make glufosinate more desirable than many if not all of the presently used herbicides to control wild proso millet in corn.

Corn varieties resistant to glufosinate and glyphosate were genetically engineered by insertion of genes conferring resistance. Resistant varieties escape the action of glufosinate by producing an enzyme that metabolizes glufosinate, while other varieties escape the action of glyphosate by an altered site of action insensitive to glyphosate (Duke, 1990). Such varieties are currently available and are being implemented in many weed control programs by growers.

The objectives of this study are to evaluate wild proso millet control with currently registered herbicides and with glufosinate and glyphosate in transgenic corn, to compare treatment effects on corn yield and cost effectiveness, and to determine optimum application timing of glufosinate for effective wild proso millet control.

MATERIALS AND METHODS

In 1998, corn was planted at two sites with previous histories of wild proso millet infestations. At site 1, conventional hybrid Dekalb 626 was planted May 10, 1998 and glyphosate resistant hybrid Dekalb 363RR was planted at site 2 on May 25. Corn was planted in 30 inch rows at both sites. The treatments shown in the table were applied to the two sites for the control of wild proso millet and broadleaf weeds. Crop height at site 1 and 2 at time of application was 12 inches and 8 inches, respectively. Treatments were applied at both sites on June 25. The experiment was a randomized complete block design with three replications. Individual plots measured 30 feet by 4 rows. Control and injury were evaluated on July 17 and yield at site 2 was determined on August 29 (Table). All data were subjected to analysis of variance and Fisher's LSD (α=0.05) was determined.

Field experiments in 1999 will be conducted in grower's fields in two locations with previous histories of wild proso millet infestations. Plots will be planted to a glufosinate resistant corn variety and then divided and treated with EPTC, isoxaflutole, nicosulfuron, metolachlor, alachlor, rimsulfuron plus thifensulfuron, nicosulfuron plus thifensulfuron plus atrazine, and acetochlor at the maximum recommended label rates. In addition, glufosinate will be applied at the maximum label rate at three stages of crop growth: 6 inches, 12 inches and 18 inches. A randomized block design will be used with all treatments replicated four times. Wild proso millet control was evaluated at 2 weeks, 4 weeks, and 8 weeks, and yield data will be collected after which statistical analysis will take place. Given significant differences, economic yield of each herbicide treatment will be determined and compared.

Trials will also be conducted under greenhouse conditions in 1999. A glufosinate resistant corn variety will be planted along with wild proso millet in flats of soil. Glufosinate will be applied at the full recommended rate and at half the rate at three stages of crop growth, 3 inches, 6 inches and 12 inches. Acetochlor will be used as a conventional control comparison. A randomized block design replicated three times will be used. Control data and yield data will be subjected to statistical analysis.

RESULTS AND DISCUSSION

In 1998, no crop injury was evident at either location. Glyphosate, sulphosate, nicosulfuron, nicosulfuron plus dicamba, and nicosulfuron plus rimsulfuron plus atrazine provided favorable early season control of wild proso millet (Table). All treatments but Mon 12000, Mon 12000 plus Mon 13900, and nicosulfuron were effective control for common lambsquarters. Control of redroot pigweed was good to excellent with all treatments except Mon 12000 plus Mon 13900 at site 1. Yield was not significantly different at site 2 and was not measured at site 1.

Unfortunately, control data in 1998 was collected once at three weeks after treatment, so possible differences in late season control are not apparent. Although this study shows no data to substantiate the claim, past research shows that late season control has been inadequate and/or sporadic for most herbicides tested for the control of wild proso millet (Harvey, 1990).

CONCLUSION

Although broad spectrum herbicides such as glyphosate and glufosinate may not be a panacea for the control of wild proso millet in corn, they are a promising alternative to currently available herbicides. They lack residual control for a weed which continues to germinate throughout the season, replenishing the seed bank and providing competitive pressure to the crop. However, this is a problem reported with all other herbicides used for its control (Shenk, et al., 1990). These are, of course, generalizations. In 1999, we will get a better idea of how glufosinate will perform as a management tool, how it will compare to other herbicidal strategies and how economic factors may influence its use as opposed to other herbicides.

Weed control is not the only factor to consider in choosing an herbicide program, however. Economic factors and environmental concerns should be taken into account in choosing management programs. Often, consumer acceptance of transgenic crops can be a concern. In our particular study silage corn is grown to be fed to the growers own dairy cattle, this isn't such a concern, but in many cases it is because the use of transgenic crops is hotly debated throughout North America and Europe.

Table. Wild proso millet control in Dekalb 626 (site 1) and transgenic Dekalb 363RR (site 2), 1998.

		Site 1		Site 2		
		Corn injury	Wild proso millet control	Corn injury	Corn yield	Wild proso millet control
Treatment	Rate	July	July	July	Sept.	July
	oz/A	%			T/A	%
Glyphosate	16			0	22	87
Glyphosate	8			0	22.4	97
Glyphosate[a]	16			0	21.1	99
Sulfosate[b]	24			0	22.4	90
Sulfosate[b]	12			0	21	87
Sulfosate[a,b]	24			0	18.9	95
Ammonium sulfate	64			0	19.3	3
Mon 12000[c]	1	0	3	0	21.7	3
Mon 12000 +mon 13900[c]	0.077+0.23	0	8	0	21.6	17
Nicosulfuron[d,e]	1	0	78	0	21.1	83
Nicosulfuron +dicamba	1+8	0	75	0	18.3	78
Nicosulfuron +rimsulfuron +atrazine[c,e]	0.19+0.19+12	0	68	0	17.7	90
Atrazine[f]	16	0	0	0	19.5	25
Check		0	0	0	16.4	0
LSD (0.05)			12.8		7.42	25.7

[a] Ammonium sulphate added at 4 lb/A.
[b] Non-ionic surfactant added at 0.75 oz/gal.
[c] Non-ionic surfactant added at 0.5% v/v.
[d] Crop oil added at 1% v/v.
[e] Ammonium sulphate added at 3 lb/A.
[f] Crop oil added at 1qt/A.

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EFFICACY OF GLUFOSINATE AMMONIUM IN GLUFOSINATE TOLERANT CORN. Monte D. Anderson, Senior Field Development Representative, AgrEvo USA Company, Gretna, NE 68028.

Abstract. Glufosinate ammonium was registered in 1997 for selective use in corn containing a gene for glufosinate tolerance. Five year results on crop tolerance, weed control, and crop yields were summarized. Superior crop tolerance was obtained using glufosinate ammonium versus conventional corn herbicides in GA tolerant corn. Overall efficacy on annual weed species was similar to traditional preemergent and postemergent herbicides. Yields of glufosinate treatments on GA tolerant corn were equal to or better than standard corn herbicides.

GLYPHOSATE EFFICACY ON IVYLEAF MORNINGGLORY IN GLYPHOSATE TOLERANT CORN AND SOYBEAN. M. W. Marshall, K. Al-Khatib, and L. Maddux, Research Assistant and Assistant Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506; and Professor, Kansas River Valley Experiment Station, Kansas State University, Rossville, KS 66533.

INTRODUCTION

Development of transgenic crops, such as glyphosate-resistant corn and soybeans, allows widespread use of the nonselective herbicide glyphosate. However, in the past, repeated use of a single mode of action herbicide has resulted in weed species shifts. Species that are marginally controlled, such as ivyleaf morningglory, could emerge as a problem weed because of its higher level of tolerance to glyphosate.

MATERIALS AND METHODS

Experimental Layout. Field experiments were conducted at near Manhattan and Rossville in northeastern Kansas. Field design consisted of a randomized complete block design with six 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 over-seeded with ivyleaf morningglory and density counts were taken every 4 weeks using a 0.48 m^2 quadrant.

Corn. Dekalb DK 580RR corn was planted in Manhattan and in Rossville. Herbicide treatments applied: 1) atrazine plus metolachlor (1.68 kg/ha) at 0 days after planting (DAP) followed by atrazine plus bromoxynil (0.84 kg/ha) 24 DAP; 2) glyphosate (1.12 kg/ha) at 30 DAP; 3) glyphosate (1.12 kg/ha) 30 DAP followed by glyphosate (0.84 kg/ha) 45 DAP; 4) atrazine plus metolachlor (1.68 kg/ha) at 0 DAP followed by interrow cultivation 30 DAP at a depth of 10 cm; 5) glyphosate (0.84 kg/ha) at 24 DAP followed by interrow cultivation 30 DAP at a depth of 10 cm; and 6) atrazine plus metolachlor (1.68 kg/ha) at 0 DAP followed by glyphosate (1.12 kg/ha) 30 DAP. Treatments other than glyphosate are commercially formulated tank-mixes.

Soybean. Dekalb CX367cRR soybean was planted in Manhattan and Rossville. Herbicide treatments applied: 1) metribuzin plus metolachlor (2.24 kg/ha) at 0 DAP followed by bentazon plus acifluorfen plus COC (1.03 kg/ha)

30 DAP; 2) glyphosate (1.12 kg/ha) at 30 DAP; 3) glyphosate (1.12 kg/ha) at 30 DAP followed by glyphosate (0.84 kg/ha) 45 DAP; 4) metribuzin plus metolachlor (2.24 kg/ha) at 0 DAP followed by interrow cultivation 40 DAP at a depth of 10 cm; 5) glyphosate (0.84 kg/ha) at 30 DAP followed by interrow cultivation 40 DAP at a depth of 10 cm; 6) metribuzin plus metolachlor (2.24 kg/ha) at 0 DAP followed by glyphosate (1.12 kg/ha) 30 DAP. Treatments other than glyphosate are commercially formulated tank-mixes.

RESULTS AND DISCUSSION

In general, atrazine plus metolachlor in corn and metribuzin plus metolachlor in soybean showed the greatest suppression of ivyleaf morningglory (Figure 1 and 2). Metribuzin plus metolachlor and single application of glyphosate in Rossville soybean plots (Figure 4) showed 0 yield which resulted from poor ivyleaf morningglory control during the 1998 growing season (Figure 2). Soybean yields were not different between treatments except for the one time application of glyphosate indicating that adding another glyphosate application improves ivyleaf morningglory suppression and crop yield (Figure 4). Ivyleaf morningglory populations were highest among the single applications of glyphosate (Figure 1 and 2). Cultivation reduced interrow ivyleaf morningglory populations, but failed to control ivyleaf morningglory within the crop row (Figure 4). Split application of glyphosate gave the highest yield in corn and soybean compared to one time application of glyphosate (Figure 3 and 4), indicating a dose response in ivyleaf morningglory.

CONCLUSIONS

Preemergent treatments (atrazine plus metolachlor in corn and metribuzin plus metolachlor in soybean) combined with standard postemergent treatments performed equally or better than glyphosate treatments alone. Using a preemergent program with glyphosate improved early season control of ivyleaf morningglory populations. Ivyleaf morningglory populations were controlled more by two applications of glyphosate than a single application. Interrow cultivation failed to control ivyleaf morningglory within the row making mechanical harvest difficult. Failure to control ivyleaf morningglory in the early season resulted in complete crop coverage and total yield loss.

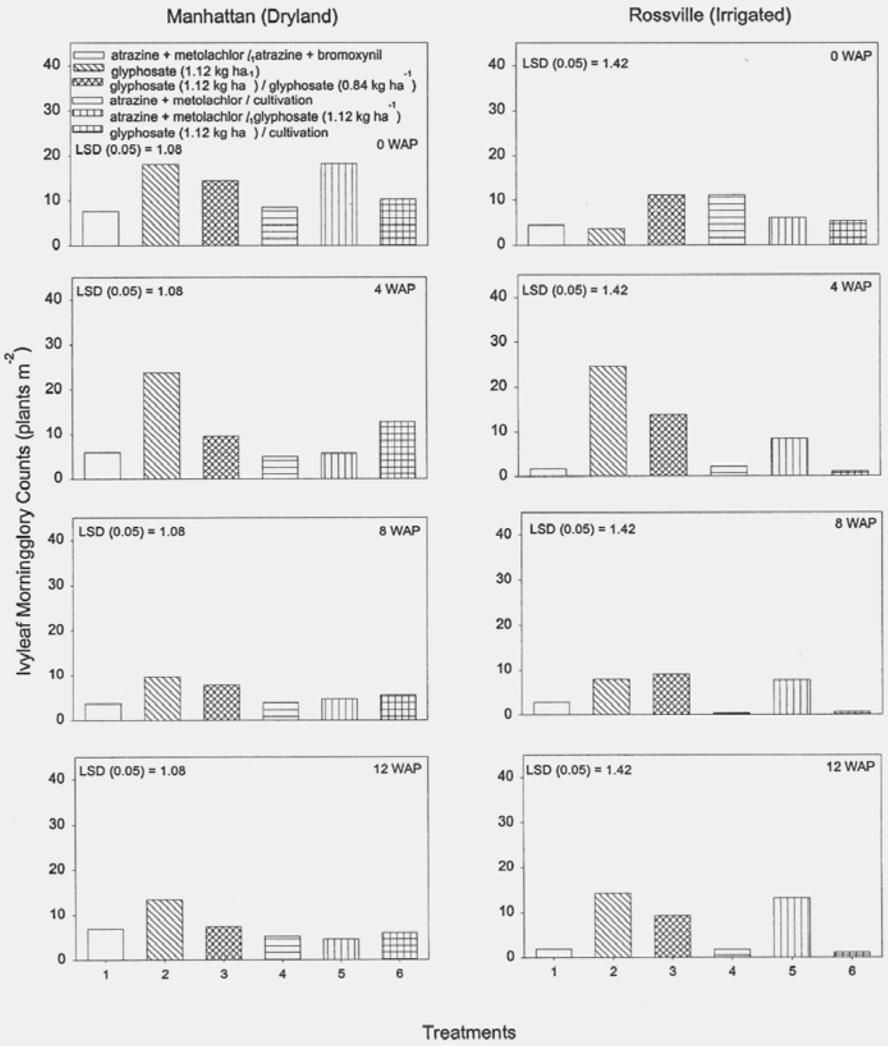

Figure 1. Ivyleaf morningglory control in corn as affected by herbicide.

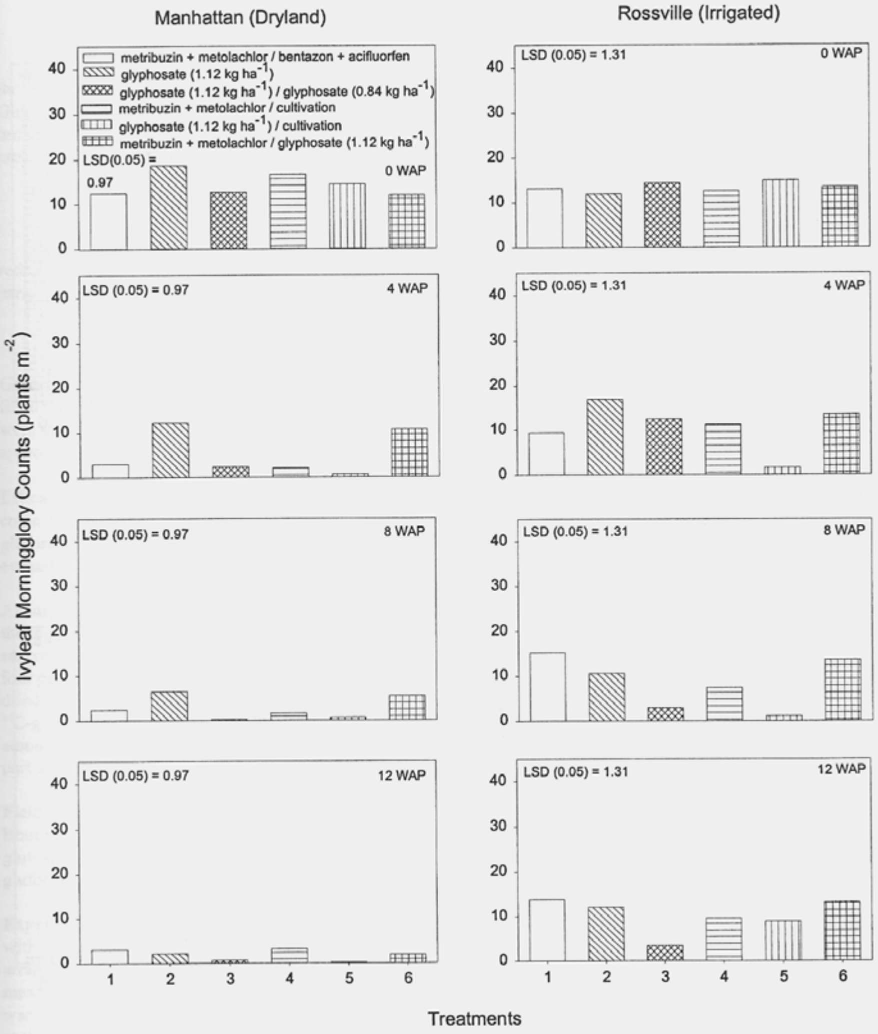

Figure 2. Ivyleaf morningglory control in soybean as affected by herbicide.

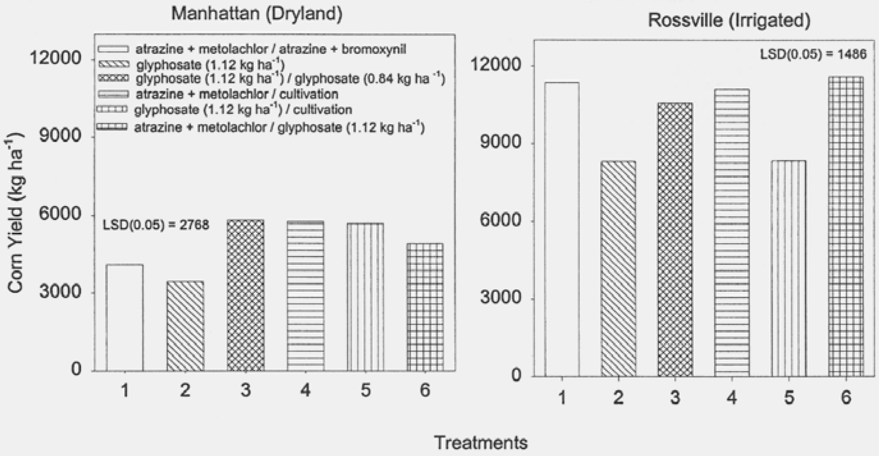

Figure 3. Corn yield as affected by herbicide.

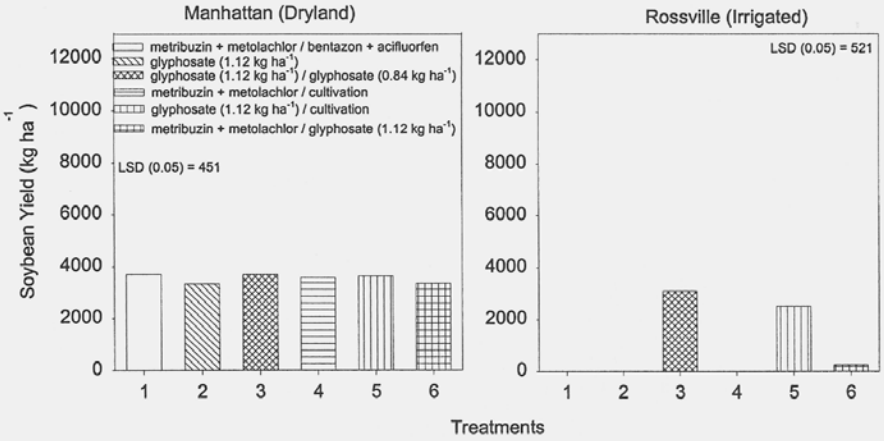

Figure 4. Soybean yield as affected by herbicide.

GLUFOSINATE EFFICACY, ABSORPTION AND TRANSLOCATION IN PIGWEED SPECIES (*AMARANTHUS* SPP.) AS AFFECTED BY TEMPERATURE. Elmé Coetzer, Kassim Al-Khatib, Dallas E. Peterson, and Monte D. Anderson, Graduate Student, Associate Professor, and Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506; Field Development Representative, AgrEvo, Gretna, NE 68028.

INTRODUCTION

Palmer amaranth, redroot pigweed and common waterhemp are important weeds in the Midwest. Resistance in these pigweed species to acetolactate synthase (ALS)-inhibiting herbicides is becoming more common. Glufosinate-ammonium is a glutamine synthetase inhibitor that is nonselective and controls a broad spectrum of broadleaf weeds. The use of glufosinate might be an alternative to control these species when glufosinate resistant crops systems are adapted.

OBJECTIVES

Study the effect of temperature on glufosinate efficacy, absorption and translocation on Palmer amaranth, redroot pigweed and common waterhemp. Evaluate the effect of single and sequential applications in soybeans at early, normal and late planting dates.

MATERIALS AND METHODS

Growth conditions. Plants were grown for both growth chamber studies at 16/21, 21/26 and 26/31 C in containers filled with a 1:1 (v/v) mixture of sand and Morril loam. A 16 h photoperiod and light intensity of 550 $\mu mol^{-2} s^{-1}$ were maintained for each of the three temperature regimes. Average relative humidity was maintained at approximately 50%.

Efficacy Study. Glufosinate was applied at 0, 205, 410 and 820 g $ha^{-1}$when Palmer amaranth, redroot pigweed or common waterhemp were at the 9-leaf stage. Photosynthesis was measured on the fifth leaf 1, 3 and 7 days after glufosinate application. Two weeks after treatment chlorophyll content was determined and weed control was evaluated on a percent basis with 0 = no herbicide effects and 100 = visible plant death.

Absorption and Translocation Study. Treatments were applied at the 6-leaf stage. ^{14}C-glufosinate was applied to the third oldest leaf as eight, 1 µl drops (84 Bq μl^{-1}). Treated leaves were harvested 6, 24 and 96 h after treatment and rinsed in 10 ml double distilled water for 30 s to remove unabsorbed ^{14}C-glufosinate. Plants were sectioned into four parts: material above treated leaves, treated leaves, material below treated leaves and roots. Plant parts were air dried, combusted and quantified by liquid scintillation spectrometry to determine the translocation patterns of ^{14}C-glufosinate. 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.

Field study. Asgrow 2704 glufosinate resistant soybeans and the three pigweed species were planted at Ashland Bottoms near Manhattan, KS on May 5, May 24, and June 16, 1998. Treatments consisted of single applications of glufosinate at 410 g ha^{-1} at 2 to 5, 6 to 9, and 13 to 16 cm pigweed height, as well as sequential applications of glufosinate at 410 or 293 g ha^{-1}at 2 to 5 cm and then again 2 weeks later. A weedy control was also included..

Experimental Design and Data Analysis. The experimental design for the growth chamber study was a split plot with temperature as the main plot and treatment as the subplot. The absorption and translocation study was also arranged as a randomized split plot design with temperature as whole plot but with harvest time as subplot. The measurements on the different plant parts were treated as repeated measures. 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. All treatments were replicated four times and the studies were repeated twice. The experimental design for the field trial was a strip plot with planting date as main plot, pigweed species and treatment as subplots. Treatments were replicated four times.

RESULTS AND DISCUSSION

Efficacy Study. Photosynthesis was rapidly inhibited one day after treatment (data not shown). Herbicide treatment decrease the chlorophyll content two weeks after treatment, but there were no differences among the species (Figure 1). No differences in control of Palmer amaranth at the three temperature regimes were observed. The same is true for redroot pigweed, except for the high application rate at 21/26 C where control was lower (60%). Control of common waterhemp was greater at the 16/21 and the 26/31 C regimes (Figure 2).

Absorption and Translocation Study. Absorption takes place mainly in the first six hours after treatment (96%). No differences were observed among the three species at the different sampling dates (Figure 3). Most of the herbicide remained in the treated leaf, but translocation to the other parts was evident 24 and 96 hours after treatment. Translocation of absorbed glufosinate increased from 8 to 16% as time increased from 6 to 96 hours after treatment. The herbicide was evenly distributed between the above and below sections. (Figure 4).

Field Study. Control was similar between Palmer amaranth and redroot pigweed 21 days after treatment (DAT). Pigweed control 28 days after treatment was higher than 70 and 80% with the 293 and 410 g ha^{-1} sequential applications, respectively (Table 1). However, soybean yield was similar in the two sequential applications (Table 2).

CONCLUSIONS

No differences in control were observed among the three species at the different temperature regimes. Glufosinate absorption takes place mainly in the first six hours after treatment. Complete coverage is extremely important for good control, because most of the herbicide stays in the treated areas. Two applications, of which one is early in the growing season, gave the best control.

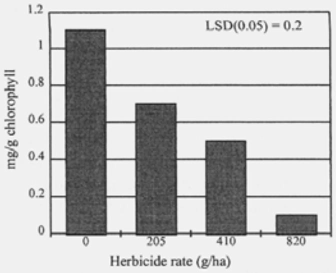

Figure 1. Chlorophyll content of Palmer amaranth, redroot pigweed and common waterhemp as affected by different glufosinate rates.

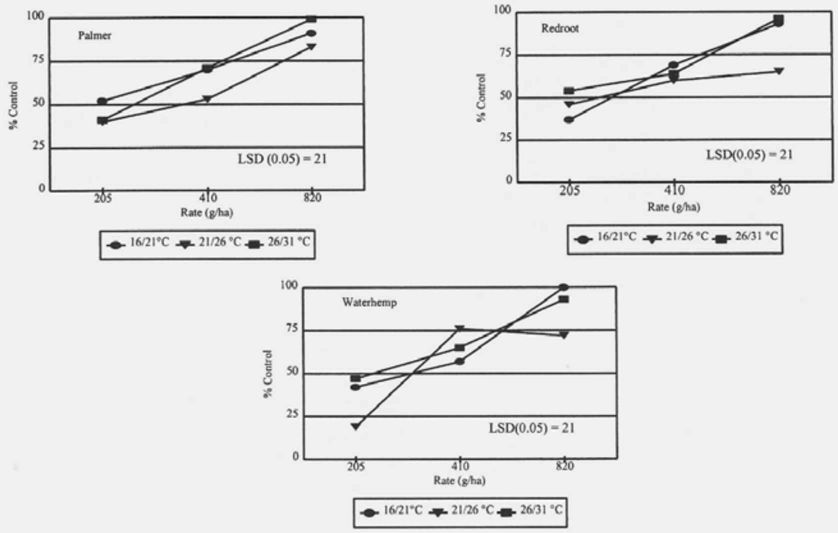

Figure 2. Palmer amaranth, redroot pigweed and common waterhemp control as affected by different glufosinate rates.

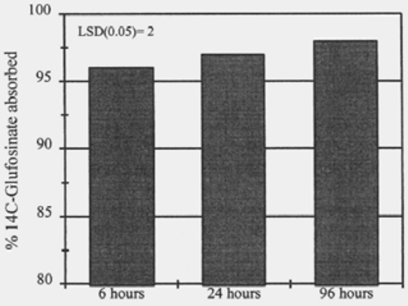

Figure 3. ^{14}C-glufosinate absorption in Palmer amaranth, redroot pigweed and common waterhemp (averaged across species and temperature).

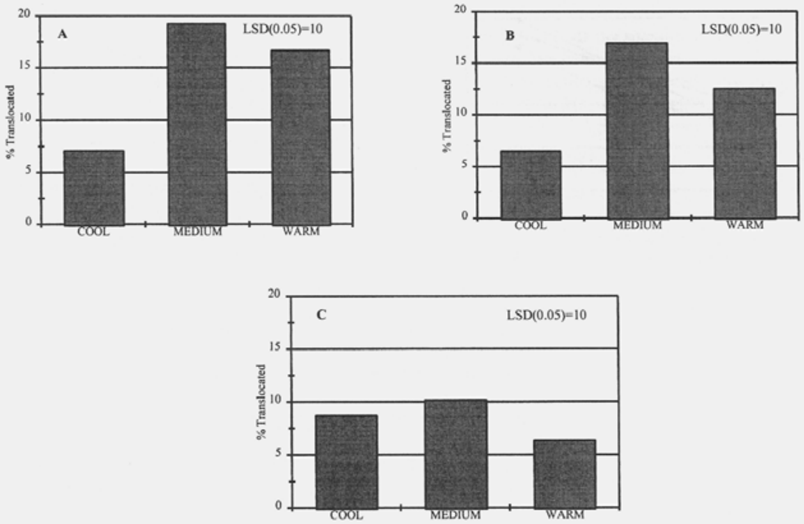

Figure 4. Percent translocation of ^{14}C-glufosinate out of the treated leaf for A) Palmer amaranth, B) redroot pigweed and C) common waterhemp (across sampling dates) at three temperature regimes cool=16/21 C, medium=21/26 C, and warm=26/31 C.

Table 1. Palmer amaranth, redroot pigweed and common waterhemp control as affected by glufosinate (averaged across planting dates).

Glufosinate rates	Pigweed height	Palmer	Redroot	Waterhemp
$g\ ha^{-1}$	cm		% control	
410	2 to 5	60	55	82
410	6 to 9	57	56	80
410	13 to 16	68	67	83
410	2 to 5/2 wk later[a]	83	83	89
293	2 to 5/2 wk later[a]	74	72	87
LSD (0.05)		7	7	7

[a] Two applications.

Table 2. Soybean yield for 1998 (averaged across pigweed species).

Glufosinate rates	Pigweed height	Planting date		
		Early	Normal	Late
g ha^{-1}	cm		kg ha^{-1}	
410	2 to 5	1672	1972	911
410	6 to 9	1020	1592	1079
410	13 to 16	821	1499	1069
410	2 to 5/2 wk later[a]	2181	2350	1379
293	2 to 5/2 wk later[a]	1936	2142	962
Control		620	1337	539
LSD (0.05)		376	376	376

[a] Two applications.

YIELD POTENTIAL AND RESPONSE OF GLYPHOSATE-RESISTANT SOYBEAN VARIETIES TO IMIDAZOLINONE HERBICIDES. John M. Hofer, Dallas E. Peterson, W. Barney Gordon, Scott A. Staggenborg, Dale L. Fjell, and Kassim Al-Khatib, Graduate Research Assistant, Professor, Associate Professor, Assistant Professor, Professor, and Associate Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506.

Abstract. Field studies were conducted in 1998 at Ashland Bottoms, Manhattan, and Belleville, Kansas to evaluate the yield potential of glyphosate-resistant soybean varieties and their response to imidazolinone herbicides. Ten conventional and 10 glyphosate-resistant, Group 3 soybean varieties were compared based on seed company recommendations for north central Kansas. All soybean varieties were treated with a preemergence application of pendimethalin at 1110 g/ha followed by a postemergence application of imazethapyr at 71g/ha at Ashland Bottoms and Belleville or a preemergence application of pendimethalin followed by a postemergence application of imazamox at 44g/ha at Manhattan. Glyphosate-resistant soybean varieties also received a postemergence and sequential application of glyphosate at 1120 g/ha at all sites.

Soybean response to pendimethalin followed by postemergence applications of imazethapyr or imazamox was similar for conventional and glyphosate-resistant soybeans. Yields of glyphosate-resistant soybean varieties were similar when a preemergence pendimethalin and postemergence application of imazethapyr or imazamox was compared to a postemergence and sequential application of glyphosate. Yields among glyphosate-resistant and conventional soybean varieties varied by location. Soybean yields were higher at Ashland Bottoms than at Manhattan or Belleville. Glyphosate-resistant soybean varieties had lower yields than conventional varieties at Ashland Bottoms and Belleville. Yields of glyphosate-resistant and conventional soybean varieties were generally the same within seed companies at Manhattan. Conventional and glyphosate-resistant varieties from Asgrow, and conventional varieties from Pioneer were among the top yielding soybeans at all sites.

TALL MORNINGGLORY CONTROL IN ROUNDUP READY COTTON. Michael Ronquillo, Cheryl Fiore, and Jill Schroeder, Undergraduate Student, Research Assistant, and Associate Professor, Department of Entomology, Plant Pathology, and Weed Science, New Mexico State University, Las Cruces, NM 88003.

Abstract. Tall morningglory is one of the most difficult weeds to control in cotton production in southern New Mexico. Glyphosate resistant cotton varieties offer additional management strategies for this weed. The objective of this research was to evaluate postemergence (POST) applications of glyphosate or glyphosate plus pyrithiobac for the

control of tall morningglory and other broadleaf weeds in cotton 'Deltapine 5690RR'. The postemergence programs for weed control were compared to soil-applied herbicides followed by glyphosate alone or in combination with other herbicides applied postemergence. Cotton was planted on May 1, 1998 in rows spaced 40 inches apart. The experiment was established with a randomized complete block design and four replications. Twenty-eight treatments were evaluated including a weedy control and a hand-weeded control. POST treatments were applied to cotton that was 6 inches tall, and late POST treatments were applied to 10-inch-tall cotton. Visual evaluations of weed control by species were made on a scale of 0 (no control) to 100 (complete control). Yields were obtained by hand-picking the open bolls from plants in 15 feet of row per plot. Control of tall morningglory, Palmer amaranth, and oakleaf thornapple was greater the 90% in the treatments including early POST, POST directed, and late POST directed applications of glyphosate or an early POST and POST directed application of glyphosate plus pyrithiobac. Lint plus seed yield for these treatments were comparable to the yield of the hand-weeded control, which was 1741 lb/A. Yield of the weedy control averaged 82 lb/A.

WEED CONTROL AND CROP TOLERANCE IN IMIDAZOLINONE-RESISTANT CANOLA WITH IMIDAZOLINONE AND SULFONYLUREA HERBICIDES. Traci A. Rauch, Curtis Rainbolt, and Donald C. Thill, Support Scientist, Graduate Research Assistant, and Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83844-2339.

Abstract. Imidazolinone-resistant canola currently is grown in Canada and soon will be available in the United States with imazamox as the labeled herbicide. In the Pacific Northwest, imidazolinone-resistant canola will be grown in rotation with cereal crops and spring legumes. Sulfonylurea herbicides are used widely in cereals to control weeds and imazethapyr, an imidazolinone soil-applied herbicide, is used in legumes to control broadleaf weeds. Sometimes sulfonylurea herbicides can drift onto canola and severely injure the crop. Imazethapyr and some sulfonylurea herbicides can persist in the soil from one growing season to the next and adversely affect growth of a subsequent canola crop. Canola cultivars resistant to imidazolinone and sulfonylurea herbicides would not be injured following exposure to these herbicides allowing for greater rotational crop flexibility. Three studies were established in 1998 at the University of Idaho Plant Science Farm near Moscow, Idaho to evaluate weed control and crop safety in imidazolinone-resistant canola with imazamox, cross resistance of imidazolinone-resistant canola to the sulfonylurea herbicides nicosulfuron, thifensulfuron, and thifensulfuron/tribenuron, and differential tolerance of imidazolinone-resistant canola and non-resistant 'Legend' canola to low rates of imazethapyr. The first two studies were randomized complete blocks with four replications. Imazamox was applied at five rates when the imidazolinone-resistant canola had 2- to 4-leaves. Imazamox (0.027 to 0.090 kg/ha) did not injure the imidazolinone-resistant canola and controlled redroot pigweed, wild oat, interrupted windgrass, and volunteer wheat 93% or greater. Nicosulfuron, thifensulfuron plus quizalofop, and thifensulfuron/tribenuron plus quizalofop were applied at three rates when the imidazolinone-resistant canola had 2- to 3-leaves. Thifensulfuron/tribenuron plus quizalofop at 0.018 + 0.06 kg/ha and 0.026 + 0.06 kg/ha stunted the imidazolinone-resistant canola 3% at 16 DAT, but showed no signs of injury by 27 DAT. Yield of all plots treated with sulfonylurea herbicides did not differ from the untreated check. The third study was a strip plot. Main plots were two canola varieties, non-resistant 'Legend' canola and imidazolinone-resistant canola, and subplots were five rates of imazethapyr applied preplant incorporated. The interaction (herbicide treatment by canola variety) and the main effects (herbicide treatment and canola variety) were not significant for canola stand counts and yield, but all factors were significant for stand reduction (percent of the untreated check). Stand reduction was greater in 'Legend' canola than imidazolinone-resistant canola (15 vs. 0%) and generally increased with increasing imazethapyr rate in 'Legend' canola. Canola seed yield was abnormally low and lack of differences among treatments likely was affected by adverse growing conditions.

QUACKGRASS CONTROL IN WHEAT WITH SULFOSULFURON. Curtis R. Rainbolt, Suzanne M. Sanders, and Donald C. Thill, Graduate Research Assistants and Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83844.

Abstract. Quackgrass control in wheat is difficult, in part, because there are no selective herbicides for its control. Field studies were conducted in 1997 and 1998 in winter and spring wheat, respectively, near Potlatch and Bonners Ferry, ID to evaluate quackgrass control in wheat with sulfosulfuron. The 1997 experiments were designed as a randomized complete block factorial. Treatments consisted of sulfosulfuron applied at two times (3 to 5 and 6 to 8 quackgrass leaf stages) at rates of 4, 9, 18, 26, 36, and 72 g/ha and an untreated control. In 1998, the experiments were designed as a split-plot factorial with the 1997 herbicide treatments as main plots. Subplots were one half of each main plot and received the same treatment that was applied in 1997. Quackgrass control was not affected by application time at either location in 1997 or 1998. In 1997, sulfosulfuron applied at 26 g/ha or greater visibly controlled quackgrass 72 to 94%. Average visible control of quackgrass was 99% in plots retreated in 1998 and 73% in plots that were treated only in 1997 when compared to the untreated control. Quackgrass biomass was 86% less in plots sprayed both years compared to plots sprayed only in 1997. Quackgrass biomass was 92% less in plots sprayed both years with sulfosulfuron at 9 g/ha or greater than in the untreated plots. All herbicide retreated plots produced more spring wheat grain than the untreated control at Bonners Ferry, while grain yield varied greatly among treatments at Potlatch.

MON 37500 EFFICACY AS AFFECTED BY RATE, ADJUVANTS, AND CARRIERS. Brian L. S. Olson, Kassim Al-Khatib, Phillip W. Stahlman, Scott K. Parrish, and Paul J. Isakson, Graduate Research Assistant and Associate Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66502; Professor, Kansas State University Agriculture Research Center-Hays, Hays, KS 67601; Manager, Pacific Northwest Agronomy Center, Monsanto Co., Spokane, WA 99208; and Product Technical Specialist, Monsanto Co., Englewood, CO 80155.

INTRODUCTION

Winter annual grasses such as downy brome (*Bromus tectorum*) BROTE, jointed goatgrass (*Aegilops cylindrica*) AEGCY, and cheat (*Bromus secalinus*) BROSE are difficult to control in wheat (*Triticum aestivium*) fields. Downy brome and jointed goatgrass may reduce wheat yields by 56 and 27%, respectively. However, MON 37500, a sulfonylurea herbicide, has shown great promise in controlling and suppressing these weed species. Maximizing the control or suppressing characteristics of MON 37500 in field situations while not causing injury to different wheat varieties in various environments is important to farmers.

OBJECTIVES

Evaluate the effect that different application rates, spray adjuvants, and spray carriers have on the control of downy brome, jointed goatgrass, and cheat, and possible injury to wheat by MON 37500.

MATERIALS AND METHODS

Two hard red winter wheat varieties, Jagger and KSU 2137, were planted into 3 by 7.6 m plots at Manhattan and Hays, KS in October of 1997. Downy brome, jointed goatgrass, and cheat were planted in 2.5 m strips across the plots. Herbicide POST treatments were applied on November 18 and 21, 1997 in Hays and Manhattan, respectively when the weeds were at the 2 to 4-leaf stage. The herbicide spray mixture used are in Table 1 and 2. The foliar liquid 28% N is listed as UAN. All treatments were applied at 140 L/ha using a backpack sprayer equipped with XR8002 nozzles. Visual injury ratings were determined every 4 to 6 weeks with weeds counts (plants/0.1m^2) being taken in the early spring. At harvest, wheat height and yield were determined. The experimental design was a split-strip block with wheat variety as the main plot and herbicide as the split block with weed species as the strip block.

RESULTS

MON 37500 at 46 g/ha with either surfactant had the best weed control and wheat yield at Hays (Table 1). MON 37500 at 46 g/ha without surfactant provided adequate weed control and yield, but the 24 g/ha rate had decreased weed control and yield at Hays (Table 1). MON 37500 at 24 g/ha with either surfactant and UAN provided early season injury, 31 to 38%, to wheat which may have decreased yields at Hays (Table 1). There was no difference in yield between MON 37500 at 46 g/ha with or without surfactant; however, the treatments with surfactant provided greater weed control at Manhattan (Table 2). MON 37500 at 24 g/ha in UAN with AG-98 caused the greatest early season injury to wheat, but this injury did not reduce yield at Manhattan (Table 2).

CONCLUSIONS

Downy brome and cheat are more susceptible to MON 37500 application than jointed goatgrass. A spray mixture of MON 37500 in water with an adjuvant provided the most effective control of downy brome. MON 37500 treatment combinations with UAN as a carrier or water as a carrier with a surfactant provided adequate control of cheat. There was no difference in wheat injury due to variety. There was no visible injury to wheat at harvest or decline in yield due to MON 37500 application at Manhattan; however, early season injury of wheat at Hays when MON 37500 was applied with UAN may or may not have decreased yield.

Table 1. Herbicide spray mixtures, visual ratings, and yield as affected by MON 37500 at Hays, KS.

				Wheat injury	Control May 20, 1998			
Treatment	Rate	Adjuvant[a]	Carrier	Nov. 1997	BROTE	AEGCY	BROSE	Wheat yields
	g/ha			%				kg/ha
MON 37500	46	none	water	0	79	10	97	5440
MON 37500	24	none	water	1	50	8	88	4770
MON 37500	46	Sun-It II	water	2	96	13	98	5470
MON 37500	24	Sun-It II	water	1	83	9	97	5270
MON 37500	46	none	1:1 water/UAN	6	82	12	99	5260
MON 37500	24	none	1:1 water/UAN	3	63	9	95	5010
MON 37500	46	AG-98	water	3	93	11	97	5590
MON 37500	24	AG-98	water	0	69	11	97	5170
MON 37500	46	none	UAN	15	78	12	93	5050
MON 37500	24	none	UAN	12	63	11	94	4820
MON 37500	24	Sun-It II	UAN	31	93	10	98	5100
MON 37500	24	AG-98	UAN	38	89	12	96	5090
Chlorsulfuron	23	Sun-It II	water	1	16	4	18	4960
Weedy check	0	none	water	0	0	0	0	4330
LSD (0.05)				2.5	5	2	3	290

[a] Sun-It II and AG-98 were applied at 1.4 and 0.5% v/v.

Table 2. Herbicide spray mixtures, visual ratings, and wheat yield as affected by MON 37500 in Manhattan, KS.

Treatment	Rate	Adjuvant[a]	Carrier	Wheat injury Nov. 1997	Control May 20, 1998			
					BROTE	AEGCY	BROSE	Wheat yields
	g/ha			%	%	%		kg/ha
MON 37500	46	none	water	0	84	11	97	5280
MON 37500	24	none	water	1	64	9	93	5090
MON 37500	46	Sun-It II	water	0	94	13	98	5120
MON 37500	24	Sun-It II	water	1	92	10	97	5190
MON 37500	46	none	1:1 water/UAN	0	84	11	99	5020
MON 37500	24	none	1:1 water/UAN	0	63	9	99	5130
MON 37500	46	AG-98	water	3	95	10	98	5140
MON 37500	24	AG-98	water	4	94	14	97	5180
MON 37500	46	none	UAN	1	88	13	99	4990
MON 37500	24	none	UAN	1	62	11	93	4970
MON 37500	24	Sun-It II	UAN	9	91	14	99	5000
MON 37500	24	AG-98	UAN	21	91	14	97	5030
Chlorsulfuron	23	AG-98	water	3	9	8	24	4650
Weedy check	0	none	water	0	0	0	0	4710
LSD (0.05)				2.5	5	3	4	291

[a] Sun-It II and AG-98 were applied at 1.4 and 0.5% v/v.

TRALKOXYDIM DOSE AND WILD OAT DENSITY EFFECTS ON WILD OAT SEED PRODUCTION IN SPRING BARLEY.

David S. Belles and Donald C. Thill, Graduate Research Assistant and Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83344-2339.

Abstract. High wild oat control costs have caused some barley growers to use reduced rates of herbicides; the consequences are not understood. Two field studies were conducted near Moscow and Genesee, ID to determine the effect of wild oat density and tralkoxydim dose on wild oat seed production in barley. Tralkoxydim was applied at 0.025, 0.05, 0.1, 0.15, and 0.2 kg/ha to five wild oat densities (3, 41, 61, 141, and 156 plants/m^2) and (3, 43, 61, 111, and 114 plants/m^2) Moscow and Genesee, respectively. An untreated control also was included. Wild oat control, barley and wild oat biomass, wild oat panicle and seed numbers, and barley yield were determined. Barley was not injured. The number of wild oat seeds, averaged over wild oat density, was 3674/m^2 in the control and 4140, 35, 1, 3, and 0 seeds/m^2 in Moscow, 3345/m^2 in the control and 1684,1053, 195, 36, and 32 seeds/m^2 in Genesee for the 0.025, 0.05, 0.1, 0.15, and 0.2 kg/ha tralkoxydim rates, respectively. The wild oat seed number averaged 138, 3464, 4794, 5518, 4460 and 6, 2640, 4940, 4114, and 5028 in control plots for low to high densities in Moscow and Genesee, respectively. Wild oat densities usually did not affect yield at any density when sprayed with tralkoxydim at 0.1 kg/ha or greater. Unsprayed wild oat densities equal to or greater than 61 plants/m^2 reduced barley yield in Genesee. All densities reduced barley yield at Moscow. In two greenhouse experiments designed and conducted similarly to those in the field, wild oat seed production was similar to Moscow in the first experiment and Genesee in the second experiment.

DEFINING OPTIMUM HERBICIDE RATE AND TIMING FOR WILD OAT CONTROL IN SPRING WHEAT.

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Abstract. Field trials were conducted at Scott and Saskatoon, SK from 1994 through 1997 to determine the optimum rate and timing for five post-emergent herbicides used to control wild oat in spring wheat. The herbicides tested were clodinafop-propargyl, fenoxaprop-P, flamprop, imazamethabenz and tralkoxydim. Herbicides were applied at the recommended label rate, 0.67X or 0.33X the recommended rate at the 2-, 4- or 6-leaf stages of wild oat. Wild oat infestation was moderate to heavy at Saskatoon and light to moderate at Scott.

The highest level of wild oat control was achieved with clodinafop-propargyl applications at all stages and rates at both locations. At Saskatoon, wild oat control with fenoxaprop-p was intermediate to that provided by clodinafop-propargyl and the other graminicides at all stages and rates. Wheat seed yield was highest with clodinafop-propargyl applications at all stages. A clear distinction was not evident between the influence of the other graminicides, relative to that of clodinafop-propargyl, on crop yield at both locations. Except in the case of imazamethabenz, wild oat biomass and wheat seed yield decreased or were unaffected as herbicide application was delayed. Delayed application of imazamethabenz increased wild oat biomass and resulted in the largest decreases in wheat seed yield. These time of application effects on seed yield resulted in similar declines in net economic returns.

At Saskatoon, where wild oat pressure was relatively high, wild oat biomass increased and wheat yield declined rapidly as herbicide rate was reduced. At Scott, where wild oat populations were relatively light, wild oat biomass increased marginally and wheat seed yield was decreased slightly or unaffected when herbicide rates were reduced. Treatment at the label or 0.67X label rates were necessary to maximize net economic returns, although this trend was most apparent with the relatively heavy wild oat infestations at Saskatoon.

USE OF REMOTE SENSING TO EXPLORE HARD RED WINTER WHEAT COMPETITIVE CHARACTERISTICS.

Amanda E. Stone[1], Thomas F. Peeper[1], Eugene G. Krenzer[1], John B. Solie[2], and Marvin L. Stone[2], Graduate Research Assistant and Professors, [1]Department of Plant and Soil Science and [2]Department of Biosystems and Agricultural Engineering, Oklahoma State University, Stillwater, OK 74078.

Abstract. Since no herbicide is currently available for selective jointed goatgrass control in continuous winter wheat, growers must rely on cultural practices to suppress jointed goatgrass. Recent research has revealed substantial differences in the ability of various popular wheat cultivars to compete with jointed goatgrass. Currently used indices of cultivar characteristics are not clearly linked to cultivar competitiveness. Thus, we are exploring the potential of remote sensing to monitor wheat growth over the winter growing season to identify growth characteristics related to a particular cultivar's ability to compete. This will be accomplished with the use of a field portable dual channel spectrometer measuring canopy reflectance over the range of 250 to 1200 nm. A digital camera will be used to record cultivar appearance. Reflectance measurements and digital images will be recorded weekly for selected wheat cultivars and jointed goatgrass. These measurements will be related to changes in ground cover, changes in greenness of the foliar canopy and changes in live biomass through the winter.

WEEDS OF RANGE AND FOREST

TOLERANCES OF VARIOUS PERENNIAL GRASSES TO METSULFURON, CHLORSULFURON, SULFOMETURON, PICLORAM, AND CLOPYRALID.

Tom D. Whitson and Kristi K. Rose, Professor and Research Associate, Department of Plant Sciences, University of Wyoming, Laramie, WY 82071-3354.

Abstract. The establishment of perennial grasses in areas infested with noxious weeds is an important part of a sustainable weed management system. Two experiments were established in 1996 and 1997 to determine the tolerances of various perennial grasses to various herbicides. Experiment one, was seeded to eight perennial grasses following spray applications of the following treatments: metsulfuron at 0.3, 0.6, and 1.2 oz/A, chlorsulfuron at 0.5, 0.75 and 1.5 oz/A, sulfometuron at 0.75 and 1.5 oz/A and the combination of clopyralid plus 2,4-D(A) at 0.19 + 1 lb/A. Each of the nine herbicide treatments were applied 120, 90, 30, and 0 days before grasses were seeded on August 15, 1997. Experiment two was seeded to eight perennial grasses following spray application with the following treatments: picloram at 0.13, 0.25, and 0.5 lb/A and clopyralid at 0.13 and 0.5 lb/A. Each of the five herbicide treatments were applied 64, 44, 24, and 0 days prior to seeding on July 10, 1997.

In experiment one grasses had injury levels that were unacceptable for all herbicide applications and rates for a period of at least 60 days following treatment. Species tolerance was greatest with green needlegrass and least with orchardgrass and western wheatgrass. Meadow bromegrass, sheep fescue, switchgrass and Russian wildrye were intermediate in herbicide tolerance. In experiment two injury levels on two species of 40% were found with applications of picloram at 0.25 and 0.5 lb/A applied less than 24 days before seeding. Luna pubescent wheatgrass and Nordan crested wheatgrass were the least tolerant species while meadow bromegrass, bluebunch wheatgrass, Russian wildrye, pubescent wheatgrass, western wheatgrass and thickspike wheatgrass had excellent tolerance after 24 days following application.

PREPLANT APPLICATIONS OF PICLORAM AND CLOPYRALID ON THREE RANGE GRASS SPECIES.

Vanelle Carrithers, Tom Whitson, Roger Sheley, Jay Gehrett, and Mary Halstvedt, Senior Research Biologist, Dow AgroSciences, Mulino, OR 97042; Professor, University of Wyoming, Laramie, WY 82070; Professor, Montana State University, Bozeman, MT 59717; SprayTech, Walla Walla, WA 99362; and Senior Research Biologist, Dow AgroSciences, Billings, MT 59106.

Abstract. Three locations were established during 1997 in Washington, Wyoming, and Montana to determine the effect of preplant applications of picloram and clopyralid on range grass establishment.. Herbicides were applied at intervals prior to planting three range grass species: 'Goldar' or 'Secar' bluebunch wheatgrass, 'Nordan' crested wheatgrass, and 'Luna' pubescent wheatgrass. Preplant application intervals were: 0, 24, and 44 days in Montana and Wyoming; 7, 32, and 52 days in Washington; and an additional time of 62 days in Wyoming. Picloram was applied at 0.125, 0.25, and 0.5 lb/A and clopyralid was applied at 0.125 and 0.5 lb/A. Applications were made with CO_2 backpacks at 15 to 20 gpa. First year data were visual assessments of grass vigor or establishment. Second year data included measurements of dry weight (biomass) averaged from two subsamples taken from 0.25 or 0.5 m^2 quadrates within each plot.

Across all grass species, only picloram at 0.5 lb/A applied 0 to 7 days prior to planting caused visual differences in the establishment of grass species. Clopyralid rate or time of application had no significant effect on the establishment of any grass species. The most significant factor in grass establishment was grass variety.

Biomass data in the second season after planting showed no differences between treatment rates and time of application across all grass species. The most significant difference in yield was associated with grass variety rather than with herbicide treatment or timing effects. Yield from lowest to highest was: Goldar or Secar bluebunch wheatgrass; Nordan crested wheatgrass; and Luna pubescent wheatgrass. The visual effect of 0.5 lb/A picloram

from the first year did not did not translate into an effect on biomass in the second year, though there did seem to be a trend toward reduction in yield with applications closer to planting.

The most significant factor in establishment of seeded grasses was grass variety. The most significant factors for second year biomass were grass variety and location.

THE COMPETITIVE EFFECTS OF FIVE COOL-SEASON GRASSES ON DALMATIAN TOADFLAX (*LINARIA GENISTIFOLIA* SSP. *DALMATICA*).

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INTRODUCTION

Dalmatian toadflax (*Linaria genistifolia* spp. *dalmatica*) is a noxious weed that is still grown as an ornamental in some places (Lajeunesse et al. 1993, Robocker 1974). This plant is a member of the Scrophulariaceae family and a native of the Mediterranean region (Robocker 1974, Whitson 1996). Dalmatian toadflax is distributed throughout the western and northeastern United States and western Canada. Dalmatian toadflax is very competitive and decreases desirable forage species (Lajeunesse et al. 1993).

The roots of Dalmatian toadflax grow as deep as 1.8 m with lateral roots extending up to 3 m away from the parent plant. Vegetative buds that form on lateral roots produce new plants. The woody stems grow 30 to 91 cm tall (Lajeunesse et al. 1993). The toadflax leaves are broad, heart-shaped, and have smooth margins and a waxy texture (Lajeunesse et al. 1993, Robocker 1974). The leaves are alternate and crowded on the stem with a whitish or bluish cast to the green color. Flowers are bright yellow with an orange "throat" and a long spur. Flowering occurs in midsummer to early fall. One toadflax plant can produce up to 0.5 million seeds. The seeds are tiny (1.6 mm in diameter) and angular with irregular wings (Lajeunesse et al. 1993). Seeds remain viable for up to ten years in the soil (Robocker 1974). Dalmatian toadflax is not considered poisonous, but this may be because it is not palatable and livestock poisoning reports are rare (Butler and Burrill 1994).

Seedling establishment is a crucial part in the growth of Dalmatian toadflax (Lajuenesse et al. 1993, Robocker 1974). In order to become established seedlings need to be free from severe competition and have favorable moisture, light, and temperature (Robocker 1974). Once a toadflax plant is established it can produce seed and become very competitive in the first year of growth (Lajuenesse et al. 1993).

Rangeland in good condition will prevent the infestation of Dalmatian toadflax, whereas overgrazing will give toadflax the advantage. Small infestations of toadflax can be controlled by handpulling or by intensive cultivation for 2 years (Lajeunesse et al. 1993). Picloram applied in the fall immediately following a killing frost or chlorsulfuron applied in the spring or fall to actively growing plants will control toadflax (Whitson 1997). Reinvasion does occur so retreatment will be necessary (Lajeunesse et al. 1993). *Brachypterolus pulicarius*, a toadflax flower feeding beetle that reduces seed production and *Calophasia lunula*, a toadflax feeding moth that reduces root reserves and plant vigor are currently being distributed in the United States. There are several other biological control agents that are pending release (Rees et al. 1996).

Five grasses were seeded to determine their competitive ability with Dalmatian toadflax. Grasses were selected because of their ability to compete and to allow land managers an opportunity to select grasses to meet various goals. Each grass species has characteristics that make them suitable in different situations.

'Bozoisky' Russian wildrye is an introduced, cool-season bunchgrass used for pasture and range seeding. It is long-lived and grows best in areas with loam and clay soils. Russian wildrye is resistant to cold, drought, is winter hardy, and moderately salt tolerant. It begins growth early in the spring and will grow throughout the summer if there is adequate soil moisture. It provides excellent winter forage when cured because it is high in digestibility and protein (Asay and Horton).

'Critana' thickspike wheatgrass is a native cool-season grass. It has an extensive rhizomatous root system, forms a tight sod, and has excellent seedling vigor. Growth is best on medium to coarse textured soils but has established successfully in low fertility areas. Thickspike wheatgrass is often used in revegetation or erosion control (Anonymous, 1984).

'Hycrest' crested wheatgrass is an introduced, cool-season, long-lived, vigorous growing bunchgrass. It is extremely drought tolerant because of its deep root system. Crested wheatgrass performs well on many soil types, is very winter hardy, and moderately tolerant to salinity. It is often used in reclaiming abandoned cropland and is recommended for spring and early summer grazing because quality declines quickly in the summer (Asay and Horton).

'Luna' pubescent wheatgrass is an introduced, cool-season, sod forming grass that greens up early in the spring. It is long-lived, spreads by rhizomes, and easy to establish. Pubescent wheatgrass is closely related to intermediate wheatgrass, but is more drought tolerant and winter hardy. This grass grows on soil types ranging from sand to clay with tolerance for low fertility, drought, and alkaline soils. It is used for reclamation and erosion control. Pubescent wheatgrass provides dense cover for nesting birds (Anonymous 1989, Leyendecker 1964).

'Sodar' streambank wheatgrass is a native cool-season perennial grass. It is low growing, sod forming, and spreads rapidly producing good ground cover. Streambank wheatgrass is drought tolerant, alkali tolerant, has vigorous seedlings, and germinates quickly with very little rainfall. Livestock do not readily eat this grass and forage yields are generally low. Streambank wheatgrass can be used for a low maintenance lawn because of its ability to tolerate unfavorable conditions. It is also used for highway shoulders and is an effective barrier to weed invasion once established (Douglas and Ensign, 1954).

The objectives of this study were two fold; first to determine production differences of five cool-season perennial grasses and their effects on Dalmatian toadflax yields and second to determine competitive differences between spring and fall seeding dates.

MATERIALS AND METHODS

This study was conducted on the USDA ARS High Plains Grassland Research Station near Cheyenne, Wyoming. The dryland site had been previously disturbed and Dalmatian toadflax (*Linaria genistifolia* spp. *dalmatica* L.) had invaded the site. Soils were a sandy loam consisting of 63% sand, 18% silt and 19% clay with a 6.5 pH, and 3% organic matter. The precipitation ranges from 30.63 to 61.39 cm with a 22 year average of 45.36 cm (17.86 inches). The area was sprayed with picloram at 0.56 kg/ha on September 10, 1994. The study was arranged in a randomized complete block design with three replications. The study was rototilled then seeded on April 6, 1995 and August 15, 1995. Grasses seeded were Critana thickspike wheatgrass (*Elymus lanceolatus*), Bozoisky Russian wildrye (*Psathyrostachys juncea*), Hycrest crested wheatgrass (*Agropyron cristatum*), Luna pubescent wheatgrass (*Elytrigia intermedia*), and Sodar streambank wheatgrass (*Elymus lanceolatus*). All areas were seeded with 11.2 kg PLS/ha except Russian wildrye, which was seeded at 6.7 kg PLS/ha. Dry matter yields were determined by harvesting three 0.25 m^2 quadrats per plot on July 9, 1997 and July 6, 1998. Grass and Dalmatian toadflax were clipped to a height of 2 centimeters. Other plants in the plots were clipped and weighed but not reported because they were found in minor amounts. Samples were oven dried for 48 hours at 60 C then weighed. The dry weights were used to compare the yields of the seeded areas to the untreated control.

Analysis of variance (ANOVA) was conducted using SAS. Least significant differences (LSD) were determined to compare the treatment means. Comparisons for significance were made at the 0.05 level.

RESULTS AND DISCUSSION

In 1997, the April seedings to Hycrest crested wheatgrass, Luna pubescent wheatgrass, and Critana thickspike wheatgrass Dalmatian toadflax was reduced 91, 88, and 87%, respectively. Areas seeded to Luna pubescent wheatgrass produced the greatest biomass (3363 kg/ha). Areas established in the spring to crested wheatgrass, pubescent wheatgrass, and thickspike wheatgrass showed significant reductions of toadflax. In 1997, the August seeding did not establish as quickly as the April seeding (Table 1), and no statistical differences were found in the toadflax yields in the late summer seeding. Because of the completion of the life-cycle of toadflax plants between 1997 and 1998 the August seeded grasses had an opportunity to effectively establish and compete with Dalmatian toadflax In 1998 thickspike wheatgrass and crested wheatgrass, seeded in late summer, provided enough competition to reduce Dalmatian toadflax by 95 and 94%, respectively. The third year late summer seedings were all equal to or greater in competition than those established in spring. In 1998, August seedings became fully established and reduced the amount of toadflax by a greater amount than the April seedings (Table 2). All grasses in 1998, whether seeded in the spring or late summer, significantly reduced the amount of toadflax compared to the untreated control.

Each of the grasses has characteristics that make them desirable in different situations. Russian wildrye is better adapted to areas of higher moisture and is very palatable to livestock. Thickspike wheatgrass might be a good choice for an area of low fertility. Crested wheatgrass is adapted to areas of low moisture and can withstand drought. Pubescent wheatgrass is higher in palatability and would be good for grazing. Streambank wheatgrass is low growing, not very palatable, and would be better suited to roadsides or other areas where grazing and excessive growth is discouraged. Each area to be revegetated should be assessed to determine which grasses would be most suitable depending on soil types, moisture level, and use.

CONCLUSIONS

The use of grasses to control Dalmatian toadflax is a possible long-term method of control. Other methods of control will be needed to get grasses properly established. Chemical and cultural control is needed to help get the grasses established and eliminate competition from the site. Biological control will reduce the toadflax populations after the grasses are established. Proper grazing management will allow grasses to sustain growth year after year. An integrated system using a combination of these and other methods will be necessary for the best management of Dalmatian toadflax.

Table 1. The competitive effects of five cool-season grasses on Dalmation toadflax in 1997.

	April 6, 1995 seeding			August 15, 1995 seeding		
Perennial grass	Grass	Toadflax	Reduction	Grass	Toadflax	Reduction
	kg/ha		%	kg/ha		%
(Hycrest) crested wheatgrass	2954	308	91	1723	1906	42
(Luna) pubescent wheatgrass	3363	398	88	1668	2391	27
(Critana) thickspike wheatgrass	2513	417	87	1340	1231	63
(Bozoisky) Russian wildrye	2624	1355	58	878	2033	38
(Sodar) streambank wheatgrass	2084	1809	44	1062	3244	01
Unseeded control	380	3259	0	380	3259	0
LSD (0.05)	937	2459		914	3263	

Table 2. The competitive effects of five cool-season grasses on Dalmation toadflax in 1998.

Perennial grass	April 6, 1995 seeding			August 15, 1995 seeding		
	Grass	Toadflax	Reduction	Grass	Toadflax	Reduction
	kg/ha		%	kg/ha		%
(Hycrest) crested wheatgrass	1761	258	76	2392	65	94
(Luna) pubescent wheatgrass	2153	156	86	2393	139	87
(Critana) thickspike wheatgrass	1738	252	77	1665	58	95
(Bozoisky) Russian wildrye	2871	274	75	2013	258	76
(Sodar) streambank wheatgrass	1495	415	61	1761	161	85
Unseeded control	823	1077	0	823	1077	0
LSD (0.05)	1256	571		840	462	0

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PREDICTING PLANT COMMUNITY RESPONSE TO PICLORAM ALONG A SPOTTED KNAPWEED INVASION GRADIENT.

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Abstract. Successful weed management will require methods for predicting the response of plant communities to weed management tools such as herbicides, grazing, and biological control. Models were developed for predicting plant community composition after a picloram application based on the pretreatment community. Five transects were established at two sites on an Idaho fescue/bluebunch wheatgrass habitat type along a spotted knapweed gradient. Plots (4 m^2) were established along each transect at 5% intervals ranging from native communities with 0% cover of spotted knapweed to communities comprised of 100% cover of spotted knapweed. Picloram was applied to all transects at 0.28 kg/ha in the fall of 1996. Density, percent cover, and biomass of each species was determined in plots from randomly placed 0.10 m^2 frames before treatment and during the summer of 1998. A step-down regression procedure was used to identify the best models for predicting Idaho fescue and total perennial grass density, percent cover, and biomass. A combination of P-value, R^2, and model simplicity were used to select the best regression models. The model for predicting perennial grass biomass has an $R^2 = 0.32$ and has the form: $B_{pg} = 1.47 + 0.038(B_{skw}) - 0.0004(B^2_{skw}) + 0.273(B_f)$ were B_{pg}, B_{skw}, B^2_{skw}, and B_f are the biomass for perennial grass, spotted knapweed, spotted knapweed squared, and forbs, respectively. This model may be used by land managers in predicting perennial grass biomass resulting from a picloram application.

SPOTTED KNAPWEED MANAGEMENT WITH INTEGRATED METHODS. Melissa L.Brown[1], Celestine A. Duncan[1], and Mary B. Halstvedt[2], [1]Biologist, [1]Consultant, Weed Management Services, PO Box 9055, Helena, MT 59604 and [2]Senior Research Biologist, Dow AgroSciences, 311 Horton Smith Lane, Billings, MT 59106.

INTRODUCTION

Spotted knapweed is a long-lived perennial that infests millions of acres in the Pacific Northwest. The weed can be effectively controlled with several different herbicides, however political and environmental concerns preclude or limit herbicide applications on some sites. The objectives of this study were to determine the efficacy of various management techniques alone and combination on spotted knapweed control, to study the effect of various management techniques on the plant community, and to calculate the cost of integrating methods.

Study Sites. The study was conducted at two sites in Missoula County, west-central Montana. Both locations were characterized as upland range sites dominated by either bluebunch wheatgrass (*Agropyron spicatum*) or crested wheatgrass (*Agropyron spp.*)

Table 1. Site characteristics.

	Missoula Gun Club	Blue mountain
Elevation	3200 ft, 12 to 14 inches precipitation	3600 feet, 12 to 14 inches precipitation
Soil texture	Loam	Cobbley-loam
Dominant vegetation	Seeded with crested wheatgrass, Idaho fescue, Junegrass, Canada bluegrass, and miscellaneous forbs	Native range site, bluebunch wheatgrass. Rough & Idaho fescue, and miscellaneous forbs
Spotted knapweed cover	76%	53%

Experimental Design. Twelve, 20 by 30 foot treatment plots were arranged in a randomized complete block design and replicated three times at each site. Treatments include hand pulling, mowing, herbicides, and biological agents alone and in combination with each other (Table 2).

MATERIALS AND METHODS

Herbicides. Picloram and clopyralid plus 2,4-D were applied at various rates, timings and combinations with other management methods using a CO_2 pressure regulated backpack sprayer and a hand-held boom to broadcast herbicides uniformly over vegetation and soil surfaces in each experimental plot. Applications were made using 8002 flat fan nozzles at 16 gpa and 31 psi.

Hand Pulling. Plots were hand-pulled two times per year at 4-week intervals for two consecutive years. Knapweed foliage and the top 1 to 2 inch of root were removed at early and late bud stages to prevent flowering.

Herbicide Plus Hand Pulling. Plots receiving combined herbicide and hand pulling treatments were treated with picloram at a rate of 0.125 lb/A acre in June 1997, followed by pulling treatments in 1998. Herbicides were applied using methods described above.

Mowing. Mowing treatments were administered using a standard push-mower two times per year at the early and late bud stages for two consecutive years. The first mowing operation took place when knapweed plants were bolting, and was followed by successive mowing treatments, at 4-week intervals.

Mowing Plus Herbicides. Plots receiving combined herbicide and mowing treatments were mowed at the late bud stage and then treated with either picloram at 0.125 lb/A or clopyralid plus 2,4-D at 0.095 + 0.5 lb/A in September 1997. Herbicides were applied using methods described above.

Insects, Herbicide Plus Insects. To prevent insect migration between plots, 6.5 by 18-foot metal enclosures were erected in the center of each biological control plot at both sites. Thirty knapweed root weevils (*Cyphocleonus achates*) were released inside each enclosure. Plots receiving combined biological control and herbicide treatments were treated with picloram at 0.09 lb/A in June 1997, prior to root-weevil release in August 1997.

Sampling Methods. Post-treatment vegetation cover data for all treatments were collected in August 1997 and June and August 1998. Visual percent control evaluations of each treatment were made in August 1997 and 1998.

Point-frame cover data were collected from five evenly spaced locations along 16-foot transects through the center of biological control enclosures. In all other plots, post-treatment vegetation data were sampled from ten evenly spaced point-frame locations along transects running diagonal from the front-left to back-right corner. Point-frames were placed perpendicular to center over the transect line. Canopy cover was estimated for spotted knapweed, collective grass, litter, bare ground, and miscellaneous forbs.

Data Analysis. Percent cover and percent control data were analyzed using the LSD Means Comparison test at the p=0.05 level. Cost of each treatment per acre was calculated using an hourly wage for hand pulling, commercial mowing and chemical application rates, and local herbicide and biological agent prices.

RESULTS AND DISCUSSION

Table 2. Treatment rates, timing, percent spotted knapweed control and treatment costs.

Treatment	Rate[a]	Plant growth stage	Application date		Aug. 4, 1998 control		Cost/A[c]
			1997	1998	Flower[b]	Plant[b]	2 YRS
			Month/day	Month/day	%	%	$
Hand-pull (bolted plants)	2 X	Early & late bud	6/20	6/20			
			7/20	7/22	100a	56d	13,900.00
Picloram plus	0.125	Bolt	6/2	----			
Hand-pull (rosettes + mature)	1 X	Late bud	----	7/21	100a	98ab	97.90
Mowing	2 X	Early & late bud	6/20	6/19			
			7/20	7/17	99a	0f	200.00
Mowing plus	1 X	Late bud	7/20	----			
Picloram	0.125	Fall regrowth	9/29	----	100a	100a	75.37
Mowing plus	1 X	Late bud	7/16	----			
Clopyralid+2,4-D	0.095 + 0.5	Fall regrowth	9/29	----	100a	93b	77.67
Picloram	0.125	Fall regrowth	9/29	----	100a	96ab	25.37
Clopyralid+2,4-D	0.095 + 0.5	Fall regrowth	9/29	----	100a	79c	27.67
Picloram	0.25	Bolt	6/2	----	99a	98ab	30.75
Clopyralid+2,4-D	0.19 + 1	Bolt	6/2	----	93b	93b	35.37
Cyphocleonus achates	30/plot	Flower	8/27	----	0d	0f	90.00
Picloram	0.09	Bolt	6/2	----			
Cyphocleonus achates	30/plot[d]	Flower	8/27	----	46c	46e	113.58
Untreated					0d	0f	
LSD (0.05)					4.96	6.11	

[a] Herbicide rate lb/A, x = number of times.

[b] Values followed with the same letter do not significantly differ (p=0.05).

[c] Cost based on the following information: Hand pulling wages $9.00/hr; weevils $1.00/insect; mowing $50/A; picloram $86.00/gal; clopyralid + 2,4-D (Curtail) $30.70/gal; ground application $20.00/A.

[d] Due to low density of spotted knapweed plants, one plot received only 15 weevils in the picloram plus root weevil treatment.

Picloram at rates of 0.125 lb/A and above, and clopyralid plus 2,4-D at 0.19 + 1 lb/A provided greater than 90% control one year following application (Table 2). Mowing alone did not provide control of knapweed plants, but reduced flowering. Mowing combined with clopyralid plus 2,4-D at 0.095 + 0.5 lb/A provided significantly better knapweed control than this herbicide rate alone. Hand pulling alone eliminated flowering and provided 56% control of spotted knapweed plants. Insects alone or in combination with picloram at 0.09 lb/A did not provide acceptable spotted knapweed control. Mowing twice for 2 consecutive years and insects alone did not control spotted knapweed.

Hand pulling for two years significantly increased bare ground, but did not effect grass, litter, and other forb cover compared to the control. Herbicide treatments alone and in combination with hand pulling and mowing increased grass cover by greater than 44%. Mowing and insects alone had no significant effect on grass cover, litter, or forbs compared to the control (Table 3).

Herbicides alone provide the most effective spotted knapweed control for the lowest cost. The most cost-effective treatments were picloram at 0.125 and 0.25 lb/A, and clopyralid plus 2,4-D at 0.19 + 1 lb/A (Table 2). Herbicides at half the standard rate can be combined with mowing or hand pulling to improve initial control or maintain control over a longer period of time. Insects alone and combined with herbicides may prove more cost effective if insects establish and maintain long-term control. Hand pulling twice for 2 consecutive years was the most expensive treatment and provided less than 60% spotted knapweed control after two seasons. Hand pulling is not an economically viable option on dense knapweed infestations.

Table 3. Percent knapweed, grass, forb, litter, and bare ground cover.

Treatment	Rate[a]	Knapweed[b] Aug. 1998	Grass[b] Aug. 1998	Forb[b] June 1998	Litter[b] Aug. 1998	Bare ground[b] Aug. 1998
		%				
Hand-pull (bolted plants)	2 X	40b	23.7e	2c	18.3a-d	13.7a
Picloram plus Hand-pull (rosettes + mature)	0.125 1 X	2.5de	80a	3.3bc	12.3cd	3.3bcd
Mowing	2 X	70.8a	10.3f	1.3c	15.3a-d	6.3b
Mowing plus Picloram	1 X 0.125	0e	66.2bc	1.5c	25.2a	5.8bc
Mowing plus Clopyralid+2,4-D	1 X 0.095 + 0.5	1.5e	70.3b	6.2ab	14bcd	5.8bc
Picloram	0.125	1.7e	69.5b	1.5c	23.3ab	4.3bcd
Clopyralid+2,4-D	0.095 + 0.5	12.3d	57c	3.8abc	19.3abc	2.8bcd
Picloram	0.25	0.5e	87a	2.3bc	8.2d	2.3bcd
Clopyralid+2,4-D	0.19 + 1	3.7de	86.8a	1.6c	8.3d	0.7d
Cyphocleonus achates	30/plot	61.5a	11.7f	1.3c	22.7abc	1d
Picloram *Cyphocleonus achates*	0.09 30/plot[c]	25.5c	41.3d	7.7a	16a-d	4bcd
Untreated		65.2a	16.3ef	2c	14.8a-d	2.7bcd
LSD (0.05)		101	9.36	3.89	10.58	3.95

[a] Herbicide rate lb/A, x = number of times.

[b] Values followed with the same letter do not significantly differ (p=0.05).

[c] Due to low density of spotted knapweed plants, one plot received only 15 weevils in the picloram plus root weevil treatment.

GRASS DEFOLIATION INTENSITY, FREQUENCY, AND TIMING EFFECTS ON SPOTTED KNAPWEED INVASION.

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Abstract. Preventing the invasion of uninfested rangeland is central to managing spotted knapweed. Intensity, frequency, and timing of grass defoliation determine the ability of grasses to tolerate grazing and resist weed invasion. We hypothesized that as grass defoliation intensity increases, spotted knapweed cover, density, and biomass would increase, that increasing defoliation frequency would increase the intensity effect, and that spring defoliation would cause a greater increase in spotted knapweed than summer defoliation. We hand clipped grasses in 1 m^2 plots at two spotted knapweed infested Idaho fescue (*Festuca idahoensis* Elmer) co-dominated sites in Western Montana. Clipping treatments were four intensities (0, 30, 60, and 90% of the foliage), three frequencies (at 14-day intervals), and two timings (spring beginning in mid-May and summer beginning in mid-July), factorially arranged in a randomized-complete-block design for a total of 28 treatments with four replications. Treatments were applied in 1995 and 1996. Analysis of variance showed grass cover and density were reduced by defoliation intensity of 90%. Defoliation frequency greater than once caused a reduction in grass cover and density at the 60% intensity. Spring defoliation caused a greater reduction in grass cover and density than summer defoliation. Grass biomass was reduced by 30% clipping. Grass defoliation intensity greater than 60% caused an increase in spotted knapweed cover and density. Defoliation more than once increased spotted knapweed cover, and spring defoliations increased spotted knapweed cover compared to summer defoliations. Spotted knapweed biomass was not affected by defoliation treatments. Our study suggests that an annual single grass defoliation of 60% or less, regardless of the season, will not increase spotted knapweed invasion on rangeland.

INTEGRATING 2,4-D AND SHEEP GRAZING TO MANAGE SPOTTED KNAPWEED INFESTED RANGELAND.

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Abstract. Spotted knapweed is rapidly invading rangeland throughout the northwestern United States, decreasing forage production, plant species diversity, and wildlife habitat. Spotted knapweed management may be enhanced by integrating several control methods. The objective of this study was to determine the effects of integrating 2,4-D and repeated sheep grazing on spotted knapweed infested plant communities. Four treatments were applied in a randomized complete block design and replicated three times at each site. The treatments were: 1) 2,4-D amine 2.1 kg ha^{-1} applied in the spring, 2) sheep grazing (95% knapweed utilization) repeated three times in 1998, 3) 2,4-D amine 2.1 kg ha^{-1} applied in the spring and sheep grazing (95% knapweed utilization) repeated three times in 1998, and 4) a control which did not receive 2,4-D or sheep grazing. At peak standing crop spotted knapweed density, grass and spotted knapweed biomass, and percent cover of spotted knapweed, downy brome, other grasses, litter, and bare ground were measured in 1998. Data were analyzed using analysis of variance. Both sheep grazing and 2,4-D application lowered spotted knapweed seed head density and biomass. The 2,4-D treatment increased downy brome biomass and cover at site one. However, when sheep grazing was combined with 2,4-D, downy brome biomass and cover were lowered from that of the 2,4-D alone. Sheep grazing alone had bare-ground and litter cover similar to that of the control while plots treated with 2,4-D had higher bare-ground cover and lower litter cover.

REVEGETATING SPOTTED KNAPWEED INFESTED RANGELAND IN A SINGLE ENTRY. Roger L. Sheley, James S. Jacobs, and Daniel E. Lucas, Assistant Professor, Postdoctoral Research Associate, and Granite County Extension Agent, Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, MT 59717.

Abstract. Introducing and establishing competitive plants is essential for the successful management of spotted knapweed infested rangeland where a desirable understory is absent. Our objective was to determine a herbicide-mix that would maximize grass establishment in spotted knapweed-cheatgrass-bluegrass infested rangeland in a single fall application. On two sites in Montana, 8 herbicide treatments none, glyphosate at 0.5 kg/ha^{-1}, picloram at 0.14 and 0.28 kg/ha^{-1}, clopyralid plus 2,4-D at 0.21 + 1.12 kg/ha^{-1}, picloram plus glyphosate at 0.14 + 0.5 kg/ha^{-1}, picloram plus glyphosate at 0.28 + 0.5 kg/ha^{-1}, clopyralid plus 2,4-D plus glyphosate at 0.2 + 1.12 + 0.5 kg/ha^{-1} and three seeded grass species 'Luna' pubescent wheatgrass, bluebunch wheatgrass, and 'Bozoyski' Russian wildrye were applied in a spilt-plot design with four replications in the late-fall of 1994 and 1995. Spotted knapweed and grass density were measured in 1995, 1996, and 1997, and biomass was measured in 1997 at peak standing crop. Density data were analyzed as a split-split-plot in time, and biomass data were analyzed as a split-plot using analysis of variance. By the end of the study, picloram applied at either 0.14 or 0.28 kg/ha^{-1} in the late-fall consistently yielded lowest spotted knapweed density and biomass. Initially, glyphosate alone lowered spotted knapweed density and increased grass biomass compared to that of the control. However, glyphosate treated plots had more spotted knapweed and less seeded grass established by the end of the study. Luna pubescent wheatgrass consistently yielded the high test density and biomass of the seeded grasses. We believe a single-entry revegetation program applying picloram in late-fall combined with a fall-dormant seeding will maximize seedling establishment in spotted knapweed infested rangeland.

RESPONSE OF SPOTTED KNAPWEED, OTHER FORBS, AND GRASS TO 2,4-D AND N-FERTILIZER COMBINATIONS. Jane M. Krueger, James S. Jacobs, and Roger L. Sheley, Research Associate, Postdoctoral Research Associate and Assistant Professor, Department of Plant, Soil and Environmental Sciences, Montana State University, Bozeman, MT 59717.

Abstract. Preventing the invasion of uninfested rangeland is central to managing spotted knapweed. Intensity, frequency, and timing of grass defoliation determine the ability of grasses to tolerate grazing and resist weed invasion. We hypothesized that as grass defoliation intensity increases, spotted knapweed cover, density, and biomass would increase, that increasing defoliation frequency would increase the intensity effect, and that spring defoliation would cause a greater increase in spotted knapweed than summer defoliation. We hand clipped grasses in 1 m^2 plots at two spotted knapweed infested Idaho fescue (*Festuca idahoensis* Elmer) sites in Western Montana. Clipping treatments were four intensities (0, 30, 60, and 90% of the foliage), three frequencies, at 14-day intervals, and two timings (spring beginning in mid-May and summer beginning in mid-July), factorially arranged in a randomized complete block design with four replications for a total of 28 treatments each replication. Treatments were applied in 1995 and 1996. Analysis of variance showed grass cover and density were reduced by defoliation intensity of 90%. Defoliation frequency greater than once caused a reduction in grass cover and density at the 60% intensity. Spring defoliation caused a greater reduction in grass cover and density than summer defoliation. Grass biomass was reduced by 30% clipping. Grass defoliation intensity greater than 60% caused an increase in spotted knapweed cover and density. Defoliation more than once increased spotted knapweed cover, and spring defoliations increased spotted knapweed cover compared to summer defoliations. Spotted knapweed biomass was not affected by defoliation treatments. Our study suggests that an annual single grass defoliation of 60% or less, regardless of the season, will not increase spotted knapweed invasion on rangeland.

STATUS OF BIOLOGICAL CONTROL OF SPOTTED AND DIFFUSE KNAPWEEDS IN THE NORTHWESTERN UNITED STATES.

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Abstract. Spotted and diffuse knapweed have become established in about a third of the lower 48 states and are serious pests in at least four states. Of 12 species of exotic insects introduced for biological control, about seven have become well established. In addition to the seedhead flies, *Urophora affinis* and *U. quadrifasciata*, which are widely established in the west, the root-feeding insects *Agapeta zoegana*, *Cyphocleonus achates*, and *Sphenoptera jugoslavica* are well established west of the Rocky Mountains. The seedhead moth, *Metzneria paucipunctella*, is widespread in the milder climate of the Pacific Northwest, whereas the seedhead weevil, *Larinus minutus* is becoming well established on both sides of the continental divide. Research is focusing on evaluation of environmental restrictions to the establishment and impact of these biological control agents to determine if foreign exploration for better-adapted agents in specific cold-climate regions in Central Asia are warranted.

FACTORS BEING CONSIDERED THAT MAKE RUSSIAN KNAPWEED A HIGHLY COMPETITIVE PLANT.

Rick M. Bottoms[1], Curtis J. Nelson[1], Tom D. Whitson[2], and John H. Coutts[1], Extension Agronomist, Professor, Research Associate, and Professor, [1]University of Missouri, Columbia, MO 65211 and [2]University of Wyoming, Laramie, WY 82071.

Abstract. In previous studies it is evident there exists a competitive advantage by Russian knapweed in other plant communities. Observations suggest allelopathy and a competitive adaptability that lead to the success in a variety of environments; precipitation zones, soil types, neighboring plant species, plant densities, fertility levels and other stress inducing factors. A competitive advantage was determined to occur unless suppressed long enough by herbicides, to allow the introduction and establishment of an improved grass monoculture. The success of either monoculture; knapweed or grass is primarily attributed to a combination of allelopathy, moisture and nutrients. Allelopathy tends to dominate in dryer environments and nutrient availability appears to dominate to the success of a plant species in more moist environments. The competitive advantage of a monoculture of Russian wildrye cv. 'Bozoisky', is attributed to the dense fibrous root system and the ability to capture needed plant moisture and nutrients. Schrow suggests, "A competitive advantage may exist by grasses when competing with a tap rooted plant for potassium." Continued analysis may confirm preliminary results suggesting either potassium and or iron nutrient elements contribute to the success of either Russian knapweed or Russian wildrye dominance.

THE EFFECT OF PICLORAM AND PICLORAM PLUS 2,4-D ON DALMATIAN TOADFLAX CONTROL.

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Abstract. Dalmatian toadflax is a persistent, perennial weed that is well established throughout the western United States and western provinces of Canada. Although picloram has been used to control Dalmatian toadflax, there is little information regarding the effect of herbicide retreatment and application timing. The objective of this study was to determine efficacy of picloram initial treatments, retreatments, and time of application on Dalmatian toadflax.

Experiments were conducted at sites near Boulder, MT and Toole, UT. Initial picloram applications of 0.25, 0.375, and 0.5 lb/A were made on Dalmatian toadflax at bloom stage in mid June, 1994 in MT and 1995 in UT.

Fall application of picloram at 0.25, 0.375, and 0.5 lb/A alone and picloram plus 2,4-D at 0.28 + 1, 0.38 + 1.5, and 0.54 + 2 lb/A were made in mid-September, 1995 at both locations. Retreatments were repeated annually or biannually depending on initial herbicide application rate.

There was a significant difference in Dalmatian toadflax control between MT and UT, so data is discussed separately for the two locations. At the MT location, picloram alone at 0.25, 0.375, and 0.5 lb/A applied at bloom growth stage provided greater than 90% Dalmatian toadflax control one year following treatment. Two years following treatment, control was less than 80% for picloram at 0.25 and 0.375 lb/A. Retreatment with these two rates increased control to 81 and 99%, respectively, the following year. Fall applications of picloram alone provided 80% control or greater at all rates applied one year following treatment. Retreatments of fall applied picloram at 0.25 lb/A and 0.375 lb/A alone and in combination with 2,4-D and were made in 1996. Picloram plus 2,4-D at all rates provided slightly better control than picloram alone 2 years following treatment (Table).

Dalmatian toadflax control was lower at the UT location, especially with fall applications, possibly due to dry conditions or lack of perennial grass competition at the site. Initial applications of picloram alone and picloram plus 2,4-D provided less than 80% control one year following treatment regardless of application timing except for picloram plus 2,4-D at 0.5 + 2 lb/A. Retreatments were made in 1996 to fall applied plots at picloram rates less than 0.5 lb/A and to picloram alone at 0.25 lb/A applied at bloom stage. Retreatments in 1997 were made to all plots. Control with bloom stage applications was significantly greater than those applied in the fall and provided greater than 80% control at the end of 3 years. Only picloram at 0.5 lb/A alone and in combination with 2,4-D and picloram plus 2,4-D at 0.375 + 1.5 lb/A provided acceptable Dalmatian toadflax control in the fall at the UT location.

In summary, picloram applied at the flower stage provides more consistent control of Dalmatian toadflax than those applied in the fall. The addition of 2,4-D to picloram rates 0.25 lb/A and 0.375 lb/A improves Dalmatian toadflax control over picloram alone. Picloram at 0.25 lb/A applied 3 consecutive years or picloram at 0.375 lb/A applied for 2 years provided good control of Dalmatian toadflax when applied at the flower growth stage. Picloram at the label rate of 0.5 lb/A provides the most consistent control of Dalmatian toadflax at either flower or fall growth stage.

Table. Treatment rates, timing, and percent Dalmatian toadflax control.

Treatment	Rate	Plant growth stage	Retreatment applied				Control					
			1996		1997		1 YAT[a]		2 YAT[a]		3YAT[a]	
			MT	UT	MT	UT	MT	UT	MT	UT	MT	UT
	lb/A						%					
Picloram	0.25	Flower	Y	Y	N	Y	92a	51b	77g	74ab	81b	86a
Picloram	0.375	Flower	Y	N	N	Y	99a	53ab	81fg	60b	99.7a	81a
Picloram	0.5	Flower	N	N	N	Y	96a	79ab	85ef	69ab	80b	86a
Picloram	0.25	Fall regrowth	Y	Y	N	Y	80a	3c	91b-e	3d	53d	25c
Picloram	0.375	Fall regrowth	Y	Y	N	Y	96a	12c	96abc	25c	70c	74ab
Picloram	0.5	Fall regrowth	N	N	N	Y	96a	54ab	100a	65b	92a	86a
Picloram+2,4-D	0.28 + 1	Fall regrowth	Y	Y	N	Y	80a	5c	95a-d	0d	100a	55b
Picloram+2,4-D	0.38 + 1.5	Fall regrowth	Y	Y	N	Y	96a	56ab	89cde	71ab	100a	94a
Picloram+2,4-D	0.5 + 2	Fall regrowth	N	N	N	Y	100a	83a	95a-d	90a	18e	84a
Untreated												
LSD (0.05)							27.6	27.3	6.8	22.1	9.4	19.7
STD DEV							16.2	18.8	4	15.3	5.5	13.6
CV							17.9	40	4.4	28.6	8.4	18

[a] Years after treatment.

POST EMERGENCE CONTROL OF PURPLE NUTSEDGE. David M. Kopec and Jeff J. Gilbert, Extension Specialist and Research Specialist, Turf, Plant Sciences Department, University of Arizona, Tucson, AZ 85721.

INTRODUCTION

Purple nutsedge *(Cyperus rotundus)* is a troublesome and problematic perennial weed in turfgrass. Its prolific growth from various vegetative structures and tolerance to mowing pressure greatly contribute to it's persistence. Selective chemical control is highly desirable from a cultural management standpoint. A field trial was established to measure the affects of single and repeat applications of sulfentrazone, halsulfuron, and imazaquin to highly infested mowed swards of purple nutsedge.

MATERIAL AND METHODS

A turfgrass rough on a municipal golf course was selected for a field trial to measure the effectiveness of activity of sulfentrazone on purple nutsedge from post emergence applications. Turf plots were 5 by 8 inches and consisted of 45 to 95% purple nutsedge. Each plot was split in half to include the herbicide treated turf, while the remaining half remained untreated. Treatments included sulfentrazone as a single application at the rates of 0.125, 0.25 and 0.375 lb/A. As split applications, sulfentrazone was applied at 0.125/0.125 lb/A, 0.250/0.250 lb/A and 0.375/ 0.125 lb/A combination rates. Halsulfuron was applied as 0.062 lb/A single and as a 0.062/0.062 lb/A split application rate. Imazaquin was applied as a 0.5 lb/A single and as a 0.5/0.5 lb/A split application rate. All treatments were replicated three times. All treatments were applied initially on June 17, 1996, with the second (split) application on July 23, 1996. Treatments were applied using a CO_2 backpack sprayer at 29 psi with a 3 nozzle boom at 20-inch spacing using 8004 nozzles. The delivery rate was 115 gpa.

On nine occasions both halves of the 30 plots were scored visually for percentage of living purple nutsedge. Percent control for each date was determined by the formula 1- (% treated/%control) x 100. Data were subjected to the analysis of variance technique and LSD values were calculated for mean separation only when the P value for treatment effects was 0.05, or less.

RESULTS AND DISCUSSION

There were four evaluation after the initial applications 10, 18, 25, 31 days after treatment (DAT/1), and five evaluations after the respective second (split) applications were made 3, 8, 17, 28, 38 (DAT/2). Mean treatment responses for percent control are provided in the Table.

Single application results. There were five treatment regimes to observe after the initial application. Overall, there was slight activity from sulfentrazone at the lowest rate, 0.125 lb/A, which averaged between 9 to 16% from 10 to 31 DAT/1. At 10 DAT/1 there was no difference for the percent control between the three rates of sulfentrazone, which were slightly less than that of halsulfuron and imazaquin. There was no statistical difference for percent control between the 0.25 and 0.375 lb/A rates of sulfentrazone throughout the first month of post application evaluations. Control was about 20% greater for the 0.375 lb/A rate at 18 and 25 DAT/1, but not at 31 DAT/1. Maximum control was first achieved at 31 DAT/1 from sulfentrazone from the single applications made on June 17. Both halsulfuron and imazaquin had greater amounts of control at 18, 25 and 31 DAT/1, compared to the sulfentrazone treatments at large. The level of control was 1.5 to 2 times greater for these products, when compared to sulfentrazone, across rates. Still, control was around 60% at maximum (for both halsulfuron and imazaquin) from a single application only. Mean separation values (for treatment mean separation) were quite large for the first four evaluation dates, and the overall of F-ratio statistic for the herbicide treatment effect was not statistically significant.

Split-application results. The overall treatment effect was significant on all four evaluation dates after the second (split) application was made on July 22, 1996. With the single application and split application treatments, there were now ten treatments total (five single and five split application treatments). Among sulfentrazone treatments, applied one time only, there was a carry over effect for up to 53 days after the first application. The 0.125 lb/A rate remained low (7 to 15% control), while the 0.25 and 0.375 lb/A rates of sulfentrazone did not exhibit a rate dependant response at that time. Control from the single application of halsulfuron decreased with time, ending at 33% control on August 20, 1996. At the termination of the test, imazaquin exhibited about the same level of control as halsulfuron from a one time single application at the 0.5 lb/A rate. The repeat applications of sulfentrazone enhanced chemical control. The low rate combination (0.125/0.125 lb/A) resulted in brief control of 84% (31 July) which subsided to 33% for 9 August and 20 August.

The low level of control (8%) on 26 July for two of the sulfentrazone treatments can not be explained. Perhaps a lack of foliage (from mowing) before the second application, or minimal regrowth from underground growing points following treatment may have affected the amount of relative plant material for visual ratings. Since the mode of uptake is not known for sulfentrazone, it is not possible to explain the increased activity at 8 days from the split application (8 DAT/2) among sulfentrazone treated nutsedge. Maximum control was achieved for the sulfentrazone split application treatments 8 DAT/23, which was not the case for halsulfuron or imazaquin which generally had greater absolute control towards the end of the test.

The sulfentrazone treated turf which received two applications responded accordingly in order of the initial (first) application rate. The sulfentrazone 0.375/0.125 lb/A treatment generally had better control than the 0.25/ 0.25 lb/A treatment. Both of these treatments resulted in a total of 0.5 lb/A applied from two applications. The highest levels of control were achieved by imazaquin and halsulfuron, which were about 10% higher than the 0.375/0.125 lb/A sulfentrazone treatment.

By the close of the experiment, regrowth was occurring on all plots to some extent. This is typical of purple nutsedge, since it is capable of re-growth from either shallow underground bulbils, or from nutlet meristems.

CONCLUSIONS

Sulfentrazone provided low levels of purple nutsedge control from single applications. Compared to the single applications of halsulfuron and imazaquin at previously established label (1x) rates, sulfentrazone may need to be applied at a rate of 0.375 lb/A or higher, to achieve an effect similar to the other chemicals. However, neither of the single applications of halsulfuron or imazaquin reached 70%. This level of performance would not fully satisfy weed control expectations in a commercial setting for this persistent and troublesome weed.

Sulfentrazone provided the highest level of weed control on purple nutsedge as a split (combination rate) treatment at 0.375/0.125 lb/A. This particular treatment resulted in 93% control at 8 days after application. From this data, it appears that sulfentrazone should be tested at the split application rates of 0.375/0.125, 0.375/0.25 and 0.375/0.375 lb/A. In addition, since the “high up front” application rates of sulfentrazone 0.375 lb/A for the split combination treatments provided the greatest amount of weed control, additional treatments of 0.5/0.125, 0.5/0.25, 0.5/0.375 and 0.5/0.5 lb/A should be tested under desert conditions to assess enhanced weed control with commercially available products which have established and known label rates. Additional treatments in a new and different rate structure appear warranted to increase initial control and longevity of effect.

Table. Response of purple nutsedge to applications of sulfentrazone, imazaquin and halsulfuron made in 1996, University of Arizona.

		Control with single application[b]				Control with single and split application[b]			
Treatment[a]	Rate	27 June 10 DAT[c]	5 July 18 DAT[c]	12 July 25 DAT[c]	18 July 31 DAT[c]	26 July 3 DAT[c]	31 July 8 DAT[c]	9 Aug 17 DAT[c]	20 Aug 28 DAT[c]
	lb/A	%				%			
Sulfentrazone	0.125	9	13.3	6.9	15.5	7.7	4.2	16.3	11.1
Sulfentrazone	0.25	11.8	19.5	32.9	42.7	40.7	38.9	31	27.8
Sulfentrazone	0.375	10.8	26.7	26.7	36	8.3	40	21.7	13.3
Sulfentrazone	0.125/0.125	-	-	-	-	8.3	84	33.8	33.3
Sulfentrazone	0.25/0.25	-	-	-	-	70.4	81.6	63.6	58.2
Sulfentrazone	0.375/0.125	-	-	-	-	82.9	93.9	85.3	76.9
Halsulfuron	0.062	14.6	38.8	67.1	61.5	45.2	53	45.2	33.3
Halsulfuron	0.062/0.62	-	-	-	-	61.9	64.2	96.7	96.1
Imazaquin	0.5	21.4	33.8	49.7	63.8	38.3	32.9	40	37
Imazaquin	0.5/0.5	-	-	-	-	75.4	86.8	94.4	89.7
TEST MEAN[d]		13.5	26.4	36.7	43.9	43.9	57.9	52.8	47.7
LSD VALUE[e]		32.6	47.8	51.9	52.5	53	56.3	43.9	44
DAT #1 (initial trts appl'd)		10	18	25	31	39	44	53	64
DAT #2 (combination trts appl'd)					3	8	17	28	

[a] Initial applications for identical products at the same identical initial rate appear as one value only.

[b] Initial applications made June 17, 1996. Second (split) applications made July 23, 1996, for combination treatments only.

[c] Days after treatment.

[d] Test Mean = mean of all treatments on each evaluation date.

[e] LSD Value=LSD mean separation statistic. Differences between treatment means must be larger than the LSD value for true treatment differences to occur.

A SURVEY OF NOXIOUS WEEDS IN COLORADO. Suellen May[1], K. George Beck[1], and John E. Mitchell[2], Graduate Research Assistant, Associate Professor, and Range Scientist, [1]Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80538 and [2]USDA Forest Service/Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO 80521.

Abstract. Successful weed management on a regional scale requires an estimation of the presence of weeds and the loss incurred by noxious weed infestations. This weed survey was conducted to determine the extent of noxious weeds in Colorado. In the fall of 1997, a questionnaire was sent to county weed supervisors and agricultural extension agents in each of the 63 Colorado counties to determine: weed acreages by land type, the three most troublesome weeds in each county, estimated lost forage production, and rapidly increasing weeds. The questionnaire requested information on the following weeds: leafy spurge, diffuse knapweed, Russian knapweed, spotted knapweed, yellow toadflax, dalmation toadflax, purple loosestrife, whitetop, perennial pepperweed, and Canada thistle. Forty-nine counties responded to the survey with all regions except the northwest indicating that Canada thistle was the most troublesome weed and accounting for the greatest number of acres (396,000). Russian knapweed accounted for the second largest acreage (167,700) and leafy spurge accounted for the third largest acreage (96,800). The remaining weeds surveyed were estimated to have the following distribution: 83,000 A of diffuse knapweed, 49,600 A of whitetop, 34,600 A of dalmation toadflax, 26,900 A of perennial pepperweed, 5,800 A of spotted knapweed, and 400 A of purple loosestrife. While these data are substantially better than none, a more rapid and objective method to survey noxious weeds is needed.

WEEDS OF HORTICULTURAL CROPS

VEGETATION MANAGEMENT IN FIELD-GROWN FLOWER CROPS.

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Abstract. Field-grown flower crops have become a major segment of the flower industry in California. With the influx of overseas cut flowers from greenhouses, price and profit from field-grown materials are high. New species and cultivars are also a part of this increasing market. Weeds are found in all crops and in the past they were controlled with preplant fumigation, cultivation, and hand weeding, expensive methods of control. Methods were needed that will control weeds, reduce grower costs, and be environmentally sound. Field studies with soil solarization, greenwaste mulches, and herbicides have been conducted on transplants of *Limonium* sp., *Delphinium* sp., *Antirrhinum* sp., *Callistephus* sp., *Helianthus* sp. and Dutch iris bulbs.

Two to three inches of fine composted or coarse greenwaste mulches have been effective for weed control and promote growth of Dutch iris, *Delphinium* and *Limonium*, but decrease growth of *Callistephus* and *Antirrhinum*. Winter annual weeds were controlled except around the transplant. Dutch iris bloom was delayed with mulches. Preplant solarization has controlled annual weeds, was safe on all species evaluated and increased plant growth of annual flowers, but not bulbs. Herbicides have been evaluated on each crop but are specific to each crop.

AZAFENIDIN: A NEW HERBICIDE FOR CITRUS, GRAPES, AND POME FRUIT IN ARIZONA, CALIFORNIA, OREGON, WASHINGTON.

J. Robert C. Leavitt, Wayne J. Steele, Hugo T. Ramirez, Rod W. Warner, Norm D. McKinley, Jeffery L. Pacheco, Fred. W. Marmor, Robert H. N. Park, Ronnie G. Turner, and Gil E. Cook, Senior Development Representative, Senior Development Representative, Development Representative, Senior Development Representative, Field Supervisor, Senior Development Representative, Field Station Manager, Product Development Manager, Product Development Manager, and Residue Program Development Representative, E.I. DuPont de Nemours and Co., Inc., Wilmington, DE 19880.

Abstract. Azafenidin is a broad-spectrum herbicide that will provide extended weed control in citrus, grape, and pome fruit. Azafenidin is currently pending registration in the United States, Latin America, Europe, Asia, Australia, and New Zealand. Applied preemergence to weeds at 8 to 16 oz/A, azafenidin will control most broadleaf and grassy weeds, and suppress sedge weeds, including: common mallow, redstem and whitestem filaree, coast fiddleneck, redroot pigweed, common lambsquarters, panicle willowweed, horseweed, wild oat, large crabgrass, barnyardgrass, annual bluegrass, seedling Johnsongrass, and yellow nutsedge. Duration of control depends upon application rate. At 8 to 16 oz/A, azafenidin can provide weed control for up to 10 months. The activity of azafenidin is independent of soil texture, organic matter content, or temperature. Incorporation by rainfall or overhead irrigation is essential for optimum performance.

Applied postemergence to weeds, azafenidin can provide control of some newly emerged weeds under 1 inch tall, such as barnyardgrass, annual bluegrass, redroot pigweed, common mallow, and redstem and whitestem filaree. Azafenidin can also be tank mixed with a contact herbicide, such as glyphosate or gramoxone in order to provide broad spectrum control of larger emerged weeds and residual weed control.

In a crop response study, azafenidin has been applied directly to the foliage of orange transplants at rates up to 16 oz/A without causing any negative crop response other than some transient leaf speckling on new growth. In citrus field tests, excellent crop tolerance was demonstrated when azafenidin was applied preemergence at up to eight times (128 oz/A) the anticipated label use rate. In other field tests, citrus treated preemergence with azafenidin has had increased trunk diameter growth compared to the untreated check. Several varieties from each citrus crop

were tested. Orange varieties were: Hamlin, Navel, Tangelo, Temple, Valencia; lemon varieties tested were: Limco, Lisbon; grapefruit varieties tested were: Ruby Red, Duncan.

Azafenidin applied preemergence to grapes in field tests at excess rates (24 to 32 oz/A) has not demonstrated any visual phytotoxicity other than transient chlorosis, nor had any effect on cane or shoot growth, sugar development, percent sucrose at harvest, or yield. Grape varieties tested include: Cabernet Sauvignon, Merlot, Barbera, Flame seedless, Chadonnay, Grenache, Sauvignon blanc, Thompson seedless.

Azafenidin applied preemergence to apples and pears in field tests at excess rates (24 to 32 oz/A), has not caused any visible phytotoxicity nor had any effect on trunk diameter growth or yield. Apple varieties tested include: apple-Fuji, Rome, Pacific Gala, Pink Lady; pear varieties tested included: Chemise, Bosc, Anjou, Bartlett.

In Magnitude of Residue tests, it has been shown that azafenidin residues do not accumulate in fruits of citrus, grapes, or pome, when applied at efficacious rates.

In soil dissipation tests at Madera, California, azafenidin had a half life of 129 days. Azafenidin has been tested for mobility in many types of soil, and is considered to have intermediate to low soil mobility.

In the acute battery of toxicity tests required for US EPA pesticide registration, the oral LD_{50} to rats of azafenidin was greater than 5000 mg/kg. The dermal LD_{50} was greater than 2000 mg/kg and the inhalation LC_{50} was greater than 5.5 mg/l. Azafenidin was not an eye irritant, a dermal irritant, or a dermal sensitizer. Based on the results of these tests, azafenidin is considered to exhibit very low acute toxicity.

Azafenidin is an effective broadleaf and grass preemergence weed control agent for citrus, grape, and pome fruit with excellent crop tolerance, and is safe to workers and the environment.

YELLOW NUTSEDGE (*CYPERUS ESCULENTUS* L.) CONTROL IN DRY BULB ONIONS (*ALLIUM CEPA*).

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Abstract. Yellow nutsedge (*Cyperus esculentus* L.) has become a significant problem for onion producers in Southwest Idaho over the past decade. Currently, there are few herbicides available to onion growers that effectively and consistently control yellow nutsedge. In 1997, four trials, were conducted at different locations (two in Canyon County near Parma, ID and two in Malheur County near Nyssa, OR), to evaluate postemergence applied (POST) herbicides for the control of yellow nutsedge and crop tolerance. One of the locations in Malheur County had supplemental water delivered through a drip irrigation system while all other locations for both years had furrow irrigation as a delivery system. In 1998, two trials were conducted at different locations (both in Malheur County, one near Nyssa, OR and one near Adrian, OR), to further evaluate POST applied herbicides under different climatic and field conditions.

In 1997, the control of yellow nutsedge at the sub-surface drip irrigation site was substantially lower for all herbicide treatments compared to the surface furrow irrigated locations. Weed control results with each herbicide treatment in 1997 was relatively consistent among the furrow irrigated sites. Halosulfuron at 0.042 and 0.084 lb/A gave 96% or better control of yellow nutsedge at all locations, but effectively eliminated all onion stands. Under furrow irrigation systems, pendimethalin plus SR-metolachlor/benoxacor at 1.5 + 0.91 lb/A, pendimethalin plus SR-metolachlor/benoxacor plus dimethenamid at 1.5 + 0.91 + 1 lb/A and dimethenamid plus metolachlor at 1 + 0.91lb/A controlled 90% or better of the target weed species. A reduction in quality of the marketable crop occurred where moderate populations of yellow nutsedge existed through the growing season.

Weed control in 1998 with SR-metolachlor/benoxacor plus dimethenamid at 0.91 + 0.64 lb/A, SR-metolachlor/benoxacor plus dimethenamid at 0.91 + 1.17 lb/A, and SR-metolachlor/benoxacor plus S-dimethenamid plus pendimethalin at 0.91 + 0.064 + 1 lb/A provided 88% or better control of yellow nutsedge 30 days after treatment (DAT) at both locations. However, by 51 DAT, only SR-metolachlor/benoxacor plus S-dimethenamid plus pendimethalin at 0.91 + 0.064 + 1 lb/A provided 90% or better control at both locations. Herbicide injury to onions of 3% or less was observed at one location during the 30 DAT evaluation. By 51 DAT evaluation no visible injury was detectable. In general, the Adrian, OR location had more injury visible and lower yellow nutsedge control yield with a higher percentage of medium and culls than did the Nyssa, OR location. Overall, better nutsedge control and higher yields were obtained in 1997 than in 1998. This may be partially attributed to the unusually wet and cool spring and early summer of 1998.

HERBICIDE/RHIZOCTONIA INTERACTION ON POTATO. Scott A. Fitterer[1], Richard K. Zollinger[1], Neil C. Gudmestad[2], and Gary A. Secor[2]. Research Specialist, Associate Professor, Professor, and Professor, [1]Department of Plant Sciences and [2]Department of Plant Pathology, North Dakota State University, Fargo, ND 58015.

INTRODUCTION

Diseases caused by soilborne pathogens are one of the most difficult problems for potato growers. It is difficult to limit the spread of soilborne pathogens because they are moved easily with seed tubers, irrigation water, plant debris, windblown soil, and farm equipment. *Rhizoctonia* canker, known as black scurf, is a major concern and a serious disease of potato found in all production areas of the world. There are several strains of this fungus, the one that attacks potato, usually anastomosis group 3 (AG-3) is often well established in most fields. Potato development is effected from emergence to harvest. Poor stands are produced when cankers form on emerging sprouts. The problem is particularly severe when emergence and early crop development are retarded by cold, wet conditions, especially in fine textured soils. The stolon canker phase of the disease develops during early tuber initiation. Young tubers can actually be "pruned off" by the pathogen. Seed and soil treatments have not been effective in heavily infested soils and returns may not justify the cost. Crops severely effected by the *Rhizoctonia* fungus often produce a high percentage of tubers misshaped, cracked, nonuniform sized, or discolored by sclerotia on their surface. *Rhizoctonia* can seriously limit the marketable yield.

Herbicides have been shown to increase the severity of *Rhizoctonia* disease on cotton, snap bean, and sugarbeet. Among the herbicides registered in North Dakota for use in potato, EPTC, linuron, trifluralin, and pendimethalin have been shown to increase *Rhizoctonia* disease severity, although not on potato (Altman and Rovira. 1989. Can. J. Pi. Path. 11: 166-172 and Mahound et al. 1993. Plant Dis. 77:79-86). The biological interaction between herbicides and fungicides is apparently controlled by many factors including weather, date of planting, location, and soil type (Mahound et al. 1993. Plant Dis. 77:79-86). Many crop protection chemicals, particularly herbicides and growth regulators, produce changes in the physiology and development of crop plants which may result in substantial alteration in disease susceptibility. Three effects appear to be involved, (a) changes in the composition of the host which modify its suitability as a substrate for growth and development of specific pathogens, (b) changes in natural defense mechanisms, and © changes in host structure which may result in greater susceptibility to infection or provide a more favorable environment for epidemic development of disease (Altman and Rovira. 1989. Can. J. Pi. Path. 11: 166-172). The objectives of this study was to determine what role, if any, pre- and post- emergence herbicides have on *Rhizoctonia* disease severity.

MATERIALS AND METHODS

Preplant incorporated (PPI) treatments were applied and incorporated with a rototiller to a depth of 2 inches on May 21, 1998. 'Russet Burbank' potato was planted May 22, 1998 and hilled June 6. Pre-emergence (PRE) treatments were applied on June 9 and post-emergence (POST) herbicides were applied June 24, 1998. All herbicides were applied at labeled rates to the center 8 feet of the 12 by 25 feet plots. PPI treatments were applied with a bicycle wheel type plot sprayer, delivering 17 gpa at 40 psi through 8002 flat fan nozzles, while PRE and POST treatments were applied with a CO_2 pressurized backpack sprayer, delivering 17 gpa and 8.5 gpa at 40 psi through 8002 and 8001 flat fan nozzles, respectively. The experiment was a randomized complete block design with three replicates per treatment. Potato plants were evaluated weekly, from June 16 to July 14, for stem and stolon *Rhizoctonia* infection or girdling. Twenty plants were sampled weekly, from each plot, evaluating percent stems and stolons with *Rhizoctonia* and percent stems and stolons girdled.

RESULTS AND DISCUSSION

No potato injury was observed throughout the season. Ratings for the first three weeks did not show an increase in *Rhizoctonia* disease for any treatment reading. It is important to note that POST treatments were not applied until June 24, therefore ratings for these treatment on June 16 and 23 reflect untreated plots. In weeks four (July 7) and five (July 14) significant differences were found. Herbicides which caused an increased severity of *Rhizoctonia* and/or girdling in weeks four and five were: pendimethalin, trifluralin, metolachlor, rimsulfuron, SAN 582, and sethoxydim plus petroleum oil (PO). Trifluralin and pendimethalin applied PPI increased stem *Rhizoctonia* incidence while pendimethalin PRE increased stolon *Rhizoctonia* incidence on July 7. On July 14, pendimethalin PPI increased incidence of stem *Rhizoctonia* and stolon girdling, metolachlor PPI and sethoxydim plus petroleum oil POST increased incidence of stem and stolon girdling, rimsulfuron PRE increased incidence of stolon *Rhizoctonia* and girdling, and SAN 582 PPI and PRE increased incidence of stolon *Rhizoctonia*.

SUMMARY

In summary, no potato injury was observed throughout the season from hilling, herbicides, or environment. Our findings of increased *Rhizoctonia* severity by trifluralin and pendimethalin are similar to those found in other crops by Altman and Rovira in 1989, El-Kahadem and Papavizas in 1984, and Mahound et al. in 1993. Results from one location and one year of data also show increased severity of *Rhizoctonia* from metolachlor, rimsulfuron, SAN 582 and sethoxydim. Results did not show an increased severity of *Rhizoctonia* from EPTC or linuron, in potato, as found, in other crops, by Altman and Rovira in 1989 and Mahound et al. in 1993. Choosing the right herbicide may be an effective measure in reducing *Rhizoctonia* infection in potato, especially in known problem areas and when environmental conditions are favorable.

Table. Rhizoctonia and injury ratings for potato stem and stolons.

		June 16				June 23				June 30				July 7				July 14			
		Stems		Stolons		Stems		Stolons		Stems		Stolons		Stems		Stolons		Stems		Stolons	
Treatment	Rate	R[a]	G[a]	R[a]	G[a]	R[a]	G[a]	R[a]	G[a]	R[a]	G[a]	R[a]	G[a]	R[a]	G[a]	R[a]	G[a]	R[a]	G[a]	R[a]	G[a]
	lb/A	%																			
PPI																					
EPTC	4.4	39	28	3	0	51	19	13	8	67	39	27	22	49	26	16	14	48	34	21	15
Trifluralin	0.75	45	13	3	3	53	30	16	10	68	34	19	19	83	45	31	24	78	39	27	13
Pendimethalin	1.25	23	8	3	3	62	25	13	10	64	41	16	15	83	41	26	19	89	45	23	19
Metolachlor	2	33	15	1	0	67	33	22	19	60	30	24	20	66	24	22	16	78	62	27	23
SAN 582	0.66	30	20	3	3	53	24	9	5	44	37	21	17	46	28	21	18	64	33	31	17
PRE																					
Trifluralin	0.75	40	12	3	3	56	30	14	12	60	28	21	19	60	32	25	24	58	22	14	6
Pendimethalin	1.25	41	27	1	0	56	30	16	13	58	33	24	20	51	27	64	22	61	39	25	16
Metolachlor	1.67	30	18	3	1	52	33	14	11	56	31	20	18	63	34	22	16	74	32	18	12
Linuron	1.25	21	16	1	1	63	30	19	18	58	40	23	21	66	27	46	43	69	44	22	17
Metribuzin	0.75	39	23	2	0	69	45	23	19	63	30	22	18	57	35	23	20	55	42	23	16
Rimsulfuron	0.31	31	25	5	5	61	31	17	13	59	40	20	17	73	41	32	25	77	38	33	21
Meto+metr[b]	2.87+0.63	31	24	6	3	74	33	22	20	64	25	21	18	52	25	18	15	72	41	20	10
SAN 582	0.66	37	26	4	1	50	21	12	11	59	30	18	14	46	28	21	18	64	33	31	17
POST																					
Metribuzin	0.38	20	12	0	0	52	22	6	6	71	43	25	24	70	33	24	21	61	33	17	11
Rims+NIS[c]	0.31+0.25%	35	21	4	4	59	36	17	17	65	38	22	17	56	35	19	15	71	48	23	16
Sethoxydim+PO	0.2 +1 qt	24	24	1	0	58	30	19	17	70	41	25	22	65	37	26	23	78	66	28	20
Untreated		31	10	2	0	59	37	18	16	66	40	31	22	62	31	24	23	67	35	19	8
LSD (0.05)		NS	NS	NS	NS	NS	NS	NS	10	NS	NS	NS	NS	18	NS	22	NS	17	19	11	9

[a] R = with rhizoctonia, G = girdled.
[b] Meto+metr = metolachlor plus metribuzin.
[c] Rims = rimsulfuron.

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

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. Broccoli, cantaloupe, carrot, lettuce, onion, spinach, and processing tomato varieties were screened for tolerance to low-rate herbicides at four locations in California. Postplant preemergence herbicides tested at all locations were: carfentrazone at 0.05 and 0.1, cloransulam at 0.0156 and 0.0312, dimethenamid at 0.94, 1, 1.1 and 1.2, halosulfuron at 0.032 and 0.047, rimsulfuron at 0.0156 and 0.0313 and sulfentrazone at 0.19 and 0.25 lb/A. 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. 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 30 to 60 days after application and crop biomasses were taken at 50 to 60 days after application.

RESULTS AND DISCUSSION

Broccoli was tolerant to sulfentrazone at 0.19 lb/A, and moderately tolerant to carfentrazone at 0.05 and 0.1 lb/A (Table 1). Broccoli was not tolerant to cloransulam, halosulfuron or rimsulfuron at tested rates. Cantaloupe, was tolerant to carfentrazone at 0.05, halosulfuron at 0.032 and sulfentrazone at 0.19 lb/A (Table 1). Crop injury to cantaloupe resulting from cloransulam or rimsulfuron was not acceptable. Carrot was tolerant and moderately tolerant to carfentrazone at 0.05 and 0.1 lb/A, respectively (Table 2). Carrot may be tolerant to sulfentrazone at rates of 0.19 lb/A and less, therefore further work is planned. Carrot did not tolerate cloransulam, halosulfuron, or rimsulfuron. Lettuce was tolerant to carfentrazone at 0.05 and 0.1 lb/A (Table 2). Lettuce did not tolerate cloransulam, dimethenamid, halosulfuron, rimsulfuron or sulfentrazone at tested rates. Onion was tolerant to carfentrazone at 0.05 and 0.1 lb/A or sulfentrazone at rates of 0.19 lb/A (Table 3). Onion was not tolerant to cloransulam, halosulfuron or rimsulfuron. Spinach was tolerant to carfentrazone at 0.05 but not at 0.1 lb/A (Table 3). Spinach injury resulting from cloransulam, halosulfuron, rimsulfuron or sulfentrazone was not acceptable. Tomato was tolerant to carfentrazone at 0.05 and 0.1, halosulfuron at 0.032, or rimsulfuron at 0.016 and 0.032 lb/A and marginally tolerant to sulfentrazone at 0.19 lb/A (Table 4). Tomato was not tolerant to cloransulam. Broccoli, carrot, cantaloupe, onion and tomato tolerance to dimethenamid was not well characterized in 1998 and we plan to continue evaluation of this herbicide in 1999. None of these vegetables were tolerant to cloransulam, and we plan no further work with this herbicide. This work was supported by the USDA Pest Management Alternatives Program.

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

Herbicide	Rate	Broccoli Stand	Broccoli Biomass	Broccoli Injury[a]	Cantaloupe Stand	Cantaloupe Biomass	Cantaloupe Injury[a]
	lb/A	% untreated	% untreated	0 to10	% untreated	% untreated	0 to10
Carfentrazone	0.05	74	99	1.5	99	149	2.9
Carfentrazone	0.10	74	89	0.7	92	138	4.3
Cloransulam	0.016	57	0	9.5	29	0	10
Cloransulam	0.031	43	0	9.5	17	0	10
Dimethenamid	0.94	111	94	3.8	81	74	3
Dimethenamid	1	84	61	6.2	39	--	5.7
Dimethenamid	1.1	57	67	5	41	353	2.5
Dimethenamid	1.2	100	140	1	47	57	1
Halosulfuron	0.032	41	0	9.2	138	169	2
Halosulfuron	0.047	44	0	9.4	81	99	3.7
Rimsulfuron	0.016	53	43	7.6	91	259	5.8
Rimsulfuron	0.031	64	0	9.3	26	2	9.7
Sulfentrazone	0.19	250	290	2.5	106	97	2.4
Sulfentrazone	0.25	52	72	4.3	135	195	6.7
Untreated		100	100	0.1	100	100	1.1

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

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

		Carrot			Lettuce		
Herbicide	Rate	Stand	Biomass	Injury[a]	Stand	Biomass	Injury[a]
	lb/A	—— % untreated ——		0 to10	—— % untreated ——		0 to10
Carfentrazone	0.10	79	92	1.4	93	125	0.4
Cloransulam	0.016	32	2	8.2	45	0	10
Cloransulam	0.031	32	1	9.9	32	0	10
Dimethenamid	0.94	32	10	8.5	27	4	10
Dimethenamid	1	58	--	4.7	0	30	8.9
Dimethenamid	1.1	83	88	3.3	52	83	5.5
Dimethenamid	1.2	28	16	7.5	37	8	9.5
Halosulfuron	0.032	48	11	7	54	6	9.8
Halosulfuron	0.047	67	--	6.1	30	17	8.9
Rimsulfuron	0.016	69	--	4.6	36	16	8.8
Rimsulfuron	0.031	51	22	7	48	0	10
Sulfentrazone	0.19	91	--	0.9	60	80	3.7
Sulfentrazone	0.25	54	99	1.7	13	24	9
Untreated	--	100	100	0.5	100	100	0.6

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

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

		Onion			Spinach		
Herbicide	Rate	Stand	Biomass	Injury[a]	Stand	Biomass	Injury[a]
	lb/A	—— % untreated ——		0 to10	—— % untreated ——		0 to10
Carfentrazone	0.10	102	140	1.4	50	64	4.4
Cloransulam	0.016	91	0	10	30	0	10
Cloransulam	0.031	26	0	10	30	0	10
Dimethenamid	0.94	86	26	4.8	100	136	0
Dimethenamid	1	88	198	4.7	--	27	5.9
Dimethenamid	1.1	--	--	4.5	142	--	0
Dimethenamid	1.2	67	72	4	80	43	2.3
Halosulfuron	0.032	74	0	8.7	20	20	9.7
Halosulfuron	0.047	50	49	6.7	20	13	8.8
Rimsulfuron	0.016	77	90	7.7	27	14	8.2
Rimsulfuron	0.031	49	0	10	60	0	8.8
Sulfentrazone	0.19	107	165	2.5	0	13	7.7
Sulfentrazone	0.25	42	0	8.8	0	0	10
Untreated	--	100	100	1.1	100	100	0.2

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

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

		Tomato		
Herbicide	Rate	Stand	Biomass	Injury[a]
	lb/A	—— % untreated ——		0 to10
Carfentrazone	0.10	113	240	2.4
Cloransulam	0.016	27	0	9.9
Cloransulam	0.031	27	0	10
Dimethenamid	0.94	48	96	3.3
Dimethenamid	1	84	90	4.1
Dimethenamid	1.1	260	270	1
Dimethenamid	1.2	38	78	2
Halosulfuron	0.032	118	114	1.6
Halosulfuron	0.047	84	100	3.2
Rimsulfuron	0.016	130	166	1.3
Rimsulfuron	0.031	113	243	0.4
Sulfentrazone	0.19	79	101	3.9
Sulfentrazone	0.25	79	57	7.2
Untreated	--	100	100	1.2

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

CROPPING SYSTEMS FOR INTENSIVE DESERT VEGETABLE PRODUCTION. Milton E. McGiffen, Jr.[1], Chad Hutchinson[1], Charles Sanchez[2], Jose Aguiar[3], John C. Palumbo[2], Michael Matheron[2], David W. Cudney[1], and Nick Toscano[1], Extension Specialists and Postdoctoral Research Associate, University of California, Riverside, CA 92521; [2]Resident Director and Research Scientists, Yuma Agricultural Center, University of Arizona, Yuma, AZ 85364; and [3]Farm Advisor, University of California Cooperative Extension, Indio, CA 92201.

Abstract. Desert vegetable growers have become increasingly interested in sustainable production systems. Many are attracted by the higher market price commanded by organic produce. Environmental concerns and an interest in enriching the soil have encouraged others to consider incorporating cover crops and related methods into conventional production systems. Cover crops have been used successfully in other crop production areas as both a soil-incorporated green manure and as soil surface mulch for weed control. Desert areas offer unique opportunities for production of heat-tolerant cover crops during the summer before the fall/winter crops are planted. Desert growers recognize this unique opportunity, and have encouraged our research effort by rapidly adopting our suggestions and encouraging further investigation into sustainable desert agricultural systems.

A multidisciplinary team of research and extension personnel from the Universities of Arizona and California has been working with growers to develop organic and other sustainable production systems for the low desert. Current experiments test whether cover crops can be used effectively and beneficially in desert vegetable production systems. Multi-year field experiments in California and Arizona are comparing rotations of sudangrass and cowpea cover crops combined with reduced or conventional tillage in conventional, Integrated Crop Management (ICM), and organic vegetable production systems. All aspects of crop production are being examined, including: yield, economics, pest management, and soil parameters. Our approach has been to integrate several scientific disciplines to produce research results requested by growers, rapidly disseminate the results, and encourage frequent grower input to direct research and extension programs.

Specific objectives include:

1) Evaluate the effectiveness of organic mulches at providing non-chemical weed suppression, optimizing soil temperature regimes, and moderating soil moisture loss in reduced tillage (surface mulch) systems;

2) Evaluate the effectiveness of cover crops at improving soil organic matter, soil structure, and soil fertility in conventional tillage (incorporated) systems;

3) Develop cost studies for desert ICM and organic based vegetable production systems;

4) Disseminate information through intensive contact with Progressive Farmer groups in the low desert (who will also supply input on how to adapt our findings to working farms), and through newsletters, meetings, and websites of organizations interested in sustainable agriculture. Frequent field days and grower meetings will ensure rapid adoption of findings and adaptation of future research projects to better meet grower needs;

5) Adapt previously derived cost studies to compare the costs and net benefits of conventional, organic, and other production methods. Cost comparisons will be prepared for all production systems to aid growers, lending institutions, and others in comparing potential benefits.

A website with updated information may be found at: http://cnas.ucr.edu/~bps/hcoopext.htm.

EFFECTS OF COVER CROPS AND TILLAGE SYSTEM ON WEEDS IN VEGETABLE ROW CROPS. R. Edward Peachey and Ray D. William, Senior Research Assistant and Professor, Department of Horticulture, Carol Mallory-Smith, Assistant Professor, Department of Crop and Soil Science, and Andrew A. Moldenke, Department of Entomology, Oregon State University, Corvallis, OR 97331.

INTRODUCTION

Cultural practices such as soil tillage and fallow season cover cropping are key events in annual row crop production systems that can be used to manage weeds populations (Liebman and Dyck, 1993; Schreiber, 1992; Shilling et al, 1986). Pigweed has become resistant to triazine herbicides which has greatly increased the cost of row crop production in the Pacific Northwest (Suwanagul, 1995). Nightshades are prolific because herbicides typically used in row crops do not provide complete control (Blackshaw, 1991). The objectives of this research were to determine the effects of cover crop practices and tillage rotational strategies on summer annual weed communities including pigweed and nightshade.

MATERIALS AND METHODS

Two sets of experiments were conducted at the Oregon State University Vegetable Research Farm in the Willamette Valley of Western Oregon on a silty clay loam soil. In the first field experiment, we evaluated the effect of cover crops and spring soil disturbance on weed emergence in sweet corn. Cover crops of spring barley, spring oat, rye and mustard were planted in the fall and killed in the spring with glyphosate in three years on the same plots. Half of each cover crop plot was tilled in the spring while the remaining portion of each cover crop plot was left undisturbed creating a strip-plot arrangement with cover crop and spring tillage as main effects. Sweet corn was planted with a Cross-slot®, notill planter (Saxton, 1990) in mid-June in each of three years. Emerged weeds were counted at 4 to 6 weeks after planting (WAP). Atrazine and nicosulfuron were applied at 6 WAP to control weeds and reduce the potential of recharging the soil seed bank.

In the second set of experiments, we evaluated the effect of tillage rotational strategies on weed emergence and crop yield. Four tillage rotation treatments were imposed on a cropping rotation of snap beans, followed by fall tillage and cover crop planting, sweet corn, fall tillage and winter wheat, and then snap beans. In the spring preceding snap beans and sweet corn planting, specific plots were disked and tilled or remained undisturbed, depending on the tillage rotation treatment (Table 1). These treatments are designated ST (spring tilled before the vegetable crop was planted) and NST (no spring tillage before planting). Subplots within each tillage rotation included three levels of weed management intensity. Snap beans and sweet corn were planted with a cross-slot notill planter into both conventionally tilled and undisturbed seedbeds. The entire rotation was replicated twice with the crop rotation of the second replication out of phase by 1 year. Soil samples (10 cm in diameter by 3.8 cm in depth) were taken from each plot before and after tillage in the spring. Seeds were extracted from the soil using the method described by Malone (1967).

RESULTS AND DISCUSSION

Experiment one. Weed emergence was greatest where the soil was tilled in the spring (ST) and the cover crops incorporated (Table 2). Eliminating spring tillage (NST treatments) reduced pigweed and nightshade emergence by 77 and 97 percent respectively.

Within the untilled plots, increasing cover crop biomass tended to reduce weed emergence (Table 2, Figure 1). The effect was most noticeable with nightshade, as all cover crops had less nightshade emergence than the fallow treatment. However, only the rye cover crop suppressed pigweed emergence compared to the fallow treatment, and this level of cover crop residue would be very difficult to manage in Western Oregon.

Cover crop species had less influence than tillage system on weed emergence (Table 2, Figure 1). In the spring-tilled system, pigweed emergence tended to increase as cover crop biomass increased. The exception was the rye cover crop that had the same pigweed emergence as the fallow treatment. A similar trend was noted with nightshade.

Experiment two. In the first year (1997) of the tillage rotation study of snap beans, spring soil disturbance significantly increased emergence of both pigweed and nightshade (Table 3). Pigweed emergence with the low rate of metolachlor and lactofen was less in the NST treatments than ST treatments at the same level of herbicide. The effect on nightshade was nearly the same.

Soil seedbank analysis indicated that differences in weed emergence between the ST and NST treatments were not caused by changes in seed position during tillage. The percent of pigweed and nightshade seeds that emerged was 91 and 99% less in NST than ST treatments, respectively (Table 3).

In the second year (1998) of the tillage rotation study, both pigweed and nightshade emergence was significantly lower in NST-ST or ST-NST treatments than in ST-ST treatments, with or without herbicides. Pigweed and nightshade responded differently to the tillage rotations. Pigweed emergence was greatest when the soil was tilled before snap beans; nightshade emergence was greatest when the soil was tilled before corn planting. Even though weed emergence was least in the NST-NST treatment, neither pigweed nor nightshade emergence in this treatment differed from NST-ST or ST-NST treatments.

SUMMARY

Spring tillage was the most important factor regulating weed emergence in both experiments, reducing pigweed and nightshade emergence by 77 and 97 percent, respectively. Weed seed distribution during tillage, though important for pigweed (data not included), did not account for the differences in emergence between ST and NST treatments.

Eliminating spring tillage in one of two years in a row crop system significantly reduced pigweed and nightshade emergence. Additionally, pigweed and nightshade emergence in the NST-ST or ST-NST treatments was less than or equal to the ST-ST treatment, but with only half of the herbicide use.

These results demonstrate that tillage rotations may effectively reduce pigweed and nightshade populations in row crop systems. Tillage rotations also may reduce herbicide use without sacrificing pigweed and nightshade control. Challenges can be expected with these systems, however, including increased slug damage and greater variability of crop stand establishment in the year that spring tillage is eliminated. Additionally, important pigweed and nightshade population shifts occurred in these trials within two years due to tillage practice and weed management level. Population shifts can be expected with other weed species or soil organisms that are adapted to untilled spring soils, possibly nullifying gains made in reducing summer annual weed populations such as nightshade and pigweed.

Table 1. Tillage rotation treatments for experiment two.

	Year 1		Year 2		Year 3		Year 4	
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
	Crop							
Tillage treatment[a]	Snap beans	Winter cover crop	Sweet corn	Winter wheat	Winter wheat	Wheat residue	Snap beans	Winter cover crop
	Primary tillage sequence[b]							
ST-ST	+	+[c]	+	+	+	-	+	+
NST-ST	-	+	+	+	+	-	-	+
ST-NST	+	+	-	+	-	-	-	+
NST-NST	-	+	-	+	-	-	-	+

[a] ST = spring tilled; NST = no spring tillage.

[b] (+) primary tillage before planting sweet corn, snap beans, wheat or cover crop; usually disking twice followed by vertical tine rototiller. (-) primary tillage excluded before crops were planted.

[c] Tillage includes sub-soiling before cover crop planting in the fall of the year before sweet corn.

Table 2. Effect of cover crops and spring tillage on weed emergence in sweet corn 4 weeks after planting.

		Weed emergence					
		1995		1996		1997	
Cover crop	Tillage[a]	Pigweed	Nightshade	Pigweed	Nightshade	Pigweed	Nightshade
		No./m^2					
Barley	NST	20	1	2	7	0	1
Barley	ST	106	33	5	25	5	77
Mustard	NST	44	0	-	-	0	1
Mustard	ST	78	44	-	-	5	60
Oats	NST	15	0	2	0	1	1
Oats	ST	132	99	8	20	6	57
Rye	NST	5	0	1	2	1	0
Rye	ST	80	69	5	16	6	72
Fallow	NST	21	7	3	6	0	0
Fallow	ST	79	47	9	27	9	81
Anova (p value)							
Cover crop		0.87	0.30	0.80	0.05	0.89	0.59
Tillage		0.08	0.005	0.04	0.0001	0.03	0.001
Cover crop x tillage		0.61	0.23	0.78	0.42	0.81	0.06

[a] ST = spring tilled; NST = no spring tillage.

Table 3. Tillage effects on weed emergence and percent of weed seeds in the soil that emerged in the first year (1997) of the tillage rotation study.

	Herbicide and rate			Pigweed		Nightshade	
Tillage[a]	Metolachlor	Lactofen	Plots		Seedbank emergence[c]		Seedbank emergence
	lb/A		No.	No./m^2	%	No./m^2	%
NST	0	0	16	0.9 b[b]	0.4 b	0.4 b	0.1 b
NST	1	0.125	16	0 b	0 b	0 b	0 b
NST	2	0.1875	15	0.0 b	0.0 b	0.2 b	0.1 b
ST	0	0	16	6.9 a	4.9 a	87.6 a	10.2 a
ST	1	0.125	16	0.2 b	0.1 b	0.9 b	0.3 b
ST	2	0.1875	16	0 b	0 b	0.1 b	0 b

[a] ST = spring tilled; NST = no spring tillage.

[b] Numbers in the same column followed by the same letter do not differ statistically ($p=0.05$).

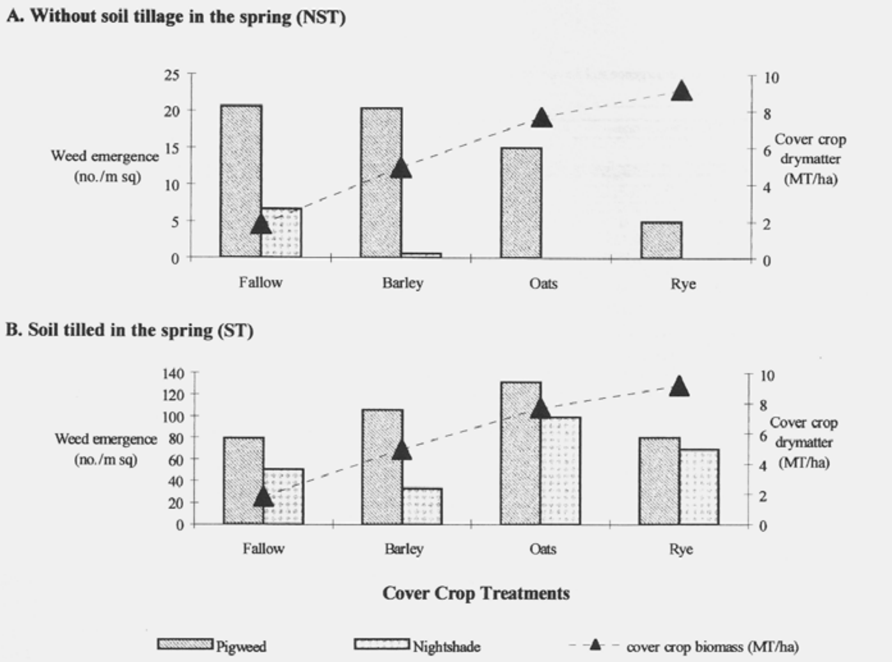
[c] Percent of weed seeds of soil seedbank that emerged at 4 WAP sweet corn accounting for changes in seed distribution during tillage.

Table 4. Effect of tillage rotations on weed emergence in the corn (second year) of a snap bean, corn, and wheat rotation.

Tillage rotation	Metolachlor rate	Plots	Pigweed	Nightshade	Annual bluegrass	Barnyard-grass	Purslane	Sow-thistle	Total
	lb/A	No.	No./m^2						
ST beans-ST corn[a]	0	8	78 a	119 a	9	2	1	0 c	208 a
ST beans-ST corn	1	8	4 cd	12 bcd	0	0	0	0 c	16 cde
ST beans-ST corn	2	8	1 d[b]	16 b	0	0	0	0 c	17 cd
NST beans-ST corn	0	8	14 c	17 bc	3	2	6	19 a	62 b
NST beans-ST corn	1	8	1 d	8 cdef	0	0	0	3 b	12 cdef
NST beans-ST corn	2	8	1 d	9 cde	0	0	0	1 bc	11 def
ST beans-NST corn	0	8	31 b	2.5 efg	0	0	1	0 c	35 c
ST beans-NST corn	1	8	0.1 d	0.5 g	0	0	0	0 c	1 h
ST beans-NST corn	2	8	0 c	0.3 g	0	0	0	0 c	0.5 h
NST beans-NST corn	0	8	5.1 cd	0.5 g	0	0	1	0 c	7 fgh
NST beans-NST corn	1	8	1.1 cd	0 g	0	0	0	1 c	2 gh
NST beans-NST corn	2	8	0 d	0 g	0	0	0	0 c	0 h

[a] ST = spring tilled; NST = no spring tillage.

[b] Values in the same column followed by the same letter do not differ statistically.



A. Without soil tillage in the spring (NST)

B. Soil tilled in the spring (ST)

Figure 1. Cover crop effects on pigweed and nightshade emergence in soils that were untilled (A) or tilled (B) in the spring before sweet corn was planted.

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THE EFFECTS OF PRE-EMERGENCE APPLICATIONS OF SULFENTRAZONE HERBICIDE AND PERENNIAL RYEGRASS OVERSEEDING OF *POA ANNUA* INFESTATION OF WINTER TURF UNDER DESERT CONDITIONS.

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INTRODUCTION

A field test was conducted to evaluate the herbicide sulfentrazone for pre-emergence efficiency for annual bluegrass (*Poa annua)* control, at the time of overseeding bermudagrass with perennial ryegrass in the fall. Six rates of sulfentrazone, 0.125, 0.187, 0.25, 0.375, 0.5 and 0.625 lb/A, were applied to both non-overseeded and overseeded bermudagrass turf in September 1997. The turf was overseeded on October 3, at the rate of 18 lb/A seed/acre. Sulfentrazone was applied on September 30. Plots were evaluated for initial ryegrass establishment and turfgrass visual quality for two months after emergence. *Poa annua* control was evaluated on six dates from November 1997 to May 1998. Experimental design was a split plot (overseeding as the main plot and herbicide rates as the subplot) with eight replications. Visual estimates of percent *Poa annua* were assigned to all plots, including overseed only and non-overseed only controls, and used for an initial analysis of variance technique. Means of two control plots/replication were used to analyze treatment control effects in each rep. Percent weed control was calculated for overseeded turf, using an "overseed only" control, while percent weed control for non-overseeded turf used the values of the "non-overseed only" control.

RESULTS AND DISCUSSION

Turf Establishment. Ryegrass establishment (as % plot ryegrass) was affected by sulfentrazone applications on October 31 and November 17, but not by or afterwards on December 18. On the first evaluation date, mean percent ryegrass stand ranged between 55 to 58% for the 0.378, 0.5 and 0.625 lb/A rates, while the overseed-only control had a mean of 76%. By November 17, all plots had 95% or greater turf stand of perennial ryegrass, except for the sulfentrazone treatments of 0.5 and 0.625 lb/A, which had roughly 92% cover. By December 1997, all plots were similar in ryegrass stand (93 to 97%) (data not shown).

***Poa annua* Control**. *Poa annua* ratings were assigned to all plots on six dates from November 1997 through May 1998. For November and December 1997 (early season control), there was a significant affect of overseeding with perennial ryegrass, as well as from that of sulfentrazone. there was no interaction of the two. For November and December ratings, the *Poa annua* could not be detected within the overseed turf, but could be identified in the non-overseed (dormant bermudagrass) turf. The main effect of overseeding practice showed that non-overseeded plots (averaged over all herbicide rates) had mean plot scores of 8 and 37% weed infestation levels on November and December, respectively (Table 2).

Annual bluegrass control was determined in November and December among non-overseeded plots only, since the weed could not be identified within the overseeded plots at that time. For December and November, percent control of Poa ranged from 7 to 74% among sulfentrazone treated bermudagrass (non-overseeded) turf. Sulfentrazone at the highest rate of 0.625 lb/A provided 74 and 68% control in November and December, respectively. Rates less than this were inconsistent for Poa control and ranged from 7 to 40% from 0.125 to 0.5 lb/A across both of these months (Table 1).

For the months of January and March 1998, there was significant main effects for the herbicide and the overseed (turf surface), with no interaction of the two. For the months of April and May, only the overseed (turf surface) main effect was significant. The overall effect of herbicide (sulfentrazone) and the herbicide x overseed interaction were both nonsignificant. This demonstrated lack of late season control of *Poa annua*, regardless of the overseeding effect and that physical overseeding (addition or perennial ryegrass) had a large affect on suppression of *Poa annua*.

When averaged over all herbicide rates, non-overseeded turf (dormant bermudagrass) had 65 and 80% percent weed infestation, while overseeded turfs had 10% weed infestation in both January and March 1998, respectively (Table 2).

When averaged across both turf surfaces, percent *Poa* infestation ranged from 24 to 41% control and from 35 to 49% control in January and March, respectively. The highest rate of sulfentrazone at 0.625 lb/A had the least amount of actual infestation (25 and 35% in January and March, respectively), but these levels would be inadequate for acceptable commercial performance.

For non-overseeded turf (dormant bermudagrass only), percent weed control ranged from 10 to 45% for January and from 1 to 20% in March, respectively. Sulfentrazone at rates at less than 0.625 lb/A were inconsistent for rate response. Again, percent control at the highest rate tested 0.625 lb/A was inadequate for commercial acceptability.

Among overseeded turf (perennial ryegrass), percent weed control ranged from 0 to 59% in both January and March 1998. Percent control here was based on the overseeded/no herbicide plot means as the correct background control. Again, adequate weed control was not achieved, even when overseeding competition was added from the perennial ryegrass overseeding.

For the final two evaluations, only the overseeding practice effect was significant for actual plot weed infestation levels (April and May 1998). When averaged overall herbicide treatment levels, percent turf infested with *Poa* was 70 and 53% for non-overseeded turf and 16 and 9% for overseeded (perennial ryegrass) turf in April and May, respectively (Table 2). Among sulfentrazone treated plots, percent plot infestation levels ranged from 40 to 46% weed cover in April, and from 27 to 33% weed cover in May. April would be peak expression for Poa and after flowering would decline in May.

Among non-overseeded turf (dormant bermudagrass), percent weed control ranged from 0 to only 6% for sulfentrazone treated plots in April and from 0 to 19% in May (Table 2). Again, the herbicide main effect was not significant. Among overseeded (perennial ryegrass) turf, percent weed control ranged from 0 to a maximum of 59% for sulfentrazone at the 0.625 lb/A rate in April, and from 0 to 36% in May. The response was not rate dependent at rates less than 0.5 lb/A

Interaction means for the actual amounts of *Poa annua* infestation levels listed in Table 2 show the effect that overseeding had on actual infestation levels of percent plot annua. While the highest applied rate of sulfentrazone (0.625 lb/A) had the least amount of weeds, these levels would not be acceptable for commercial use. These results are the extension of including both non-overseed (dormant bermudagrass) and overseeded (perennial ryegrass) turfs with herbicide treatments (with respective controls).

Previous studies on this site in 1996 to 1997 were performed on overseeded plots only, where non-overseeded areas on plot borders showed mixed results. Therefore, it was decided to proceed with the treatment structure incorporated here. In the 1996 to 1997 test, percent *Poa annua* control was greater, when all plots were overseeded. It should also be noted that weed pressure was greater in 1997 to 1998.

Poa annua is notorious for competition with desirable turfgrass species, especially when mowed closely, irrigated and fertilized regularly. While competition from ryegrass was noticeably demonstrated here, the increased actual amounts of *Poa annua* in dormant bermudagrass was not offset by sulfentrazone alone, nor was sulfentrazone effective with overseeding for control/suppression of *Poa annua* in winter turfs at any rate below 0.625 lb/A.

Table 1. Mean percent plot *Poa annua* percentages[a] for the main effect of overseeding practice. University of Arizona, 1997 to 1998.

		Poa annua					
Main effect	Level	Nov. 1997[b]	Dec. 1997[b]	Jan. 1998	Mar. 1998	Apr. 1998	May 1998
		%					
Overseed[c]	yes	NT[d]	NT[4]	10^{B}	10^{B}	16^{B}	9^{B}
	no	8	32	65^{A}	81^{A}	70^{A}	53^{A}

[a] Percent plot weed infestation of *Poa annua* (0 to 100%). Values are mean of 8 replications, and are averaged over all sulfentrazone herbicide application treatments. Letters denote statistical difference between treatments, DNMR test, P=0.05.

[b] No visible *Poa* in overseeded (perennial ryegrass) plots in November and December 1997.

[c] Overseeding practice. Yes = overseeded with perennial ryegrass. No = dormant bermudagrass.

[d] Non detectable.

Table 2. Percent plot *Poa annua*[a] and percent weed control[b] of overseeded[c] and non-overseeded turfgrass after treatments of sulfentrazone[d]. University of Arizona, 1997 to 1998. Percent *Poa annua* plot cover, followed by % weed control.

Turf composition	Herbicide rate	*Poa annual* plot cover (weed control)					
		Nov. 1997	Dec. 1997	Jan. 1998	Mar. 1998	Apr. 1998	May 1998
	lb/A	% (%)					
Non-overseed	0	15 --	43 --	80 --	89 --	73 --	57 --
Overseed	0	0 --	0 --	14 --	14 --	20 --	9 --
Non-overseed	0.125	7 (49)	24 (40)	57 (30)	74 (17)	70 (5)	46 (19)
Overseed	0.125	0 (0)	0 (0)	11 (19)	10 (34)	17 (0)	10 (0)
Non-overseed	0.187	8 (28)	36 (13)	70 (11)	88 (0)	74 (0)	56 (0)
Overseed	0.187	0 (0)	0 (0)	11 (0)	11 (0)	14 (4)	9 (1)
Non-overseed	0.25	9 (35)	35 (22)	69 (14)	80 (10)	71 (3)	51 (10)
Overseed	0.25	0 (0)	0 (0)	10 (21)	8 (29)	16 (0)	8 (23)
Non-overseed	0.375	13 (19)	39 (8)	70 (11)	88 (1)	70 (3)	52 (7)
Overseed	0.375	0 (0)	0 (0)	11 (30)	12 (5)	16 (0)	10 (13)
Non-overseed	0.5	6 (60)	33 (25)	66 (16)	80 (9)	69 (5)	57 (2)
Overseed	0.5	0 (0)	0 (0)	9 (25)	7 (22)	16 (18)	9 (0)
Non-overseed	0.625	2 (73)	13 (68)	45 (45)	66 (26)	68 (6)	47 (15)
Overseed	0.625	0 (0)	0 (0)	5 (57)	5 (59)	11 (36)	7 (12)
Test Mean[e]	% Plot Poa	4	16	38	45	43	31
Test Mean	% Control overseed only[b]	NA[g]	NA	25	19	2	6
LSD Value	% Control overseed only[b]	NA	NA	NS	NS	NS	NS
Test Mean	% Control non-overseed[b]	44	29	21	11	3	9
LSD Value[f]	% Control non-overseed[b]	NS	NS	26	16	NS	NS

[a] Percent plot of *Poa annua* , 0 to 100%. Values are the mean of eight replications.

[b] Percent weed control for overseed plots = (1-TRT/REP control mean of overseeded turf) *100. Percent weed control for non-overseeded turf = (1-TRT/REP control mean of non-overseed turf) *100.

[c] Turf overseeded on September 30, 1997, seeding rate of 18 lb/1000 ft^2.

[d] Sulfentrazone applied on October 3, 1997.

[e] Mean of all treatments on each date for % plot *Poa* infestation (0 to 100%).

[f] LSD value = least significant difference mean separation statistic.

[g] NA = Not applicable. Overseed plots with no visible *Poa*, November and December 1997.

OPTIONS FOR PREEMERGENCE AND POSTEMERGENCE WEED CONTROL IN DESERT ONION PRODUCTION.

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Abstract. Nine different herbicides were evaluated when applied preemergence alone or in combinations in a series of field tests conducted during 1997 to 1998. Minimal crop injury was observed from treatments that included pendimethalin, propachlor, metolachlor, dimethenamid, ethofumesate, and bensulide. Higher rates tested of pendimethalin, metolachlor, dimethenamid, and bensulide as well as lactofen and thiazopyr were phytotoxic to the onions. Pendimethalin caused greater crop injury under sprinkler irrigation compared to furrow irrigation. Metolachlor and dimethenamid caused more onion injury with furrow irrigation than under sprinkler irrigation. London rocket, sowthistle, and common mallow were adequately controlled by many of the treatments but yellow sweetclover escaped most of the preemergence treatments. Early applications of bromoxynil at rates as low as 0.063 lb/A reduced sweetclover compared to the untreated. Onions treated at the one true leaf stage plus the flag leaf did not exhibit significant injury. Oxyfluorfen applied at 0.063 lb/A to 1-leaf onions did not cause significant crop injury. More injury was observed for postemergence applications when the highest label rates were applied when onions were at the recommended 2-leaf stage of growth. Larger weeds were not adequately controlled by the later applications. Lactofen at 0.125 lb/A was comparable to oxyfluorfen when applied postemergence. Sulfentrazone applied postemergence did not offer acceptable weed control but was safe on onions.

AGRONOMIC CROPS

IMAZAMOX COMBINATIONS FOR WEED CONTROL DURING ESTABLISHMENT OF ALFALFA GROWN FOR SEED.

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Abstract. Weed control during alfalfa establishment is critical for the production of weed free alfalfa seed. Losses due to weeds include both reduced yields from competition and contamination by weed seeds. The recent loss of 2,4-DB ester has limited the herbicide options available for alfalfa seed producers. Additionally, high temperatures during establishment can further restrict the herbicides that can be used without injury to the alfalfa crop. Imazamox and other herbicides offer the potential to control weeds during alfalfa seed crop establishment with minimal crop injury. A trial was initiated to evaluate imazamox, imazethapyr, 2,4-DB amine, bentazon, bromoxynil, and pyridate alone and in combinations for weed control and crop tolerance in establishment of alfalfa grown for seed. All treatments were compared to 2,4-DB ester. The predominant weed species present was hairy nightshade with low populations of common lambsquarters and kochia. Herbicide treatments were applied with a CO_2 pressurized backpack sprayer calibrated to deliver 20 gpa at 30 psi. The study was a randomized complete block design with three replications. Herbicide treatments were applied May 6, 1998. Temperatures were greater than 27 C for several days following the applications resulting in severe alfalfa injury by some treatments. Bromoxynil alone caused significant alfalfa injury and increased injury with other herbicides when applied in a tank mixture. Imazamox combinations with bromoxynil or 2,4-DB generally increased alfalfa injury compared to imazamox applied alone. Imazamox at 0.063 lb/A injured alfalfa more than any other rate of imazamox applied alone. Combinations of imazamox (0.032 lb/A) with pyridate or bentazon also resulted in increased injury. While bentazon alone was not very injurious, combinations of any other herbicide with bentazon resulted in severe injury. Imazamox alone and tank mixtures containing imazamox provided better control of hairy nightshade than bentazon, bromoxynil, 2,4-DB, and 2,4-DB ester. A few treatments containing pyridate provided control similar to treatments containing imazamox. Common lambsquarters control was similar among most treatments except bentazon alone provided almost no control. Kochia control was poorest with bentazon, 2,4-DB, and 2,4-DB ester all applied alone. Alfalfa seed yields were variable and bentazon applied alone was the only treatment that did not increase yields in comparison to the untreated check.

Table. Alfalfa injury, weed control, and alfalfa seed yield with postemergence herbicide combinations, 1998.

Treatment[a]	Rate	Alfalfa injury May14, 1998	Alfalfa injury May 27, 1998	Alfalfa injury June 16, 1998	Alfalfa injury June 30, 1998	Weed control[b] SOLSA	Weed control[b] CHEAL	Weed control[b] KOCSC	Alfalfa seed yield[b]
	lb/A	%							lb/A
Imazamox	0.024	7	3	3	5	92	80	83	579
Imazamox + bromoxynil	0.024 + 0.25	43	48	35	25	90	95	90	515
imazamox + 2,4-DB	0.024 + 0.5	30	62	17	27	93	92	95	454
Imazamox	0.032	10	10	2	7	93	87	92	555
Imazamox + bromoxynil	0.032 + 0.25	45	42	28	23	92	93	95	579
Imazamox + 2,4-DB	0.032 + 0.5	47	77	48	43	88	90	90	518
Imazamox	0.04	22	27	23	30	93	88	95	569
Imazamox + bromoxynil	0.04 + 0.25	38	35	42	37	92	93	90	645
Imazamox + 2,4-DB	0.04 + 0.5	25	38	37	30	92	87	95	476
Imazamox	0.048	17	30	15	15	93	85	95	559
Imazamox	0.063	25	60	62	53	95	92	95	484
2,4-DB	0.5	7	0	3	8	43	92	58	468
Bromoxynil	0.25	28	47	13	30	63	90	95	498
2,4-DB ester	0.5	7	3	2	3	65	85	55	513
2,4-DB + bromoxynil	0.5 + 0.25	58	52	25	33	62	87	95	444
Pyridate	0.94	13	12	3	8	82	90	95	556
2,4-DB + pyridate	0.5 + 0.94	23	18	7	13	88	95	95	610
Imazamox + pyridate	0.032 + 0.94	25	28	33	25	95	95	95	580
Bentazon	1	10	3	5	23	60	3	30	353
Imazamox + bentazon	0.032 + 1	53	58	48	42	93	92	95	523
Bentazon + pyridate	1 + 0.94	50	48	52	43	70	92	95	519
Bentazon + 2,4-DB	1 + 0.5	30	23	10	27	63	75	88	515
Bentazon + bromoxynil	1 + 0.25	50	52	22	43	50	90	95	418
Pyridate + bromoxynil	0.94 + 0.25	60	63	48	45	68	95	95	448
Imazethapyr	0.063	5	15	5	5	95	87	95	613
Imazethapyr + bromoxynil	0.063 + 0.25	23	25	18	15	95	95	95	658
Untreated		0	0	0	0	0	0	0	197
LSD (0.05)		15	17	21	20	14	9	25	162

[a] NIS (0.25% v/v) and 32% nitrogen solution (1% v/v) were added to all treatments containing imazamox or imazethapyr. Treatments were applied May 6.

[b] Weed control ratings taken June 16. Alfalfa seed harvested September.

THE USE OF NORFLURAZON FOR PURPLE NUTSEDGE CONTROL IN ALFALFA. William B. McCloskey[1] and Timothy Knowles[2], Associate Specialist and Assistant Agent, [1]Department of Plant Sciences, University of Arizona, Tucson, AZ 85721 and [2]La Paz County Cooperative Extension, University of Arizona, Parker, AZ 85344.

Abstract. Purple nutsedge is difficult to control in established alfalfa stands. EPTC granules applied just before irrigation can suppress purple nutsedge in established alfalfa when treatment is initiated prior to emergence of nutsedge shoots in the spring and if multiple treatments are made each season. Although nutsedge foliage in the hay can be reduced by multiple eptam applications, in many situations the number of nutsedge shoots per unit area may continue to increase (Tickes, B; 1991; Eptam granules for nutsedge control in established alfalfa; Yuma County Farm Notes; September 1991; University of Arizona Cooperative Extension; Yuma, AZ). Thus, Eptam treatments must be continued for more than one season and probably for the life of the alfalfa stand to maintain suppression of purple nutsedge. The necessity for repeated EPTC treatments and the lack of long-term reductions in purple nutsedge populations in alfalfa fields prompted the investigation of alternative control methods.

A 2 year norflurazon application program was initiated in the spring of 1996 in 2 yr old 'CUF 101' alfalfa that had about 61 to 74% purple nutsedge ground cover within the alfalfa stand. The soil where the experiments were conducted was a Gilman loam that contained 2.03% organic matter, 44% sand, 62% silt, and 18% clay. Norflurazon formulated as a 5% sand granule (Zorial 5G) was applied in spring 1996 and 1997 at application rates of 1, 1.5, 2, and 3 lb/A. The herbicide granules were applied using a ground driven Valmar granule applicator and the field was irrigated a day or two after application to incorporate the herbicide. Split applications were made each summer in four of eight treatments for total annual norflurazon rates of 2, 3, and 4 lb/A-year. Purple nutsedge control in the fall of 1996 was marginal at all rates in all treatments after one or two applications of norflurazon. However, two annual norflurazon granule applications during April and August of 1996, and March and June of 1997 at total rates of 3 to 4 lb/A-year provided good purple nutsedge control in established alfalfa in 1997 with the split applications providing the best control (Table 1). The 2 lb/A-year treatment applied in split applications also provided suppression of purple nutsedge but the reduction in population levels was not as good as at the higher rates (Table 1). The alfalfa did not exhibit norflurazon injury symptoms in any of the treatments. In the fall of 1997, each plot was divided into two subplots. One set of subplots was disced twice and replanted with alfalfa. Alfalfa planted into these subplots was not affected by the residual soil concentrations of norflurazon. In the other set of undisturbed subplots, the residual soil concentrations of norflurazon continued to provide substantial suppression of purple nutsedge in 1998. However, by August 1998, the 3 lb/A-year (1.5 + 1.5) rate only provided marginal to fair nutsedge suppression (51%), while the 4 lb/A-year (2 + 2) rate still provided satisfactory suppression (75%). At rates of 2 lb/A-year or less, the residual effects of norflurazon declined to low levels in 1998 and did not keep purple nutsedge population levels from rebounding to pretreatment levels.

Alfalfa fields are typically planted in the fall (October and November) in Arizona. The current norflurazon granule label indicates that norflurazon should not be applied to seedling alfalfa until five months after planting. However, depending on weather patterns, purple nutsedge frequently emerges in February before the alfalfa is five months old. Therefore, a second experiment was conducted in the spring of 1998 to evaluate the tolerance of seedling alfalfa to norflurazon applied at planting (0) or 6, 14, or 20 weeks after planting. At each application time, rates of 0, 1.5, 2, 3, or 4 lb/A of norflurazon were applied using a ground driven Valmar granule applicator. All norflurazon rates applied at planting substantially reduced alfalfa populations (Table 2). Norflurazon at rates ranging from 1.5 to 4 lb/A applied at 6, 14, and 20 weeks after planting did not result in observable herbicide injury symptoms on the alfalfa and did not effect alfalfa seedling emergence and stand establishment. These applications also did not reduce the fresh weight of alfalfa foliage harvested on July 1, 1998.

Table 1. Experiment 1. Effect of residual norflurazon on purple nutsedge control in 1997 to 1998 in a Parker Valley alfalfa field. The first 1997 norflurazon treatments were applied on March 6, 1997 and the second part of the split application treatments were applied on June17, 1997.

		Purple nutsedge control[a]				
Treatment	Rate	Sept. 11, 1997	Oct. 13, 1997	May 30, 1998	July 6, 1998	Aug. 7, 1998
	lb/A	%				
Untreated	-	0 d	0 f	0 e	0 d	0 e
Norflurazon	1 + 1	61 bcd	50 cde	38 bc	34 cd	24 cd
Norflurazon	1.5	46 d	36 e	19 d	16 e	15 de
Norflurazon	1.5+ 1.5	81 ab	74 b	68 a	63 b	51 b
Norflurazon	2	49 d	45 de	23 cd	25 de	24 cd
Norflurazon	2 + 2	92 a	89 a	83 a	83 a	75 a
Norflurazon	3	71 abc	64bc	46 b	43 c	36 bc
Norflurazon[b]	2 + 1	59 cd	53 cd	39 bc	38 cd	30 cd

[a] Data are means of four blocks; means within a column followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's Multiple Range Test.

[b] The initial norflurazon application in this treatment was 2 lb/A of Zorial Rapid 80 applied on April 30, 1996. Most of the Zorial Rapid 80 was intercepted by purple nutsedge foliage and not the soil. Thus, the norflurazon was not incorporated by the irrigation following application and poor control was initially obtained. Therefore, the granular norflurazon formulation was used for all subsequent applications.

Table 2. Alfalfa plant stand counts for various dates and fresh weights harvested on July 1, 1998.

Norflurazon application date	Application rate	Alfalfa stand counts[a]				Alfalfa fresh weight[b]
		Dec.4, 1997	Dec. 30, 1997	Jan. 21, 1998	Apr. 2, 1998	
WAP[c]	lb/A	plants/ft^2				(lb/plot)
0	0	31.7 a	17.8 a	-	15.6 a	-
	29.8	12.9 b	6.4 b	-	8.0 b	-
	40.1	10.9 b	5.6 b	-	8.0 b	-
	59.1	9.7 b	3.5 bc	-	7.3 bc	-
	80.3	4.8 c	2.1 c	-	4.2 c	-
6.4	0	-	14.3 a	18.4 a	18.2 a	161 a
	29.2	-	12.4 a	19.3 a	18.1 a	162 a
	39.2	-	13.8 a	20.9 a	19.5 a	178 a
	58.7	-	13.0 a	19.9 a	19.1 a	167 a
	78.1	-	13.1 a	22.4 a	19.8 a	183 a
13.7	0	-	-	-	18.9 b	201 a
	30.6	-	-	-	21.1 a	197 a
	41.1	-	-	-	19.7 ab	195 a
	61.2	-	-	-	20.6 a	186 a
	82.2	-	-	-	19.9 ab	197 a
20.4	0	-	-	-	18.8 a	176 a
	30.6	-	-	-	21.2 a	170 a
	41.1	-	-	-	21.2 a	166 a
	61.2	-	-	-	20.7 a	177 a
	82.2	-	-	-	20.2 a	175 a

[a] Data are means of four plots with three or four 0.25 m^2 subsamples per plot. Means within an experiment (i.e., WAP application time) within columns followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's Multiple Range Test.
[b] Data are means standardized to 600 sq ft per plot. Means within an experiment (i.e., WAP application time) within columns followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's Multiple Range Test.
[c] WAP = Weeks after planting.

IMAZAMOX FOR WEED CONTROL IN SEEDLING ALFALFA GROWN WITH A NURSE CROP.

Stephen D. Miller, Stephen M. Van Vleet, and Paul J. Ogg, Professor and Research Associate, Department of Plant Sciences, University of Wyoming, Laramie, WY 82071 and Senior Scientist, American Cyanamid, Longmont, CO 80501.

Abstract. Weeds compete with alfalfa for moisture nutrients and light reducing crop yields and shortening stand life. A stand thinned by weed competition in its first growing season may never achieve its full yield potential. Many alfalfa producers in Wyoming prefer to seed alfalfa in the spring with a nurse or companion crop (normally a small grain) to control weeds and to minimize soil crusting and soil erosion. However, small grain seedlings compete with alfalfa much the same as grassy weeds. The loss in alfalfa production the first year from competition with the small grain nurse crop can never be regained. Studies were conducted at three irrigated sites in Southeast Wyoming during 1997 and 1998 to compare weed control and nurse crop removal with imazamox and imazethapyr in seedling alfalfa. In addition, the influence of additives on weed control and alfalfa tolerance with imazamox was also evaluated at these sites. Plots were 9 by 30 feet, arranged in a randomized complete block design and replicated three times in all trials. All treatments were applied with a CO_2 pressurized knapsack sprayer delivering 20 gpa at 40 psi.

Imazamox was more effective than imazethapyr for removal of nurse crops from seedling alfalfa. Further, imazamox provided 10 to 15% better control of common lambsquarters, field sandbur and downy brome than imazethapyr. Control of other weed species was similar with both herbicides. Weed control and alfalfa tolerance with imazamox was influenced by additive. Imazamox treatments containing methylated sunflower oil and aqueous nitrogen provided the greatest weed control, but also increased alfalfa injury.

WEED CONTROL BY CUTTING AND/OR IMAZAMOX IN SEEDLING ESTABLISHMENT OF ALFALFA FOR FORAGE. M. R. Dietz-Holmes, A. J. Bussan, and J. A. Holmes, Research Associate, Weed Specialist, and Research Associate, Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, MT 59717.

Abstract. Researchers are continually in search of alternative methods of weed control. In competitive perennial crop systems such as alfalfa, an alternative approach aimed at suppressing target weed species rather than eradication may result in cost-effective weed control. The purpose of this study was to evaluate the effectiveness of a management strategy combining low herbicide inputs of imazamox and timing of cuttings for control of grass and broadleaf weeds in newly planted alfalfa. Imazamox is an experimental herbicide and a member of the chemical family imidazolinones. It is effective against a broad spectrum of grasses and broadleaf weeds.

Alfalfa was established at two sites, one in a dryland and one in an irrigated agronomic system. The dryland site was located at the Central Agricultural Research Center, Moccasin, MT and the irrigated site was located at Toston, MT. Treatments consisted of imazamox alone, imazamox plus cutting and untreated controls in a randomized complete block design. A single rate of 7.08 g/A imazamox was applied at the 2-inch height stage of alfalfa in herbicide treatments. Three different cutting regimes were applied corresponding to the pre-bud, flower, and mature stages of weedy grasses in the plots.

Five weed species including: volunteer barley, pinnate tansymustard, common lambsquarters, prickly lettuce, and Russian thistle were present at the dryland site. Both prickly lettuce and common lambsquarters were controlled effectively by all treatments. Russian thistle and pinnate tansymustard were moderately controlled by the imazamox treatment alone. However excellent control was observed in the cutting and combined treatments, suggesting that imazamox did not improve control with these two weeds. In contrast, volunteer barley was not controlled following imazamox alone or cutting alone but combined treatments resulted in excellent control.

Kochia, volunteer wheat, green foxtail, common lambsquarters, shepherdspurse, and mustard spp. were present at the irrigated site. Green foxtail control was only controlled by imazamox alone treatments. Shepherdspurse and common lambsquarters were controlled by all treatments. Mustards were controlled equally by all imazamox treatments. Volunteer wheat control was maximized when cut at the flower-stage, whether imazamox was applied or not. Volunteer wheat was not controlled by any other imazamox treatments. Combining treatments were most effective for controlling kochia as it was not managed by imazamox or cutting alone. Imazamox plus cutting at the pre-bud and flower timings increased the control of kochia to 100% .

The results from this experiment indicate that there was significant improvement in weed control of volunteer barley in a dryland system and kochia in an irrigated system by combining cutting with imazamox. Further research will document the effect of weed management treatments on alfalfa establishment and stand longevity.

EFFECTS OF ADJUVANTS ON POSTEMERGENCE HERBICIDES IN ALFALFA. Mick Canevari and Don Colbert, Cooperative Extension, University of California, Stockton, California 95205 and Field Development, American Cyanamid, Lodi, CA 95240.

Abstract. Research was conducted in the spring months on seedling alfalfa for control of broadleaf weeds using imazethapyr and 2,4-DB. An experiment was also conducted in the summer on established alfalfa with clethodim and sethoxydim for control of annual grasses. All herbicides were compared alone and with four commercial type adjuvants which included a methylated seed oil, non-ionic surfactant, crop oil concentrate and an organosilicone. UN-32 liquid fertilizer was compared with the NIS on imazethapyr and clethodim herbicides only. Control of wild radish and wild sunflower was best with imazethapyr. The best control of common lambsquarters was achieved with 2,4-DB. The greatest control of yellow foxtail and witchgrass was achieved with clethodim but was not statistically better than sethoxydim. Certain adjuvants showed a significant difference in weed control for all herbicides tested. The organosilicone and MSO adjuvants worked well with 2,4-DB, whereas the MSO, silicone, and NIS with the liquid fertilizer added to the spray were best applied with imazethapyr. All adjuvants performed equally well with clethodim except the NIS without the addition of liquid fertilizer. Sethoxydim had the highest control with the COC, with other adjuvants showing comparable results but at a lower control level than the COC.

Crop injury to alfalfa was significant with 2,4-DB and two adjuvant combinations. The MSO and COC treatments showed twice the injury compared to the NIS or organosilicone adjuvant which were much safer to the alfalfa. Crop injury with other herbicides and adjuvant combinations was not significant.

CHARACTERIZING THE SPATIAL DISTRIBUTION OF CROP PESTS FOR THE DEVELOPMENT OF OPTIMAL SAMPLING PLANS AND MANAGEMENT UNITS. Dawn Y. Wyse-Pester[1], Lori J. Wiles[2], and Philip Westra[1], Graduate Research Assistant, Plant Physiologist, Professor, [1]Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523 and [2]USDA-ARS-WMU, Ft. Collins, CO 80523.

Abstract. Many pests were intensively sampled in two corn fields (53 and 71 ha) in 1997 and 1998. The objective was to characterize the spatial dependence of economically important pests including corn rootworm eggs, weed seedlings, triazine resistant pigweed seedbank, and nematode populations. These characterizations could improve sampling plans and distribution maps allowing a producer to site-specifically manage these pests and reduce inputs and costs. Three sampling grids were established across both fields: a regular 76 m square grid, random-directed grid imbedded in the regular grid, and 7.6 m star grid. Weed seedlings were sampled at all 1303 locations, while rootworm and nematode populations were observed at 213 regular grid locations. Individual pest populations tended to be patchy leaving 0 to 96% of the field pest-free and average pest densities ranged from 0.1 to 164 per sampling unit. Geostatistical analysis used to characterize spatial dependence determined that pigweed seedlings were correlated up to a distance of 45 m and nightshade to 88 m for field 2 in 1998. However, spatial dependence was not detected for the other pest species at the selected scales. Additional samples below 7.6 m may be required to characterize spatial structure for rootworm egg and nematode populations in these fields. Quantifying the degree of spatial dependence that individual pests occur at will help researchers develop optimal sampling plans needed to create pest distribution maps.

ECOTYPIC VARIATION IN SOUTHWESTERN TALL MORNINGGLORY.

Amy G. Anchieta, Jill Schroeder, and David Daniel, Undergraduate Student, Associate Professor and Assistant Professor, Department of Entomology, Plant Pathology and Weed Science and University Statistics Center, New Mexico State University, Las Cruces, NM 88003.

Abstract. Western plant ecotypes are sharply differentiated from their eastern counterparts because of the extremes that a plant must adapt to in the west. Tall morningglory appears to be no exception to this generalization. Tall morningglory from southwest New Mexico and from Mississippi were grown together in a greenhouse to determine the ecotypic variation. Seeds were gathered from morningglories in a field in southwest New Mexico determined to be tall morningglory by their distinctly straight sepals. These seeds were then grown in the greenhouse to determine proper species and to distinguish different leaf types. Three different leaf types were identified including heart-shape, deeply-lobed ivyleaf, and predominately heart-shaped with edges. Seeds gathered from plants with the three leaf types were cultivated and compared with plants grown from seed obtained from Mississippi State University. Two small and two large leaves were selected from each plant. The trichome density on each leaf was determined by counting the trichomes within a 0.3 cm square at 10 times magnification. The NM type of heart-shaped leaves with edges had the highest trichome density on the adaxial surface (mean≈51) followed by NM heart-shaped (mean≈36), NM ivy-leaf (mean≈31) and MS morningglory (mean≈27). The p-value for shape varying with pubescence density on the adaxial surface was 0.0362 and the abaxial surface was 0.0066. The next comparison involved comparing seed scars using scanning electron microscopy. The final comparison evaluated the response of the ecotypes to pyrithiobac applied postemergence.

GERMINATION AND EARLY GROWTH OF WILD AND CULTIVATED PROSO MILLET BIOTYPES.

Decio Karam[1,2], Philip Westra[1], and Scott J. Nissen[1], Graduate Research Assistant, Professor, and Associate Professor, [1]Department of Bioagricultural Science and Pest Management, Colorado State University, Ft. Collins, CO 80523 and [2]Brazilian Agricultural Research Corporation (EMBRAPA).

Abstract. Wild proso millet is a serious weed problem in corn, potato, sugarbeet, wheat, and soybean in at least ten states of the United States. Wild proso millet biotypes are being studied at Colorado State University under greenhouse and laboratory conditions. Germination and early growth of 12 proso millet biotypes were evaluated. Seeds produced under greenhouse conditions were used to evaluate germination, radicle length, percent seed coat, and seed weight. Seeds were germinated in germination boxes on moist blotting paper. Germination was measured at 5- and 14-days, and radicle length was measured at 5-days after transferring the seeds to the germination boxes. The early plant growth was observed for plants grown in 4 cm diameter by 21 cm long cones for the first 7 days, and in 8 cm diameter by 30 cm long cones for days 7 through 14. The cones were filled with a commercial potting mixture. A randomized block design in a factorial arrangement was used. Measurements of plant height, number of tillers, leaf area, leaf dry matter, root dry matter, tiller dry matter, and stem dry matter were taken at 1 day intervals for 14 days after emergence. Leaf area ratio, specific leaf area, leaf weight ratio, relative growth ratio and absolute growth ratio was derived from the data collected. Differences among germination rates, radicle length, seed weight, and seed coat were observed. Biotypes of wild and cultivated proso millet showed differences in growth parameters evaluated.

ZA1296: A VERSATILE PREEMERGENCE AND POSTEMERGENCE BROADLEAF HERBICIDE FOR CORN.

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Abstract. ZA1296 is a new herbicide being developed by Zeneca Ag Products for preemergence and postemergence broadleaf weed control in corn.

For broad spectrum pre-emergence weed control, a premix of ZA1296 and acetochlor is under development. This premix has been evaluated for several years in conventional, reduced tillage, and no-till fields with excellent

results. ZA1296/acetochlor provides control of many important weeds including: velvetleaf, pigweeds and waterhemps, common lambsquarters, common ragweed, kochia, common sunflower, jimsonweed, nightshade, smartweed, giant foxtail, green foxtail, yellow foxtail, barnyardgrass, large crabgrass, fall panicum, and several other species.

ZA1296 has also been extensively tested as a postemergence herbicide. For optimum postemergence herbicide performance, the addition of crop oil concentrate, alone or with UAN fertilizer, is recommended. Broad spectrum grass and broadleaf weed control can be attained by preemergence applications of acetochlor or other grass herbicides followed by ZA1296 applied postemergence, or by a postemergence tank-mix of ZA1296 with a postemergence grass herbicide. Corn exhibits excellent tolerance to both preemergence and postemergence applications of ZA1296.

EFFECT OF PYRITHIOBAC AND CHILLING ON EARLINESS OF PIMA COTTON. Martina W. Murray and Jill Schroeder, Graduate Research Assistant and Associate Professor, Entomology, Plant Pathology and Weed Science Department, New Mexico State University, Las Cruces, NM 88003.

Abstract. Pyrithiobac is registered for over-the-top weed control in upland cotton (*Gossypium hirsutum* L.), but not Pima cotton (*G. barbadense* L.). Pima cotton may be more sensitive, particularly if stressed. The objective of this study was to determine if pyrithiobac affects plant parameters contributing to Pima "earliness", and if chilling stress immediately before or after application increases response. Pima cultivar S-7 was treated with 0, 0.07, or 0.29 kg ha^{-1} pyrithiobac in combination with one of three chilling regimes, consisting of 3 days in a growth chamber with a 20/12 C day/night regime just prior to or just after herbicide application, or no chilling. Plants were initially grown in a growth chamber with day/night temperatures of 28/20 C. Herbicide treatments were applied 16 days after planting. Three days later, all plants were moved to a greenhouse. Measured parameters included visible injury 1 week after treatment, date of first bloom, node number of the first reproductive branch, and plant height and mean distance between nodes 4 months after planting. Plant height and date of first bloom were not affected by pyrithiobac treatment. Pyrithiobac, at 0.07 and 0.29 kg ha^{-1}, caused visible injury, increased the node of the first reproductive branch by approximately one node, and reduced mean distance between nodes. Neither chilling treatment increased crop response. In summary, pyrithiobac caused visible injury to container-grown Pima cotton, and could potentially affect crop earliness.

ABSORPTION AND FATE OF DIMETHENAMID IN PINTO, BLACK AND NAVY BEANS. Galen Brunk, Lynn Fandrich, Dodi Kazarian, Patrick Miller, Scott Nissen, and Philip Westra, Research Assistant, Graduate Research Assistant, Graduate Research Assistant, Research Associate, Associate Professor and Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523.

Abstract. During the 1996 growing season, dry bean injury occurred in the Midwest after preemergent dimethenamid applications. Most of the injury was associated with black or navy bean varieties. It was hypothesized that injury was related to differential absorption, translocation, or metabolism among dry bean market classes. The effects of growth stage and product formulation were evaluated using ^{14}C-dimethenamid to quantify shoot and foliar dimethenamid absorption, translocation, and metabolism. Hypocotyls, cotyledons, unifoliates, and trifoliates of each dry bean market class absorbed similar amounts of dimethenamid. Within 12 hours, pinto, black and navy trifoliate leaves absorbed 55, 60 and 55%, respectively, of the applied dimethenamid. Within 24 hours, technical and formulated dimethenamid moved across the cuticle at similar rates but remained in the treated leaves.

No significant differences were found in dimethenamid metabolism in trifoliate leaves of pinto, black, and navy beans. After 12 hours, 1, 2 and 4% of applied dimethenamid remained as the parent compound in black, navy, and pinto beans, respectively. These results suggest a high potential for dimethenamid shoot and foliar absorption by pinto, black and navy dry beans; however, the observed differential field injury may not be explained by differences in dimethenamid absorption, translocation or metabolism.

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

Abstract. The response of varieties of hard red winter wheat (*Triticum aestivum* L.) to F-8426, and several additives in an irrigated and dryland system were studied in 1997 and 1998. Additives included in the experiment were 2,4-D ester, 28-0-0 nitrogen, surfactant (NIS) and a safening agent (ACA). Formulations of F-8426 were tested against each other in 1998. The dryland experiment was located at the Research and Extension Center, Archer and the irrigated site at the Research and Extension Center, Torrington, WY. Wheat was analyzed based on injury, height, heads/m, 200 seed weight, test weight, protein and yield. For both years, the wheat cultivar Yuma was the most susceptible to the herbicide F-8426 but yielded the highest at both the dryland and irrigated site. Pronghorn had significantly more heads/meter but Yuma had significantly more seeds/head thus accounting for the larger yield. No significant difference was found comparing formulations at Archer or Torrington. There were no significant differences in the number of wheat heads/meter, number tillers, number leaves, height, seeds/head, seed weight, or yield due to herbicide treatments in the irrigated or dryland site, however, there were differences in varieties.

FLUFENACET & ISOXAFLUTOLE: A NEW BROADSPECTRUM HERBICIDE FOR CORN. James R. Bloomberg, John P. Sleesman, Inci Dannenberg, and Gary J. Aagesen, Bayer Corporation, Kansas City, MO 64120.

Abstract. Flufenacet (FOE 5043) and isoxaflutole is a new, broadspectrum soil-applied corn herbicide under development by Bayer Corporation. The trade name of this premix product is EPIC®. It is formulated as a 58% dry flowable which contains 48% flufenacet and 10% isoxaflutole. It mixes well in either water of sprayable grade liquid fertilizer carriers. Flufenacet and isoxaflutole may be applied either preplant surface, preplant incorporated or preemergence in conventional, reduced-tillage or no-till corn. At recommended usage rates of 0.32 to 0.81 kg/ha, flufenacet and isoxaflutole controls of a wide array of annual grass and broadleaf weeds, including barnyardgrass, crabgrass, woolly cupgrass, foxtails, goosegrass, fall panicum, wild proso millet, witchgrass, velvetleaf, pigweeds (including waterhemp sp.), jimsonweed , kochia, common lambsquarters, marestail, nightshade (eastern/black), common ragweed, Pennsylvania smartweed and wild sunflower. Corn tolerance to this premix is excellent. Flufenacet and isoxaflutole will offer growers the convenience of broadspectrum weed control using a low rate, dry flowable formulation.

EFFECT OF PREHARVEST HERBICIDES ON DURUM QUALITY. Richard K. Zollinger[1], Frank A. Manthey[2], and Scott A. Fitterer[1], Associate Professor, Assistant Professor, and Research Scientist, [1]Department of Plant Sciences and [2]Department of Cereal Science, North Dakota State University, Fargo, ND 58105-5051.

Abstract. An experiment was conducted at Fargo, ND, to evaluate herbicides applied preharvest in durum wheat. Herbicide labels restrict application of most preharvest herbicides until wheat is in the hard dough stage, at 30% or less grain moisture, when green color is gone from stem nodes, and at least 7 days prior to harvest. Growers may make applications earlier to allow sufficient time for weed desiccation from systemic herbicides. Paraquat is being considered for labeling for preharvest use in wheat because of quicker desiccation. 'Ben' durum wheat was planted April 28, 1998. Plots were kept weed free by applying tralkoxydim plus Scoil at 0.18 lb/A plus 1.5% v/v and bromoxynil plus MCPA ester at 0.25 + 0.25 lb/A to small weeds. The 50% grain moisture treatments were applied on July 23, 1998 at the soft dough crop wheat kernel stage. The 30% grain moisture and 9 days before harvest treatments were applied on July 29, 1998 at the hard dough wheat kernel stage. Treatments at 3 days before harvest were applied on August 4, 1998 at the ripe wheat kernel stage. Treatments were applied to the center 8 feet of the 10 by 40 foot plots with a CO_2 pressurized backpack sprayer delivering 8.5 gpa at 40 psi through 8001 flat fan nozzles. The experiment had a randomized complete block design with three replicates per treatment. Plots were harvested August 9, 1998. Durum wheat was milled and processed at the NDSU Durum Wheat Quality and Pasta Processing Laboratory according to American Association of Cereal Chemists Methods.

Paraquat was applied at 0.25, 0.38, and 0.5 lb/A at 9 and 3 days before harvest. Glyphosate - ipa salt at 0.75 lb/A, glyphosate - tms salt plus nonionic surfactant at 0.68 lb/A + 0.25% v/v, glyphosate plus 2,4-D at 0.59 + 0.9 lb/A, and glyphosate plus dicamba at 0.75 + 0.25 lb/A were applied at 50% and 30% grain moisture.

Grain yield, seed test weight, vitreous kernel content, germination injury, and falling number are important quality parameters to growers. Test weight, vitreous kernel content, kernel size, and kernel weight are important quality parameters to durum millers. Protein content, sedimentation rate, falling number, wet gluten, gluten index, semolina color, and pasta quality are important quality parameters to pasta processors.

Grain from treatments applied 9 days before harvest or 30% grain moisture or later generally did not differ from grain from untreated plots. Parameters indicating durum quality not affected by preharvest herbicides were: vitreous kernel content (82 to 93%); whole kernel protein (12.3 to 13.4% dry basis); falling number (390 to 428 seconds - value indicates no sprout damage); grain yield; total germination, sum of normal and injured seedlings (72 to 82%); semolina extracted from grain (67 to 69%); brightness of semolina, brightness increases with the value (84 to 85); yellow reading of semolina, yellowness increases with the value (22 to 23); wet gluten content, a measure of desirable protein in semolina (26.5 to 29.9%); and ash content (0.87 to 0.91% dry basis). Glyphosate applied alone or in combination with 2,4-D or dicamba at 50% grain moisture wheat stage reduced durum wheat test weight, 1000 kernel weight, percent large kernels, percent normal wheat seedlings, but increased percent injured seedlings and semolina protein. Preharvest herbicides can affect durum wheat quality.

ITALIAN RYEGRASS CONTROL IN WHEAT WITH MKH 6562 AND OTHER NEW HERBICIDES. Matthew A. Barnes, Jason P. Kelley, and Thomas F. Peeper, Graduate Research Assistant, Senior Agriculturist, and Professor, Department of Plant and Soil Sciences, Oklahoma State University, Stillwater, OK 74078.

Abstract. Italian ryegrass is a competitive winter annual weed and has become a significant problem in winter wheat production in Oklahoma. Current herbicide treatments may fail to adequately control of Italian ryegrass. Also, winter wheat is often used as forage for cattle prior to jointing, which precludes use of diclofop because it has a full season grazing restriction. Also, resistance to diclofop and sulfonylurea herbicides has been reported.

Research was conducted to compare MKH 6562 and FOE 5043 plus metribuzin with standard treatments for Italian ryegrass control. MKH 6562 at 0.027 lb/A controlled Italian ryegrass 53 to 98% and injured wheat 0 to

13%. When applied at 0.040 lb/A, MKH 6562 controlled Italian ryegrass 55 to 97% and injured wheat 0 to 43%. FOE 5043 plus metribuzin at 0.250 lb/A + 0.094 lb/A controlled Italian ryegrass 78 to 97% and injured wheat 0 to 10%. FOE 5043 plus metribuzin at 0.250 + 0.125 lb/A controlled Italian ryegrass 59 to 100% and injured wheat 0 to 75%. Diclofop at 0.5 lb/A controlled Italian ryegrass 93 to 99% and injured wheat 0 to 9%. Controlling Italian ryegrass typically increased wheat yield. Research is currently in progress to confirm these results.

EMERGENCY PLANTBACK RESPONSE TO MON 37500. Patrick W. Geier, Phillip W.Stahlman, and Jeffrey A. Koscelny, Assistant Scientist and Professor, Kansas State University Agricultural Research Center, Hays, KS 67601, and Marketing Development Representative, Monsanto Company, Hays, KS 67601.

Abstract. MON 37500 is an experimental sulfonylurea herbicide for control of winter annual grass and broadleaf weeds in winter wheat. Field experiments were conducted at Hays and Stockton in northwest Kansas in 1998 to determine the response of summer crops planted into failed winter wheat treated with MON 37500. MON 37500 was applied PRE at 35 or 69 g/ha to growing wheat. Wheat was destroyed the following April with a blanket application of glyphosate, and summer crops no-till planted into the plots. MON 37500 at 35 and 69 g/ha reduced early-season growth of non-IR corn 18 and 24% at Hays, and reduced growth of IT and non-IT corn 30 to 70% at Stockton. MON 37500 at 35 or 69 g/ha reduced IT and non-IT corn yield 19 to 46% at Stockton, and non-IR corn yield at Hays 49 and 68%, respectively. MON 37500 did not affect IR corn yield at Hays. Non-STS soybean growth was stunted by MON 37500 at either rate at Hays and Stockton. STS-soybean growth and yield were not reduced by any MON 37500 treatment at either location. MON 37500 reduced non-STS soybean yield 31 and 46% at Stockton and 52% when the 69 g/ha rate was applied at Hays. Early-season grain sorghum growth was reduced 50 to 85% with MON 37500 at 35 g/ha at each location, and 85 to 97% at each location with the 69 g/ha rate. MON 37500 at 35 g/ha decreased grain sorghum yield 80% at Stockton but did not reduce yield at Hays. The 69 g/ha rate reduced grain sorghum yield 60 and 99% at Hays and Stockton, respectively.

PROSO MILLET DOSE RESPONSES TO MON 37500. 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. MON 37500 is a selective sulfonylurea herbicide for use in wheat, but it can persist in the soil. To evaluate proso millet as a potential rotational crop in wheat production systems, a dose response bioassay was carried out under greenhouse conditions. A rooting soil was prepared with 9 parts of clay loam soil and 1 part of metro-mix, with 15 g of a slow release fertilizer added to each kg of the mixture. A stock solution of MON 37500 at 0.596 g L^{-1} (twice the field rate, equal to 69.5 g ha^{-1}) was prepared; from which 9 dilute solutions were derived (1X, 0.5X, 0.25X, 0.125X, 0.062X, 0.031X, 0.016X, 0.008X, and 0.004X). A spraying chamber calibrated for 117 L ha^{-1} distributed the herbicide solutions on the surface of the pots. The pots were watered 1 hour after treatment and as the rooting soil dried out. Seed emergence was assessed 14 DAT (days after treatment), and dry weight at 33 DAT. The study was repeated a second time. Multiple comparison statistical methods and log-logistic regression were used to analyze emergence and dry weight data, respectively. MON 37500 did not affect proso millet emergence. However, MON 37500 reduced proso millet growth by 20%, at the 2.24 g ha^{-1}dose. Proso millet appeared to be sensitive to MON 37500 residues in the soil. The type of soil, other environmental variables, and the amount of herbicide remaining in wheat production systems should also be assessed in order to provide a correlation with the doses used in the experiment.

CHEAT CONTROL IN WINTER WHEAT WITH MON 37500. Jason P. Kelley and Thomas F. Peeper, Senior Agriculturist and Professor, Department of Plant and Soil Sciences, Oklahoma State University, Stillwater, OK 74078.

Abstract. In the 1996 to 1997 growing season, three field experiments were established in Oklahoma to evaluate MON 37500 for selective cheat control. MON 37500 was applied preemergence or postemergence to 1- to 3-leaf wheat, tillered wheat, in January, and in February at 0.25, 0.37, 0.44, and 0.5 oz/A. A standard treatment was included at each application timing. Standard treatments were 0.37 oz/A of chlorsulfuron plus metsulfuron applied preemergence, 0.3 oz/A of chlorsulfuron plus metsulfuron plus 3 oz/A metribuzin applied to 1- to 3-leaf wheat, and 0.38 lb/A of metribuzin at the tillered, January, and February timings. Wheat injury was less and cheat control greater with MON 37500 than the standard treatments at three of five application timings.

In the 1996 to 1997 and 1997 to 1998 growing season, sixteen field experiments were conducted to evaluate the effect of MON 37500 application timing on wheat injury, cheat control, and wheat yield. MON 37500 was applied at 0.5 oz/A at 3 week intervals, from fall preemergence to mid-March. Cheat control was generally higher with the fall and March treatments than the January and February treatments, when the cheat was not as actively growing. The preemergence treatment controlled cheat less than postemergence treatments in nine of 16 experiments. Treatments applied in October or November generally controlled cheat more than other treatments. All MON 37500 treatments increased wheat yield compared to the untreated check, but October or November applied treatments generally had higher yields.

EFFECTS OF MON 37503 ON CROPS SEEDED AFTER SIMULATED WHEAT CROP FAILURE. Amanda E. Stone, Thomas F. Peeper, and Jason P. Kelley, Graduate Student, Professor, and Senior Agriculturalist, Department of Plant and Soil Science, Oklahoma State University, Stillwater, OK 74078.

Abstract. When winter wheat is destroyed by wind, hail, frost, or drought after a herbicide such as MON 37503 has been applied. Farmers often plant a warm season crop. To determine the effect of MON 37503 on crops seeded in such conditions. Experiments were conducted in 1997 and 1998 on a silt loam soil with 2% organic matter content and 4.7 pH. To simulate destruction, the wheat was sprayed with glyphosate each year. In 1997 three rates of MON 37503 were used, the label rate of 0.031 lb/A and 0.016 and 0.023 lb/A. MON 37503 was sprayed on April 15, 1997 and three days later corn and IR corn were planted. Grain sorghum and soybeans were planted two weeks later. During the summer stands were counted and plant heights were measured. Crops were harvested at maturity and grain yield corrected for moisture content.

In 1998, an experiment was conducted at the same location, with two rates of MON 37503, the labeled rate of 0.031 lb/A and 0.062 lb/A rate, which were sprayed on March 28. The corn and IR corn were planted two weeks later. A month and a half later the grain sorghum, soybeans, STS soybeans, and pearl millet were planted. Throughout the summer stands were counted and plant heights were measured. In the fall, the crops were harvested and yields were recorded. The labeled rate of MON 37503 did not reduce yield of IR corn either year, and reduced corn yield only in 1997 (14%). Soybean yields were not reduced either year. Grain sorghum yield was reduced 55% in 1997, but there was no reduction in 1998.

DOWNY BROME CONTROL AND WINTER WHEAT VARIETY TOLERANCE TO SULFOSULFURON. Robert N. Klein and Jeffrey A. Golus, Professor and Extension Research Technologist, University of Nebraska West Central Research and Extension Center, North Platte, NE 69101.

Abstract. Studies were conducted to evaluate downy brome control in winter wheat with sulfosulfuron and to observe winter wheat variety response to sulfosulfuron. Also a study was conducted to determine the optimum time to apply sulfosulfuron to winter wheat to control downy brome. Two sites, Ogallala and Grant, were used. Plots

were sprayed using a tractor mounted sprayer with a 15 foot boom (six 11004XR nozzles on 30 inch spacing) at 10 gpa, 20 psi nozzle pressure, and 5.5 mph. At Ogallala, the wheat was planted September 20, 1997. PRE treatment was applied on September 26, E POST on October 15, with downy brome 1 inch tall, POST on November 6, with downy brome 1.5 inches tall, and Spring on April 9, 1998 with downy brome 2 inches tall. Plots were rated visually on May 4 for downy brome control and data shown in Table 1. Ogallala plots were harvested on July 11. At Grant, POST was sprayed on December 1, 1997 with downy brome 1 to 2 inches tall, and Spring on March 25, 1998 with downy brome 1 to 2 inches. These plots were rated visually on May 14 and data shown in Table 1.

Table 1. Control of downy brome with sulfosulfuron.

		Downy brome control		Ogallala
Time of application	Sulfosulfuron rate	Ogallala (May 4)	Grant (May 14)	yield
	lb/A	%		Bu/A
Preemergence	0.031	75	--	30
Early postemergence	0.031 + NIS 0.5%	99	--	38
Postemergence	0.031 + NIS 0.5%	61	68	25
Spring	0.031 + NIS 0.5%	41	45	19
Untreated Check		0	0	16
LSD (0.05)		3.8	15.6	3.9

Another study was conducted in no-till winter wheat. Plots were established in randomized complete block design and sprayed using a ten foot boom (six 11002XR nozzles on 20 inch spacing), at 13.5 gpa and nozzle pressure of 22 psi. Preplant treatment was applied on September 12, 1997, Preemergence treatment on October 3, and Postemergence on November 7, with downy brome being up to 2 inches tall at that time. Percent downy brome control rated visually on May 21, 1998. Plots were harvested on July 1. Data shown in Table 2.

Table 2. Control of downy brome in no-till winter wheat.

Treatment	Sulfosulfuron rate	Timing	Downy brome control	Yield
	lb/A		%	Bu/A
Check			0	57
Sulfosulfuron + NIS	0.031 + 0.5%	PP	90	60
Sulfosulfuron + NIS	0.031 + 0.5%	PRE	97	58
Sulfosulfuron + NIS	0.031 + 0.5%	POST	89	59
LSD (0.05)			5.3	NS

Also evaluated was winter wheat variety tolerance to sulfosulfuron. Thirty nine varieties of winter wheat were planted at six locations, with six replicates at each location. Three of the replicates (2, 4 and 6) were sprayed with sulfosulfuron nonionic surfactant at 0.031 lb/A + 0.5% v:v during the fall of 1997. The other three replicates were not sprayed with sulfosulfuron. The wheat variety plots were planted at each respective location on the following dates: Keith on September 15, Perkins on September 16, Dundy on September 18, Red Willow on September 27, Custer on September 17, and Lincoln on September 26. Treatments at each location were sprayed on the following dates: Keith October 15; Perkins, Dundy and Red Willow on October 16; Custer November 6; and Lincoln on November 5. These plots were harvested the summer of 1998. No differences in yield among the replicates at a location could be attributed to the application of sulfosulfuron (Table 3). At Red Willow, yields were lower as we progress into the plot area due to moisture and fertility differences. At Perkins, yields were lower as one moves into the experiment because of a late spring freeze. At Custer, the first rep was not harvested due to severe lodging.

Table 3. Winter wheat variety response to sulfosulfuron.

Rep	1998 Winter wheat yields							Average w/o Perkins and Red Willow
	Keith	Perkins	Dundy	Red Willow	Custer	Lincoln	Total average	
	Bu/A							
1[b]	64.94	59.30	67.68	80.33	-	86.98	71.85	73.21[c]
2[a]	66.53	46.48	72.73	73.65	81.74	89.89	71.79	77.73
3[b]	64.23	41.66	73.06	69.22	84.15	89.49	70.30	77.73
4[a]	65.57	39.40	71.44	60.33	79.00	89.58	67.55	76.39
5[b]	64.08	38.46	75.47	58.03	79.96	90.36	67.73	77.47
6[a]	62.76	34.59	73.02	50.93	82.20	89.35	65.48	76.84
Average	64.69	43.32	72.23	65.37	81.41	89.28		

[a] Sulfosulfuron applied at 0.031 lb/A.

[b] No herbicide treatment.

[c] Would be 75.26 if Custer average (81.41) used to replace first rep.

JOINTED GOATGRASS RESPONSE TO MON 37500: THREE YEAR SUMMARY. Phillip W. Stahlman and Francis E. Northam, Professor and Research Associate, Kansas State University Agricultural Research Center-Hays, 1232 240th Ave., Hays, KS 67601.

Abstract. Field experiments were conducted 3 years near Hays, KS to investigate response of jointed goatgrass in winter wheat to MON 37500 plus nonionic surfactant applied postemergence in the fall and spring at 0.031 lb/A + 0.5% v/v. Jointed goatgrass populations in nontreated control plots averaged 1.8 plants/m^2 in 1996 and 2.8 plants/m^2 in both 1997 and 1998. Fall-applied MON 37500 reduced jointed goatgrass plant density 50, 25, and 57% in 1996, 1997, and 1998, respectively. Spring-applied MON 37500 did not reduce jointed goatgrass plant density any of the 3 years. The number of jointed goatgrass reproductive tillers per plant was reduced about 50% in 1997, regardless of application date, and 62% by the fall-applied treatment in 1998. However, tiller number in spring-treated plots was not reduced in 1998. Reproductive tillers were not counted in 1996. Spikelet numbers per spike were reduced 12% averaged over application times and years; differences between fall and spring application times were not significant. Calculations of combined reductions in plant density, tillers per plant, and spikelets per spike totaled 73 and 29% fewer spikelets per unit area for fall and spring treatments, respectively. Accordingly, there was a trend of declining dockage in wheat due to jointed goatgrass spikelets favoring the fall treatment in 2 of 3 years. Germination of spikelets from MON 37500-treated plants was reduced 0 to 29%; effect of application time on spikelet germination was inconclusive.

MON 37500 EFFICACY AS AFFECTED BY AIR TEMPERATURE AND SOIL MOISTURE. Brian L. S. Olson, Kassim Al-Khatib, Phillip W. Stahlman, Scott K. Parrish, and Paul J. Isakson, Graduate Research Assistant and Associate Professor, Department of Agronomy, Kansas State University of Manhattan, KS 66502; Professor, Kansas State University Agriculture Research Center-Hays of Hays, KS 67601; Manager, Pacific Northwest Agronomy Center, Monsanto Co., Spokane, WA 99208; and Product Technical Specialist, Monsanto Co., Englewood, CO 80155.

INTRODUCTION

Cheatgrass (downy brome, cheat, and Japanese brome) has become more prevalent and approximately infests 13.2% of wheat fields in Kansas (Peterson and Stahlman, 1995). A new sulfonylurea herbicide, MON 37500, has shown promise in controlling downy brome and providing some control of wild oat and jointed goatgrass; however, less than adequate control along with injury symptoms to wheat have been observed by Geier et al. (1998). Inconsistency in MON 37500 efficacy may be attributed to environmental conditions after application or differences in growth stage of downy brome at application.

Temperature can alter the efficacy of a herbicide as seen with chlorsulfuron toxicity to green foxtail with more green foxtail control occurring at 10 and 20 C than 30 C (Nalewaja and Woznica, 1985). High temperatures also increased control of common bean and redroot pigweed with atrazine (Al-Khatib et al. 1992).

Soil moisture also affects herbicides. Low soil moisture levels caused a terbutryn application to injure wheat (Wu et al. 1974), whereas imazamethabenz controlled more blackgrass plants when soil moisture was increased (Malefyt and Quakenbush, 1991).

OBJECTIVE

Evaluate the effects of temperature and soil moisture on the control of jointed goatgrass, downy brome, wild oat, and potential injury to wheat by MON 37500.

MATERIALS AND METHODS

'Len' spring wheat, jointed goatgrass, downy brome, and wild oat were planted in 11.4-cm-diam. containers filled with soil. The soil was a 1:1 mixture of sand and Morril loam (fine-loamy, mixed, mesic Typic Argiudolls). Containers were placed in the greenhouse and watered daily until plants emerged. The temperatures were 21/16 C ± 2 C day/night with a 16/8 h day/night photoperiod.

Temperature Experiment. After emergence, plants were thinned to 3 per pot, and pots were moved to the growth chambers. The PPFD was 250 uE/ m^2/s with a 14/10 h day/night photoperiod, and the plants were watered as needed. The pots were assigned randomly to a temperature regime: 25/23 to 25/23 (I), 25/23 to 5/3 (II), 5/3 to 25/23 (III), or 5/3 to 5/3 C (IV) day/night temperatures before and after application, respectively.

MON 37500 rates of 24 and 46 g/ha were applied using a Research Track Sprayer equipped with an 80015LP tip and calibrated to deliver 187 L/ha at 175 kPa. The herbicide was applied when the plants were at the 5-leaf stage. Controls received no herbicide.

Visual ratings of jointed goatgrass, downy brome, and wild oat control and wheat injury were determined weekly until harvest based on a scale of 0 = no control or crop injury to 100 = complete mortality. Plants were harvested 28 days after treatment (DAT).

At harvest, two plants in each pot were randomly selected to measure leaf area and leaf dry weight, whereas the other plant was used to measure chlorophyll content. Leaf area was measured using a LI-COR model 3100 area meter. The leaves were then dried at 65 C for 48 h and weighed. Chlorophyll content was determined as described by Arnon (1949).

Soil Moisture Experiment. 'Len' wheat, jointed goatgrass, downy brome, and wild oat were grown under two soil moisture regimes in a greenhouse kept at 21/16 C with a 16/8 h day/night photoperiod. Full field capacity and one-third field capacity were used. Field capacity was determined by saturating air dried soil with water, and then measuring the increase in weight after gravity water drained from the container (Bruce and Luxmoore 1986). Soil moisture was maintained throughout the study by weighing the pots daily and replenishing water to the desired weight (± 0.5 g). Plants were sprayed at the 5-leaf stage with MON 37500 application rates of 24 or 46 g/ha with a control. Visual ratings were taken weekly, and plant harvest measurements as described in the temperature study were taken three weeks after MON 37500 application.

Experimental Design and Data Analyses. The temperature study was arranged as randomized split block design which was run twice with two replications in each run. The main plots were temperature, and the subplots were application rates. The soil moisture study was arranged as a randomized complete block design which was run twice with four replications in each run. Data were analyzed using analysis of variance, and means were separated by LSD at 0.05.

RESULTS AND DISCUSSION

Temperature Experiment. Wheat, jointed goatgrass, downy brome, and wild oat responded differently to MON 37500 under different temperature regimes (Table 1). MON 37500 caused slight injury, less than 10%, to wheat with most temperature regimes, except regime IV (temperature maintained at 5/3 C before and after application) where no injury symptoms were observed. MON 37500 injured wheat more with regime II, 25/23 to 5/3 C, than other temperature regimes; however, plants recovered from herbicide injury and appeared normal at harvest. Control of jointed goatgrass was greater when MON 37500 was applied at 46 g/ha with temperature regime I, 25/23 to 25/23 C, and III, 5/3 to 25/23 C, than with regime II or IV. Growth of the jointed goatgrass was inhibited initially causing plant stunting, but leaves continued to grow normally. Visible control of downy brome increased with all temperature regimes as the application rate increased with the greatest control occurring with temperature regimes I and III. Visible MON 37500 control of wild oat was greater at the higher application rate with the greatest control occurring with temperature regimes I and III.

Leaf area and leaf dry weight were different for each species at the three application rates (Table 2). These values were averaged across temperature regimes, because no species by temperature interaction occurred. Wheat leaf area and leaf dry weight were not reduced by MON 37500 application. Jointed goatgrass was reduced in leaf area by 53% when MON 37500 was applied at 46 g/ha, whereas leaf dry weight was reduced by 47%. Downy brome leaf area and leaf dry weight were reduced by 89 and 79%, respectively, when MON 37500 was applied at 46 g/ha. Wild oat leaf area and leaf dry weight were reduced by as much as 41and 28%, respectively.

Chlorophyll contents of wheat, jointed goatgrass, downy brome, and wild oat also responded differently to MON 37500 (data not shown). Chlorophyll content was averaged across temperature regimes, because no species by rate by temperature interactions occurred. The MON 37500 application rates of 24 and 46 g/ha did not reduce the chlorophyll content in wheat or jointed goatgrass. Chlorophyll contents of downy brome and wild oat were reduced by 69 and 29%, respectively, when 46 g/ha of MON 37500 was applied. This implies that the chlorophyll in wheat and jointed goatgrass is less sensitive to MON 37500 because of increased degradation of the herbicide by these species.

The differences in plant responses to MON 37500 under low temperature regimes may be attributed to slow growth at the 5/3 C temperature and less MON 37500 foliar absorption (Olson et al. 1997). Because MON 37500 has a half-life of approximately 3 days when exposed to sunlight, a decrease in uptake would allow the herbicide to photo degrade quickly (Hatzios et al. 1998) .

Soil Moisture Experiment. Wheat, jointed goatgrass, downy brome, and wild oat responded differently to MON 37500 when they were grown at one-third and full field capacities (Table 3). Wheat was not injured by MON 37500 at the two soil moisture levels. Jointed goatgrass showed greater visible control at full field capacity than at one-third field capacity. Downy brome was controlled more at full field capacity than at one-third field capacity. In general, downy brome growth was reduced more at the higher MON 37500 application rate. Wild oat was also controlled more at full field capacity than at one-third field capacity.

Leaf area and leaf dry weight of wheat, jointed goatgrass, downy brome, and wild oat varied in their responses to MON 37500 (Table 4). These values were averaged across soil moistures, because no moisture by species interaction occurred. Wheat leaf area and leaf dry weight were not reduced by MON 37500. Jointed goatgrass leaf area and leaf dry weight were reduced by as much as 54 and 50% when MON 37500 was applied at 46 g/ha. Leaf area and leaf dry weight of downy brome were reduced by 80 and 74%, respectively, when MON 37500 was applied at 46 g/ha. Leaf area and leaf dry weight of wild oat were also reduced by as much as 62 and 49%, respectively, when MON 37500 was applied at 46 g/ha.

Chlorophyll contents of wheat, jointed goatgrass, downy brome, and wild oat were affected differently by MON 37500 (data not shown). These values were averaged across soil moistures, because no moisture by species interactions occurred. Total chlorophyll content of wheat and jointed goatgrass was not affected by MON 37500. Chlorophyll content in downy brome and wild oat were reduced by 69 and 29% when MON 37500 was applied at 46 g/ha.

Absorption of MON 37500 has been shown to be unaffected by soil moisture (Olson et al. 1997); therefore, lower efficacy at the one-third field capacity could be attributed to a slower metabolic rate, because the plants were less biologically active (Wu et al. 1974).

SUMMARY

This study showed that wheat has a high tolerance to MON 37500 under various environmental conditions. Jointed goatgrass had the least susceptibility to a MON 37500 application whereas downy brome had the greatest. More suppression and control of jointed goatgrass, downy brome, and wild oat occurred at the 25/23 C temperature and at full field capacity.

Table 1. Visible injury rating for wheat, jointed goatgrass, downy brome and wild oat at 28 days after treatment as affected by temperature when MON 37500 was applied at the 5-leaf stage.

		Visible injury			
Temperature treatment	MON 37500 rate	Wheat	Jointed goatgrass	Downy brome	Wild oat
	g/ha	Bu/A			
I 25/23 to 25/23[a]	0	0			0
	24	6	13	60	19
	46	6	29	93	38
II 25/23 to 5/3	0	0	0	0	0
	24	6	11	25	24
	46	10	18	45	25
III 5/3 to 25/23	0	0	0	0	0
	24	0	10	73	21
	46	5	29	93	40
IV 5/3 to 5/3	0	0	0	0	0
	24	0	5	36	20
	46	0	10	43	28
LSD (0.05)		ns	13	13	13

[a] Day/night temperatures before and after MON 37500 application, respectively.

Table 2. Leaf area and leaf dry weight for wheat, jointed goatgrass, downy brome, and wild oat as affected by temperature and MON 37500. Means were averaged across temperatures.

Species	Herbicide rate	Leaf area	Leaf dry wt
	- g/ha -	- cm^2 -	- g -
Wheat	0	85	0.40
	46	83	0.42
Downy brome	0	114	0.39
	46	13	0.08
Jointed goatgrass	0	129	0.62
	46	61	0.33
Wild oat	0	131	0.54
	46	77	0.39
LSD (0.05)		27	0.09

Table 3. Visible injury ratings of wheat, jointed goatgrass, downy brome and wild oat as affected by soil moisture and MON 37500.

Soil moisture (field capacity)	MON 37500 rate	Visible Injury			
		Wheat	Jointed goatgrass	Downy brome	Wild oat
	g/ha	%			
One-third	0	0	0	0	0
	24	0	14	26	22
	46	1	23	38	37
Full	0	0	0	0	0
	24	0	23	67	38
	46	1	33	76	59
LSD (0.05)		ns	9	9	9

Table 4. Leaf area and leaf dry weight for wheat, jointed goatgrass, downy brome, and wild oat as affected by temperature and MON 37500. Means were averaged across soil moistures.

Species	Herbicide rate	Leaf area	Leaf dry wt
	- g/ha -	- cm^2 -	- g -
Wheat	0	115	0.55
	46	112	0.52
Downy brome	0	188	0.65
	46	37	0.17
Jointed goatgrass	0	151	0.84
	46	70	0.42
Wild oat	0	209	0.91
	46	79	0.46
LSD (0.05)		46	0.19

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DIFFERENT RESIDUE MANAGEMENT OPTIONS IN PERENNIAL RYEGRASS AND THEIR EFFECTS ON ANNUAL BLUEGRASS GERMINATION. Matthew D. Schuster and Carol A. Mallory-Smith, Graduate Research Assistant and Assistant Professor, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331-3002.

Abstract. Legislation over the past decade has reduced the number of grass seed acres that can be burned. As a result, there has been an increase in the amount of viable annual bluegrass seed, a serious contaminant of perennial ryegrass fields in the Willamette Valley of Oregon. Two field trails were established to determine the impact of these different residue management options on annual bluegrass germination. Other factors evaluated were soil moisture, yield, and seed contamination at harvest. The experimental design was a randomized complete block with three treatments and four replications. The treatments consisted of full straw, bale/flail, and vacuum sweep. Annual bluegrass germination was significantly lower in the vacuum sweep treatments than the full straw or bale/flail treatments (p-value: 0.001 and 0.002, respectively), but there was no difference between the full straw and the bale/flail treatments (p-value: 0.73) at Site 1. At Site 2, annual bluegrass germination in the vacuum sweep treatment was significantly lower than the bale/flail treatment (p-value: 0.01). However, the full straw was not different from the bale/flail or the vacuum sweep treatments (p-value: 0.30 and 0.12, respectively). The moisture levels among treatments were different over time for Site 1 but not Site 2 (p-value: 0.04 and 0.62, respectively). Yields and seed contamination was not different for each site.

HERBICIDE TIMING FOR WOOLLYLEAF BURSAGE CONTROL. Randall S. Currie and Curtis R. Thompson, Associate Professor, Kansas State University, Southwest Research and Extension Center, Garden City, KS 67846, and Associate Professor, Kansas State University, Southwest Area Extension Office, Garden City, KS 67846.

Abstract. The noxious weed, woolly leaf bursage, is a deep-rooted perennial that infests over 80,000 acres in Kansas. Control strategies have been limited and inconsistent. Herbicide treatments that included: clopyralid at 0.14 and 0.28 kg/ha; fluroxypyr at 0.84 kg/ha plus 0.56 kg/ha dicamba or 1.1 kg/ha 2,4-D; picloram at 0.28 kg/ha plus 0.56 kg/ha dicamba, or 1.1 kg/ha 2,4-D; and glyphosate at 1.7 kg/ha plus 1.1 kg/ha dicamba or 2,4-D were applied to woolly leaf bursage at flower (August 15) or 30 days after flowering in 1991, 1994, and 1997. Although in 2 out of 3 years, a significant herbicide by application timing interaction occurred, no statistically significant trend was evident. Although not statistically significant, picloram plus 2,4-D treatments 11 months after treatment provided by 10 to 20% more control in all 3 years when applied at flowering. However, 9 months after treatment regardless of application timing, all treatments containing picloram provided greater than 94% control. Picloram plus dicamba provided 77 to 99% control applied at flowering in all years 11 months after treatment. Although not statistically different, picloram plus 2,4-D out performed this treatment in all years 11 months after treatment, providing 89 to 100% control. All others treatments provided inconsistent control.

FIELD BINDWEED CONTROL OVER A FOUR-YEAR PERIOD WITH REPEATED HERBICIDE TREATMENT.

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Abstract. Field studies were conducted at Garden City and Hays, KS to evaluate repeated herbicide applications over a 4 year period for field bindweed control in a winter wheat-grain sorghum-fallow cropping system. Herbicides were applied postemergence in the fall of 1994 following wheat harvest, the following spring or summer either preplant or postemergence in grain sorghum, and again that fall after sorghum harvest, 11 to 12 months after the first application. Plots were tilled between applications and after final herbicide treatment as needed. Herbicide treatments each time were: quinclorac plus 2,4-D amine at 0.28 + 1.1 kg/ha; glyphosate plus 2,4-D isopropylamine at 0.65 + 1.1 kg/ha; dicamba plus 2,4-D LVE at 0.56 + 1.1 kg/ha; picloram plus 2,4-D LVE at 0.28 + 1.1 kg/ha; 2,4-D LVE at 1.1 kg/ha; and quinclorac plus 2,4-D amine at 0.28 + 1.1 kg/ha for the first application followed by quinclorac plus 2,4-D amine at 0.14 + 0.56 kg/ha for the second and third applications. The control treatment consisted of tillage alone. Tillage was used as necessary at both locations from the spring of 1996 to fall wheat planting. Wheat stubble at the Hays location was managed in a no-till system for the summer of 1997 using a tank mix of cyanazine plus paraquat 2.2 kg/ha + 1.1 kg/ha or 1.1 kg/ha paraquat as needed. In contrast, extensive tillage was used during this period at Garden City. In the fall of 1997, glyphosate plus 2,4-D at 0.56 + 0.71 kg/ha was applied over entire plot area. Field bindweed stand was reduced by 85 to 100% for the first year after treatments. Control of bindweed was also represented by higher grain sorghum yields compared to the control treatments. Four years after the initial treatment, bindweed control was still from 50 to 90% at both locations. Grain sorghum yields in 1998 were not different at Hays but some difference was found at Garden City between herbicides which may have been due to more soil water in the no-till system. Although it was difficult to differentiate between treatments, other than the untreated control, both field experiments show that treatments applied 4 years prior still effected control of field bindweed. However, this control was not consistently expressed in grain sorghum yields.

IMPROVING THE EFFICIENCY OF EPTC USE IN POTATO PRODUCTION.

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Abstract. EPTC is used extensively in the San Luis Valley of Colorado to control annual grasses, volunteer barley and several broadleaf weeds. Chemigation has become the preferred method of applying EPTC and applications are generally made without regard for environmental conditions that could influence EPTC efficacy. Field studies were conducted to evaluate: EPTC losses during chemigation; effects of soil moisture on co-distillation; and soil dissipation. EPTC losses during chemigation ranged for 15 to 45% and appear to correlate will with increasing air temperature. Over a temperature range from 55 to 90 F EPTC concentrations decreased by 0.9% per degree F. Soils that were pre-irrigated before chemigation lost 60 to 80% of applied EPTC within 24 h of application, while EPTC losses from dry soil ranged between 10 and 15%. Soils were sampled 0, 1, 3, 7, 10, 15, and 38 days after application to evaluated soil dissipation. The half-life of EPTC was between 10 and 15 days and by 38 days EPTC levels were near background. These results indicate that potato growers in the San Luis Valley can improve EPTC efficiency by including certain environmental parameters in their chemigation programs.

INTEGRATING FLUROXYPYR INTO WESTERN US CROPPING SYSTEMS. Clark C. Oman, Phil Westra, Scott Nissen, and Jacinto Gonzales, Graduate Student, Professor, Associate Professor, and Postdoctoral Research Associate, Department of Bioagricultural Science and Pest Management, Colorado State University, Ft. Collins, CO 80523.

Abstract. Fluroxypyr at 1, 2, 3, and 4 oz/A was applied post emergence to potatoes var. Russet Norkotah that were 4 to 8 inches in height. A dose response was observed between fluroxypyr rate and tuber weight, with statistically significant reductions in tuber weight for 3 and 4 oz/A treatments. Higher rates caused a serious disintegration of tuber tissue. Examination of tuber viability is currently underway. Kochia control in fallow with fluroxypyr was compared to control with dicamba and pyridate. Two to 4 inch tall kochia was treated with fluroxypyr at four rates (1, 2, 3, and 4 oz /A), dicamba (2 and 4 oz /A), and pyridate (16 oz/A). Fluroxypyr provided good control of kochia at the 3 and 4 oz/A rates (86.7 and 90% respectively) which was similar to control provided by dicamba and pyridate. In greenhouse studies, fluroxypyr dose response in six kochia accessions showed that most accessions were very sensitive to fluroxypyr, showing a GR_{50} value of approximately 0.8 oz/A when treated at the 1 to 2 inch tall stage of growth.

POSTEMERGENCE RIMSULFURON EFFICACY IN POTATOES WITH VARIOUS ADJUVANTS. Dennis J. Tonks[1], Charlotte V. Eberlein[2], Mary J. Guttieri[1], and Felix E. Fletcher[1], Postdoctoral Research Associate, Professor, Support Scientist, and Technician, University of Idaho, [1]Aberdeen Research and Extension Center, Aberdeen, ID 83210 and [2]Twin Falls Research and Extension Center, Twin Falls, ID 83303.

Abstract. Field studies were conducted in 1997 and 1998 to evaluate the effects of adjuvants on postemergence rimsulfuron activity in potatoes. Rimsulfuron was applied at 9, 18, 26, and 35 g/ha in combination with nonionic surfactant (NIS), crop oil concentrate (COC), methylated seed oil (MSO), or silicone-polyether copolymer (SIL). Treatments were applied postemergence to 2- to 4-leaf volunteer oats, common lambsquarters, hairy nightshade, and redroot pigweed, and 1- to 3-cm kochia when potatoes were 8-to 13-cm tall. Overall, crop safety with rimsulfuron plus additives was excellent, with injury $\leq$6% even at higher than labeled rimsulfuron rates (35g/ha). Generally, weed control increased as rimsulfuron rate increased. Additives affected weed control with rimsulfuron; additive effectiveness was MSO>COC[3]>NIS>SIL. Rimsulfuron plus MSO improved volunteer oat, hairy nightshade, kochia and common lambsquarters control compared to rimsulfuron plus NIS. Redroot pigweed control was >95% for all treatments except the lower rates of rimsulfuron plus SIL. Although common lambsquarters control was enhanced when rimsulfuron was mixed with MSO compared to NIS, control was not commercially acceptable when common lambsquarters populations were high. The SIL adjuvant usually decreased rimsulfuron activity compared to the other treatments.

OFF TARGET MOVEMENT OF PHENOXY HERBICIDES FROM RICE FIELDS DURING AND FOLLOWING AERIAL AND GROUND APPLICATIONS. D. E. Bayer, Professor Weed Science Program, and N. B. Akesson, Professor Emeritus, Biological and Agricultural Engineering, University of California, Davis, CA 95616.

INTRODUCTION

Data from the 1996 test run series indicated that D-8 jets nozzles (simple plate orifice) on the Bell Jet Ranger (model 206) helicopter produced a fraction (16 to 19%) of the drift loss from the fixed wing airplane (AgCat) with 6520 fan nozzles. But the AcuFlow nozzles on the UH-1B helicopter showed much lower drift at only 2% of the losses from the AgCat and 11% of the drift of the D 8 jets on the Jet Ranger. Earlier field tests show that jets, either tube or simple orifice, as opposed to the fan types on the fixed wing aircraft, would reduce the drift substantially, but not to the level of the slower flying (50 to 60 mph) helicopters (Yates et al. 1977).

METHODS AND MATERIALS

The trials conducted in 1996 in Sutter county, utilized 2,4-D amine at 0.75 lb/A in 10 gal of total mix applied to four rectangular rice plots of 12.6 A each. The 1996 aerial applications were made with three different aircraft: the first, an AgCat fixed wing aircraft equipped with 6520 fan nozzles (Spraying Systems Co) directed with the airstream and operated at 40 lb/in^2. These produced a spray drop size of approximately 400 to 500 mm (microns) vmd (volume median diameter);the second was a Bell UH-1B helicopter with AcuFlow 0.028 inch diameter jet nozzles (Bishop Mfg. Co.) operated at 20 lb/in^2 pressure and producing a drop size of 500 to 700 mm vmd; and the third was a Bell 206 Jet Ranger helicopter equipped with D-8 orifice jet nozzles (0.125 inch orifice diameter) and operated at 20 lbs/in^2 pressure, which produced a drop size of 700 to 800 μm vmd (Table 1). All plots were located side by side, with the longest dimension in the North/South direction. Each treated plot was 247 by 2350 feet (12.6 A), separated by equal width plots, which served as buffers during the spray tests. Two of the plots were sprayed with the AgCat aircraft, one at 90 mph and the other at 100 mph (plots one and six of fig 1). Plot two was a buffer, while plot three was sprayed at 60 mph with the Jet Ranger helicopter, and plot four was a buffer. Plot five was sprayed with the Bell UH-1B helicopter fitted with the AcuFlow nozzles (Table 1). The wind was very stable during the 1996 spray trial and come from the N N West at 10 to 13 mi/hr 90 degrees to the spray swaths (Akesson and Yates 1988).

The 1997 trials (Table 1, Fig 2) were conducted in Colusa county with the UH-1B helicopter equipped with the AcuFlow nozzles, operated at 23 lb/in^2 pressure as was used in 1996. This was compared to three plots spayed with ground equipment: one, an XR8002 fan nozzle, operated at 20 to 25 lb/in^2 which produces spray drops of approximately 300 to 320 μm vmd; two, the ground rig with Turbo T-jet nozzles, 11002 fan type nozzle also operated at 20 to 25 lb/in^2, producing a drop size of 375 to 400 μm vmd; and three., the Turbo Flood jet, TFVS2 operated at 25 to 30 lb/in^2, which produces a drop size of 730 to 750 μm vmd. The four rice plots were approximately 1000 by 700 ft and varied from 17.2 to 18.5 A. MCPA was used for these trials at 0.5 lb/A in 10 gal of total mix. Two plots, one and two, followed by three and four were sprayed at approximately the same time to reduce the effects of weather to a minimum. However, the wind stayed very stable with a direction out of the NW at 8 to 10 mph throughout the four spray trials. The helicopter started spraying plot one at the same time as the ground rig began on plot two, separated by a 200 foot buffer just to the East of plot one. The ground rig utilized the Turbo T-jets nozzles; spray booms were about 5 feet above the rice sprayed a 75 foot swath, operating at 5 to 6 mph. The helicopter flew about 8 to 10 feet above the rice and at 55 mph taking a 35 foot swath.

The second set of runs were made with two ground rigs operated simultaneously on plots three and four, which were separated by a 200 foot buffer and were located just to East and West of each other and South of plots one and two. On plot three the ground rig used the XR 8002 fan nozzles and on plot four the ground sprayer used the Turbo Flood-jet TFVS2 nozzles (Akesson et al., 1995).

Table 1. Operating conditions for the various sprayers used in the 1996 trials.

Plot	Equipment	Velocity	Swath width	Swaths	Nozzles	Inside dia.	Spacing	Nozzles	Nozzle pressure	vmd[a]
		mph	ft	No.		in	in	No.	lb/in^2	mn
1996										
Five	UB-1B	55	40	6	AcuJlow	0.028	6	70	23	500 to 700
Three	J. Ranger	60	40	6	D-8 jets	0.126	7	47	20	700 to 800
Six	AgCat	90	40	6	6520 fan	-	9.5	38	30	400 to 600
One	AgCat	100	40	6	6520 fan	-	9.5	38	30	400 to 500
1997										
One	UH-1B	55	35	20	AcuFlow	0.028	6	70	23	500 to 700
Three	Gnd XR[b]	5-6	75	9	XR8002 fan	-	20	45	20-25	300 to 320
Two	Gnd T-Jet	5-6	75	9	Turbo T-Jet	11002	20	45	20-25	375 to 400
Four	Gnd T-Jet	5-6	75	9	Turbo F-Jet	TFVS2	40	23	25-30	730 to 750

[a] vmd (volume median diameter).

Air Filters and Cotton Plant Drift Sensors. Off-target movement from these applications of 2,4-D amine (1996) and MCPA (1997) were measured with high volume glassfiber air filters, placed in pairs about 100 feet distant from the downwind side of the plots and operated at about 20 feet (cubic feet per minute) air flow. Cotton plants in one gal pots were grown in a lath house at the University greenhouse, about one month in advance of the field tests. The plants were transported to the field site in a closed van. Plant bioassay (visual rating), and LGC (liquid/gas chromatography) for analysis of both filters and cotton plants was used to determine phenoxy concentration. One-half of the cotton plants were harvested immediately after exposure in the field and analyzed for phenoxy by LGC technique, while the remaining plants were returned to a greenhouse on the University campus were symptoms were allowed to develop. Visual evaluations were made at two and four weeks after exposure. Weed control in the sprayed plots was rated at four weeks following the applications.

The off target drift during the application period of about 20 minutes was measured by the first set of cotton plants and the air filters. Then new filters were placed on the air samplers and 4-h sampling periods were made: 1) directly following the application, 2) at 24 h, 3) at 48 h, and 4) at 72 h; the latter for the MCPA run only. Cotton plants were placed on the downwind side of the plots immediately following the completion of the spraying, and two plants were removed at 24 h, 48 h, and 72 h (for MCPA only) following the spray applications.

RESULTS AND DISCUSSION

The 1996 trials indicated that the jet nozzles on the Jet Ranger helicopter produced but a fraction of the drift of the fixed wing AgCat. Drift. The Jet Ranger showed about 16% (filters) and 19% (cotton plants) of the AgCat drift levels. There was little difference in filter deposits between the AgCat trial at 90 mph vs the 100 mph run. The slower speed gave a slightly higher deposit level on the cotton plants, but it would appear that a greater velocity difference would have to be used in order to obtain any significant difference in drop size due to aircraft speed.

The 1996 trials showed further that the AcuFlow nozzles on the UH-1B caused even lower drift than the Jet Ranger, in fact the lowest for the entire series of drift runs. This was only 2% of the air burden caused by the AgCat, and only 11% of that of the Jet Ranger. Cotton plants used for the UH-1B trial showed but 16% of the drift level obtained from the Jet Ranger with the orifice jet nozzles. Since both helicopters were operated at around 55 mph, each had a swath width of 35 to 40 feet, their rotors and spray booms were very nearly the same, it is persuasive to think that the AcuFlow tube jet vs the orifice plate nozzles were responsible for this difference between the two helicopters in downwind drift.

The results from the 1997 trials show that the XR 8002 fan nozzles on the ground rig produced by far the greatest amount of drift loss as found on both the cotton plants and the air filters. The filter data show the Turbo T-jet nozzles to be next highest, dropping below the XR nozzles by 75%, or only 35% as much drift resulted from the Turbo T-Jet nozzles as from the XR 8002 (Figure 2).

The cotton plant residue analyses showed a similar trend with 1.125 ppm as the highest level from the XR nozzles, dropping to 0.645 for the Turbo Flood-Jets and to 0.195 ppm for the Turbo T-Jets. This is likely due to the wind which blew over five of the eight cotton plants on Plot two, Figure 2.

Both chemical analysis and visual evaluations established that there was no contamination of the test plants before or following any of the treatments. Visual ratings of the cotton plants exposed to MCPA drift during the 1997 field trials are shown in Table 2.

Table 2. Cotton plant exposure ratings MCPA 1997, during application.

Equipment	Plot	Plant location	Injury[a]			
			Overall[a]	Overall[b]	Old leaves[c]	New leaves[d]
	No.					
UH-1B	one	East	1	0	0	0
		West	2	“	1	“
Gnd Turbo-T-J[e]	two	East	1.5	“	1.5	“
		West	0.5	“	0.5	“
Gnd XR-Fan	three	East	4	“	1.5	“
		West	4.5	“	2.5	“
Gnd Turbo-F-J	four	East	3.5	0.5	3.5	“
		West	3	0	1.5	“

[a] Visual ratings based on: 0 no symptoms to 10 severe symptoms.
[b] Overall plant leaf rating, 2 and 13 weeks after spraying exposure.
[c] Rating of old leaves on Oct. 6, exposed July 9, significant re-growth had occurred.
[d] Rating of the new leaves developing at plant apex, after returned to the lath house.
[e] Gnd means ground equipment.

The visual ratings follow the MCPA analysis data in that the XR fan nozzle plot produced by far the greatest drift effects on the cotton plants. Although the Turbo Flood-Jet plot showed the next highest drift effect, the Turbo T-Jet plot where the cotton plants were blown over would likely have been comparable with the filter data if the plants had remained upright. The plants from the helicopter UH-1B plot were almost symptom free, which agrees with the MCPA analysis on the filters and from the plants.

Re-entrainment or Lift-off of Phenoxies From Plants Following Treatment.
The movement of herbicide from the treated crop back into the air constitutes a form of re-entrainment or lift-off and may originate as a vapor (from high volatility herbicides), or as particles in the form of crystals or dusts, which are blown off the treated rice. The lift-off that occurred from our 1996 and 1997 field trials was monitored by placing air (4 hrs each day) and plant sample collectors exposed for 24, 48 (and MCPA only 72 hrs) on the downwind side of the treated fields following the spray treatment (Day et al, 1959).

Table 3. Residues in filters and cotton plants during and following phenoxy applications 1996.

Collection period	AgCat		Jet Ranger		UH-1B	
	Filters	Plants	Filters	Plants	Filters	Plants
	μg	ppm	μg	ppm	μg	ppm
During application	54.8	0.367	9.01	0.078	1.03	0.013
During LO, 72 hrs	1	0.275	1	0.275	1	0.275
% LO/application	1.8	75	11	352	97	2115

The lift-off (1996) of 2,4-D from the treated rice to the cotton plant and air filter samplers is shown in Table 3. This is for 3 days following application on July 16, 1996. The visual damages to the test plants held for observation were also significant for day 1 and 2, although LO (lift-off) for day 2 data did have a wind reversal which reduced the air sampler and plant exposure significantly. By day 3 there was no further effect on the cotton plants and greatly reduce residue caught in the air filters. Note that the percent of lift-off vs losses during application was found by dividing the lift-off by the application data both for the plants and the air filters. The air filters were operated only 4 h while the cotton plants were out for a 24 h exposure on each of the 3 days. But this also shows another factor which must be taken into consideration when relating lift-off to losses during application. As can be seen from Table 3, this percent varies greatly, from 75 to 2115% for the plant data and 1.8 to 75% for the filters, depending which of the losses of the three applicators was used.

Table 4. Residues in filters and cotton plants during and following phenoxy applications 1997.

Collection	Gnd Xr		Gnd T-Jet		Gnd F-Jet		UH-1B plot 1	
period	Filters	Plants	Filters	Plants	Filters	Plants	Filters	Plants
	µg	ppm	µg	ppm	µg	ppm		
During application	172.5	1.125	43	0.195	15.3	0.645	7.5	0.34
During LO, 48 h	10.9	0.119	10.9	0.119	10.9	0.119	10.9	0.119
% LO/application	1.1	10.6	25.3	61	71	18.4	14.5	35

The data shown in Table 4 illustrates the problem that occurs even when the low volatility amine formulations of the phenoxies are used. Though the application drift may be very low, such as shown with the UH-1B helicopter, the fact remains that the phenoxies do continue to re-entrain into the air from the treated field for 3 to 5 days at measurable amounts. The amounts that come off appear to be a function of the wind velocity, thus giving credence to the theory that most of the phenoxy is being carried in the air as small crystalline particles as a result of the evaporation of the water carrier during and following the application. After the treated rice field is dry, the crystals of phenoxy may be blown off the plants, hence the wind strength can enter into the LO equation as well as during the application. During the application the stronger the wind the greater distance the released herbicide will be carried, but the concentration at any point downwind actually decreases as the velocity increases, the airborne material is simply being spread out over a broader and longer distance, hence less concentrated at any one point. Visual ratings of the cotton plants exposed during the lift-off regime, indicated heavy symptoms for the first day exposure only, but symptoms were still evident on this cotton plant set at the October 6 evaluation.

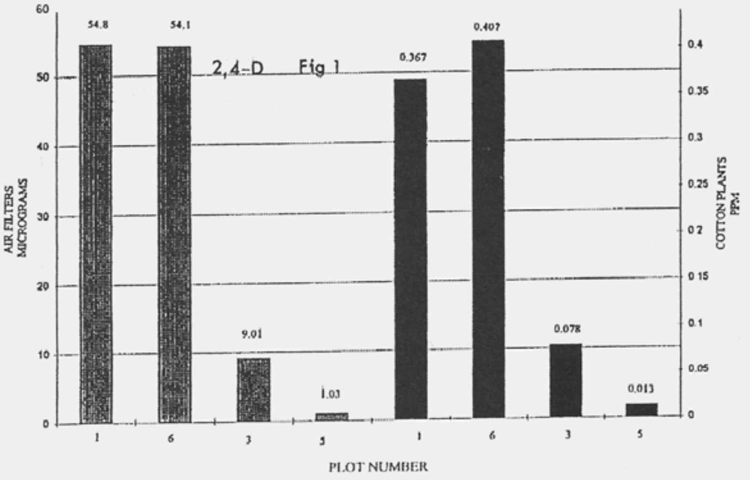
Weed Control Evaluation in the 1997 Plots.

Plot 1, UH-1B Helicopter. The weed vegetation present was composed of 70% redstem *(Ammannia sp)*, 20% ricefield Bulrush (*Scipus mucronatus*), and 10% smallflower umbrella sedge *(Cyperus difformis*). Weed control was estimated to be 80% overall, but was marginal for the redstem. Although redstem was scattered throughout the plot, there were several long narrow strips across the plot (in line with the spray path) suggesting streaking from the helicopter. Redstem was prevalent in that strip as was roughseed bulrush. In other areas there were many dead weeds.

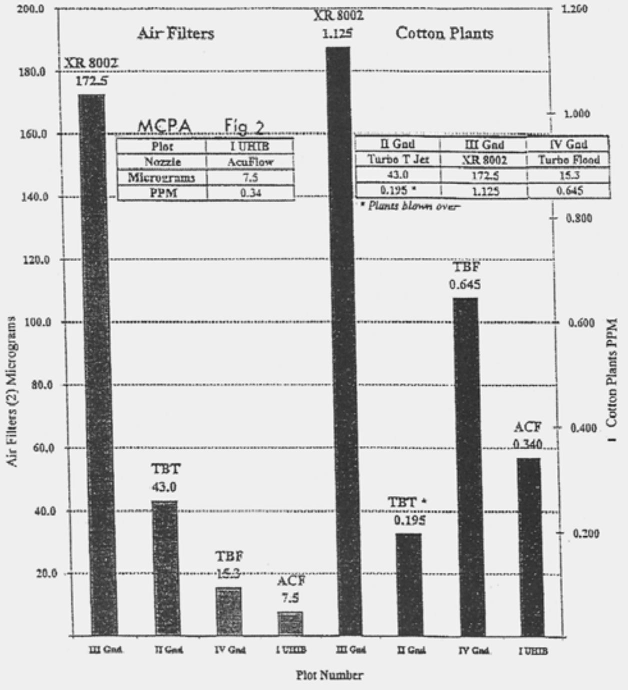
Plot 2 Ground, Turbo T-Jet nozzles. The weed vegetation present was composed of 88% smallflower umbrellasedge, 10% redstem and 2% ricefield bulrush. Overall weed control was excellent at about 99%. There were a few scattered smallflower umbrellasedge plants in the field and an occasional small cluster of other weed plants. Many dead weed skeletons were evident throughout the plot.

Plot 3 Ground, Turbo Flood-Jet. The weed vegetation present was composed of 90% smallflower umbrellasedge, 8% redstem, and 2% ricefield bulrush. Overall weed control was good at about 90%. The center of the field was virtually weed free. Scattered plants were found around edges of the field and into the field about 100 feet. Redstem was the most prevalent weed present that was not fully controlled, especially in the east end of the field.

Plot 4 Ground Rig XR 8002 nozzles. The weed vegetation present was composed of 78% smallflower umbrellasedge, 20% redstem, and 2% ricefield bulrush. Overall weed control was excellent at about 99%. There were a few weeds around the margins of the field and into the field 50 to 100 feet. There were occasional cattails (*Typha sp*) scattered around the edges and ends of the field.



2,4-D Fig 1



MCPA Fig 2

Plot	I UHIB
Nozzle	AcuFlow
Micrograms	7.5
PPM	0.34

II Gnd	III Gnd	IV Gnd
Turbo T Jet	XR 8002	Turbo Flood
43.0	172.5	15.3
0.195 *	1.125	0.645

* *Plants blown over*

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WEED CONTROL IN GLYPHOSATE RESISTANT SUGARBEET. Don W. Morishita[1], Michael J. Wille[1], and Robert W. Downard[2], Associate Professor, Support Scientist, and District Sales Manager, [1]Department of Plant, Soil, and Entomological Sciences, University of Idaho, Twin Falls, ID 83303-1827 and [2]Novartis Seeds, Inc. Twin Falls, ID 83303.

Abstract. Chemical weed control in sugarbeet requires intensive management of herbicide application rate and timing with currently available sugarbeet varieties and herbicides. Development of glyphosate-resistant sugarbeet will provide growers with an additional tool for managing weeds in this crop. Experiments were conducted in 1997 and 1998 at the University of Idaho Research and Extension Center near Kimberly, Idaho. The objectives of these experiments were to evaluate grass and broadleaf weed control in glyphosate-resistant sugarbeet grown with and without cultivation. Cultivation is a standard practice in sugarbeet production. All experiments were conducted under sprinkler irrigation with treatments arranged in a randomized complete block design with three or four replications. Herbicides were applied in a 10-inch band using 8001 even fan nozzles at 20 gpa or applied broadcast with 11001 flat fan nozzles at 10 gpa. A CO_2 pressurized bicycle-wheel sprayer was used to apply herbicide treatments. Glyphosate was applied at 0.375 and 0.75 lb/A in the cultivation comparison experiment and 0.75 lb/A in the other experiments. Herbicide treatments were evaluated visually for crop injury and weed control two times during the growing season. Kochia, common lambsquarters, redroot pigweed, hairy nightshade, green foxtail, and volunteer wheat were the major weed species in these experiments. Sugarbeet yields were determined by harvesting the center two rows of each plot with a mechanical harvester.

Sugarbeet was not injured significantly by any glyphosate application in either year. In 1997 kochia and common lambsquarters control ranged from 93 to 100% with all sequential glyphosate applications. A single glyphosate alone application at the 4-leaf stage was not enough to control the broadleaf weeds or green foxtail into late July. All herbicide treatments in 1998, controlled redroot pigweed, common lambsquarters, kochia, hairy nightshade, and annual sowthistle 95 to 100%. In 1998, a single application of glyphosate was applied in combination with CGA-77102, BAS 656 07 H, or ethofumesate. All of these treatments effectively controlled all weeds present. Weed control with sequential applications of desmedipham + phenmedipham + triflusulfuron plus sethoxydim was generally not as good as the sequential glyphosate treatments in 1997. In 1998, ethofumesate applied preemergence followed by two sequential applications of ethofumesate + desmedipham + phenmedipham + triflusulfuron controlled all weed species equal to the glyphosate treatments. Weed control was nearly 100% regardless of the number of cultivations. Similar to weed control all sequential glyphosate treatments in 1997 had yields equal to the handweeded check. Only glyphosate applied one time and the standard weed control treatment did not yield as high as the handweeded check. Sugarbeet yield in the herbicide treatments in 1998 ranged from 30 to 35 ton/A. These were all significantly greater than the untreated check, which yielded 12 ton/A. Sugarbeet yield with no cultivation was equal to one or two cultivations. Based on these data, it appears that sequential glyphosate applications are effective in controlling weeds throughout the growing season. Single applications of glyphosate plus CGA-77102, BAS 656 07 H, or ethofumesate applied at the sugarbeet 4- to 5-leaf stage shows promise for allowing growers to control weeds with a single herbicide application.

EFFECTIVENESS OF GLYPHOSATE AND GLUFOSINATE TREATMENTS FOR WEED CONTROL IN HERBICIDE RESISTANT SUGARBEET SYSTEMS. Corey J. Guza[1], Corey V. Ransom[2], Carol Mallory-Smith[1], and Don Morishita[3], Graduate Research Assistant, Assistant Professor, Assistant Professor and Associate Professor, Department of Crop and Soil Science, [1]Oregon State University, Corvallis, OR 97330-3002; [2]Malheur Experiment Station, Oregon State University, Malheur, OR 97914; and [3]Department of Plant, Soil and Entomological Sciences, University of Idaho, Kimberly, ID, 83303.

Abstract. The development of glyphosate and glufosinate resistant sugarbeet varieties provides a new tool for postemergence weed control. Two field studies were conducted at Ontario, OR, with glyphosate and glufosinate resistant sugarbeets. A third study, conducted in Kimberly, ID, included only glyphosate resistant plants. The studies examined glyphosate and glufosinate rates, timings and combinations with residual herbicides applied preplant incorporated (PPI) or applied as tank mixtures for the control of common lambsquarters, hairy nightshade and redroot pigweed. A standard herbicide program was used as a comparison in each study. Glyphosate treatments at Ontario provided greater control than the standard for hairy nightshade and redroot pigweed. At Kimberly, glyphosate treatments combined with s-dimethenamid provided slightly less control of common lambsquarters and redroot pigweed than the standard treatments. In the glufosinate trial, hairy nightshade control was lower for treatments with ethofumesate applied at 1 lb/A PPI followed by an application of glufosinate (0.26 lb/A) to 2- and 3-inch weeds compared to the standard. Treatments including glufosinate tank mixed with 1 lb/A of ethofumesate as a layby application provided less control compared to the standard with the exception of treatments of 0.36 lb/A of glufosinate.

PERFORMANCE OF GLUFOSINATE AND GLYPHOSATE FOR WEED CONTROL IN TRANSGENIC SUGARBEETS IN CALIFORNIA. Robert F. Norris and John A. Roncoroni, Associate Professor and Staff Research Associate, Weed Science Program, Vegetable Crops Department, University of California, Davis, CA 95616.

Abstract. Experiments were conducted in 1997 and 1998 to evaluate selectivity and weed control in transgenic sugarbeets treated with glufosinate or glyphosate. RoundupReady sugarbeets showed excellent tolerance to 0.7 kg/ha of glyphosate as single or multiple applications, and Liberty-Link beets showed similar tolerance to single or multiple applications of 0.5 kg/ha of glufosinate. Sugarbeets of a local non-transgenic variety were killed by either herbicide. Single postemergence treatments of either herbicide did not provide adequate season-long control of mixed annual weeds, including barnyardgrass, witchgrass, tumble pigweed, black nightshade, and common lambsquarters. This was attributed to lack of residual activity of the herbicides coupled with continued germination of weeds that occurred after the herbicide application. Repeat applications timed when later emerging weeds were at about the two- to four-leaf growth stage provided over 95% control of weeds, when 0.7 kg/ha of glyphosate, or 0.5 kg/ha of glufosinate, was applied at each application. Rates lower than 0.5 kg/ha of glufosinate, or 0.7 kg/ha of glyphosate, did not provide adequate weed control. Repeat applications of glyphosate did not control all plants of little mallow present in the plots. Barnyardgrass control by glufosinate was only partial and many treated plants were able to resume growth. Addition of ammonium sulfate to glufosinate did not improve efficacy against black nightshade and tumble pigweed. Both transgenic sugarbeet varieties showed some agronomic limitations in comparison with local varieties, indicating that further plant breeding may be required before the transgenic varieties are commercially acceptable.

WEED CONTROL IN TRANSGENIC SUGARBEETS. 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, P.O. Box 3354, University of Wyoming, Laramie, WY 82071.

Abstract. Field experiments were conducted in 1997 and 1998 at two locations; the Powell and Torrington Research and Extension Centers, Wyoming, to evaluate the time and number of applications as well as the rate needed to control weeds effectively in Roundup Ready and Liberty Link sugarbeets. The sugarbeet varieties were planted in 22 inch rows in a clay loam soil with 1.3% OM at Powell and in 30 inch rows in a sandy loam soil with 1.2% OM at Torrington. Plots were 10 by 30 feet with three replications arranged in a randomized complete block design. Glufosinate resistant sugarbeet trials consisted of two rates of glufosinate (0.27 with or without ammonium sulfate and 0.36 lb/A) and three-way application starting at cotyledon, 2- or 4-leaf stage with one or two week interval. Glyphosate resistant sugarbeet trials consisted of one rate 0.75 lb/A and two or three way applications starting at cotyledon, 2- or 4-leaf stage with two or three week interval. Kochia, common lambsquarters, redroot pigweed, wild mustard, hairy nightshade, and green foxtail infestations were moderate (20 to 25 plants/yd^2) and uniform throughout the experimental sites.

Weed control in glufosinate resistant sugarbeets was excellent (90 to 100%) when glufosinate was applied at 2- or 4-leaf stage. Glufosinate at the rate of 0.36 lb/A was more effective in controlling weeds than the 0.27 lb/A. However, ammonium sulfate at 17 lb/100 gal enhanced weed control by 5 to 10%. Weed control with the three way application of glyphosate in glyphosate resistant sugarbeets was excellent (97 to 100%). Similar results were achieved with the two way application when glyphosate was applied at the 2- or 4-leaf stage with three week interval (96 to 100%).

EFFECTS OF SUGARBEET PLANT POPULATION AND WEED CONTROL TREATMENT ON WEED COMPETITION. Steve L. Young, Don W. Morishita, and Michael J. Wille, Graduate Research Assistant, Associate Professor, and Research Support Scientist, Twin Falls Research and Extension Center, University of Idaho, PO Box 1827, Twin Falls, ID 83303-1827.

Abstract. Early to mid-season weed control is critical for sugarbeet stand establishment. A dense intra-row leaf canopy is desirable as soon as possible in order to shade out emerging weeds and reduce their competitiveness. Sugarbeet populations of 100 to 105 plants/30 m (Low), 125 to 130 plants/30 m (Medium), 150 to 155 plants/30 m (Optimum), and 175 to 180 plants/30 m (High) were established and treated with three different herbicide combinations to determine their effect on weed emergence and competition. Weed emergence counts were taken weekly from emergence to 2 weeks after row closure. In the handweeded checks of all sugarbeet populations, kochia and green foxtail densities within the crop row peaked at 25 to 45 plants/m^2 between June 4 and 13. The one exception was kochia in the High population, which ranged from 0 to 10 plants/m^2 the entire season. Across all sugarbeet populations, redroot pigweed and common lambsquarters attained maximum densities of nearly 800 and 100 plants/m^2, respectively on June 4. Ethofumesate applied preemergence (PRE) with no sequential herbicides effectively controlled green foxtail 98 to 100%, but was ineffective on all other weeds, independent of sugarbeet population. Ethofumesate applied PRE followed by either a single POST application or two sequential POST applications of ethofumesate plus desmedipham plus phenmedipham plus triflusulfuron controlled kochia, common lambsquarters, and redroot pigweed 94 to 100%. Green foxtail control averaged 98 to 100%. The level of weed control in sugarbeets is more dependent on herbicide regime and number of applications rather than competition from higher sugarbeet populations. In terms of sugarbeet yield and quality, a single POST application was just as effective controlling weeds as two POST applications.

WEED CONTROL IN NO-TILL SUNFLOWERS WITH SULFENTRAZONE. Stephen D. Miller and Stephen M. Van Vleet, Professor and Research Associate, Department of Plant Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Farmer interest in spring seeded crops for dryland cropping systems continues to increase each year in southeast Wyoming. Spring seeded crops (corn, millet and sunflower) offer growers the opportunity to manage winter annual grassy weeds in their dryland wheat, grow crops two out of three years instead of every other year and to make dryland farming more economically stable in this region. Sunflower with its drought tolerance has generally performed better than the other crops in this region. There currently are a number of excellent grass herbicides available for weed control in sunflower. However, herbicides for broadleaf weed control are quite limited. Sulfentrazone, a commercial soybean herbicide, has shown excellent results for broadleaf weed control in sunflower.

Trials were established under dryland conditions at the Research and Extension Center, Archer, WY from 1995 to 1998 to evaluate weed control and sunflower response to sulfentrazone applied alone or in combination with other herbicides. Plots were 10 by 30 feet. with three replications arranged in a randomized complete block design. Herbicide treatments were applied with a CO_2 pressurized knapsack sprayer delivering 20 gpa at 40 psi as an early preplant (20 to 30 days prior to seeding sunflower) or a preemergence treatment applied immediately after seeding sunflower. Sunflower variety Capri was planted directly into standing wheat stubble with a row crop air seeder at a population of 17,000 seed/A all years. All plots were oversprayed with glyphosate (0.28 lb/A) at the time of planting to control emerged vegetation all years.

Sulfentrazone at rates of 0.125 to 0.25 lb/A provided good to excellent (80 to 100%) control of redroot pigweed, kochia or Russian thistle at both application timings. However, sunflower tolerance to sulfentrazone was very sensitive to rate and application timing. Sunflower tolerance to sulfentrazone was best with 0.125 to 0.19 lb/A early preplant or 0.125 lb/A preemergence. Sulfentrazone combinations with dimethenamid, metolachlor or pendimethalin provided excellent (95 to 100%) broadspectrum weed control at all application timings; however, preemergence combinations generally resulted in sunflower injury regardless of application rate.

HERBICIDE RESISTANT WEEDS OF THE WEST. Ian H. Heap, WeedScientist, WeedSmart, P.O. Box 1365, Corvallis, OR 97339.

Abstract. The 1998 USA survey of herbicide-resistant weeds recorded 35 herbicide-resistant weed biotypes in the 16 western states of the United States. There are 24 weed species that have evolved resistance to one or more of nine herbicide modes of action (WSSA groups 1, 2, 3, 4, 5, 6, 7, 8, and 15) in western USA. Wild oat, which has evolved resistance to four herbicide modes of action (WSSA groups 1, 2, 8, and 15) and kochia, which has evolved resistance to three herbicide modes of action (WSSA groups 2, 4, and 5) are among the most serious herbicide-resistant weed species of the west. These two species are particularly troublesome in small grains in the states of Montana, North Dakota, Idaho, Washington, Colorado, and Oregon. In California ALS inhibitor resistant weeds in rice are widespread and causing major changes in herbicide usage. Resistance to bensulfuron has been identified in California arrowhead, smallflower umbrella plant, redstem, and ricefield bulrush in rice fields in California. The following lists the number of resistant weed biotypes found in each of the 16 states considered in this review - CA (9), KS(9), WA (9), ID (8), MT (8), OR (8), ND(6), CO (4), HI (3), NE(2), NM (2), WY (2), AR (0), AK (0), NV (0), and UH (0). 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.

WEED CONTROL WITH IMAZAMOX IN IMI® WHEAT. J. R. Roberts, J. P. Kelley, and T. F. Peeper, Graduate Research Assistant, Senior Agriculturist, and Professor, Department of Plant and Soil Sciences, Oklahoma State University, Stillwater, OK 74078.

Abstract. Field research was conducted in north central Oklahoma during the 1997 to 1998 growing season to evaluate imazamox for grassy weed control in winter wheat. Fidel IMI® wheat was planted at each location, and imazamox was applied at 0.024, 0.032, 0.04, and 0.048 lb/A, and MON 37500 was applied at 0.5 oz/A in the fall and/or spring. Rye control was 70 to 100% with imazamox, and 3 to 25% with MON 37500 depending on rate, timing, and location. Cheat control was 100% with imazamox and MON 37500. Italian ryegrass control was 74 to 99% with imazamox, and 78 to 80% with MON 37500 depending on rate, timing, and location. Jointed goatgrass control was 80 to 100% with imazamox, and 0 to 9 % with MON 37500. Tank mixing imazamox with 2,4-D or MCPA revealed some antagonism. Research is being repeated during the 1998 to 1999 growing season.

EFFECTS OF SPRING CROPS, AND WINTER WHEAT PLANTING DATE ON CONTROL JOINTED GOATGRASS. Caleb D. Dalley and John O. Evans, Graduate Research Assistant, Professor, Department of Plant, Soils, and Biometerology, Utah State University, Logan, UT 84322-4820.

Abstract. Jointed goatgrass has become a serious weed problem for wheat growers west of the Mississippi River. To improve management of this weed, a better understanding of the effects spring crops, wheat planting date, and tillage intensity are needed. Two identical experiments were established in northern Utah (one starting in 1996, the other in 1997) to study the effects of these management practices on population and reproduction of jointed goatgrass, soil seedbank dynamics, crop yield, and crop dockage over a 5 year period. With nearly identical populations of jointed goatgrass, wheat yield was 25 and 35% better in wheat planted in September that in October in 1997, and 1998, respectively. Jointed goatgrass population density was reduced 97% in safflower for both years. Soil seedbank measurements in fallow following wheat and safflower showed a 10-fold increase in seed concentrations in fallow following October planted wheat over September planted wheat and safflower. Jointed goatgrass population densities in fallow following safflower were 54 and 75% less than fallow following September and October planted wheat respectively. Contamination of harvested wheat and safflower was also greatest in October wheat plantings. 1997 harvests had 0.64, 0.54, and 2.37 g jointed goatgrass per kg harvested crop in safflower, September, and October planted wheat, respectively. 1998 harvests had 0, 24.5, and 38.5 g/kg, respectively as before. Tillage intensity applications began in the summer of 1998 for the experiment starting in 1996. There are no results available at this time for tillage treatments.

FLUCARBAZONE-SODIUM - A NEW HERBICIDE FOR GRASS CONTROL IN WHEAT. Hans J. Santel[1], Bryan A. Bowden[2], Veldon M. Sorensen[2], Klaus H. Mueller[3], and Joseph Reynolds[3], [1]Bayer Corp., Kansas City, MO 64120; [2]Bayer Inc., Etobicoke, ONT M9W 1G6, Canada; and [3]Bayer AG, 51368 Leverkusen, Germany.

Abstract. Flucarbazone-sodium is a new sulfonylaminocarbonyltriazolinone herbicide being developed by Bayer. The products acts as an inhibitor of the enzyme acetolactate synthase (ALS). It provides excellent activity against grass weeds and several important broadleaf weeds when applied postemergence to wheat. In field experiments conducted between 1993 and 1998 in Canada and the U.S., the product has demonstrated strong and consistent activity against wild oat and green foxtail. At the suggested use rate of 30 g/ha both weeds were selectively controlled in wheat, particularly in spring wheat. Full control of biotypes being resistant to ACCase inhibiting herbicides, triallate or dinitroanilines also was observed indicating the value of flucarbazone-sodium to manage a variety of resistant grasses.

Very low toxicity of flucarbazone-sodium, 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 flucarbazone-sodium.

Low persistence and mobility of flucarbazone-sodium was observed in the field. Its half-life was 14 to 26 days in dissipation studies. No residues were found below the 6 to 12 inch soil layer in field trials. Flucarbazone-sodium indicated a low potential to bioaccumulate and insignificant concentrations in drinking water were estimated from model calculations.

Flucarbazone sodium showed little toxicity for birds, fish, green algae, daphnia, honeybees and earthworms. The use of the products will result in a minimal risk for fish, birds aquatic and terrestrial invertebrates and algae.

CONTROL OF WILD OAT, GREEN FOXTAIL AND SELECTED BROADLEAF WEEDS IN SPRING WHEAT WITH FLUCARBAZONE-SODIUM. [1]Ronald Brenchley, [1]Dallas E. Rasmussen, [1]Hans J. Santel, [2]Veldon M. Sorensen, [2]Bryan A. Bowden, [2]Patrick G.M. Bulman, [2]David E. Feindel, [2]Bruce Gibb, and [2]Blaine M. Tomolak, [1]Bayer Corp., Kansas City, MO 64120 and [2]Bayer Inc., Etobicoke, ONT M9W 1G6, Canada.

Abstract. Flucarbazone-sodium is a new sulfonylaminocarbonyltriazolinone herbicide being developed by Bayer. The product acts as an inhibitor of the enzyme acetolactate synthase (ALS). Flucarbazone-sodium has shown excellent efficacy against wild oat and green foxtail when applied post emergence in spring wheat at the proposed use rate of 30 g/ha. Efficacy and yield trials have been conducted from 1994 to 1998 in the three Canadian prairie provinces and in the spring wheat growing areas of the United States. Weed efficacy was maintained when flucarbazone-sodium was mixed with numerous tank-mix broadleaf partners and non-ionic surfactants. In weed free yield trials, flucarbazone-sodium applied at 2X proposed usage rates indicated no yield loss when mixed with any broadleaf tank-mix partner or with assorted non-ionic surfactants. Flucarbazone-sodium also provided control of ACCase and triallate resistant wild oat and ACCase and DNA resistant green foxtail. All spring wheat and durum wheat varieties tested were safe to applications of flucarbazone-sodium.

FENOXAPROP-P-ETHYL plus AE F107892 (PUMA) FOR USE IN CEREALS. Charles P. Hicks, Kevin B. Thorsness, and Thomas W. Kleven, Field Development Representatives and Biologist, AgrEvo USA Company, Wilmington, DE 19808.

Abstract. Fenoxaprop-p-ethyl plus AE F107892 (Puma) is a new postemergence herbicide that is being developed by AgrEvo USA Company. The combination of fenoxaprop-p-ethyl plus the safener, AE F107892, controls wild oat, green foxtail, yellow foxtail, foxtail millets, proso millet, volunteer corn, barnyardgrass, blackgrass and windgrass and is safe on wheat, barley and durum wheat. Research was conducted in 1996, 1997 and 1998 to evaluate fenoxaprop-p-ethyl plus AE F107892 in tank mix combinations with various broadleaf herbicides for control of wild oat, foxtails and barnyardgrass. Trials were located North Dakota, Minnesota, Colorado, Idaho and Washington.

Fenoxaprop-p-ethyl plus AE F107892 applied at 58.5 g/ha in tankmix combination with tribenuron plus MCPA ester or dicamba plus MCPA ester provided excellent control (90 to 91%) of green foxtail. Fenoxaprop-p-ethyl plus

AE F107892 applied at 71 g/ha in tankmix combination with tribenuron plus MCPA ester or dicamba plus MCPA ester provided good control (86 to 87%) of yellow foxtail. Fenoxaprop-p-ethyl plus AE F107892 applied at 117 g/ha in tankmix combination with bromoxynil, bromoxynil/MCPA, thifensulfuron/tribenuron or MCPA ester provided wild oat control equal to or greater than imazamethabenz plus bromoxynil/MCPA ester plus Scoil or tralkoxydim plus bromoxynil/MCPA ester plus Turbocharge. Three way tankmix combinations of fenoxaprop-p-ethyl plus AE F107892 applied at 117 g/ha with fluroxypyr plus thifensulfuron/tribenuron, MCPA ester or clopyralid/MCPA ester provided wild oat control equal to or greater than tralkoxydim plus bromoxynil/MCPA ester plus Turbocharge. From 1996 to 1998, Fenoxaprop-p-ethyl plus AE F107892 tankmix combinations with various broadleaf herbicides provided consistent control of wild oat, barnyardgrass and foxtail species. Where slight antagonism was observed, grass control was equal to or greater than that provided by the standard treatment.

FLUROXYPYR (STARANE) FOR CONTROL OF KOCHIA AND OTHER BROADLEAF WEEDS IN WHEAT AND BARLEY. Bruce Riggle[1], Rick Bearmore[1], Glen Mundt[2], John Jachetta[3], and Kent Redding[3], [1]United Agri Products, Greeley, CO 80632; [2]Snake River Chemicals, Caldwell, ID 83605; and [3]Dow AgroSciences, Indianapolis, IN 46077.

Abstract. STARANE, is a newly registered herbicide containing the active ingredient, fluroxypyr–MHE. In 1998, the EPA granted Section 18 Emergency uses to Washington, Idaho, Montana, Michigan, and Oregon for the suppression of volunteer potatoes and in North and South Dakota for control of SU-resistant kochia. Dow AgroSciences received a full Environmental Protection Agency (EPA) Section 3 Federal registration in October 1998 with residue tolerances for wheat, barley, and oats. Platte Chemical Co., an affiliate of United Agri Products, jointly developed registration data for fluroxypyr with Dow AgroSciences. Fluroxypyr provides adequate suppression of volunteer potatoes for the prevention of the spread of the potato late blight pathogen and excellent control of all kochia biotypes, including SU-resistant kochia, as well as other important hard to control problem weeds in wheat, oats, and barley. Fluroxypyr environmental toxicology profile shows that it is not acutely toxic to fish and Daphnia magna or green algae and that it has low toxicity to birds and honey bees. The soil half-life is from 1- to 4-weeks and it has little or no toxic effects on soil residing organisms. The primary degradation path in the soil is through microbial action. Fluroxypyr does not present any significant environmental hazard due to leaching through the soil profile. Fluroxypyr provides a high degree of crop safety and is safe on cereals from the 2-leaf stage (Zadoks 12) to heading emergence (Zadoks 45), on corn from the 2- to 6-leaf stage, and on sorghum from the 2- to 7-leaf stage. It is most effective when applied to weeds that are actively growing as it has a systemic action. Like many of the other auxin type herbicides, fluroxypyr has a complex mode of action that disrupts plant cell growth. Fluroxypyr is a member of the pyridinyloxyacetic acid family that also includes triclopyr. Fluroxypyr-MHE, unlike other ester-based herbicides is not volatile and can be applied close to susceptible neighboring crops such as grapes, sugarbeets, sunflowers, and soybeans, with minimal risk. Fluroxypyr is rapidly absorbed by weeds and is rainfast within one hour after application. Fluroxypyr can be applied as a tank mixture with wild oat herbicides. After a 120-day interval, there are no crop rotation restrictions. Fluroxypyr provides broadleaf weed control (85 to 100% control) on a number of annual and perennial species including catchweed beadstraw, kochia, velvetleaf, common cocklebur, common chickweed, common ragweed, common purslane, morningglory (sp), and hemp dogbane.

WEED CONTROL IN WINTER WHEAT WITH CARFENTRAZONE-ETHYL, 2,4-D, AND PROSULFURON. Robert N. Klein and Jeffrey A. Golus, Professor and Extension Research Technologist, University of Nebraska West Central Research and Extension Center, North Platte, NE 69101.

A study was conducted in 1997 to evaluate the addition of NIS and 28% N to improve efficacy of carfentrazone-ethyl with 2,4-D when applied at low gallonage. The gallonages were 5, 7.5 and 10 gpa. The experiment was a randomized complete block design with three replications and treatments were applied on April 16 with a tractor mounted sprayer. Sprayer boom was shielded and 15 feet long (six 11002XR nozzles on 30 inch spacing). Nozzle pressure was 25 psi, 5 gpa treatments were applied at 6.1 mph, 7.5 gpa treatments were applied at 4.1 mph, and 10 gpa treatments were applied at 3.1 mph. Weeds at application included: blue mustard, close to blooming; evening primrose, rosette 0.5 to 5 inches; tansy mustard, mostly bolted up to 4 inches; smallseed falseflax, rosette 1 to 5 inches; tumble mustard, mostly bolted. All weeds looked severally injured and were going to die on April 27, with no crop injury observed on April 29. Smallseed falseflax and tumble mustard control was visually rated on June 5, results shown in Table 1. Greenflower pepperweed and blue mustard were not in all plots, but controlled 100% where present.

Table 1. Carfentrazone-ethyl with 2,4-D, nonionic surfactant and 28% N in winter wheat, 1997.

				Weed control	
Treatment	Rate	Additives	Volume	Smallseed falseflax	Tumble mustard
	lb/A		gpa	%	
Carfentrazone-ethyl + 2,4-D	0.023 + 0.25	28% N 1 qt/A	10	99	100
Carfentrazone-ethyl + 2,4-D	0.023 + 0.25	28% N 1 qt/A	7.5	99	100
Carfentrazone-ethyl + 2,4-D	0.023 + 0.25	28% N 1 qt/A	5	98	100
Carfentrazone-ethyl + 2,4-D	0.023 + 0.25	28% N 1 qt/A + NIS 0.25% v:v	10	100	100
Carfentrazone-ethyl + 2,4-D	0.023 + 0.25	28% N 1 qt/A + NIS 0.25% v:v	7.5	99	100
Carfentrazone-ethyl + 2,4-D	0.023 + 0.25	28% N 1 qt/A + NIS 0.25% v:v	5	99	100
Carfentrazone-ethyl + 2,4-D	0.023 + 0.25	28% N 50% v:v	5	99	100
Carfentrazone-ethyl + 2,4-D	0.023 + 0.25	28% N 50% v:v + NIS 0.25% v:v	5	99	100
Carfentrazone-ethyl + 2,4-D	0.023 + 0.25	28% N 75% v:v	5	100	100
LSD (0.05)				NS	NS

A study was conducted in 1996 to examine the application parameters of carfentrazone-ethyl with 2,4-D. Nozzle type, gallonage, and carrier were varied. Extended range Flat Fan and Turbo TeeJet nozzles were used. Gallonages were 5, 10, and 20 gpa. Water, 28% N and 50% v/v water/28% N were the different carriers. The experiment was a randomized complete block design with four replications. All plots were sprayed using a 3-point, 15 foot shielded boom sprayer (6 nozzles on 30" spacing) on May 22. The treatments were carfentrazone-ethyl (0.023 plus 2,4-D at 0.25lb/A with the exception of one treatment that contained only 28% N 20 gpa. Extended range Flat Fan and Turbo TeeJet nozzles were used at 5, 10, and 20 gpa with 28% N added at 2% v:v and water being the carrier. Extended range Flat Fan nozzles were also used to apply 5, 10, and 20 gpa treatments with 28% N used as the carrier, the 10 gpa water and 10 gpa 28% N carrier treatment, and the 20 gpa treatment of 28% N alone. The 5 gpa treatments were applied with 11002 XR and TT11002 VP nozzles at 20 psi and 5.54 mph. The 10 gpa treatments were applied with 11002 XR and TT11002 VP nozzles at 20 psi and 2.77 mph. The 20 gpa treatments were applied with 11004 XR and TT11004 VP nozzles at 20 psi and 2.77 mph. Weeds present at application included: kochia up to 4 inches, Russian thistle 1 to 4 inches, common lambsquarter 1 to 3 inches, and annual sunflower and slimleaf lambsquarter 0.5 to 3 inches. Crop injury was rated 1 and 2 weeks after treatment data shown Table 2. Weed control was rated 4 and 6 weeks after treatment and data shown in Table 2.

Table 2. Carfentrazone-ethyl with 2,4-D and 28% N in winter wheat, 1996.

Treatment	Rate	Application nozzle	Crop injury		Weed control			
					Kochia		Russian thistle	
			May 29	June 6	June 17	July 4	June 17	July 5
	lb/A		%					
Carfentrazone-ethyl + 2,4-D + 28% N	0.023 + 0.25 + 2% v:v	5 gpa Flat Fan	0	3	84	81	73	74
Carfentrazone-ethyl + 2,4-D + 28% N	0.023 + 0.25 + 2% v:v	10 gpa Flat Fan	0	5	91	89	80	81
Carfentrazone-ethyl + 2,4-D + 28% N	0.023 + 0.25 + 2% v:v	20 gpa Flat Fan	0	5	93	92	84	85
Carfentrazone-ethyl + 2,4-D + 28% N	0.023 + 0.25 + 2% v:v	5 gpa TrboTjet	0	0	83	79	73	73
Carfentrazone-ethyl + 2,4-D + 28% N	0.023 + 0.25 + 2% v:v	10 gpa TrboTjet	0	4	90	89	81	80
Carfentrazone-ethyl + 2,4-D + 28% N	0.023 + 0.25 + 2% v:v	20 gpa TrboTjet	0	5	91	90	81	84
Carfentrazone-ethyl + 2,4-D + 28% N	0.023 + 0.25	5 gpa Flat Fan	3	4	85	81	75	75
Carfentrazone-ethyl + 2,4-D + 28% N[a]	0.023 + 0.25	10 gpa Flat Fan	18	12	90	88	81	82
Carfentrazone-ethyl + 2,4-D + 28% N[a]	0.023 + 0.25	20 gpa Flat Fan	26	19	94	94	85	88
Carfentrazone-ethyl + 2,4-D + 28% N[b]	0.023 + 0.25	20 gpa Flat Fan	11	10	94	93	85	85
28% N		20 gpa	25	15	-	-	-	-
LSD (0.05)			3	3	7	8	8	8

[a] 28% N used as carrier.

[b] 10 gpa water and 10 gpa 28% N.

In the 1996 study, the greatest crop injury occurred with 28% N as the carrier, although a small amount occurred with 28% N 2% v:v Table 2. The 20 gpa treatments caused the most injury. Weed control was significant or close to being significant at the 5% level between the 5 gpa and 10 gpa treatments, but was not significant between the 10 gpa and 20 gpa treatments (Table 2). There was also no significant difference between the flat fan and Turbo TeeJet nozzles at any gallonage or with 28% N used as the carrier. The 28% N caused more crop injury but did not increase weed control significantly. In 1997, all treatments were effective in controlling smallseed falseflax and tumble mustard (Table 3). Increasing the 28% N did not cause crop injury at 5 gpa. Much more injury occurred at the 10 and 20 gpa levels in 1996.

A study was also conducted in 1997 to evaluate weed control in winter wheat with prosulfuron. Plots were laid out in a randomized complete block design with four replications and applied on April 16 using a CO_2 backpack sprayer with a ten foot boom (six 11002XR nozzles on 20 inch spacing). Nozzle pressure was 22 psi and carrier volume 13.5 gpa. Weeds present at application included: blue mustard, close to blooming; evening primrose, rosette 0.5 to 5 inches; tansy mustard, mostly bolted up to 4 inches; smallseed falseflax, rosette 1 to 5 inches; tumble mustard, mostly bolted. Percent control was visually rated on May 13 and June 5. Blue mustard and tumble mustard were controlled 100% on both dates, with smallseed falseflax control listed in Table 3. No crop injury was visible on either date.

Table 3. Smallseed falseflax control with prosulfuron in winter wheat, 1997.

Treatment[a]	Rate	Smallseed falseflax control	
		May 13	June 5
	lb/A	%	
Prosulfuron + NIS	0.018	70	90
Prosulfuron + dicamba + NIS	0.0134 + 0.094	64	83
Prosulfuron + dicamba + NIS	0.009 + 0.125	58	76
Prosulfuron + bromoxynil + MCPA + NIS	0.0134 + 0.375	81	97
Prosulfurom + 2,4-D amine + NIS	0.0134 + 0.25	75	95
Triasulfuron + dicamba + NIS	0.0134 + 0.094	43	46
LSD (0.05)		7.5	9.5

[a] NIS applied at 0.25% v:v.

The addition of bromoxynil plus MCPA or 2,4-D amine to prosulfuron at 0.0134 lb/A resulted in significantly increased control of smallseed falseflax than the addition of dicamba. Also, the addition of bromoxynil plus MCPA or 2,4-D amine to prosulfuron at 0.0134 lb/A did not significantly increase control over prosulfuron alone at 0.018 lb/A.

CLODINAFOP-PROPARGYL: A NEW POSTEMERGENCE GRASS HERBICIDE FOR WHEAT.

Dain E. Bruns, Kenneth E. Brown, Jerry R. Hensley, and Daniel W. Kidder, Field R&D Representative, Field R&D Representative, Regional Manager, and Technical Manager, Novartis Crop Protection, Inc, Greensboro, NC 27419.

Abstract. Clodinafop-propargyl is an aryloxyphenoxy propionate herbicide being developed by Novartis Crop Protection, Inc. (Greensboro, NC) for annual grass weed control in Spring and Winter wheat. Clodinafop-propargyl is formulated with cloquintocet-mexyl, a safener that improves crop safety by enhancing clodinafop-propargyl metabolism in wheat. A specially formulated oil adjuvant (COC) is recommended to optimize grass weed control from clodinafop-propargyl. Wild oat, green foxtail, yellow foxtail, barnyardgrass, annual ryegrass, persian darnel, and proso millet, but not Bromus nor broadleaf species, are highly susceptible to clodinafop-propargyl at rates of 56 or 70 g/ha. Clodinafop-propargyl has no crop rotation restrictions to any crop and can be tank mixed with dicamba, bromoxynil, bromoxynil plus MCPA ester, MCPA amine and ester, prosulfuron, and other dicot herbicides. Clodinafop-propargyl is rapidly absorbed by plants and is rainfast in 30 min. Clodinafop-propargyl inhibits acetyl-coenzyme-A-carboxylase causing weed growth to cease within 48 h after treatment. Clodinafop-propargyl has low soil leaching potential, no PRE activity at normal use rates, and a soil half-life of a few hours to 5 days with degradation primarily by microorganisms. Clodinafop-propargyl has an acute oral and dermal LD_{50} of greater than 2000 mg/kg and an inhalation lethal concentration (LC_{50}) of more than 3500 mg/m^3. At the low labeled use rates of 56 and 70 g/ha and short half-life, clodinafop-propargyl is safe to users and the environment. Clodinafop-propargyl at 56 or 70 g/ha plus COC at 0.8 or 1% v/v, respectively, gave similar wild oat and foxtail control alone or with bromoxynil plus MCPA ester at 560 g/ha as fenoxaprop at 56 or 92 g/ha and tralkoxydim at 200 g/ha (plus recommend adjuvant at 0.5% v/v) with or without bromoxynil plus MCPA ester at 560 g/ha, averaged across four to six locations in MT, SD, and ND.

RESPONSE OF TWO KOCHIA ACCESSIONS TO PRE- AND POST-EMERGENT APPLICATIONS OF DICAMBA.

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Abstract. Greenhouse experiments were conducted to evaluate the response of two kochia accessions to dicamba applications. Two field soils were used in the experiment: a sandy loam soil with 1.2% organic matter and a clay loam soil with 2.1% organic matter. Flats that were 10 cm wide, 30 cm long, and 5 cm deep were filed with 800 g of field soil. Twenty seeds from one of two kochia accessions were planted in each flat. One of these kochia accessions was susceptible to dicamba and the other was not controlled by dicamba based on a previously determined efficacy experiments. Each soil and kochia accession combination was subjected to nine treatments that were replicated three times. The treatments were: an untreated control, 0.125 and 0.25 lb/A dicamba applied pre-emergent, 0.125 and 0.25 lb/A dicamba applied to soil only, 0.125 and 0.25 lb/A dicamba applied to foliage only; and 0.125 and 0.25 lb/A dicamba applied to soil and foliage. Individual kochia plants were evaluated 28 days after treatment for percent control. Plant ratings were averaged within each flat and the average used in analysis. Pre-emergent applications of either dicamba rate provided at least 85% control of either kochia accession averaged across soil types. Post-emergent applications of dicamba only controlled the susceptible kochia accession. The vigor of both kochia accessions tended to be lower when dicamba was applied compared to the control plants.

COMPETITION OF JOINTED GOATGRASS AND WINTER WHEAT AS INFLUENCED BY WHEAT HEIGHT, SEED SIZE, AND PLANTING DENSITY. Joseph P. Yenish, Steven S. Seefeldt, and Frank L. Young, Extension Weed Scientist, Department of Crop and Soil Sciences, Washington State University, Agronomist and Research Agronomist, USDA-ARS, Pullman, WA 99164.

Abstract. A factorial study was conducted to determine development characteristics and competitive effects of wheat height, size of planted seed, seeding density, and all interactions. Tall and short isolines of the winter wheat variety 'Nugaines' were used to ensure uniform genetic makeup for all traits other than height. Seed was sorted into three sized lots for each isoline; seed large enough to be captured on a 4.4-mm mesh screen (large), seed which passed through a 4-mm screen, but captured on a 3.6-mm screen (small), and the unsorted seed (mixed). Weight of 100 seed were 4.3, 2.5 and 3.4 grams for the large, small and mixed lots, respectively. Wheat was planted on October 15, 1997 in 18-cm rows at an average of 40 (100%) and 60 (150%) pure live seed per linear m of row. Following wheat planting, jointed goatgrass spikelets were broadcast over the entire plot area at a rate of 270 live spikelets m^{-2}. Stand counts recorded in November and February showed more rapid initial establishment and greater final stand density of wheat with the 150% seeding rate and large seed. Winter wheat seedling height was measured at approximately 2 week intervals beginning March 20, 1998. Large wheat seed consistently had taller seedlings prior to true stem elongation. Additionally, short wheat had taller seedlings than tall wheat. Jointed goatgrass height measurements showed that isoline height affected jointed goatgrass height only at the last measurement prior to true stem elongation and was shorter with the short isoline. Jointed goatgrass height and dry weight measured at approximately the time of true stem elongation of wheat indicated that large seeded wheat reduced jointed goatgrass dry matter and increased jointed goatgrass height relative to small seeded wheat. Jointed goatgrass heights were not significantly different for any main effect following wheat stem elongation. Jointed goatgrass tillers per plant on May 20 averaged 3.5, 4.8, and 6.1 for large, mixed, and small seed lots of wheat, respectively. Wheat grain yield in competition with jointed goatgrass was significantly different for isoline height with yields of 186 and 154 g m^{-2} for the short and tall isolines, respectively. Jointed goatgrass biomass and spikelet weight at harvest was significantly different for each main effect. Jointed goatgrass averaged 73.8 and 42.3 g biomass and 16 and 4.9 g spikelets m^{-2} for short and tall isolines, respectively; 54.8, 43.9, and 75.4 g biomass and 9.7, 8.1, and 13.7 g spikelets m^{-2} for mixed, large, and small seeded lots, respectively; and 75.3 and 40.8 g biomass and 14 and 7 g spikelets m^{-2} for 100 and 150% seeding rates, respectively.

WEED CONTROL IN GLYPHOSATE, IMIDAZOLINONE, AND GLUFOSINATE-RESISTANT CANOLA. Brian M. Jenks, Weed Scientist, North Dakota State University, North Central Research Extension Center, Minot, ND 58701.

Abstract. The objective was to evaluate weed control with preplant incorporated and postemergence combinations in glyphosate, imidazolinone, and glufosinate-resistant canola. In North Dakota, soil conditions were very dry for the first 30 days after seeding (0.5 inch rainfall). We received 8 inches of rainfall the remainder of the growing season. Flea beetle population was high during the dry period and early crop growth was severely hindered in the imidazolinone and glufosinate canola. Some postemergence treatments were delayed due to cold temperatures and high winds. Wild oat was the only major weed present.

All imazamox treatments provided good wild oat control. However, yields were much higher when imazamox was applied to smaller wild oat compared to larger wild oat. Canola yields were much higher when early-season wild oat competition was reduced with trifluralin, trifluralin plus imazamox, or imazamox applied early-post.

In the glufosinate study, all PPI or early-post treatments provided good wild oat control. However, control and yields were much higher when glufosinate was applied to 3-leaf wild oat compared to 5-leaf wild oat. Wild oat control was slightly higher with the split application of glufosinate compared to single applications. Canola yields

were much higher by reducing early-season wild oat competition with either trifluralin, trifluralin plus glufosinate, or glufosinate applied early-post. The addition of sethoxydim did increase wild oat control and canola yield. Kochia was present in the experimental area, but populations were not uniform and therefore not rated; however, kochia was controlled in glufosinate-treated plots.

In the glyphosate study, flea beetle population was high in surrounding fields, but there was little or no damage to the glyphosate-tolerant canola which had been treated with imidacloprid. Wild oat control was excellent with all glyphosate treatments. Any treatments receiving the late-post application caused lower leaves to turn a purplish color and also delayed flowering. Delayed flowering was not observed with the early- or mid-post applications. Yield decreased with later applications when glyphosate was applied at 6 or 12 oz/A alone. Weed competition and/or crop injury may have contributed to the yield decrease. A decreasing yield trend was not observed in the split applications of glyphosate.

DOWNY BROME RESPONSE TO IMAZAMOX RATE AND APPLICATION TIMING.

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Abstract. Downy brome is prevalent in much of the winter wheat growing region of the western United States. Researchers indicate that downy brome infestations are expanding as a result of the increased use of conservation tillage practices and semi-dwarf winter wheat cultivars. The similarities in growth habit between winter wheat and downy brome not only result in significant winter wheat yield reductions, but have also made selective herbicidal control difficult to achieve. The use of herbicides with downy brome activity in conjunction with herbicide resistant winter wheat cultivars is a recent technology which could provide for the needed crop selectivity.

Research was conducted at Kalispell, MT and Corvallis, OR to evaluate the efficacy of imazamox for downy brome control as a function of use rate and application timing utilizing herbicide resistant winter wheat. Herbicide resistant winter wheat was planted in downy brome infested fields at 78 and 135 kg/ha at Kalispell and Corvallis, respectively. Imazamox was applied at 0, 9, 18, 27, 36, 45, and 54 g/ha. Applications were made when downy brome seedlings were at the 2- to 3-leaf and 2- to 3-tillering stages of growth.

Downy brome control was greatest when applications were made at the 2- to 3-leaf stage, with greater than 95% control being achieved at both locations at the 36 g/ha rate. However, control at the 2- to 3-tiller stage differed between locations. Overall, control was less complete at Kalispell with the 2- to 3-tiller applications. However, this response was noticeable only at the lower rates. Downy brome control still exceeded greater than 95% when applied at rates of 36 g/ha or more. In contrast, imazamox failed to provide commercially acceptable control at Corvallis when applied at the 2- to 3-tiller stage. Downy brome control at Corvallis was less than 35 % when applied at the 2- to 3-tillering stage with the highest rate tested.

TEACHING AND TECHNOLOGY TRANSFER

EXAMINING EXAMINATIONS. Robert L. Zimdahl and Lynn Fandrich, Professor and Graduate Teaching Assistant, Weed Research Laboratory, Colorado State University, Fort Collins, CO 80523.

Abstract. Examinations take many forms. Each is a challenge for the teacher who wants to be fair and teach while evaluating learning. Ideally examinations are designed to challenge students who approach each one with some trepidation and a desire to do well. Writing an examination, whether oral, essay, multiple choice, short, or long is an art that can be learned. A good examination covers the subject while challenging yet not frustrating or angering students. As students and as young teachers, all of the examinations we took and created used what we call the seek and ye shall find model. In these examinations, the teacher demands that students know all of the material referenced or presented. Students feel compelled to guess, while studying, what question might be asked and the expected answer. It is our view that this is an inefficient use of student time. Lately we have switched to what we call the study and ye shall know model. This model reveals to students before the examination what the teacher regards as important by distributing a lengthy list of potential exam questions in advance of each major examination. The questions that appear on the subsequent examination are taken directly from the distributed list.

THE NOXIOUS WEED MANAGEMENT SHORT COURSE. Barbra H. Mullin, Celestine Lacey Duncan, and Steven Dewey, Weed Coordinator, Montana Department of Agriculture, Helena, MT 59620; Owner, Weed Management Services, Helena, MT 59604; and Extension Weed Scientist, Plant Science Department, Utah State University, Logan, UT 84322-4820.

Abstract. The Noxious Weed Management Short Course is designed to provide in-depth training on noxious weed biology, identification, and management to federal and state land managers to improve weed management on agency lands and to encourage cooperation among all land managers in solving the noxious weed problem at the local level. The course was first held in 1990 as part of a challenge cost-share agreement between the USDA Forest Service and the Montana Weed Control Association. The course has expanded to include a wide variety of public and private land managers who want to improve their understanding of noxious weed control. The course is currently sponsored by the Western Society of Weed Science and weed management professionals active in WSWS serve as instructors in the course. The training program is designed to encourage interaction between instructors and participants. Teaching methods include lab and field exercises and classroom sessions. It is a fast paced, 3 day course that provides a lot of good information and fun at the same time. Course participants are enthusiastic about the course format and interest in the course continues to grow. Each session is limited to 35 participants and the course fills early each year. With increased interest in the course and weed management activities, two sessions were held in 1997 and 1998, with two planned for 1999.

ACTIVE LEARNING SESSIONS IN WEED SCIENCE EXTENSION. Ray D. William, Professor and Extension Specialist, Horticulture Dept., Oregon State University, Corvallis, OR 97331.

Extension faculty prefer darkened rooms, slide projectors whirling, and an occasional conversation with several participants. As an Extension specialist, I have been there; done that! Several years ago, however, faculty discussions on improving teaching stimulated my inquiry of learning research and subsequent invention of active learning sessions. This paper describes several sessions designed as interactive, hands-on, learner-owned events. Our assumption (and experience!) is that these sessions fit within a series of day-long "lecture" topics or slide presentations, thereby complimenting the various learning styles (Kolb 1984, Myers and McCaulley 1985; Herrmann 1998) present at agricultural meetings or workshops. Also, all sessions are meant to be modified for your style or needs.

ACTIVE LEARNING SESSIONS

Discovery sessions are designed to share information and practices among professionals (William and Lev, 1996). Attendees form groups of four to five people to list "what do you really want to learn today." After 3 minutes, topics are grouped on a flip chart, time is assigned to categories, and we begin with something that generates discussion. A good choice of topic is "what pre-emergence practice really works?" Peers who experience success will readily volunteer their knowledge. As discussion proceeds, I introduce the science validating practice or raise questions for additional inquiry.

Two things we have discovered: first, eyebrows will rise in groups of 100 or more if someone volunteers an illegal label use. Rather than assume the "bad guy" role, I ask "why all the raised eyebrows?" Second, 10% of participants will express strong preference for organized lectures. Perhaps one reason for their popularity is that 90% of attendees prefer hands-on or active learning. In closing, everyone is thanked for their help with the session including the 10% who may return to their preferred style during remaining presentations.

Drift sessions balance participatory mapping with information delivery followed by development of a pre-spray checklist. Attendees begin each session by drawing a spray area or field and identifying sensitive sites within 0.5-mile, including sites such as those occupied momentarily as school bus stops or joggers running along a field edge. A general list is compiled from discussion. A concurrent exercise involves mapping crop calendars to compare sensitive overlaps between adjacent crops. Also, applicator distractions are mapped using an image of a cab and horizon. Attendees are encouraged to use those techniques with employees or as training with peers.

Drift information along with climatic and topographical considerations are presented for 60 minutes. The session ends with groups developing pre-, post-, and emergency spray checklists. Again, a list is completed as part of the discussion. Evaluations of these sessions range from 10% preferring lecture (they dislike participatory, hands-on activities) to a rating of 3.1 to 3.4 out of 4 for **participatory** sessions and 3.5 to 3.6 rating for information delivery. Overall, attendees expected a 20% improvement in decision-making about pesticide drift based on this program.

Discovering learning style preferences is achieved at that moment when Rachael Carson jumps out of a vehicle to ask, "what are you doing" as you prepare to spay. Some people bristle while others wonder who is Rachael Carson. A couple of participants describe her concerns about pesticides, ecology, food chains, and the environment. Learning occurs in small groups as participants discuss their response to Rachael. Most groups explain the label, describe research that validates the label, or react symptomatically.

The science of learning style preferences contrasts people who *think reductively* with those who prefer *relational thinking* and those preferring to "do" with those who "plan." Attendees begin to discover the relationship between "worms, birds, egg shells, mammals, and humans" in the relational context of a food chain. We explore both causal data and relational evidence between Kolb's (1984) learning and action styles, Myers-Brigg's (1985) behavioral inventories (Myers and McCaulley 1985), and Herrmann's (1990) creative brain theory. Following ample evidence and discussion (20 minutes), we practice responding to Rachael a second time. Having re-read and discovered that Silent Spring (1965) is mostly relational thinking, I elaborate participant responses that link organism webs, food chains, species hierarchies, or time analysis. Summarizing statements encourage professional applicators to listen, respect, and respond in frameworks meaningful to the inquirer.

Ethics sessions are designed to explore *issues* and *reasoned judgement* within an "everybody does it" premise. Participants form small groups to list issues they hear everyday. Other groups read a brief case study describing a concerned neighbor—they wait for breezes away from this person—what should they do about the silent neighbors downwind? Following a discussion of rights-based (individual and egalitarian/welfare), utilitarian, and environmental ethics, we consider the issues listed by attendees within ethical context. Sometimes we explore what makes a topic an ethical issue. With this practice, we focus on the case study and what an applicator should do about the silent neighbors. Participants practice critical thinking and *reasoned judgement* with encouragement to continue exploration of this subject on their own.

Ecology sessions explore similarities between words and practices in weed science and weed ecology rather than the jargon that intimidates and separates. Topics such as competition (resource availability), disturbance, seedbeds (safe sites), and seed bank dynamics are considered from the language of range scientists (Larson, et al 1997) rather than ecology or weed ecology. Seems to be understandable!

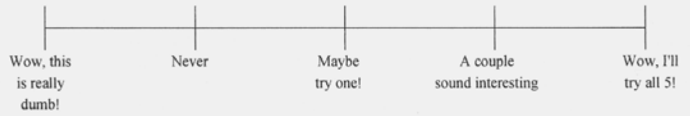
PARTICIPATORY ASSESSMENT

Assessment can be designed to inspire learning, while improving teaching in mutually beneficial ways for both the instructor and the learner. A 3-by-3 technique encourages learner reflection and continued inquiry along with clues for instructional improvement. By asking "what three things did you learn; what three questions remain?," faculty can both assess learning and improving. In Extension, we close learning sessions with stickies placed on posters near the exit where everyone can see and consider the responses. Our purpose is to improve learning rather than extract "objective" data about teacher performance.

A quantifying technique we have found especially useful involves questions designed to elicit responses along a continuum or scale. Participants place dots (●) along an incremental scale measured by words; numbers are assigned afterwards to compute a mean. An example might look like:

How useful was this paper about "active learning sessions?"

To what degree might you use one or more of these participatory learning approaches in your classroom or Extension teaching?



Questions are sometimes crafted into pre- and post-assessment with the intention of defining learning objectives, students' perspectives of their skills or understanding, and post-assessment of improvement. Each dot (●) is numbered to measure change over time.

In conclusion, we have discovered from the learning literature that combinations or blends of "establishing context or relationship" followed by "fact gathering/validation, practice, and application" improves learner-owned learning. Our approach sets context within a participatory-learning framework. "Learning moments" become opportunities to explain detail or facts at the moment when one or more learners have framed the "learning tension" or need for information in their mind. Learning becomes collaborative and shared; I learn along with learners. Learning also is FUN! Except for 10% of those attending agricultural sessions who prefer an organized lecture in outline form, others express interest and enthusiasm for integrated approaches to learning.

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WETLANDS AND WILDLANDS

NAUTIQUE: A NEW AQUATIC HERBICIDE FOR CONTROL OF MANY PROBLEMATIC SPECIES IN THE WESTERN U.S.

Terry A. Littlefield, Western Region Aquatics Technical Specialist, SePRO Corporation, Rancho Cordova, CA 95670.

Abstract. Nautique is an ethylenediamine-triethanolamine copper complex, for aquatic weed management, manufactured by SePRO Corporation and is packaged in 2, 2.5 gallon containers and is 9% elemental copper containing 0.91 lb/gal. SePRO Corporation expects full registration in all western states for the 1999 season and it is currently available in Arizona, Colorado, Idaho, Oregon, Utah, and Washington. It is a contact aquatic herbicide and rapidly penetrates into plant tissue where uptake is through plant cells where the copper ion inhibits photosynthesis. Affected plants typically drop below the water surface within 4 to 6 days of treatment. Complete plant death as a result of treatment is typically seen in 3 to 4 weeks. In some situations a second application may be required 10 to 12 weeks later. Potential use sites include potable water reservoirs, freshwater lakes, ornamental, fish, and fire ponds, aquaculture ponds, and irrigation conveyance systems. Weeds which can be managed include hydrilla, egeria, Southern naiad, horned pondweed, and widgeongrass. Additional preliminary data indicates control of water hyacinth, vallisneria, elodea, Eurasian watermilfoil, brittle naiad, and salvinia. There are no water use restrictions following use of this product, i.e., water may be used immediately for fishing, swimming, livestock watering, and irrigation. For best results it should be applied to actively growing plants on bright sunny days when water temperature is at least 60 F and can be applied diluted or undiluted however uniform coverage is recommended. This herbicide can be surface applied or injected through trailing hoses and can be applied alone or tank-mixed with other aquatic herbicides. In summary, it is a versatile new contact herbicide that provides rapid control of many problematic species with no water use restrictions.

DESIGNING WEED-RESISTANT PLANT COMMUNITIES BY MAXIMIZING COMMUNITY STRUCTURE AND RESOURCE CAPTURE.

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Abstract. In order to develop an ecological basis for designing weed-resistant plant communities, we tested the hypothesis that susceptibility to weed invasion is determined by temporal and spatial resource availability and by the ability of weeds to capture those resources. In a multiple replacement series experiment, replicated twice, three desirable species with differing spatial and temporal growth patterns (crested wheatgrass, intermediate wheatgrass, and alfalfa) and one weed (spotted knapweed) were used to determine the potential for minimizing weed invasion of established plant communities by maximizing structure and resource capture. In the experiment, the number of desirable species per plot varied, while the total number of desirable plants was held constant. Seedlings of the desirable species were planted in spring 1995. Spotted knapweed was sown in fall 1996. In the following growing season (1997), soil water use was positively correlated with the number of desirable species per plot. In 1997, spotted knapweed establishment, survival, and growth were not affected by the number of desirable species per plot or by soil water use by desirable species for those depths where soil water content was monitored. Spotted knapweed biomass was negatively correlated with the number of desirable species per plot in 1988. These results suggest weed invasion of established plant communities may be minimized by maximizing niche occupation and resource use by desirable species.

DRIZZLE HERBICIDE APPLICATION FOR WEED MANAGEMENT IN FORESTS. Philip Motooka, John Powley, Michael DuPonte, Lincoln Ching, Guy Nagai, and Galen Kawakami, Extension Specialist in Weed Science, University of Hawaii, P.O. Box 208, Kealakekua, Hawaii 96740; Extension Agent, University of Hawaii, 310 Kaahumanu Ave., Bldg 214, Kahului, HI 96732; Extension Agent, University of Hawaii, 875 Komohana St., Hilo, HI 96720; Extension Agent, University of Hawaii, 3060 Eiwa St., Room 210, Lihue, HI 96766; Noxious Weed Specialist, Hawaii Department of Agriculture, 4398A Pua Loke St., Lihue, HI 96766; and Protection Forester, Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife, 3060 Eiwa St., Lihue, HI 96766.

INTRODUCTION

With the myriad of noxious weed species that conservation foresters must manage, it is necessary for them to employ mechanical or chemical measures to suppress many species not under biological control. Mechanical control methods are labor intensive, produce short-term suppression, and may be ecologically damaging if the soil is disturbed. In addition, it is hard, dangerous work, and the risk of injuries to workers increases as they tire. Conventional spraying of herbicides, while more effective than mechanical control, does require the backpacking of water over long distances and over rough terrain and spraying at relatively high volume rates. Furthermore, the applicator must virtually walk up to every plant he treats which slows the operation and contributes to fatigue.

An application method that delivers very low volume rates and a "throw" of a few yards will greatly decrease the amount of carrier to be transported and applied and reduce the distance the applicator must walk to treat each target plant. This in turn will allow the applicator to apply the herbicide much more quickly than with the conventional method and with much less effort. Such a very-low volume (VLV) method is the drizzle method developed by Shigeo Uyeda of Kauai (Motooka, et al. 1983 and Motooka et al. 1998). The method uses an orifice disk with an orifice of 0.02 inch diameter. Through it is ejected a fine jet stream, under 30 psi pressure, that breaks into large droplets over the target plant. The wand can be waved for broadcast application, comfortably covering a 20 foot wide swath, or aimed to a height of 12 feet or as a very precise directed application. An applicator on open flat land can cover 2 A/hr or on a trail 8 feet wide, 2 mph. Other advantages of the drizzle method is that the equipment is light because of the very-low volume of carrier required, drift potential is reduced by the large droplets, the equipment is simple and not subject to breakdowns, and it can be easily converted back for conventional spraying. In a trail clearing pilot project on Koaie Trail on Kauai the drizzle application method was 128 times more labor efficient than mechanical control and more effective as well, and nine times more efficient than conventional spraying (Motooka, et al. 1998). The efficiency of conventional spraying will fall off even further where water sources are at greater intervals along the trail than the 0.5 mile on the project segment of Koaie Trail. The Division of Forestry and Wildlife of the Department of Land and Natural Resources reported that they expended 12,000 worker-hours annually on trail maintenance on Kauai, virtually all of that on vegetation management. The Koaie Trail project results suggest that the entire 109 miles of the Kauai Na Ala Hele Trail System, part of the National Trail System, can be treated with 300 worker-hours.

So far only two herbicides, in several formulations, can be used by the drizzle method because of label restrictions: glyphosate and triclopyr. Unfortunately, not all weeds are readily susceptible to applications by this method. However, crop oil carriers may increase the efficacy of triclopyr ester in foliar applications and may be useful in VLV basal bark applications as well.

PROCEDURE

Trials were conducted in the State of Hawaii to evaluate the drizzle method on various noxious weed species in pastures and forests. Species examined were: sourbush with triclopyr and paragrass with glyphosate, with water as carrier, gorse with triclopyr in crop oil, and strawberry guava, Banks melastoma, albizia, huisache and gorse with VLV basal bark applications with triclopyr ester in crop oil. Paragrass was treated with 1.5 and 3 lb/A of glyphosate in plots 20 by 15 feet in randomized complete blocks in a brackish pond in Hilo. Sourbush was treated with 0.25, 0.5, 1, lb/A triclopyr ester in plots 20 by 30 feet, in randomized complete blocks in a pasture in Onomea, Hawaii and evaluated at 3 MAT (months after treatment). All broadcast foliar applications described herein were made at a spray volume rate of 1.5 gpa. All applications described herein were made with a CO_2 powered unit at 30 psi. Gorse at Olinda, Maui was treated with triclopyr ester in crop oil carrier applied foliarly to plots 8 by 15 feet in randomized complete blocks. The rates used were 1 and 2 lb/A, each rate in 50% and 100% crop oil carrier, respectively. The plots were evaluated at 6 MAT. Albizia, melastoma and strawberry guava at Wailua, Kauai were treated with Pathfinder II™, a Dow AgroSciences ready-to-use formulation of triclopyr ester in crop oil, in completely randomized plots, each plot comprised of a single plant for albizia and a single clump for strawberry guava and melastoma. There were 10 replicates of strawberry guava, four for albizia and three for melastoma. The herbicide was applied in six streaks across the basal stems. The plots were evaluated at 9 MAT. Gorse was treated by very-low volume basal bark applications with triclopyr ester, 20% product in crop oil, at Olinda, Maui. Applications were made in 4, 6, and 8 streaks across the stems in plots each consisting of a single clump of gorse, in randomized complete blocks, and evaluated at 6 MAT. Catsclaw at Moloaa, Kauai was treated with triclopyr ester, 20 % product in Herbimax adjuvant, to basal stems in 4, 6, and 8 streaks, in randomized complete blocks, at Moloaa. Each plot consisted on a single plant about 6 to 8 feet tall. Huisache, called klu (glue) by Hawaiians, was treated similarly in a pasture at Kihei, Maui but in 10 replicates, each replicate a single shrub, completely randomized and evaluated at 3 MAT.

RESULTS AND DISCUSSION

Foliar applications with water as the carrier. Sourbush proved very susceptible to triclopyr applied by the drizzle method. The lowest triclopyr rate of 0.25 lb/A provided very good control (Table1). Sourbush was very sensitive to triclopyr and such sensitivity is ideal for drizzle application since the herbicide droplet deposition is not ideal. Paragrass was susceptible to glyphosate in an aquatic situation (Table 2). More recently, paragrass was even more susceptible to drizzle application of glyphosate in a demonstration on the Hanamaulu Stream, succumbing to 0.5 lb/A (Unpubl. Data, Dept. of Agriculture). This increased efficacy may have been the result of the addition of Silwet L-77 surfactant to the herbicide solution. Earlier work reported that lantana was very susceptible to glyphosate applied by conventional and drizzle applications (Motooka et al. 1998). Demonstration trials, unreplicated or unrandomized trials, show that molassesgrass, paragrass, palmgrass, black wattle saplings and blackberry (HITAHR 1997) were all susceptible to drizzle application of glyphosate, and blackberry and Japanese honeysuckle (HITAHR 1997) were susceptible to triclopyr. Clidemia and fayatree (HITAHR 1988) and apple-of-Sodom (HITAHR 1991) were tolerant to triclopyr applied by the drizzle method.

Foliar application with oil carriers. Gorse was tolerant of triclopyr even in conventional sprays except with Silwet L-77 (Motooka et al. 1998) and was not expected to be susceptible to drizzle applications of the herbicide. However, gorse proved susceptible to triclopyr applied with a non-phytotoxic crop oil carrier (Table 3). Sisal was also tolerant of aqueous applications of triclopyr ester (Unpubl. data) but very susceptible to the same herbicide applied in an oil carrier (HITAHR 1992). Because of the very-low volume required by the drizzle method, crop oil was more economical as a carrier. In cases where triclopyr in water proves ineffective, switching to an oil carrier represents a modest increase in cost and may provide the added boost to uptake to make the treatment effective.

Very-low volume basal bark treatments. In situations where a basal bark treatment is desirable, the drizzle unit can be used to apply a small volume of a high concentration of triclopyr in crop oil. Albizia and strawberry guava were susceptible to VLV basal bark treatments of triclopyr in crop oil (Table 4). Melastoma was somewhat tolerant but developed many short adventitious roots at the lower nodes and gradually defoliated further until 9 MAT when the trial was destroyed by a road clearing crew (Table 4). Young albizias were very susceptible but large trees survived though seriously injured. Catsclaw (Table 5) and gorse (Table 6) were very sensitive to VLV basal bark treatments of triclopyr. On the other hand, larger trees and species with impenetrable bark were tolerant e.g. huisache (Table 7) and paperbark (Unpubl. data).

CONCLUSION

Although there is still a great deal of work to do in defining the potential of the drizzle application system, e.g. species susceptibility, types of adjuvants and methods of application, the very-low volume drizzle method has already demonstrated high levels of labor efficiency and should greatly reduce the worker-hours devoted to vegetation management and increase worker safety.

Table 1. Control of sourbush with very-low volume applications of triclopyr.

	Sourbush	
Triclopyr rate	Control 3 MAT[a]	Cover
lb/A	Plant/15 m^2	%
0	48	48
0.25	14	12
0.5	8	6
1	1	2
LSD (0.05)	32	

[a]Months after treatment

Table 2. Paragrass control with drizzle applications of glyphosate.

Glyphosate rate	Defoliation 2 MAT[a]
lb/A	%
0	0
1.5	30
3	89
LSD (0.01)	14

[a]Months after treatment.

Table 3. Gorse control with drizzle applications of triclopyr in an oil carrier.

Triclopyr rate	Oil conc.	Defoliation 6 MAT[a]
lb/A	%	%
0	0	0
1	50	47
1	100	88
2	50	93
2	100	97
F		ns

[a]Months after treatment
Excluding check.

Table 4. Response of albizia, Banks melastoma and strawberry guava to very-low volume basal bark applications of triclopyr.

Species	Replicates	Defoliation 9 MAT[a]
	No.	%
Albizia[b]	4	100
Melastoma[c]	3	64
Strawberry guava	10	92 ± 5

[a]Months after treatment
[b]Saplings very susceptible. Trees 8" dbh, not included, survived.
[c]Sprouted adventitious roots at nodes.

Table 5. Response of catsclaw to very-low volume basal bark applications of triclopyr.

Streaks	Defoliation 3 MAT[a]
No.	%
0	13
4	94
6	100
8	99
LSD (0.05)	17

[a]Months after treatment.

Table 6. Gorse response to very-low volume basal bark applications of triclopyr in crop oil.

Steaks	Injury rating 3 MAT[a]	Injury rating 6 MAT[a]
No.	%	%
0	0	33
4	77	77
6	63	87
8	77	82
LSD (0.05)	24	24

[a]Months after treatment.

Table 7. Huisache response to very-low volume basal bark applications of triclopyr.

Streaks	Defoliation 3 MAT[a]
No.	%
0	4
4	19
6	31
8	58

[a]Months after treatment.

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ECONOMICS OF PASTURE WEED CONTROL. Holli A. Murdock, Steven A. Dewey, and William Mace, Graduate Research Assistant, Extension Weed Specialist, Professor, and Research Associate, Department of Plant, Soils, and Biometeorology, Utah State University, Logan, UT 84322-4820.

Abstract. Weeds can impede establishment and long term productivity of perennial grass pastures. The purpose of this study was to evaluate the efficacy of herbicides for broadleaf weed control, effects on pasture forage yield components, and the economic returns associated with each treatment. Two seedling pastures in Fairview, Idaho, and two established pastures, one in North Logan, Utah, and one at Salina, Utah, were treated with various herbicides or herbicide combinations. The treatments used were 2,4-D amine, dicamba, picloram, clopyralid, metsulfuron, metsulfuron plus 2,4-D amine, triasulfuron, triasulfuron plus 2,4-D, dicamba plus 2,4-D, clopyralid plus 2,4-D, and picloram plus 2,4-D. In 1997, treatments were applied to 10 by 30 foot plots arranged in a randomized block pattern in each field. Treatments were replicated four times. In 1997 and 1998, all plots were visually evaluated on broadleaf weed control, pasture grass injury, and clover injury. A 0.5 m^2 subplot was harvested from each plot, separated into forage and weed components, dried, and weighed to evaluate grass, weed, and legume yields.

Grass and total forage yields were influenced significantly by herbicide treatments. Some resulted in increased yields, while others caused yield reductions when compared to the check. Herbicides generally reduced broadleaf and legume yields. Economic returns varied widely between pastures and treatments. Over a two year period, only 2,4-D amine, picloram, dicamba plus 2,4-D, and picloram plus 2,4-D had a positive net economic return. In general, the total two year yield of treated plots in established pastures was not significantly different than the respective weedy checks.

LEAFY SPURGE CONTROL IN THE WESTERN U.S. WITH IMAZAPIC. Pamela J.S. Hutchinson and Paul J. Ogg, Field Research Agriculturist and Senior Field Research Agriculturist, American Cyanamid Company, Meridian, ID 83642-3445 and Longmont, CO 80503.

Abstract. Trials at locations in Idaho and Colorado were initiated to determine the effectiveness of imazapic for the control of leafy spurge in low annual precipitation areas of the Western U.S. Applications of imazapic at 0.188 lb/A were made spring 1997 at Idaho locations and spring 1998 at all locations. Treatments of imazapic applied at 0.125 or 0.188 lb/A fall 1997 and a sequential fall 1997 0.125 lb/A plus spring 1998 0.063 lb/A treatment

was also included at all locations. All treatments included SUN-IT II™ 1 qt/A plus 28 or 32% N 1 qt/A. Fall 1997 applications of imazapic at 0.125 lb/A at the Colorado locations and fall 1997 applications at 0.188 lb/A or fall 1997 plus spring 1998 sequential applications (0.125 plus 0.063 lb/A) at all locations provided > 94% leafy spurge control at fall 1998 ratings. These treatments provided the best overall control of established leafy spurge plants present at the time of the fall application and leafy spurge plants that emerged the next spring. Crested wheatgrass was tolerant to all imazapic applications. Treatments will be assessed again in 1999 to determine residual efficacy.

EVALUATION OF DIFLUFENZOPYR WITH AUXIN HERBICIDES FOR PERENNIAL WEED CONTROL. 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, Canada thistle, and spotted knapweed control. Herbicides evaluated included dicamba, picloram, 2,4-D, picloram plus 2,4-D, quinclorac, fluroxypyr, clopyralid, clopyralid plus 2,4-D, glyphosate plus 2,4-D, and imazapic.

In 1997, herbicides were applied at approximately 50% below the normal use rate for season-long leafy spurge control to determine more rapidly if the addition of diflufenzopyr increased weed control compared to the herbicides alone. Herbicides were applied in the spring at the optimum plant growth stage for each herbicide treatment. Leafy spurge control with dicamba, picloram, and fluroxypyr was increased by 3-fold 3 MAT (months after treatment) when the herbicides were applied with diflufenzopyr compared to the herbicides alone. Leafy spurge control 12 MAT was increased from 0 to 38% when diflufenzopyr was applied with dicamba, compared to the herbicide applied alone.

Canada thistle control 3 MAT was better when diflufenzopyr was applied with dicamba, 2,4-D, quinclorac, and clopyralid compared to the herbicides applied alone. For example Canada thistle control increased from 37 to 70% with dicamba, 44 to 83% with 2,4-D, and 6 to 67% with quinclorac when diflufenzopyr was applied with these herbicides. No treatment provided satisfactory Canada thistle control 12 MAT. Spotted knapweed control 3 and 12 MAT was similar regardless of herbicide or the addition of diflufenzopyr.

In 1998, experiments were established with the herbicides applied at standard use rates alone and with diflufenzopyr at various ratios (herbicide:ATI) for leafy spurge and Canada thistle control. Leafy spurge and Canada thistle control 2 to 3 MAT was greater when herbicides were applied with diflufenzopyr compared to alone, regardless of the diflufenzopyr rate. For example, leafy spurge control increased from 78 to 97% with quinclorac when diflufenzopyr was added compared to quinclorac applied alone.

In summary, leafy spurge control was increased when diflufenzopyr was applied with auxin herbicides. Canada thistle control with quinclorac was greatly 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.

BASIC SCIENCES

SIMULATED DRIFT OF CLOPYRALID ON TOMATOES, SAFFLOWER AND SUNFLOWER. W. Thomas Lanini, Ernie J. Roncoroni, and Vanelle Carrithers, Extension Weed Ecologist and Staff Research Associate, University of California, Davis, CA 95616 and Development Representative, Dow AgroSciences, Mulino, OR 97042.

Abstract. A field study was established on the Vegetable Crops Farm at Davis California to evaluate the effects of simulated drift of clopyralid on processing tomatoes, sunflower, and safflower. Clopyralid was applied at 1X, 0.1X, 0.01X, and 0.001X the maximum use rate in California (0.25 lb/A) and crops were treated at the 2-leaf stage or at flowering. Yield of red tomato fruit were reduced by the 1X rate of clopyralid, but were not significantly affected by 0.1X or lower rates (Table 1). Treatment timing did not statistically influence yield. However, the type of injury was different depending on the treatment timing. When 0.25 lb/A was applied to 2-leaf tomatoes, tomatoes were severely stunted with low fruit yield (Tables 1 and 3). When the same treatment was applied to flowering tomatoes, fruit set was delayed, resulting in a much higher green fruit yield (Table 2).

Safflower seed yields were reduced by 95, 87, and 55% by clopyralid treatment at 1X, 0.1X, and 0.01X rates, respectively (Table 4). Application timing did not influence safflower seed yield. The 1X clopyralid treatment killed most of the safflower, with the 0.1X rate causing death or severe stunting. The 0.001X rate caused etiolation of safflower when applied to seedlings, but yields were not different from the untreated control. Sunflower plants were completely killed by 1X rates of clopyralid when applied to seedlings and only a few plants survived this rate when applied at flowering (Tables 5 and 6). The 0.1X clopyralid rate also killed many sunflower plants when applied to seedlings, but was less injurious when applied at flowering (Tables 5 and 6). Sunflower yield was reduced by 40 and 97% when applied clopyralid was applied at the 0.1X rate at flowering or to seedlings, respectively (Tables 6 and 7). Seedling sunflower appeared to be more sensitive to clopyralid injury, with less injury occurring to larger plants.

Table 1. Tomato yield in response to clopyralid treatment.

Clopyralid rate	Tomato yield[a]
lb/A	lb/10ft.
0.25	22.6
0.025	64.9
0.0025	71.1
0.00025	72.1
0	69.1
LSD 0 .05[a]	16.8

[a] Average tomato yield for seedling treatment was 69.1 and for flowering was 50.8 lb/10 ft, respectively, which were not statistically significant.

Table 2. Tomato yield in response to clopyralid treatment.

Clopyralid rate	Green fruit yield	
	Seedling treatment	Flowering treatment
lb/A	lb/10 ft.	
0.25	4.4	23.9
0.025	0.9	6.1
0.0025	2.3	2.2
0.00025	1.9	1.6
0	1.6	2.1
LSD 0 .05[a]	4.8	

[a] LSD value to be used to compare all treatments and application timings.

Table 3. Tomato yield in response to clopyralid treatment.

Clopyralid rate	Rotten fruit[a]
lb/A	lb/10 ft.
0.25	2.4
0.025	9.2
0.0025	11.4
0.00025	10.2
0	11
LSD 0 .05[a]	2.4

[a] Average tomato yield for seedling treatment was 4.23 and for flowering was 3.81 lb/10 ft, respectively, which were not statistically significant.

Table 4. Safflower yield in response to clopyralid treatment.

Clopyralid rate	Safflower yield[a]
lb/A	lb/22 ft.
0.25	0.1
0.025	0.2
0.0025	0.8
0.00025	1.7
0	1.8
LSD 0 .05[a]0.4	

[a] Average safflower yield for seedling and flowering treatments was 0.9 lb/22ft.

Table 5. Average number of sunflower heads reaching maturity in response to clopyralid treatment.

Clopyralid rate	Sunflower heads	
	Seedling treatment	Flowering treatment
lb/A	No./40 ft.	
0.25	0	1
0.025	8	28
0.0025	28	36
0.00025	34	28
0	40	35
LSD 0 .05[a]	7.9	

[a] LSD value to be used to compare all treatments and application timings.

Table 6. Sunflower seed yield in response to clopyralid treatment.

Clopyralid rate	Sunflower seed yield	
	Seedling treatment	Flowering treatment
lb/A	lb/40 ft.	
0.25	0	0
0.025	0.3	4.6
0.0025	6.3	7.3
0.00025	7.4	7.5
0	9.1	7.6
LSD 0 .05[a]	2.2	

[a] LSD value to be used to compare all treatments and application timings.

Table 7. Sunflower seed yield in response to clopyralid treatment.

Clopyralid rate	Sunflower seed yield	
	Seedling treatment	Flowering treatment
lb/A	oz/seedhead	
0.25	0	0.1
0.025	0.3	2.5
0.0025	3.7	3.2
0.00025	3.6	4.2
0	3.6	3.4
LSD 0 .05[a]	0.9	

[a] LSD value to be used to compare all treatments and application timings.

GERMINATION OF HERBICIDE-RESISTANT COMMON GROUNDSEL ACROSS A THERMAL GRADIENT.

D. Eric Hanson and Carol Mallory-Smith, Research Assistant, Forest Science Department and Assistant Professor, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331.

Abstract. Herbicide-resistant common groundsel is an incipient problem in mint fields of Oregon's Willamette Valley. To investigate factors differentiating susceptible and resistant populations, we conducted a study to compare the germination rate among three biotypes of common groundsel across a range of temperatures. One biotype was resistant to bromoxynil, a second was resistant to terbacil and the third was susceptible to both herbicides. Ten seed from one of the three were placed on a moistened filter paper in a test tube. The test tubes were then placed in a thermal gradient bar with temperatures ranging from 2 to 60 C. The seeds were allowed 20 days to germinate at these temperatures. Seeds germinated when the radicle emerged 1 mm or more beyond the seed coat. Germination was assessed daily and the filter paper was moistened as needed.

To assess the differences in germination rate among the biotypes, the number of days required for 50% of the seeds to germinate was computed and compared using regression. A quadratic relationship between days to 50% germination and temperature was established (Figure) and the slopes and intercepts of the three lines compared. All three biotypes had different slopes; the terbacil-resistant biotype had the greatest slope, the bromoxynil resistant biotype had the least slope, and the susceptible biotype was intermediate. The intercept for the terbacil-resistant biotype was greater than for either the bromoxynil-resistant biotype or the susceptible one. The length of time required to reach 50% germination was least between 15 and 25 C for all three biotypes. Below 10 C, groundsel did not reach 50% germination by 20 days. No seeds germinated above 35 C. Ungerminated seeds exposed to temperatures below 30 C were still viable when germinated at room temperature. Room temperature germination decreased when the seeds had been kept at temperatures between 30 and 40 C. Seeds exposed to higher temperatures were killed. These results suggest that terbacil-resistant common groundsel is stenothermic (having a narrow temperature tolerance range) in its germination requirements, and therefore, alternative herbicide treatments are most critical when temperatures are between 10 and 25 C. Bromoxynil-resistant common groundsel is more eurythermic (having a wide temperature tolerance range) than the susceptible, making herbicide management more critical especially at above 30 C, when the former biotype germinates more rapidly than the latter.

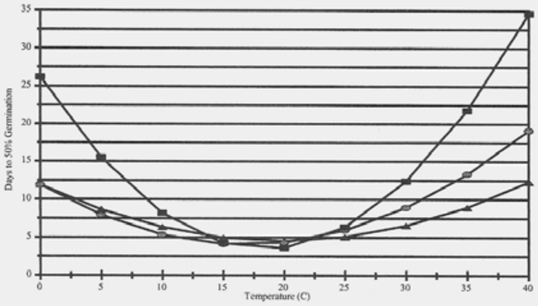

Figure. Number of days required for 50% of common groundsel seeds to germinate across a temperature gradient. Bromoxynil-resistant seeds are indicated (-▲-), susceptible seeds are indicated (-●-), and terbacil-resistant seeds are indicated (-■ -).

STRATEGY TO STUDY THE PHYLOGENETIC RELATIONSHIP AMONG DIFFERENT VARIETIES OF LOCOWEED.

Sanjeev Kulshreshtha and Tracy M. Sterling, Postdoctoral Fellow and Associate Professor, Department of Entomology, Plant Pathology and Weed Science, New Mexico State University, Las Cruces, NM 88003.

Abstract. Woolly loco (*Astragalus mollissimus*) and silky crazyweed (*Oxytropis sericea*) cause "locoism" in livestock resulting into large economic losses. So far, various chemical and mechanical means have failed to eradicate these weeds from the rangelands. However, the potential of biological control of these weeds has not yet been fully explored. As reported previously by this lab, the differential feeding behavior of the weevil insect (*Cleonidius trivittatus*) on various woolly loco varieties (*A. mollissimus* var. *bigelovii, earlei, matthewsii, mollissimus, mogollonicus* and *thompsonae*) indicates differential physio-biochemical characteristics. Therefore, a study of the phylogenetic relationship among *Astragalus* varieties found in New Mexico was initiated to find possible molecular markers which might indicate differential susceptibility to the insect feeding. This information should help develop an effective biological control strategy to better manage locoweeds. The restriction pattern of a target gene sequence, after PCR amplification (PCR-RFLP) from various locoweed varieties should aid in accomplishing our goal. Varieties were collected throughout NM and grown in greenhouse. The chloroplast genes RNA polymerase C1 and C2 (*rpo C1* and *rpo C2* of tobacco) present as a single copy, contiguous sequence on cpDNA were used for amplification and restriction analyses. As controls, cpDNA samples from pea (*Pisum sativum*), silky crazyweed and Lambert's locoweed (*O. lambertii)* were included. We have optimized a rapid and efficient method for cpDNA preparation and have prepared several batches of cpDNA from all species and varieties. The PCR reaction protocol using custom reverse primers for *rpo C1* and *rpo C2* genes for quantitative

amplification of the desired single fragment of about 4.1 kb size has been optimized. The 5' ends of the amplified fragments from pea and woolly loco var. *matthewsii* were sequenced, revealing an 80 to 90 % identity with pea and *Nicotiana.* Preliminary restriction studies on amplified DNA fragments from controls (pea and silky crazyweed), woolly loco var. *matthewsii* and *thompsoneae* show restriction site map variation. Further work is in progress to develop detailed comparative restriction analyses using cpDNA for all the varieties. Scoring of RE site variation on the physical map derived from various combinations of restrictions will be used to develop the final phylogenetic relationship among these varieties and, to find the molecular markers for biological control of locoweeds.

ISOLATING GENES ASSOCIATED WITH DICAMBA RESISTANCE IN KOCHIA. Anthony J. Kern and William E. Dyer, Graduate Research Assistant and Associate Professor, Department of Plant Sciences, Montana State University, Bozeman, MT 59717.

Abstract. We previously reported success in isolating partial cDNAs for genes that are differentially expressed in resistant (R) and susceptible (S) populations of kochia (*Kochia scoparia* L. Schrad) after treatment with the auxinic herbicide dicamba. To date, we have screened more than 40,000 cDNAs using mRNA differential display and have isolated greater than 120 cDNAs that are affected by dicamba treatment within minutes of herbicide application. Of these 120 cDNAs, expression levels of about 20 are altered in R vs. S kochia upon dicamba treatment. These results, as well as previous work showing that rates of herbicide uptake, translocation and metabolism were not different between R and S plants indicate that the mechanism of dicamba resistance likely occurs at the level of gene expression. Sequence analysis of selected cDNAs has identified several genes primarily involved in maintenance of cellular homeostasis while others are of unknown function.

INCIDENCE AND SPATIAL PATTERN OF DICAMBA RESISTANCE IN KOCHIA POPULATIONS. Marie Jasieniuk[1], William E. Dyer[2], Bruce D. Maxwell[1], and Tom K. Blake[2], Postdoctoral Research Associate, Associate Professor, Associate Professor, and Professor, [1]Department of Land Resources and Environmental Sciences and [2]Department of Plant Sciences, Montana State University, Bozeman, MT 59717.

Abstract. Kochia seed was collected from fields in 1996 to 1998 in northcentral Montana that were reported to contain kochia that was not controlled by dicamba. In each field, seed was collected from individual plants and the spatial position of parents recorded using a GPS receiver. Seed was planted in the greenhouse and 4-week old seedlings were treated with dicamba at 140 g/ha, the highest recommended rate for kochia control in small grains. Four weeks following treatment, seedlings were rated as susceptible, intermediate, or resistant to dicamba treatment. In 1996, the incidence of kochia resistant to dicamba in four of the five fields sampled was very low. No resistant seedlings were found in one field surveyed and only 1.4% of the seedlings from three fields were resistant to dicamba. In contrast, one field had an unusually high percentage of resistance. Roughly 18% of the 754 seedlings tested were resistant to dicamba. In 1997, all six fields tested contained dicamba-resistant offspring. Three fields had greater than 29% resistance, while three fields contained between 5 and 7% resistant offspring.

Spatial patterns of parent plants in each field suggested that prevailing winds in the area may be responsible for the dispersal of genes conferring resistance to dicamba via pollen or seed. One field in particular exhibited an intriguing spatial distribution of parents. Parents producing resistant offspring were oriented in a northeasterly band across the map of sampled plants, whereas parents producing only susceptible offspring were distributed fairly evenly on both sides of this diagonal band. AFLP analysis, a DNA fingerprinting technique, was used to test the hypothesis that offspring of the parents producing resistant plants were more closely related genetically than offspring of parents producing only susceptible offspring. Eighteen polymorphic bands were scored and used to estimate population genetic parameters for each subpopulation. Chi-square tests indicated that there were no significant differences in allele frequencies between the two subpopulations for the 18 loci. Nei's measure of

genetic distance between the two subpopulations, estimated at 0.0045, confirmed that the two subpopulations were not genetically distinct. Mean total gene diversity across all loci ($H_T = 0.3748$) was partitioned into diversity within subpopulations ($H_S = 0.3712$) and between subpopulations [$G_{ST} = (H_T - H_S)/H_T = 0.0096$]. A G_{ST} value of 0.0096 indicated that there was no significant gene differentiation among subpopulations. The lack of genetic differences between the two subpopulations is consistent with recent studies indicating kochia populations are generally random mating. Dendrogramic analyses suggested individuals and families that were genetically similar were spatially closer to one another in the field. Spatial relationships appeared to be independent of the occurrence of dicamba resistance and/or susceptibility.

ISOLATION AND CHARACTERIZATION OF ACETOLACTATE SYNTHASE FROM PALMER AMARANTH.

Ginger G. Light[1], Peter A. Dotray[1], and James R. Mahan[2], [1]Graduate Research Assistant and Assistant Professor, Department of Plant and Soil Science, Texas Tech University Lubbock, TX 79409-2122 and [2]Plant Biochemist, USDA-ARS, Lubbock, TX 79401.

Abstract. Pyrithiobac is a preemergence and/or postemergence-topical herbicide used to control annual broadleaf weeds in cotton (*Gossypium hirsutum*). Inconsistent weed control has been observed in the field since its commercial introduction in 1996. Improper application procedures and environmental factors such as soil moisture, light, and temperature could be the source of this inconsistency. Temperature may effect uptake, metabolism, translocation and enzyme function related to the herbicide. Enzyme inhibition may be important because the site-of-action for pyrithiobac is acetolactate synthase (ALS). This study sought to (1) characterize the kinetic parameters and inhibition sensitivity of ALS from Palmer amaranth, a target species; and (2) correlate *in vitro* inhibition analysis with whole plant inhibition.

Crude extract of leaf ALS from Palmer amaranth was utilized in activity assays performed at six pyruvate concentrations (0 to 20 K_M) and six pyrithiobac concentrations (0 to 500 nM) at nine temperatures from 10 to 50 C in 5-C increments. Kinetics parameters were determined using non-linear regression to fit the data points to the Michaelis-Menten equation. Relative inhibitor potency (I_{50}) values were determined by the pyrithiobac concentration where the velocity was half of maximal. Field activity was determined by making sixteen separate herbicide applications to 5 to 10 cm Palmer amaranth during the 1996 and 1998 growing seasons. Pyrithiobac at 105 g/ha was applied to each plot in a solution containing 1% v/v crop oil concentrate. A carrier volume of 140 l/ha was delivered using a backpack sprayer and 8002 nozzles. Field activity was based on dry weight accumulated as a percentage of non-treated plants 14-days after application. Plant temperature was monitored with infrared thermocouples and air temperature was monitored with standard thermocouples and recorded at 15-minute intervals throughout both growing seasons.

The temperature effects on the maximal velocity adhered to the Arrhenius equation at $R^2 = 0.92$ with an activation energy of 12.7 kcal/mole. Catalytic efficiency was highest at 20 C, while inhibition efficiency was greatest at 30 C. Optimal field activity occurred at air temperatures of 20 to 34 C. Comparison of field activity and relative inhibitor potency indicated that both parameters increased above 34 C. Therefore, we conclude that the thermal dependence of the ALS-pyrithiobac interaction may contribute to the observed variable weed control by pyrithiobac.

INHIBITION OF WEED SEED GERMINATION BY GLUCOSINOLATE HYDROLYSIS PRODUCTS.

Laura A. Hanson and Matthew J. Morra, Graduate Research Assistant and Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83844-2339.

Abstract. A number of agronomically important crops contain glucosinolates, organic anions that may represent a viable source of allelochemic control for a variety of soil-borne pests, including weeds. Biologically active compounds such as isothiocyanates, organic cyanides, oxazolidinethiones, and ionic thiocyanate are released following enzymatic hydrolysis of glucosinolates. Isothiocyanates, which exhibit broad biocidal activity, are the most toxic products of glucosinolate hydrolysis. The impact of glucosinolate hydrolysis products from root and leaf and stem tissues of *Brassica napus* var. 'Dwarf Essex', *B. napus* var. 'Bridger', *B. juncea*, *B. hirta* var. 'Ida Gold', and *B. hirta* var. 'UI.7102' on weed seed germination was investigated in germination bioassays using redroot pigweed, green foxtail, and hairy nightshade seeds. Seeds were planted in silt loam soil amended with chopped *Brassica* tissues and germination observed. In several instances, glucosinolate hydrolysis products significantly inhibited weed seed germination in comparison to untreated controls. Differences in germination inhibition were observed between root tissues and leaf and stem tissues, and between the varieties of *Brassica* tissues incorporated. Future efforts will focus on identification and quantification of individual glucosinolates in all plant tissues used in these experiments using HPLC-MS. Attempts will be made to correlate weed seed germination inhibition with types and quantities of predicted glucosinolate hydrolysis products. The use of plant-derived allelochemicals in weed control as an alternative to synthetic organic pesticides has the potential to minimize pesticide use and reduce the associated potential for environmental contamination while maintaining agricultural productivity.

CHARACTERIZATION OF YEARLY CHANGES IN CARBOHYDRATES IN THE ROOTS OF PERENNIAL WEEDS.

Robert G. Wilson, Lori Howlett, and Patricia Neilson, Professor and Research Assistants, University of Nebraska, Scottsbluff, NE 69361.

Abstract. Field experiments were conducted in 1997 and 1998 to examine the carbohydrate content of roots of common dandelion. Roots were exhumed each month over a 2 year period beginning in May of 1997. Roots were cleaned with water and cut into fine segments. Carbohydrates were removed with a hot water extraction and quantified by HPAE-PAD with a Dionex 500 system. Carbohydrate were reported as glucose, fructose, sucrose, and fructans (inulin). Fructans were further divided into polymers of DP 3 to 10, DP 11 to 20, and DP>20. On November 5, 1997 carbohydrate present in common dandelion roots could be divided into 0.6% glucose, 1.8% fructose, 6.5% sucrose, 30% fructans DP 3 to 10, 34% fructans DP 11 to 20, and 26% fructans DP>20. The composition of carbohydrate present in roots changed in response to moisture stress and freezing soil temperatures. As freezing temperatures occurred in late November, fructans in the category of DP 11 to 20 and DP>20 decreased while fructans in the category of DP 3 to 10 increased. During this same period sucrose and fructose concentrations increased as the plant prepared to overwinter. Application of 2,4-D at 0.56 kg/ha before freezing temperatures reduced the breakdown of fructans in the category of DP 11 to 20 and DP>20. The following May as soil temperatures increased and the plant resumed active growth, the composition of carbohydrates present in roots changed, with sucrose, fructose and fructans in the category DP 3 to 10 decreasing and fructans in the category DP 11 to 20 and DP>20 increasing. Carbohydrate development in the roots of Canada thistle, common milkweed, field bindweed, curly dock, hemp dogbane, and ground cherry were compared to common dandelion. Common dandelion and Canada thistle had similar carbohydrate composition while common milkweed, field bindweed, curly dock, hemp dogbane and ground cherry had a carbohydrate composition that was different from common dandelion.

EDUCATION AND REGULATORY

THE INTERNET - ITS HISTORY, STRUCTURE, PRESENT AND FUTURE. Gopal Krishnan, Graduate Research Assistant, Department of Horticulture, University of Nebraska, Lincoln, NB 68583-0915.

Abstract. The internet has become a part of our daily life as an information exchange medium in a short period of time compared to television or other mass media. This presentation traced the history of internet development, structure, current trends, and its future. The internet has become a reality due to innovation by thousands of people. Its beginnings can be traced to World War II and the Cold war; later development and contributions from Sun microsystems, Cisco, 3 Com and Novell led to late 1980's internet. Present day popularity of the internet is singly due to the World Wide Web, which led the way for everyone to get on the net. The internet has completely changed the way we do things, whether it is education, work, business, or entertainment. The internet's popularity has its present day problems including; clogging the net, security issues, and privacy concerns. Its future is continuously evolving and holds great promises with higher bandwidth such as Internet 2 for universities, electronic commerce, push technologies, streaming media, and other technologies.

DEVELOPING EFFECTIVE WEB SITES. Mark S. McMillan, Research Associate, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80532-1177.

Abstract. Developing a web site for agricultural outreach, reference, and research programs requires an understanding of the intended audience, and presentation of clear, concise information in an easy to navigate format. Sites that have consistent navigation aides and an appealing look and feel become familiar and easy to use. Web sites that are quick loading, contain accurate, up-to-date information, and encourage feedback can become valuable assets to the end user, and improve the likelihood that they will return to the site for future information. Sites that rely heavily upon special effects and cutting edge technologies are often slow to load, and difficult to navigate, resulting in the inability of the user to easily find the information that they were seeking, becoming frustrated, and leaving the site. Management and maintenance of a well-designed web site can be effectively accomplished using a number of web site management software programs, such as Adobe Page Mill, Corel WebMaster Suite, Microsoft Front Page and Macromedia Dreamweaver.

THE USE OF EMAIL-BASED SOFTWARE TO DELIVER A DISTANCE EDUCATION COURSE IN BIOTECHNOLOGY. Anthony J. Kern and William E. Dyer, Graduate Research Assistant and Associate Professor, Department of Plant Sciences, Montana State University, Bozeman, MT 59717.

Abstract. During the Fall Semester of 1998, a new graduate-level course was offered in the Department of Plant Sciences at Montana State University entitled Agricultural and Medical Biotechnology (PS 545). The course was offered as part of the Master of Science in Science Education curriculum and students consisted of high school and community college biology and biotechnology teachers. The course was offered using distance delivery techniques and utilized the FirstClass Intranet Client software (SoftArc, Inc., 1998). The software allowed for extensive instructor/student interactions, reliable security, invited lectures from experts around the country, and detailed weekly discussions in the class. The asynchronous approach has several advantages over real-time and web-based distance education courses, including lower cost, fewer student computer requirements, and increased speed of information delivery. This presentation included a computer-based demonstration of the course illustrating appropriate course organization, sample instructor/student interactions and a discussion of technical challenges associated with the software. This system of distance education shows promise in addressing some of the problems associated with offering and maintaining graduate courses in Weed Science among the western United States.

JOINTED GOATGRASS SYMPOSIUM

THE JOINTED GOATGRASS PROBLEM—WHERE WERE WE? WHERE ARE WE? Alex G. Ogg, Jr., Research Coordinator, National Jointed Goatgrass Research Program, P.O. Box 53, Ten Sleep, WY 82442.

Where were we? Jointed goatgrass was introduced into the U. S. around 1900, and now has spread throughout most of the winter wheat producing areas in the western US (Donald and Ogg, 1991). Jointed goatgrass became a troublesome weed in winter wheat in the 1970s, probably because of the introduction of less competitive, semi-dwarf wheat, the extensive use of nitrogen fertilizers, short crop rotations and reduced tillage. In 1993, it was estimated that jointed goatgrass had infested 5 million acres of winter wheat land and was spreading at the rate of 50,000 acres per year (Ogg, 1993). Losses in crop yield and quality were estimated at $45 million annually. At the 1993 meeting of the WSWS, a group of weed scientists and several members of the Washington State and Colorado Wheat Commissions reviewed the problem and prepared a proposal to provide funding for research and technology transfer activities on the management of jointed goatgrass in winter wheat. A national jointed goatgrass symposium was held in October 1993 to summarize the current knowledge on jointed goatgrass and to outline high-priority research needs (Table 1) (Westra and Anderson, 1993). Through the efforts of the wheat growers and their commissions, a special grant was obtained from Congress in 1994 to fund the proposed research. The funds were granted to the Cooperative State Research, Education and Extension Service-USDA, and Washington State University was designated the lead university for the program. The National Jointed Goatgrass Program has received approximately $300,000/yr for the past 5 years.

Initially, research was focused on defining the role of individual practices on the management of jointed goatgrass in winter wheat, and on grower education. Practices investigated include wheat seeding rates, planting dates, cultivar, row spacing, fertilizer placement, grazing by livestock and crop rotations. Dr. Phil Westra will discuss the results of this research and its implications on the management of jointed goatgrass in the next presentation. From the beginning, the Program has funded research on bioeconomic modeling that helps researchers identify data gaps. Economic threshold data from eight states were used to form the bases for the bioeconomic model. Eventually, the bioeconomic model will be used to test the economic outcomes of changing production and control practices to manage jointed goatgrass. Jointed goatgrass accessions were collected from many locations in the western US, and were grown for 3 years in a common nursery at Colorado State University. Climate conditions from year to year greatly affected the growth and seed production of the 53 different accessions. Biocontrol of jointed goatgrass using microorganisms to enhance decay of spikelets and seed has been investigated with some promising laboratory results, but application of this technology to field use has not been successful.

In 1995, Dr. Brian Jenks of the University of Nebraska was hired as the National Extension Coordinator to oversee and enhance technology transfer activities for the Program. Between 1995 and 1997, seven regional conferences were held in the western and mid-western US. At these conferences, presentations were given on the identification, biology and management of jointed goatgrass. In addition to the regional symposia, numerous press releases about the different research projects were made to agricultural trade and commodity publications. Other significant technology transfer activities include the establishment of a World Wide Web page (http:/www.ianr.unl.edu/jgg), publication and distribution of 2000 color posters on jointed goatgrass, production of a regional video, establishment of an FTP site for data exchange among scientists, and the production of a color slide set on jointed goatgrass. All of these technology transfer activities have enhanced greatly the awareness of the jointed goatgrass among growers and other members of the agriculture community. In 1998, Dr. Mack Thompson of Colorado State University was hired to fill the vacancy when Dr. Jenks accepted a new position. In 1998, about 12% of the Program funds were used to support technology transfer.

Where are we? Currently, research under this program is being conducted on 19 peer-reviewed projects in 10 western states, and involves the efforts of about 35 scientists. Research continues on refinement of the bioeconomic model and a user-friendly version is now available. Approximately 6% of the 1998 Program funds were used to support the bioeconomic model. Dr. Bruce Maxwell of Montana State will cover this topic in detail later in the Symposium program. At Colorado State University, 53 accessions of jointed goatgrass have been grown in a common nursery and the seed stored is available to any one wishing to conduct research on this weed. Furthermore, CSU scientists have used advanced techniques to determine that genetic diversity among these different jointed goatgrass populations is low, however this research is still in progress. Low genetic diversity among jointed goatgrass populations should improve the adaptability of control practices across the different regions were this weed occurs. At several universities, wheat cultivars have been shown to differ significantly in their competitive ability with jointed goatgrass. Some plant traits have been identified that are responsible for the competitiveness of the more competitive cultivars. A group of scientists representing four states across the western US are engaged in a study to determine the influence of tillage timing on the emergence and competition of jointed goatgrass in winter wheat. New research is under way to determine the influence of planting date of spring wheat on seed production of spring germinating jointed goatgrass.

From the beginning of the Program, there was interest in herbicide resistant wheat and the possibilities and problems associated with that technology. At least one herbicide resistant wheat has been made available for research and evaluation. Much research is needed over the next several years before this wheat can be made available to wheat producers. The status of this herbicide resistant wheat will be discussed in detail in a later presentation in this Symposium. Significant progress has been made in determining the possibility of gene transfer between wheat and jointed goatgrass. It appears that under some conditions, it may be possible for genes to move from wheat to jointed goatgrass. This information has great implications for the management of herbicide resistant wheat, and Dr. Carol Mallory-Smith will address this topic later in the Symposium. Research is under way to develop wheat germplasm that will decrease greatly the possibility of transfer of resistance genes from wheat to jointed goatgrass.

Beginning in 1996, the emphasis of the management research was shifted from individual component practices to long-term, integrated management projects. By 1997, there were four large projects in place: Pacific Northwest, Intermountain States, Central Great Plains and the Southern High Plains. In these projects, three or more individual management practices are being evaluated simultaneously for the reduction of jointed goatgrass in winter wheat. Each of these projects will be discussed in detail during the Symposium. In 1998, approximately 50% of the Program's funds are devoted to these long-term, integrated management projects.

The current priorities for funding are shown in Table 2. In FY-1999, the National Jointed Goatgrass Program will have $336,816 available for research and technology transfer activities.

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Westra, P. and R. Anderson, editors. 1993. Jointed Goatgrass: A threat to U.S. winter wheat. Proceeding of jointed Goatgrass Symposium, October 27 to 29, 1993. Denver, CO.

Table 1. Original priorities of the National Jointed Goatgrass Program.

I. Integrated Management.
  1. Design and evaluation of improved cultural practices including crop rotation, alternative crops, tillage systems and planting practices.
  2. Improved use of livestock for management, and development of biological controls.
  3. Development of herbicide options.
  4. Improved wheat seed handling and cleaning techniques.

II. Population Dynamics.
  1. Knowledge of factors affecting seedbank depletion such as the impacts of cropping systems on seed germination and decay.
  2. Knowledge of factors affecting seedbank renewal including effects of crop competition on jointed goatgrass seed production.
  3. Knowledge of competitive interactions between crops and jointed goatgrass.
  4. Knowledge of genetic variation among jointed goatgrass populations.

III. Bioeconomics..
  1. Develop decision aids based on bioeconomic models.
  2. Develop economic loss functions based on yield and crop quality loss functions.
  3. Develop cost analyses of control systems using alternative crop rotations and management practices.

IV. Technology Transfer.
  1. Improve awareness of the jointed goatgrass threat in uninfested areas by:
    a. developing a video customized for each state.
    b. developing bulletins and news releases.
  2. Prevent the introduction of jointed goatgrass into uninfested regions by:
    a. improving the uniformity of state seed laws regarding jointed goatgrass.
    b. increasing awareness of seed movement with industry organizations that are responsible
  3. Survey to develop improved information on regions highly susceptible to future infestations.
  4. Promote adoption of improved management practices.

Table 2. Priorities for funding for the National Jointed Goatgrass Research Program in 1999.

Ranking	Program area
1.	**Integrated management of jointed goatgrass**. Field research projects that combine individual weed management practices into systems that will minimize the impact of the weed on crop yield and quality, and will be profitable and environmentally sustainable. Preference will be given to proposals that are multi-state, multi-scientist and have strong economic and technology transfer components.
2.	**Technology transfer.** Transfer of new technology to producers and fieldmen is very important to this program. Regional symposia are popular and should be held every second or third year. Videos should be up-dated every second or third year. On-farm testing of new management practices is essential to help growers to adopt new practices. The World Wide Web site on jointed goatgrass should be up-dated as needed. Development of a compact disc on jointed goatgrass biology and management would enhance technology transfer.
3.	**Bioeconomic modeling.** Develop bioeconomic models that will provide within different geographic regions the ability of researchers to predict yield loss from different populations of jointed goatgrass, and to predict how changing various management practices will change economic outcomes of wheat production. Models must be user friendly.
4.	**Herbicide resistant wheat.** Recent releases of herbicide resistant wheat have shown that this technology has great potential for management of jointed goatgrass. Many questions remain to be answered before this technology can be used correctly. When and how should herbicide resistant wheat be introduced into an integrated jointed goatgrass management system? What is the probability that the herbicide resistant genes will outcross to jointed goatgrass? What is the probability that there will be selection for herbicide resistant weed populations? What management practices can producers use to prevent or at least minimize these potential problems?
5.	**Seed dormancy and longevity.** Jointed goatgrass persists in the soil only by seed. Some seed can live in the soil for five years or more. Seed dormancy plays a key role in the long life of jointed goatgrass seed in soil. Studies on the mechanisms of how dormancy develops, how it cycles over time and how it is broken would provide valuable information for the management of jointed goatgrass. Integrating information on seed dormancy with cultural control practices would provide producers with enhanced methods for controlling jointed goatgrass. Also, there is a need to focus on and to accelerate the concept and technologies of enhancing seed decay using microorganisms.
6.	**Competitive wheat.** Winter wheat cultivars differ in their ability to compete with jointed goatgrass. Not only should competitive cultivars be identified, but also the plant traits that make these cultivars more competitive must be identified. The genes controlling these plant traits need to be identified so that plant breeders working with weed scientists can develop agronomically adapted wheat varieties that will compete with jointed goatgrass.
7.	**Seed cleaning equipment.** Jointed goatgrass spikelettes (joints) are difficult to remove from harvested grain, and currently producers in some regions are being charged a significant dockage fee for grain that contains more than 0.5% jointed goatgrass. In addition, some foreign wheat buyers are imposing restrictions on grain contaminated with jointed goatgrass. Some producers are purchasing on-farm cleaners to remove jointed goatgrass spikelettes from their grain. There is a need for both short-term (evaluation of currently available seed cleaning equipment) and long-term (invention of new cleaning technologies) research to improve seed cleaning equipment to reduce or eliminate jointed goatgrass spikelettes in harvested grain.

For all priorities, preference will be given to multi-state, multi-scientist projects that have a strong technology transfer component.

EFFECTS OF INDIVIDUAL CULTURAL PRACTICES ON JOINTED GOATGRASS MANAGEMENT.

Philip Westra, Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523.

INTRODUCTION

Jointed goatgrass (*Aegilops cylindrica*) is a winter annual grass weed that infests winter wheat fields causing serious yield and dockage losses for U.S. wheat producers. Because winter wheat and jointed goatgrass share a common genome, it has been difficult to develop a selective herbicide for removal of this weed from wheat. The lack of selective chemistry to control jointed goatgrass has forced researchers and farmers to evaluate alternative control methods. Field studies were conducted from 1994 through 1998 in winter wheat production areas of the western United States by a large number of researchers and graduate students working within the framework of the national jointed goatgrass research program to evaluate the impact of cultural practices on wheat yields and management of jointed goatgrass.

RESULTS AND DISCUSSION

Studies on the response of 8 to 10 wheat cultivars in each state were conducted in Colorado, Washington, and Oklahoma. Even though different varieties were evaluated in each state, several important trends emerged from the data. In general, taller wheat varieties competed better with jointed goatgrass than short varieties, although final wheat height alone did not always correlate well with competitive ability. The rate of height development was shown to be important in Washington research. For the 93 to 94 and 94 to 95 production seasons in Washington, taller wheat varieties (shaded bars of Figure 1) suffered less yield reduction from the presence of jointed goatgrass than shorter varieties (white bar of Figure 1). In Oklahoma, variety competitiveness ranked similarly in 10 studies conducted over 3 years. Oklahoma varieties with lower yield losses from jointed goatgrass also had less dockage in harvested grain (Figure 2). Oklahoma is using sophisticated multi-band spectral analysis to evaluate wheat varieties for growth characteristics that may correlate with competitiveness with jointed goatgrass. Colorado research showed that a greater absolute growth rate for a tall wheat variety (Baca) helped explain its high competitive interaction with jointed goatgrass compared to a shorter variety (Tam 107).

Altering the wheat seeding date seldom has a positive effect on jointed goatgrass management unless an early fall flush of jointed goatgrass stimulated by timely rainfall can be killed by tillage or non-selective herbicides. Both early and late seeding dates (compared to normal seeding dates for a given region) can adversely affect wheat yields while having minimal impact on jointed goatgrass growth and development. One positive cultural practice that consistently reduced jointed goatgrass growth and seed production was to increase the normal wheat seeding rate by approximately 50%. Screening wheat seed for the largest 20% of the seed, based on seed size, also improved wheat competitiveness against jointed goatgrass, because larger seed produced more vigorous, robust wheat plants with faster growth than wheat from smaller sized seed. Reducing the width of wheat rows from 12 inches down to 4 inches also helped reduce jointed goatgrass growth and seed production. Although row width can only be reduced to approximately the 4 inch range because of soil disturbance problems, going to more narrow wheat rows does reduce the competitive impacts of jointed goatgrass.

The impact of fertilizer placement was evaluated at Wyoming and Oklahoma. Broadcast surface fertilizer application was compared to deep banding or spoke wheel fertilizer injection 4 inches deep in the soil profile, deep banding or spoke wheel injection gave a relative competitive advantage to wheat compared to jointed goatgrass. This may be because jointed goatgrass germinates from shallow soil depths which would make surface broadcast fertilizer readily available to jointed goatgrass compared to deep seeded wheat. Although jointed goatgrass seedlings can emerge from as deep as 4 inches in the soil, it emerges best from soil depths of 1 inch or less (Figure 3).

Although several herbicides provide effective jointed goatgrass control during fallow, some form of tillage, even use of sweeps as light tillage, appears to improve jointed goatgrass seed-soil contact and improves germination.

Deep plowing (at lease 6 inches deep) every 5 to 6 years, or fall burning of wheat stubble every 5 to 6 years to kill or damage many jointed goatgrass seeds can dramatically reduce jointed goatgrass populations but will not cause elimination of the problem. Deep plowing of wheat stubble distributes jointed goatgrass seed somewhat uniformly in the soil profile compared to chisel plowing which tends to leave most seeds near the soil surface (Figure 4).

CONCLUSION

Although jointed goatgrass competition with winter wheat cannot be eliminated through any combination of the cultural practices reviewed here, clearly the proper combination of these factors can severely limit the growth and seed production of jointed goatgrass itself. This suppression can hold down the jointed goatgrass population in wheat and provide growers with good economic returns in spite of having to contend with this troublesome weed. Two additional recommendations are worth noting. First, planting certified weed-free wheat seed can ensure that wheat producers do not unknowingly plant jointed goatgrass in clean fields. Secondly, using spring planted crops such as corn, sorghum, proso millet, or sunflowers in diverse rotations that keep a field out of winter wheat for 3 or 4 years can significantly reduce the jointed goatgrass population and its negative impacts in winter wheat.

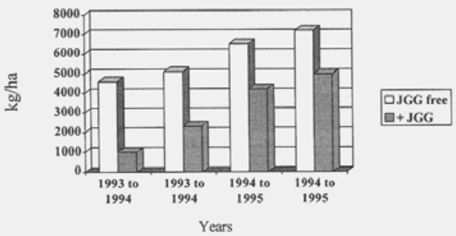

Figure 1. Competitive wheat cultivars - WA.

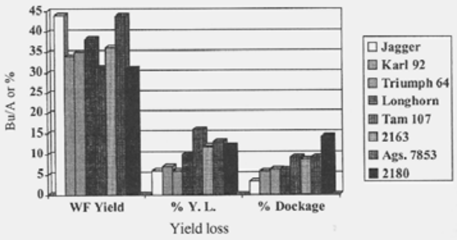

Figure 2. Wheat competitiveness with jointed goatgrass - OK.

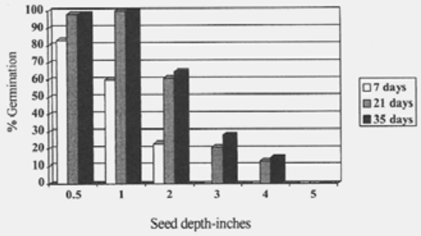

Figure 3. Seed depth and jointed goatgrass emergence.

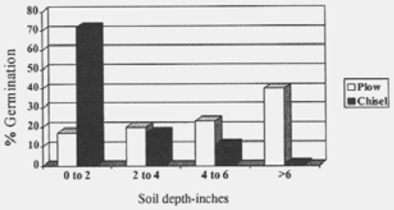

Figure 4. Tillage effects on jointed goatgrass seed distribution in the soil.

STRATEGIES FOR INTEGRATED JOINTED GOATGRASS MANAGEMENT IN THE PACIFIC NORTHWEST. Frank L. Young, Steven Seefeldt, Joe Yenish, Donn Thill, and Dan Ball, Research Agronomist, USDA-ARS, Agronomist, USDA-ARS, Assistant Professor, Department of Crop and Soil Sciences, Washington State University, Pullman, WA 99164; Professor, Department of Plant, Soil, and Entomological Science, University of Idaho, Moscow, ID 83844; and Associate Professor, Crop and Soil Science, Oregon State University, Pendleton, OR.

INTRODUCTION

Single component research has dominated weed science the past several decades. Only recently have scientists focused on long-term, inter/multi-disciplinary systems research for the management of specific weed species in cropping systems. In the PNW, jointed goatgrass was first recognized as a major deterrent to reduced or no-till winter wheat cropping systems in the 1970s. Since then, many individual chemical, cultural, mechanical, and preventive methods of jointed goatgrass control have been examined. In the PNW, loss of soil is very high because of water and wind erosion. Therefore, mechanical tillage is not a viable option for jointed goatgrass control. In the fall of 1996, a total integrated system for the management of jointed goatgrass was initiated in the field in the traditional winter wheat/fallow region of WA, OR, and ID. The multi-state project is designed to utilize the information generated from the many single component jointed goatgrass studies conducted in the PNW. Project treatments include one-time burning, crop rotation, and integrated practices for planting winter wheat. Data to be collected include: a) weed seed viability and density in the soil; b) jointed goatgrass plant density each year in each system; c) crop yield and dockage; and, d) economics and risk assessment. Specific objectives of the project are to:

Develop an integrated weed management system for the control of jointed goatgrass in winter wheat.

a. Determine the effects of stubble burning, length of crop rotation, and integrated practices for planting winter wheat on the longevity of jointed goatgrass seed in the soil.
b. Identify profitable and economically stable crop production systems for fields infested with jointed goatgrass, based on a variety of biological, economic, soil, and climatic conditions.
c. Develop a database on jointed goatgrass economic thresholds for the Pacific Northwest to support bioeconomic-modeling development by the National Jointed Goatgrass Initiative researchers.

MATERIALS AND METHODS

Field experiments were established in August or September 1996 near LaCrosse, WA, Lewiston, ID, and Heppner, OR. All subsubplots were sampled for jointed goatgrass spikelets before and after burning. Sampling locations were on the soil surface (2050 cm^2), and 0 to 10 cm and 10 to 20 cm deep (5250 cm^3) each. Subsequent spikelet sampling has been conducted every fall after harvest. All samples are taken to Pullman, WA where spikelets are separated from the soil and the seed is tested for viability. The fall 1996 sampling represents the baseline weed seed bank density at each site. Crop rotations in this project refer actually to the length of time between winter wheat crops. Specific rotations and length of time out of winter wheat are: a) winter wheat/fallow (1 yr.); b) winter wheat/spring barley/fallow (2 yrs.); and, c) winter wheat/fallow/spring wheat/fallow (3 yrs.). The OR and ID locations include both 1 and 3 yr. rotations. In WA, all three rotations are included in each of two sites. At one site the treatments were initiated in 1996, and at the second site treatments were initiated in 1997. This reduces the variability of environmental and pest incidence. At each location, all crops are grown every year and the spring crops will be produced under conservation tillage systems.

The 1997 to 1998 growing season was the first year of winter wheat production comparing the standard farmer practice with the integrated practice for the management of jointed goatgrass. Planting practices include cultivars, seeding rate, seed size, starter fertilizer, and time of fertilization (Table 1). Other than comparing winter wheat planting methods, operations are similar for all treatments such as spring barley and spring wheat planting and summer fallow tillages.

Table 1. Standard and integrated winter wheat planting practices.

Practice	Standard	Integrated
Starter fertilizer	No Phosphorous	Phosphorous
N applied	Before planting (3 mo.)	At planting
Cultivar	Favorite	Competitive
Seed size	Normal lot	Screened
Seed rate	Normal (x)	1.5 (x)
Drill	Double disk	Hoe

RESULTS AND DISCUSSION

Jointed goatgrass spikelet densities in 1996 ranged from 10 to about 280 spikelets per sample (Table 2). Baseline populations represented high, moderate, and low densities of jointed goatgrass for OR, WA, and ID respectively. The second WA site has a lower density of jointed goatgrass than the first WA site. At both OR and WA, the majority of the spikelets were on the soil surface, whereas in ID with the light density, spikelets were evenly distributed throughout the 20-cm profile.

Table 2. Baseline jointed goatgrass spikelet densities in ID, WA, and OR.

	Jointed goatgrass spikelets/sample			
Depth	ID	WA (Site 1)	WA (Site 2)	OR
Surface	4	51	17	245
0 to 10	6	4	3	34
10 to 20	3	<1	<1	3

Burning stubble after harvest in 1996 was not an effective practice for controlling jointed goatgrass in the light density at ID. At this location straw residue was less and not uniformly distributed compared to the other two sites, resulting in a cooler, incomplete burn (Table 3). Where jointed goatgrass densities were higher and stubble heavier, burning destroyed 30 and 60% of the spikelets on the soil surface at OR and WA respectively. However, the number of viable seed at both OR and WA was reduced a minimum of 93% (Table 3).

Table 3. Influence of stubble burning on jointed goatgrass, 1996.

		Jointed goatgrass		
Site	Burn	Spikelets	Seed	Viable
ID	No	6	9	8
	Yes	2	5	2
WA	No	50	65	60
	Yes	20	20	2
OR	No	275	375	360
	Yes	200	225	25

In the fall of 1997, winter wheat was planted for the first time at all three sites comparing the grower's standard planting practice with an integrated planting practice. In general, compared to the grower's practices, the integrated practices included larger seed size, narrower row spacing, higher planting density, deep banded fertilizer at the time of planting, and starter fertilizer placed with the seed. When averaged across planting practices, yields of winter wheat were slightly higher in the burned plots compared to the non-burned plots in WA and OR (data not shown). In ID, the winter wheat yield was higher in the non-burned plots compared to the burned plots. Jointed goatgrass dockage was determined in WA and OR and there was less jointed goatgrass dockage in the burned plots compared to the non-burned plots (data not shown). At all locations, integrated planting practices increased winter wheat yields compared to yields in the standard system when averaged over burning treatments (Table 4). Compared to the standard practice, integrated planting practices increased yield 20, 26, and 31% in ID, OR, and WA respectively. In OR, the integrated practice reduced dockage due to jointed goatgrass 2 percentage points compared to the standard practice (Table 4).

Table 4. Effect of standard (S) and integrated (I) planting practices on 1998 winter wheat performances in ID, WA, and OR.

Site	Practice[a]	Wheat yield	Dockage
		kg/ha	%
ID	S	2690	--
	I	3225	--
WA	S	3025	0.54
	I	3965	0.97
OR	S	3360	2.40
	I	4235	0.40

[a] S=standard, I=integrated practices.

In OR, where the jointed goatgrass density is high, the integrated planting practice increased wheat yield 21% compared to the standard practice when stubble was burned (Table 5). When stubble was not burned, winter wheat yield was increased 34% in the integrated compared to the standard practice. Regardless of the burn treatments, dockage in the integrated planting practices were below the penalty level (Table 5).

Table 5. Effect of stubble burning and planting practices on winter wheat performance and JGG in OR.

Burn	Practice[a]	Wheat yield	JGG	Dockage
		kg/ha	No.	%
No	S	3160	13	3.1
	I	4235	9	0.5
Yes	S	3495	3	1.7
	I	4235	1	0.4

[a] S=standard, I=integrated practices.

In general results of the winter wheat yield and dockage reduction in the integrated compared to the standard grower practice is promising. However, the economic feasibility and risk assessment must be evaluated for each system.

INTEGRATED MANAGEMENT STRATEGIES FOR JOINTED GOATGRASS CONTROL IN WINTER WHEAT IN THE INTERMOUNTAIN REGION. John O. Evans, Don W. Morishita, and Bruce D. Maxwell, Professor, Department of Plants, Soils, and Biometeorology, Utah State University, Logan, UT 84322-4820; Associate Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Twin Falls, ID 83303; and Associate Professor, Plant, Soil and Environmental Sciences Department, Montana State University, Bozeman, MT 59717.

For the past 6 years weed scientists throughout the western United States have conducted an intensive cooperative program to understand and control jointed goatgrass in winter wheat. This presentation is a brief summary of some research on this weed in the intermountain region. Our group at Utah State University has worked with scientists at the University of Idaho, Twin Falls, and Montana State University, Bozeman elucidating the role of tillage, crop seeding rate and date, crop rotations, and spring crops for jointed goatgrass suppression and management. Without the cooperation and assistance of scientists throughout the western United States, progress towards managing this troublesome species would be far short of where we presently are.

Twenty years ago and before, growers were locked into a winter wheat-fallow-winter wheat cropping sequence. At the time, other options were not available or not economically feasible and jointed goatgrass was not a recurring problem. In the past decade several management options were made available and some have contributed to the jointed goatgrass problem while others provide keys to successfully manage jointed goatgrass in winter wheat.

Tillage plays a crucial role in jointed goatgrass management. About 15 years ago, grain drills appeared on the market which successfully planted small grain crops in the absence of seedbed preparation. Producers were encouraged to drastically curtail or eliminate tillage to reduce soil erosion, conserve fuel resources, and to meet certain crop program compliance standards. This was done without regard to how these measures would encourage or discourage jointed goatgrass invasion. The worst case scenario regarding infestations of jointed goatgrass is that of a crop-fallow-crop rotation with no tillage practices. In one field with a heavy population of jointed goatgrass we observed over 2000 goatgrass seedlings/m^2 in no-till fallow, over 1000 seedlings in conservation fallow, and none in conventionally tilled fallow. No-till allows jointed goatgrass to grow and spread copious amounts of seed. Utah studies have revealed that any tillage helps control jointed goatgrass. Goatgrass seed has the unique ability to germinate on the soil surface, therefore reducing tillage favors jointed goatgrass. Utah studies revealed that a fall or spring chisel plow treatment followed by summer rod weeding(s) in conventional tillage significantly reduced jointed goatgrass infestations over conservational tillage (Table 1).

Table 1. Numbers of jointed goatgrass seedlings and spikelets in winter wheat following no-till, conservation, and conventional tillage.

	Jointed goatgrass seedlings and spikelets		
Tillage regime	Surface	0 to 5 cm	5 to 10 cm
	No. m^{-2}		
No-tillage			
Non-tilled	2176	2338	98
Conservation tillage			
Chisel plow (F[a]) skewtreader (Sp[a])	1300	1134	66
Subsoiler (F) skewtreader (Sp)	1343	1343	171
Conventional tillage			
Chisel plow (F) rodweeder (Su[a])	0	779	130
Chisel plow (Sp) rodweeder(Su)	0	390	0
Subsoiler (F) rodweeder (Su)	0	1201	65
LSD (0.05)	860		110

[a]F=Fall 1992, Sp=Spring 1993, Su=Summer 1993.

Conservational tillage such as a fall chisel plow or fall subsoiler followed by a spring skewtreader treatment decreased goatgrass seedlings dramatically compared to no-till. Jointed goatgrass studies conducted in southern Idaho revealed some dramatic differences regarding jointed goatgrass seedlings in winter wheat stands in two contrasting tillage regimes. Jointed goatgrass seedling counts of 1 and 5 were recorded in the crop grown in a conventional tillage farming program where as the jointed goatgrass population was an order of magnitude greater under similar weed pressures with conservational tillage procedures. Montana also reported that jointed goatgrass is more prevalent in fields under conservation tillage than in conventionally tilled fields (Schweitzer et al. 1998). Tillage is crucial in managing jointed goatgrass. Conventional tillage is superior to conservation, however conservational tillage is far better than no-till regarding the elimination of jointed goatgrass.

Another management option is to break the winter wheat-fallow-winter wheat regime. Idaho studies strongly corroborate breaking this age-old planting cycle in an effort to manage jointed goatgrass populations and suggest rotations such as winter wheat-spring wheat-fallow or continuous spring wheat. With limited moisture coming predominately in the winter months, alternatives are limited. Few markets existed for alternative spring crops such as safflower a few years ago. Now however, farmers do not have to sacrifice economic returns when growing alternative crops, the number and variety of crops that can be grown as spring crops in the intermountain region has increased. Feed wheats adapted to dryland cropping, spring wheat, barley, and safflower are satisfactory choices used to break the cycle. In eastern Idaho, barley can be grown since this area receives adequate rainfall. Spring tillage in combination with spring safflower and its accompanying soil incorporated herbicides removed 97% of goatgrass seedlings in a Utah study conducted by Dalley, (1998). The tillage regimes associated with winter wheat production works the soil when goatgrass spikelets are dormant rendering little, if any harm to them. Spring crop tillage operations on the other hand, occur when goatgrass seedlings can be rather easily destroyed. In another study, following one safflower season jointed goatgrass seedling populations in the ensuing winter wheat decreased 75% .

Table 2. Number of jointed goatgrass seedlings in safflower, September planted wheat, October planted wheat, and fallow in 1997 and 1998.

	Jointed goatgrass seedling populations	
Treatment	1997	1998
	Plants m^{-2}	
Safflower	0.34a[a]	0.34
Fallow	9.8b	11.3a
September wheat	11.1	6.8ab
October wheat	11.7	4.4b
LSD (0.05)	5.2[b]	2.9

[a] Within columns, treatments followed by the same letter are not significantly different.
[b] LSD for plants m^{-2} in 1997 is for safflower plots only, other comparisons were not significant.

Jointed goatgrass propagules were not completely eliminated by growing safflower, but their numbers were drastically reduced. Spring crops not only allow tillage that suppress jointed goatgrass but some also allow selective herbicide use. Without selective herbicides for jointed goatgrass control in wheat, spring crops along with herbicides provide an opportunity to control most annual grassy weed species. Herbicides such as trifluralin and EPTC are effective for reducing goatgrass populations in spring dicot crops. Planting spring crops eliminates the need for fall tillage to prepare seedbeds, and it allows more crop stubble overwinter thereby reducing erosion. Summer fallow plays an important role in controlling jointed goatgrass in winter wheat crops since it allows for jointed goatgrass seedling removal before they develop viable propagules. Tillage is widely used in combination with summer fallow because of the varied tillage options ranging from mild to severe tillage implements that can accommodate whatever weed intensities are encountered and can be practiced as often as needed. Excellent herbicide treatments for jointed goatgrass control in fallow are available which provide nearly 100% control (Evans et al. 1989). Chemical fallow is not widely practiced probably because it requires additional trips over fields and some are quite expensive. Glyphosate plus 2,4-D provides excellent control but requires repeated applications during the fallow season, a deterrent to farmers. From a economic viewpoint, mechanical fallow may be more cost effective.

Varying planting date provides another management option. Delaying planting time allows for mechanical or chemical removal of germinated seedlings. However, recent Utah studies show September planted wheat had 46% less jointed goatgrass seedlings in the crop than October planted wheat and the early planted wheat yielded 25% higher than late planted wheat (Table 3). The greater presence of jointed goatgrass in the late planted wheat is reflected in higher dockage percentages in October planted wheat compared to the earlier wheat planting in 1997 and 1998. Late plantings often sacrifice wheat yields. Winter wheat yield is optimal when it has 400 Growing Degree Days (GDD) between planting and winter onset (Blue et al. 1990). In northern Utah, the September planted wheat in 1997 had 438 GDD, while October planted wheat had 160 GDD in only a 30 day difference in planting date. September seeded wheat yielded 11 bu/A more than October seeded wheat (Table 3). Late planted wheat may decrease jointed goatgrass populations through preplant tillage or herbicides, but it commonly reduces yield.

Table 3. Wheat and safflower yield, and crop dockage in 1997 and 1998.

Treatment	Yield		Crop dockage[a]	
	1997	1998	1997	1998
	bu/A		g/kg	
Safflower	20.0	6.9	0.64a	0
September wheat	51.3a	76.7a	0.54a	24.5a
October wheat	40.2b	50.2b	2.37b	38.5b
LSD (0.05)	3.74	13.7	0.63	5.4

[a] Jointed goatgrass per kg wheat or safflower.

Tall stature wheat cultivars have shown to be more competitive and reduce affects of jointed goatgrass compared to semi-dwarf wheats. The use of tall cultivars, high seeding rates, and nitrogen fertilizers have been recommended to reduce jointed goatgrass production by up to 40% compared with conventional methods (Anderson et a.l, 1998). These tall wheat cultivars decrease the competitive affect of jointed goatgrass. Results from the pacific northwest using a tall and short statured wheat failed to reveal an advantage of wheat height regarding its competitive ability with jointed goatgrass. When jointed goatgrass seedling populations exceeded 400 tillers per square meter, yield of a tall statured wheat began to decline while a particular short wheat maintained its yield even in the presence of exceedingly high jointed goatgrass numbers. In Montana, Maxwell and colleagues working in fields with heavy jointed goatgrass pressures observed strikingly strong correlation between winter wheat yields and increasing winter wheat planting densities (Figure 1). When winter wheat yield was plotted as a function of increasing jointed goatgrass density (Figure 2), the trend for lowered wheat yield as jointed goatgrass populations increased was present but considerable variation existed among the measurements.

Growers are anxiously awaiting herbicide resistant winter wheat varieties. Herbicide resistant winter wheat crops will have a major role on winter wheat production in areas heavily infested with jointed goatgrass. Resistant crops will enable growers to apply herbicides directly to their winter wheat fields without harming the crop, while decreasing goatgrass infestations and suppressing its rate of spread.

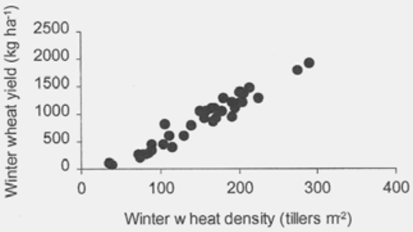

Figure 1. Winter wheat yield in Montana as a function of increasing winter wheat densities, 1996.

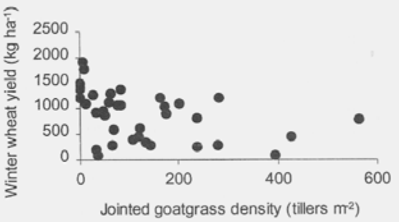

Figure 2. Winter wheat yield in Montana as a function of increasing jointed goatgrass densities, 1996.

Breaking the crop-fallow-crop cycle is key to successfully managing jointed goatgrass. Tillage destroys propagules thus decreasing soil seed reserves, any tillage is better than no tillage. Spring crops allow tillage practices, chemical use, and break the cycle. Early planting dates improve wheat yields and tall cultivars compete more effectively with jointed goatgrass. At present, combinations of various management practices are best for managing jointed goatgrass in winter wheat. Integration of farming operations that are readily controlled by the producer which have major impacts on jointed goatgrass competition include modifying the traditional winter wheat fallow rotation, using competitive winter wheat cultivars, manipulating planting date, increasing the seeding rate, and using nonselective herbicides. The appropriate spring crops include spring grain crops, sunflower, safflower, and canola. Tillage operations that best interrupt jointed goatgrass reproductive cycles, such as seedbed preparation and intensive tillage during summer fallow are also effective. The movement of jointed goatgrass propagules must be eliminated especially as it pertains to the movement of seed and farm machinery. Harvest machines particularly must be thoroughly cleaned prior to leaving jointed goatgrass infested fields. Certified weed free seed is a principle deterrent to the spread and increase of jointed goatgrass.

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INTEGRATED MANAGEMENT SYSTEMS FOR JOINTED GOATGRASS IN THE CENTRAL GREAT PLAINS. Todd A. Pester[1], Philip Westra[1], Randy L. Anderson[2], Phillip W. Stahlman[3], Gail A. Wicks[4], Drew J. Lyon[5], and Stephen D. Miller[6], Graduate Research Assistant, Professor, [1]Department of Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523; Research Leader, [2]USDA-ARS, Akron, CO 70720; Professor, [3]Kansas State University, Hays Agricultural Research Center, 1232 240th Avenue, Hays, KS 67601; Professor, [4]University of Nebraska-Lincoln, West Central Research and Extension Center, Route 4, Box #46A, North Platte, NE 69101; Associate Professor, [5]University of Nebraska-Lincoln, Panhandle Research and Extension Center, 4502 Avenue I, Scottsbluff, NE 69361; and Professor, [6]Department of Plant, Soil, and Insect Sciences, University of Wyoming, Laramie, WY 82071.

INTRODUCTION

Jointed goatgrass was introduced to North America during the early 1900s (Johnston and Parker, 1929; Mayfield, 1927) and has since become well established in winter wheat producing regions of the Great Plains and Western United States (Donald and Ogg, 1991). Once established, isolated jointed goatgrass plants growing without interference may produce over 100 tillers and as many as 1,500 spikelets per plant (Gealy, 1988) with seed remaining viable from 3 to 5 years depending upon site (Donald and Zimdahl, 1987). Detrimental impacts of jointed goatgrass include reduced grain yield and quality, and jointed goatgrass can serve as an overwintering host for pests that attack winter wheat (Donald and Ogg, 1991).

A considerable amount of research has investigated the biology of jointed goatgrass (Anderson, 1995; Gealy, 1988; Stump, 1997) and the effects of IPM-based cultural practices on its growth and reproduction (Cleary and Peeper, 1980; Donald and Zimdahl, 1987; Schweitzer et al., 1988). It has been suggested that interrupting the life cycle of jointed goatgrass with spring seeded crop rotations is presently the most effective management option (Anderson, 1995; Donald and Ogg, 1991). Due to the longevity of jointed goatgrass seed in soil, a four-year crop rotation would likely be required to reduce weed populations to manageable levels. Long-term crop rotations are often not cost-effective, particularly in regions where climatic conditions limit options to a winter wheat-fallow rotation or continuous wheat. Economic analysis is needed to help define the economic feasibility of alternative crop management strategies for suppressing jointed goatgrass. The objective of this regional research project is to determine the influence and economic feasibility of best management practices for controlling jointed goatgrass in winter wheat rotations.

MATERIALS AND METHODS

To evaluate integrated, multiple-component systems for jointed goatgrass management in winter wheat, field experiments are being conducted in CO, KS, and NE over 7 years from 1996 to 2003. Baseline populations of jointed goatgrass were established and recorded for each study location. Soil cores containing jointed goatgrass spikelets are processed using elutriation equipment in WY. Biological measurements of jointed goatgrass include seedling density, biomass, reproductive tillers, and spike and spikelet characteristics. All phases of each crop rotation occur in each year and all crops are taken to yield.

Colorado. Three studies were established in October, 1996 on private research land near Platner, CO in an area that had been in a winter wheat-fallow rotation. Jointed goatgrass was spread evenly across the study area and shallow incorporated with a mulch-treader. Five soil cores (5 by 10 cm cylinder) taken in each plot (9 by 15 m) contained an average of 0.4 jointed goatgrass spikelets for a baseline population of 462,000 spikelets/ha (46/m^2). The objective of the first study is to evaluate the effects of various tillage systems and wheat planting densities on jointed goatgrass populations and wheat yields. Experimental design is a factorial arrangement with four replications of tillage and winter wheat planting density including three winter wheat cultivars ('Akron', 'Lamar', and 'TAM 107') planted at two target densities of 45 and 67 kg/ha and tillage treatments including conventional-, reduced-, and no-tillage. Conventional-tillage treatments utilize only tillage to control jointed goatgrass and other indigenous weeds in the fallow plots. Reduced-tillage treatments utilize a combination of tillage and herbicides. No-tillage treatments utilize only herbicides for weed management. The objective of the second study is to evaluate the effects of delayed planting on winter wheat competition with jointed goatgrass. The three winter wheat cultivars are planted on two dates simulating average and delayed planting times for Planter, CO (approximately a three week interval). The objective of the third study is to evaluate the effects of spring applied nitrogen fertilizer placement on winter wheat competition with jointed goatgrass. Recommended amounts of nitrogen fertilizer are applied to the three wheat cultivars either broadcast on the soil surface or with a spoke wheel to inject fertilizer.

Kansas. The experiment was established on the KSU Agricultural Research Center near Hays, KS in October, 1996 in an area that had been in a forage sorghum-fallow cropping rotation for more than 20 years. Soil cores (10 by 10 cm cylinder) taken in each plot seeded to winter wheat in the fall of 1996 contained an average of 1.3 jointed goatgrass spikelets for a baseline population of 1,643,000 spikelets/ha (164/m^2). The crop rotations include winter wheat-fallow, winter wheat-sorghum-fallow, and winter wheat-sorghum-sunflower-fallow. Experimental design is a split-split-plot design with four replicates. Main plot is crop rotation, subplot is post-harvest tillage or post-harvest herbicide, and sub-subplot is wheat cultivar ('Ike' and TAM 107) planted in 25 cm rows or row crop planted in 76 cm rows. Sub-subplot size is 5 by 16 m.

Nebraska. The experiment was established on the WCREC near North Platte, NE in October, 1996 in a field that had been in a winter wheat-fallow rotation for over 30 years and was infested with jointed goatgrass, downy brome, and winter annual broadleaf weeds. The crop rotations include winter wheat-fallow, winter wheat-corn-fallow, and winter wheat-corn-grain sorghum-fallow. Experimental design is a strip-split-plot design with four replicates. Within crop strips and tillage levels are the main plots (post-harvest tillage or post-harvest herbicide) and subplots are winter wheat cultivars ('Pronghorn', 'Alliance', and 'Vista') planted in 36 cm rows using a hoe drill. Strips are 55 by 119 m. Individual subplot size is 5 by 18 m.

RESULTS AND DISCUSSION

Colorado. The three studies were established on wheat stubble in the fall of 1996 and persistent dry conditions through the spring of 1997 resulted in very poor winter wheat yields (data not shown). The 1997 to 1998 growing conditions were more favorable and wheat production was normal for the region. Increased wheat production in 1998 resulted in generally lower jointed goatgrass production for all measured parameters (Tables 1, 2, and 3).

Tillage System and Planting Density. In 1997, reduced-tillage treatments had more jointed goatgrass tillers/m^2 than conventional-till or no-till treatments and increased wheat density tended to decrease jointed goatgrass growth characteristics, although not significantly (Table 1). In 1998, the no-tillage treatments had more jointed goatgrass reproductive tillers/m^2 than conventional-tillage or reduced-tillage treatments. Increased wheat density from 45 to 67 kg/ha decreased jointed goatgrass growth characteristics both years.

Planting Date. In the first year (1996 to 1997) the late planting of both average and delayed planting dates and the separation of only seven days did not result in many significant differences in the variables measured (Table 2). In 1998, delayed planting resulted in lower winter wheat production (data not shown) and higher jointed goatgrass production.

Nitrogen Placement. In 1997, sub-surface nitrogen treatments significantly improved winter wheat growth characteristics (data not shown) while not significantly increasing similar jointed goatgrass growth characteristics (Table 3). During the 1997 to 1998 season few significant differences were detected but trends indicated sub-surface nitrogen treatments improved both winter wheat and jointed goatgrass growth characteristics with Akron producing the highest wheat yield (data not shown) and TAM 107 resulting in the lowest jointed goatgrass growth characteristics.

In previous research, production practices involving increased tillage, increased wheat planting density, delayed wheat planting, and fertilizer placement have been implemented but only suppressed jointed goatgrass without effectively reducing populations (Miller and Van Vleet, 1996; Schweitzer et al., 1988). Under favorable conditions jointed goatgrass populations can quickly recover and in some cases exceed initial densities (Stump, 1997).

Table 1. Main-effect treatment means for jointed goatgrass biomass, reproductive tillers, and spikelet production in winter wheat for different tillage systems, planting densities, and cultivars, Platner, CO, 1997 and 1998.

	Jointed goatgrass							
	Biomass		Tillers		Spikelets		Spikelets	
Treatment	1997	1998	1997	1998	1997	1998	1997	1998
	g/m^2		No./m^2		No./tiller		No./m^2	
Tillage system								
Conventional	34.1	9.6	101	37	7.5	7.6	752	293
Reduced	46.0	8.9	128	38	7.6	7.2	962	284
None	35.8	18.1	104	75	7.6	8.1	780	593
LSD (0.05)	8.4	5.3	23	23	NS	NS	178	191
Planting density (kg/ha)								
45	40.2	15.3	112	63	7.6	7.9	844	502
67	37.0	8.9	109	37	7.5	7.4	819	278
LSD (0.05)	NS	4.3	NS	19	NS	0.2	NS	156
Wheat cultivar								
Lamar (tall)	35.3	13.1	111	59	7.4	7.4	822	442
Akron (medium-tall)	35.8	11.2	99	48	7.6	7.8	744	386
TAM 107 (medium)	44.8	12.0	122	43	7.7	7.7	927	343
LSD (0.05)	8.4	NS	NS	NS	0.2	0.3	178	NS

Table 2. Main-effect treatment means for jointed goatgrass biomass, reproductive tillers, and spikelet production in winter wheat for different planting dates and cultivars, Platner, CO, 1997 and 1998.

	Jointed goatgrass							
	Biomass		Tillers		Spikelets		Spikelets	
Treatment	1997	1998	1997	1998	1997	1998	1997	1998
	g/m^2		No./m^2		No./tiller		No./m^2	
Planting date								
Average[a]	36.6	11.0	125	36	7.6	8.2	956	289
Delayed[b]	33.0	24.7	98	85	8.2	8.6	797	723
LSD (0.05)	NS	2.5	NS	14	0.3	0.3	NS	91
Wheat cultivar								
Lamar (tall)	28.6	17.9	94	64	7.9	7.9	719	517
Akron (medium-tall)	38.9	17.9	124	65	8.6	8.6	956	549
TAM 107 (medium)	36.9	17.8	117	53	8.8	8.8	954	451
LSD (0.05)	NS	NS	NS	NS	0.5	0.5	NS	NS

[a] October 9, 1996; September 18, 1997.

[b] October 16, 1996; October 9, 1997.

Table 3. Main-effect treatment means for jointed goatgrass biomass, reproductive tillers, and spikelet production in winter wheat for different nitrogen placements and cultivars, Platner, CO, 1997 and 1998.

	Jointed goatgrass							
	Biomass		Tillers		Spikelets		Spikelets	
Treatment	1997	1998	1997	1998	1997	1998	1997	1998
	g/m^2		No./m^2		No./tiller		No./m^2	
Nitrogen placement								
Broadcast	20.7	5.6	66	19	7.2	7.4	460	136
Sub-surface	25.8	8.5	71	28	7.6	6.7	541	197
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Wheat cultivar								
Lamar (tall)	18.9	10.4	58	33	7.4	7.6	416	257
Akron (medium-tall)	23.4	5.8	67	22	7.2	6.4	482	138
TAM 107 (medium)	27.4	5.0	81	15	7.4	7.1	603	103
LSD (0.05)	NS	NS	NS	NS	NS	0.8	NS	NS

Kansas. In 1996-1997, plots to be seeded to row crops had 2.4 times or more spikelets lying on the soil surface than plots seeded to winter wheat (data not shown). In winter wheat plots, jointed goatgrass plants generated as many as 214 reproductive tillers/m^2 resulting in "seedrains" up to 1834 spikelets/m^2 (Table 4). Differences in reproductive tillers between three- and four-year crop rotations (Table 4) is probably an anomaly because crop rotation and post-harvest weed management become contributing factors only in subsequent years when the rotations have been completed.

Jointed goatgrass populations were much lower in 1998 than in 1997, regardless of cropping sequence, wheat cultivar, or tillage system. Spring jointed goatgrass populations in winter wheat plots decreased from approximately 17 plants/m^2 in 1997 to < 1 plant/m^2 in 1998. The soil seedbank averaged 77,000 jointed goatgrass spikelets/ha after wheat harvest, 95% less than the initial 1996 population (1,643,000/ha) (data not shown). Up to 142 jointed goatgrass plants/m^2 were destroyed by fallow tillage following wheat in 1997; more were destroyed in plots receiving post-harvest herbicide compared with post-harvest tillage (133 vs. 89) (data not shown). Unlike in 1997, high densities of jointed goatgrass emerged in sorghum and sunflower crops following an abnormally wet July; nearly all died before setting seed either from the row-crop herbicides used, dry late-summer conditions, or both.

Table 4. Main-effect treatment means for jointed goatgrass density, reproductive tillers, and spikelet production in winter wheat, Hays, KS, 1997 and 1998.

	Jointed goatgrass							
	Plants		Tillers		Spikelets		Spikelets	
Treatment	1997	1998	1997	1998	1997	1998	1997	1998
	No./m^2		No./m^2		No./tiller		No./m^2	
Crop rotation								
W-S-SF-F[a]	17.1	0.07	214	0.21	8.4	7.5	1834	1.6
W-S-F	17.3	0.13	191	0.53	8.1	8.1	1544	4.2
W-F	18.3	0.09	190	0.25	8.3	7.6	1588	1.9
LSD (0.05)	--[b]	NS	--[b]	NS	--[b]	NS	--[b]	
Post-harvest weed control								
Tillage	17.2	0.08	201	0.31	8.3	7.8	1676	2.4
Herbicide	18.0	0.12	195	0.36	8.3	7.7	1635	2.8
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Wheat cultivar								
Ike (tall)	17.8	0.09	208	0.21	8.3	7.9	1741	1.6
TAM 107 (medium)	17.3	0.11	188	0.46	8.3	7.5	1569	3.6
LSD (0.05)	NS	NS	6	NS	NS	NS	57	NS

[a] W = wheat; S = sorghum; SF = sunflower; F = fallow.

[b] LSD values not presented, 3- and 4-year rotation cycles not completed in first 2 years.

Nebraska. In 1996 to 1997, jointed goatgrass densities were low due to above average rainfall in the fall (three flushes destroyed prior to planting) and below average rainfall in the spring (Table 5). Initiating tillage May 7 rather than August 7 reduced jointed goatgrass populations in the following winter wheat crop and in the corn. Additional jointed goatgrass germination in the corn and grain sorghum (primarily due to increased tillage) should reduce jointed goatgrass pressure when planted back to winter wheat.

During the second year (1997 to 1998), winter wheat plots were treated with triasulfuron at 15 g/ha in November to control emerged field pennycress. This treatment caused injury to the wheat plots identified by stunting and yield losses up to 30% (data not shown). Fallow practices the year before resulted in lower jointed goatgrass density in the tillage plots (29/m^2) compared to the herbicide plots (79/m^2) (data not shown). Wheat cultivar affected jointed goatgrass growth with Vista (short cultivar) having the largest biomass and spikelet production (Table 5). Rainfall was lower in the fall of 1997 than the previous year. Fewer flushes of jointed goatgrass emerged in the spring of 1998 as compared to 1997 resulting in higher populations and subsequently more jointed goatgrass production (Table 5). Comparisons of three- and four-year crop rotations are unrealistic, as cycles have not been completed.

Wyoming. Each fall soil cores are taken from the research plots at CO, KS, and NE and delivered to WY to determine jointed goatgrass soil seedbank using elutriation techniques. Elutriation is performed with a semi-automatic elutriator developed by North Carolina State University. The most effective setting for separation of jointed goatgrass spikelets from soil is 138 kPa air pressure and a 5-min time cycle. This setting allows recovery of 99.5% of the joints with very little soil remaining. The semi-automatic elutriator consists of four elutriator cylinders where the soil samples are agitated with a water-air mixture. The spikelets, along with any detritus, are floated out of the elutriator with the water-air mix and are retained on a 600 µm sieve. The soil and water are automatically dumped after the 5-min time cycle. The organic matter and spikelets remaining on the sieve are washed on to filter paper and subsequently placed in a Büchner suction funnel to remove excess water. The samples are left on filter paper until dry and then transferred to vials for storage and counting.

Table 5. Main-effect treatment means for jointed goatgrass density, biomass, reproductive tillers, and spikelet production in winter wheat, North Platte, NE, 1997 and 1998.

	Jointed goatgrass							
	Plants		Biomass		Tillers		Spikelets	
Treatment	1997	1998	1997	1998	1997[a]	1998	1997[b]	1998
	No./m^2		No./m^2		No./m^2		No./m^2	
Crop rotation								
W-C-S-F[c]	3	44	12	275	--	1080	--	4970
W-C-F	5	72	24	300	--	950	--	5915
W-F	2	13	9	65	--	625	--	1090
LSD (0.05)	--[d]	15	--[d]	60		370		1110
Post-harvest weed control								
Tillage	3	40	14	155	--	485	--	2930
Herbicide	3	46	16	275	--	1080	--	5050
LSD (0.05)	NS	NS	NS	50		300		905
Wheat cultivar								
Pronghorn (tall)	3	40	11	180	--	615	--	3345
Alliance (medium)	4	41	19	200	--	710	--	3785
Vista (short)	3	48	16	260	--	1025	--	4850
LSD (0.05)	NS	NS	6	60		NS		1110

[a] Data not available for reproductive tillers in 1997.

[b] Data not available for spikelets in 1997.

[c] W = wheat; C = corn; S = sorghum; F = fallow.

[d] LSD values not presented, 3- and 4-year rotation cycles not completed in first 2 years.

CONCLUSIONS

CO and KS have seen dramatic decreases in jointed goatgrass populations after only two years of the rotations while NE observed modest increases. These changes are likely the result of timely rainfall events in addition to the various treatments applied. Increased tillage and early initiation of tillage (spring vs. fall) appear to reduce jointed goatgrass production. Rotating to spring planted crops provides additional management opportunities (tillage and herbicide) to control jointed goatgrass throughout the growing season. It will be important to finish one or more full cycles of the three- and four-year rotations before making extensive conclusions.

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INFLUENCE OF CULTURAL PRACTICES ON JOINTED GOATGRASS DENSITY IN CONTINUOUS WINTER WHEAT.

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Abstract. Research has been conducted in Oklahoma on the influence of several cultural practices on the severity of jointed goatgrass infestations in continuous winter wheat. Practices investigated include seasonal grazing, starter fertilizer applications, wheat row spacing, wheat seeding rate, wheat cultivar differences, and primary tillage practice.

In Oklahoma, north Texas, and southern Kansas, winter wheat is often grazed by cattle from late fall until jointing begins the next spring. This practice removes most of the wheat leaves and decreases the ability of the wheat to compete with weeds. In replicated field experiments, grazing infested wheat increased jointed goatgrass spikelet yield by 279% at one site and 1027% at another site. Although it might be assumed that grazing would also remove jointed goatgrass foliage, the prostrate growth of jointed goatgrass compared to popular hard red winter wheat cultivars appears to minimize jointed goatgrass defoliation by grazing.

Banding starter fertilizer is the row with wheat seed at planting is often recommended for suppression of weedy annual grass species. In Oklahoma, banding liquid ammonium polyphosphate has become a widely accepted practice, not only for weed suppression, but primarily to overcome aluminum toxicity on acid topsoils. In our research, comparisons of banded versus broadcast applications of liquid ammonium polyphosphate at planting did not reveal a benefit in terms of jointed goatgrass suppression or wheat yield. In two of three experiments, banding decreased wheat yield due to poorer stands. The effect on stands was attributed to disruption of seed placement by the interaction of liquid fertilizer and soil which can accumulate on seeding equipment and disturb the pattern of seed flow from the bottom of seed boots.

Wheat row spacing research has been conducted by the authors for several years. Averaged over several replicated experiments, reducing row spacing from 9 to 3 inches, with constant seeding rates, increases wheat yield about 10%. This yield increase seems to be true in weed infested and weed free conditions, with little or no interaction found in wheat yield between weed infestations and row spacing. Because 3-inch row spacing is mechanically difficult to achieve, we have more recently shifted our row spacing comparisons to 4-, 8-, and 12-inch row spacing by using a double-run 8 inch drill modified to seed from both the large and small seed cups. In three recently completed experiments, averaged over five fertilizer placement treatments, reducing row spacing from 12 to 8 to 4 inches reduced jointed goatgrass spikes per plant from 5.9 to 5.2 to 4.8, respectively. Thus reducing row spacing tends to increase the competitive ability of wheat and suppresses jointed goatgrass seed production. Our current recommendations to wheat growers are that when they decide to purchase new seeding equipment, they should purchase equipment with as narrow of row spacing as possible, which is usually 6 inches. Since trash clearance is reduced by narrowing rows, we suggest that double disc openers by purchased. It is our opinion that the yield advantage from narrow rows outweighs the additional cost of a narrow row grain drill.

Wheat seeding rate has a major influence on jointed goatgrass seed production. Over the past 2 years we conducted six replicated experiments, where we increased the wheat seeding rate from 30 to 120 lb/A, in 0.5 bu/A increments. At all sites increasing the wheat seeding rate decreased the number of jointed goatgrass spikelets in harvested wheat. Averaged over locations, the number of jointed goatgrass spikelets per bushel of wheat was 4470, 2452, 1453, 407 with wheat seeding rates of 30, 60, 90, and 120 lb/A, respectively. Thus, increasing seeding rate will suppress jointed goatgrass. However, wheat seeding rates above 90 lb/A may not be desirable if the wheat is not grazed. High seeding rates tend to increase lodging. We have not seen substantial interactions between seeding rate and row spacing.

Wheat cultivars differ markedly in their competitive ability against jointed goatgrass. In seven of ten replicated experiments, wheat mature height was significantly negatively correlated with jointed goatgrass spikelet yield. However, height is a trait that is not expressed until winter wheat is several months old. Also, the tallest wheats in our experiments were not the more competitive than some shorter wheats. Therefore we are seeking to identify other traits that influence the competitive ability of wheat cultivars.

Primary tillage seems to affect jointed goatgrass seedling density by at least two methods. First, tillage buries the joints and places them in a more consistently moist environment, which encourages germination throughout the summer months. Secondly, deep tillage can bury the joints deep enough to prevent the coleoplile from being able to reach the surface when the seed germinates. Also, burial may increase seed predation. In our research, we compared three primary tillage treatments, a moldboard plow, an offset tandem disc, and a wide sweep. Averaged over six experiments, jointed goatgrass spikelets in one bushel of harvested grain averaged 817, 1816, and 4744 in plots with moldboard, disc, and sweep primary tillage, respectively.

Thus, cultural controls can be expected to have varying degrees of success, depending on weather, time constraints, and skill of the wheat grower. Cultural control methods can not be imposed without significant economic input, and thus may be less suitable economically and environmentally than herbicides, when and if suitable herbicides become available.

JOINTED GOATGRASS BIOECONOMIC MODEL. Bruce D. Maxwell, Associate Professor, Land Resources and Environmental Science Department, Montana State University, Bozeman, MT 59717.

INTRODUCTION

Bioeconomic models have been developed as weed management decision aids (Buhler et. al, 1997; King et. al, 1986; Kwon et. al, 1998; Lybecker et. al, 1991; Marra and Carlson, 1993; Mortensen and Coble, 1991; Taylor and Burt, 1984). The jointed goatgrass bioeconomic model (JGGBEM) was primarily designed as a research tool for synthesizing existing biological information on jointed goatgrass and giving management relevance to the new and existing biological information. In addition, through the ability to simulate different scenarios that cause variability in jointed goatgrass population dynamics and winter wheat yield, the model was used to help identify research priorities for a regional team of weed scientists. In the future the model is expected to evolve into a jointed goatgrass management decision aid.

Jointed goatgrass is a winter annual weed with nearly synchronous emergence with winter wheat, although some seedlings emerge in the spring. Spring emerging seedlings can mature and produce seeds if temperature remains low enough to vernalize the seedlings (Donald, 1984). Seedling emergence rates (seedlings/seed) can vary from 12 to 72% and have been shown to be effected by temperature, nitrate concentration and especially by depth of burial of the spikelets (Morrow et. al, 1982; Miller and Neider, 1993). In field studies conducted across the jointed goatgrass region, fall seedling survival to the spring ranged from 22% to 79% (Maxwell and Jasieniuk, 1998). In the same studies, spring seedling populations produced jointed goatgrass reproductive tillers hyperbolically with a maximum number of reproductive tillers ranging from $84/m^2$ to $4585/m^2$. Jointed goatgrass spiklet production per plant was effectively modeled using data from the same studies using jointed goatgrass reproductive tiller density and winter wheat reproductive tiller density as controlling variables. Maximum spikelet production per plant ranged from 2 to 27 when grown under field conditions with a winter wheat crop. The proportion of jointed goatgrass spikelets returning to the soil is dependent on how much is gathered by the harvest equipment as well as other dispersal vectors, but no measurements of this demographic process were found in the literature. The decline of jointed goatgrass seed in the seed bank was observed to be sigmoidal over time (Donald and Zimdahl, 1987). The impact of jointed goatgrass on winter wheat yield and yield loss was also calculated in these field studies that were conducted across the region (Jasieniuk et. al, 1999). The demographic data from the specific population transitions described in these studies were used to construct the jointed goatgrass population simulation model and the crop impact portion of the JGGBEM.

Jointed goatgrass is a unique weed management problem, because there are no current herbicides that selectively cause mortality of jointed goatgrass in winter wheat. This has created the need for an understanding of the biology of jointed goatgrass in order to design effective management strategies. The variability of the impact of the weed on yield and the population dynamics of jointed goatgrass under different cropping systems is especially of interest. Thus, a model that simulates jointed goatgrass population dynamics, its impact on winter wheat and economic returns was recognized as a valuable tool for developing management strategies as well as prioritizing future research.

RESULTS AND DISCUSSION

Model Structure. The jointed goatgrass bioeconomic model includes three major components: 1) a jointed goatgrass demographic model, 2) a crop model, and 3) an economic model (Figure 1). The jointed goatgrass demographic model is initiated by providing a jointed goatgrass seed bank density after seed rain and before fall seedling emergence. The density of seedlings in the fall and spring, and the density of reproductive tillers and seed produced are predicted using transition parameters or functions. The density of jointed goatgrass reproductive tillers is used to predict the impact of the weed on winter wheat yield loss. Alternatively the jointed goatgrass reproductive tiller density and the winter wheat reproductive tiller density are used to predict winter wheat yield. The crop reproductive tiller density and the jointed goatgrass reproductive tiller density arw used to predict jointed goatgrass seed production. The jointed goatgrass seed produced is returned to the soil seed bank with some proportion removed to simulate migration (seed removed with the crop) and seed mortality in the seed bank before completeing the annual cycle where seedling emergence will occur.

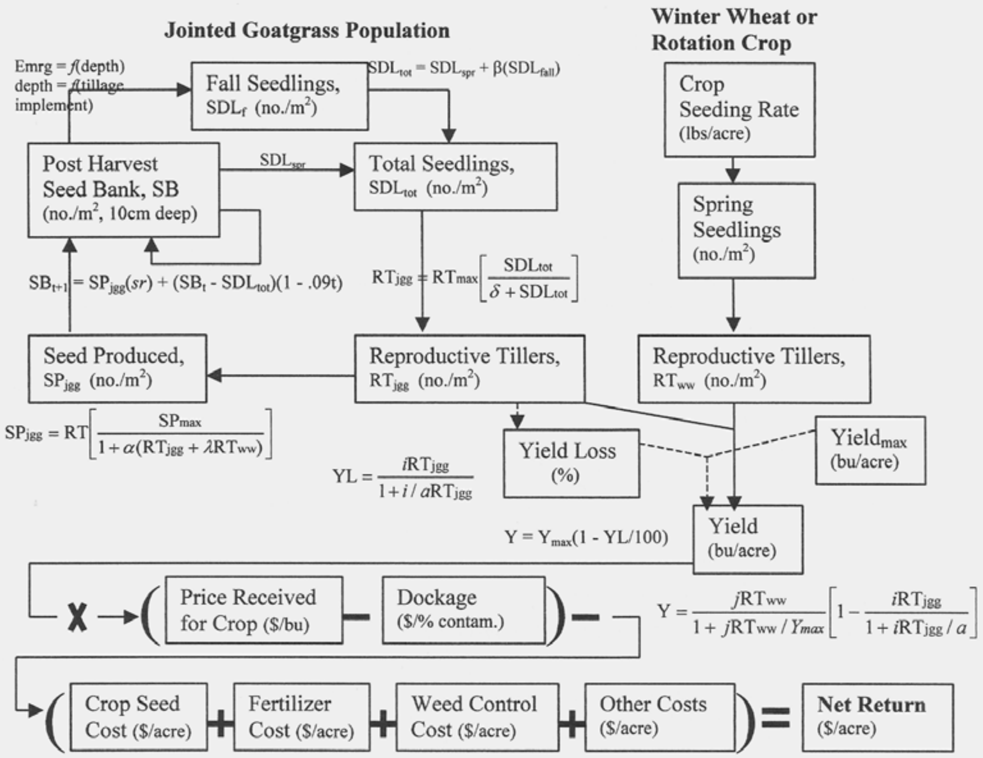


Figure 1. Diagrammatic representation of the jointed goatgrass bioeconomic model including state variables (boxes), demographic processes (arrows) and functional relationships.

The model consists of a series of difference equations representing life-cycle processes. The state variables were selected based on data availability. The equations that describe the processes in the model were selected based on biological tractability as well as empirical fit to observed data.

A simulation begins in the jointed goatgrass sub-model when a user selects a value for a summer seed bank density (SBs) following jointed goatgrass seed rain and prior to fall seedling emergence. Fall seed bank density (SBf) is calculated by subtracting the fall seedling density (SDLf) from SBs.

$$SBf = SBs - SDLf$$

Fall seedling emergence was assumed to be a function of seed depth or vertical distribution which is created by different tillage implements (Table 1 and Figure 2). The model was designed for the user to choose a jointed goatgrass vertical seed distribution in the soil by selecting a plow or a chisel tillage implement depending on which one is most frequently used (Miller and Neider, 1993). For example, if the chisel implement was used then 30% of the seed was assumed to be left on the soil surface and fall emergence ($SDLf_0$) would be 45% for the surface seed (Table 1 and Figure 2). The total number of SDLf is the sum of $SDLf_0$, $SDLf_5$, $SDLf_{10}$, $SDLF_{15}$ and $SDLf_{20}$ representing each of the depth increments from Table 1 where if there were 100 seeds in the seed bank then:

$$SDLf = (.30*100)*.45 + (.42*100)*.88 + (.17*100)*.22 + (.11*100)*.02$$

Table 1. The percent of total jointed goatgrass seed recovered from soil tilled with a plow or with a chisel and the percent emergence of jointed goatgrass seed from each depth category[a].

Soil depth	Plow	Chisel	Emergence
cm		%	
Surface	0	30	45
0 to 5	17	42	88
5 to 10	20	17	22
10 to 15	23	11	2
> 15	40	<1	0

[a] Adapted from Miller and Neider (1993).

Spring seedling emergence was estimated as the y-intercept or constant in the linear regression of spring seedling density (*SDLsp*) on fall seedling density (SDLf). Regressions were performed for each site where data was available.

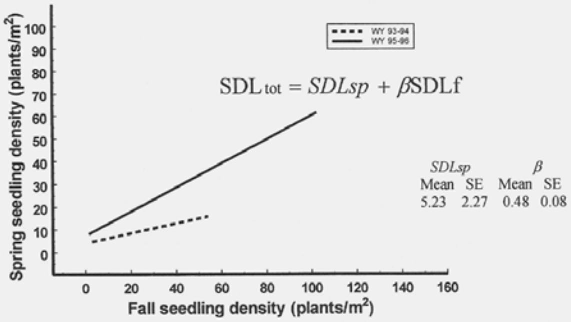


Figure 2. Spring seedling density ($\mathrm{SDL}_{\mathrm{tot}}$) as a function of fall seedling density where the constant in the regression is seedlings that emerge in the spring and the slope is the per capita survival rate of fall seedlings (β). Parameter values are from data combined over years from Archer, WY (Miller, unpublished).

The transition from spring jointed goatgrass seedlings to reproductive tiller density is an important demographic process because rotations to annual crops can significantly decrease this transition rate. The relationship between total seedling density after spring emergence and reproductive tiller density ($\mathrm{RT}_{\mathrm{jgg}}$) at harvest was assumed to be a nonlinear positive hyperbola based on the response fit to observed data from several sites and years.

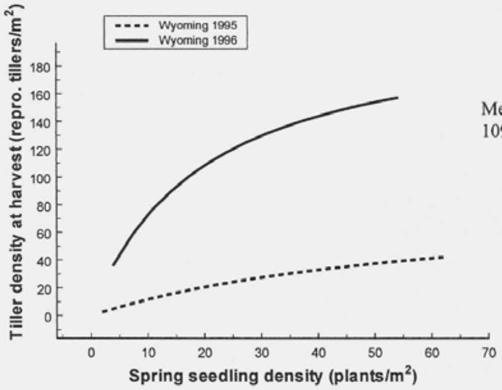
The maximum potential reproductive tiller density (RT_{max}) and the rate of reproductive tiller production as the seedling density approaches 0 (δ) were used to calculate the reproductive tiller density. The calculation of

$$\mathrm{RT}_{jgg} = RT_{max}\left[\frac{\mathrm{SDL}_{\mathrm{tot}}}{\delta + \mathrm{SDL}_{\mathrm{tot}}}\right]$$

reproductive tiller density was assumed to be dependent on the intensity or efficacy (f) of management related disturbance (e.g. planting of a spring crop, fallow, herbicide used in rotation crop, etc.) as well as a density dependent process. The following equation was used to describe mortality of juvenile jointed goatgrass plants in response to management:

$$\mathrm{RTjgg} = \mathrm{RT}_{\mathrm{jgg}} * \mathrm{rts}$$

where reproductive tillers post management (RT_{jgg}) were calculated based on RT_{jgg} before management and a survival rate (rts) assigned as an input for a simulation. If the system is in continuous winter wheat, rts would be 1.0, and if the system included fallow every other year, rts would be 1.0 in the crop years and some assigned proportion in the fallow years.



RT_{max}		δ	
Mean	SE	Mean	SE
109.63	28.13	10.41	2.60

Figure 3. Jointed goatgrass reproductive tiller density as a function of total spring seedling density. Parameter values are from data combined over years from Archer, WY (Miller, unpublished).

Jointed goatgrass spikelet production was calculated as a function of RT_{jgg} and winter wheat reproductive tiller density (RT_{WW}):

$$SP_{jgg} = RT_{jgg}\left[\frac{SP_{max}}{1+\alpha(RT_{jgg}+\lambda RT_{ww})}\right]$$

where SP_{max} was the maximum spikelet production observed and α and λ are fit parameters. Spikelet production was multiplied by 2 under the assumption that there are two seeds in each spikelet.

SPmax	α		λ	
	Mean	SE	Mean	SE
9.30	0.006	0.003	0.211	0.052

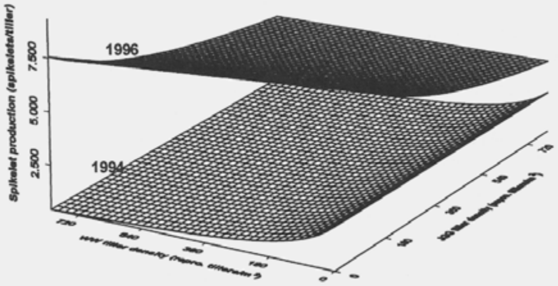


Figure 4. Jointed goatgrass spikelets produced per unit area as a function of jointed goatgrass and winter wheat reproductive tiller density. Parameter values are from data combined over years from Archer, WY (Miller, unpublished data).

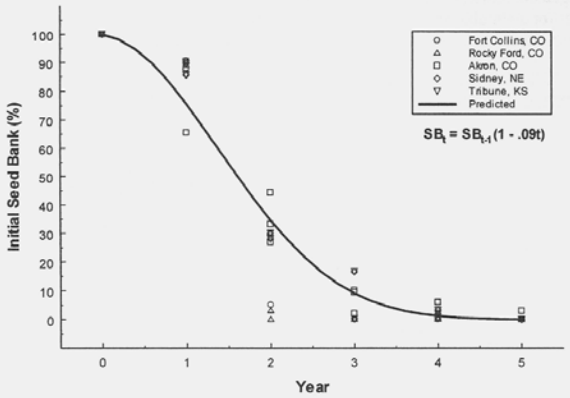


Figure 5. Observed and predicted jointed goatgrass seed survival buried 5 and 15 cm deep in the soil at 5 locations (Donald and Zimdahl, 1987).

The next summer seed bank (SBs_{t+1}) for the next generation of jointed goatgrass is calculated from the previous summer seed bank (SBs_t) and the seed rain, and accounts for seed bank losses due to germination, seed mortality (Figure 6) and migration out of the system with the crop seed.

$$SBs_{t+1} = SP_{jgg}(mr) + (SBs_t - SDL_{tot})(1 - .09t)$$

where *mr* is the proportion of seed that do not leave the system with the crop. Therefore the proportion of seed removed fom the field with the grain (1 - mr) can be used to calculate winter wheat price dockage due to contamination with jointed goatgrass spikelets.

Winter wheat seedling density (Csdl) is calculated as a function of the seeding rate which is a simulation run input as pounds of seed per acre (SR) and germination rate (cgr). To convert from seeds per acre seeding rate to winter wheat seedling density (plants/m^2) the following equation is used:

$$\mathrm{Csdl} = (2.33 * \mathrm{SR}) * \mathrm{cgr}$$

Winter wheat can be subject to winter conditions that can decrease seedling survival. The following equation includes a seedling survival parameter (css) in the transition from seedlings to reproductive tiller density (RT_{WW}).

$$RT_{WW} = \mathrm{Csdl} * \mathrm{css}$$

Winter wheat yield (Y) was calculated as a function of the assigned maximum yield for a site (Y_{max}), percent yield loss (YL) and jointed goatgrass reproductive tiller density (RT_{jgg}) as follows:

$$YL = \frac{iRT_{jgg}}{1 + iRT_{jgg}/a} \qquad \text{and} \qquad Y = Y_{max}(1 - YL/100)$$

Alternatively, yield (Y) can be calculated directly with the additional variable, crop density (RT_{ww}),

$$Y = \frac{jRT_{ww}}{1 + jRT_{ww} / Y_{max}}\left[1 - \frac{iRT_{jgg}}{1 + iRT_{jgg} / a}\right]$$

where *j*, *i* and *a* are parameter values fit with non-linear regression. The parameter *j* is the slope of the yield hyperbola as crop density approaches 0, *i* is the slope of the yield hyperbola as the weed density approaches 0, and *a* is the maximum proportional yield loss at high weed densities. Jasieniuk et. al (1999) fit the yield loss and yield functions to observed data from field experiments that were conducted across the jointed goatgrass region.

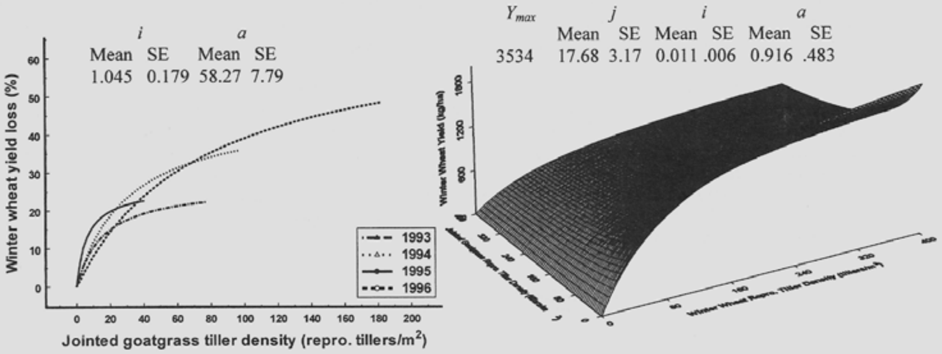


Figure 6. Yield loss and yield function for winter wheat. Parameter values were derived from fitting functions over 4 years of data from Archer, WY (Miller, unpublished).

The economic portion of the model calculates net return (NR) based on winter wheat yield (Y), the assigned price (P) that the user is expecting to receive for the wheat, assigned dockage value (d), winter wheat seed cost (Sc) which is a function of seeding rate (SR), fertilizer cost (Fc), and all other costs (O) associated with producing the crop.

$$\mathrm{NR} = \mathrm{Y} * (\mathrm{P} - \mathrm{d}) - (\mathrm{Sc} + \mathrm{Fc} + \mathrm{O})$$

The annualized net return (ANR) is calculated with the assumption of a 4% annual inflation rate as follows:

$$\mathrm{ANR} = \left[\mathrm{NR} \cdot (1+.04)^{-1t}\right] \cdot \left[\frac{.04}{1-(1+.04)^{-1t}}\right]$$

where t is the number of years in the simulation.

Model User Interface. The user interface with the JGGBEM begins with selecting a simulation scenario which determines what parameter values the model will select. The first simulation scenario is a deterministic simulation with site and year specific parameters held constant over simulated years. Parameter values are the mean of values found over years at each site or the next nearest site. In the second simulation scenario the user selects site specific parameter values by selecting a site and the model randomly parameter selects values from a normal distribution around the mean calculated from observed data over years at each site. The user selects the number of replication runs so that simulation results are expressed as a mean and standard deviation. The third simulation scenario involves the user selecting site and year specific mean parameter values where and when available. Otherwise parameter values are substituted from other years at the same site. This is a deterministic simulation. In the fourth simulation scenario the user selects site and year specific mean parameter values from normal distributions around the parameter mean where and when available. Otherwise parameter values are substituted from other years at the same site. The user selects the number or replicate simulation runs. The fifth simulation scenario involves running the model with site specific mean parameter values (deterministic) where and when available. Include weather driven emergence model and relative emergence time in the yield loss function. The sixth model run scenario is selected to conduct sensitivity analysis on the model. Specific site and years are selected for the model. Weather data and the emergence model are not included.

Following the selection of a simulation scenario, the user selects the yield or yield loss function for predicting winter wheat yield. Then the research site of interest is selected (e.g., Archer, WY). Where available, the user may also select the winter wheat variety if information exists at the site chosen. The user can then choose the number of generations (years) of the jointed goatgrass population to simulate. In addition, the user can select from three different cropping systems (continuous winter wheat, winter wheat fallow, or crop rotation including winter wheat-sunflower-fallow), and 2 tillage types (plow or chisel) which determines the distribution of jointed goatgrass in the soil profile and subsequent emergence rate. Finally, the user selects the density of jointed goatgrass seed in late summer following seed rain, but before emergence, to initiate the simulation run.

Simulation Examples: Example simulations were conducted using Archer, WY parameter values (Miller unpublished data). All of the demonstration simulations utilized simulation scenario number 2, the yield function (rather than yield loss function), chisel plow, and were initiated with 600 jointed goatgrass seed/m^2. The first simulation demonstrates the difference in annualized net return and the jointed goatgrass seed bank density when the winter wheat was planted at a 60 lb/A versus a 70 lb/A winter wheat seeding rate (Figure 8). The model suggests that the 70 lb/A seeding rate provides higher annualized net returns the first couple of years, but then decreases to be about the same as the 60 lb/A rate over time. In addition, their was no apparent advantage in decreasing the jointed goatgrass population with the increase in seeding rate.

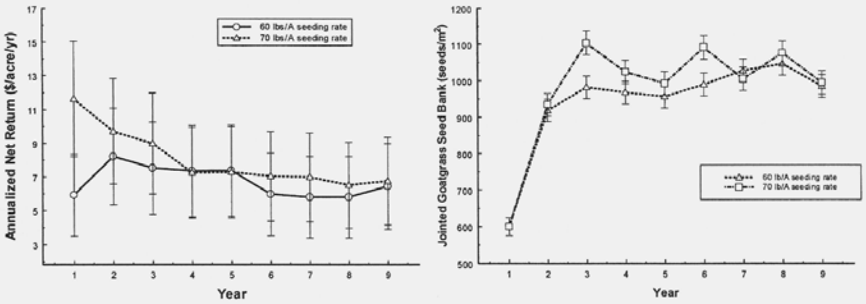


Figure 7. Simulated (JGGBEM) annualized net return (a) and jointed goatgrass seed bank density over years for winter wheat planted at 60 and 70 lbs/acre.

The second simulation compared annualized net return over a year period for 3 different cropping systems (continuous winter wheat production, winter wheat-fallow, and winter wheat-sunflower-fallow.

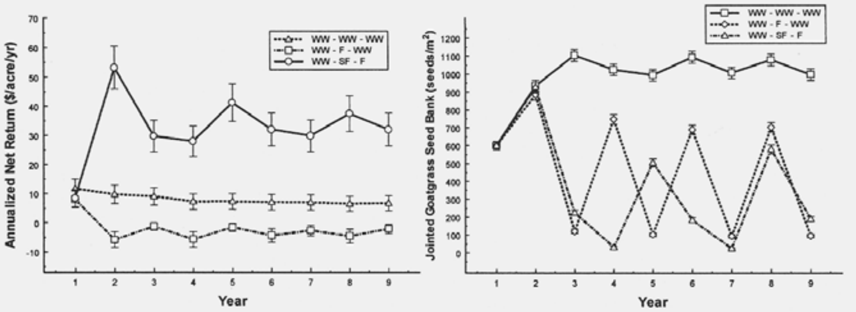


Figure 8. Simulated annualized net return and jointed goat grass seed bank density over 9 years for 3 different cropping systems.

The simulations indicated that a diversified system that included winter wheat, sunflower and a fallow year maximized annualized net returns and decreased jointed goatgrass seed banks significantly.

DISCUSSION

The jointed goatgrass population simulation model facilitated the condensation of life history and biological information on the weed and created a mechanism to prioritize future research efforts. Currently a wrold-wide-web version of the JGGBEM is under construction and will be available in the next year.

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IMIDAZOLINONE-TOLERANT WHEAT: STATUS OF HERBICIDE AND CROP DEVELOPMENT.

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Abstract. Imazamox (AC 299,263) is a relatively new imidazolinone herbicide developed by American Cyanamid. Because of its high unit activity, grass and broadleaf weed control spectrum, and favorable environmental properties, it is a significant weed management tool for many leguminous crops. Most monocot crops, including wheat, are sensitive to imazamox at efficacious use rates. American Cyanamid scientists have developed imidazolinone-tolerant wheat. The imidazolinone-tolerant wheat trait (FS4) was developed by seed mutagenesis and has an altered AHAS gene that significantly reduces binding of the herbicide to the active site of the enzyme.

A global crop development program is underway. Key partnerships with both public and private wheat breeding programs covering the major wheat classes have been established to rapidly transfer this trait into numerous commercial wheat lines. In the initial crop tolerance field trials with early experimental lines, the FS4 trait confers adequate tolerance in winter wheat. Current evaluations are underway to determine tolerance in spring wheat. Commercial availability of imidazolinone-tolerant wheat is estimated in the year 2001 for the United States, 2001 for Canada, 2000 for Australia and 2003 for Europe.

Efficacy trial results from numerous geographic locations demonstrated commercial control of many cereal grass and broadleaf weeds at postemergence-applied imazamox rates of 0.032 to 0.048 lb/A. Some of the key grasses controlled at these rates include downy brome, cheat, jointed goatgrass, ryegrass, foxtail and wild oat. Imazamox is also effective when applied in the fall or spring. Follow crop studies in many divergent wheat growing regions are also underway to determine important rotational crop guidelines. Submission for federal registration of imazamox for imidazolinone-tolerant wheat is anticipated in 1999.

MANAGEMENT OF HERBICIDE-RESISTANT WHEAT TO PREVENT OR DELAY THE OCCURRENCE OF HERBICIDE-RESISTANT JOINTED GOATGRASS.

Carol A. Mallory-Smith and George R. Hylsop, Assistant Professor and Professor, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331.

The introduction of herbicide-resistant wheats will provide growers with an option to selectively control jointed goatgrass. These resistant wheats will not, however, solve the jointed goatgrass problem. This new technology must be viewed for what it is, another weed management tool. The technology will be only as good as its management and without good management the benefit could be quickly lost. The first herbicide-resistant wheats will likely be resistant to either imazamox or to glyphosate. The basic principles of resistance management will apply to both of these wheats; however, there are distinct differences between the two herbicides that will influence the management recommendations. Management strategies must take into account jointed goatgrass biology, herbicide characteristics, and the production system.

As these new technologies are introduced, there are several weed management questions that will need to be addressed, including the selection of herbicide-resistant jointed goatgrass and the potential of the herbicide-resistance gene moving from wheat to jointed goatgrass. Management strategies must reduce the selection pressure and prevent gene movement.

In general as a herbicide's effectiveness increases, a higher selection is applied, and thus, the likelihood of selecting a herbicide-resistant weed species increases. The more often a herbicide is used, especially without herbicide rotation or without the inclusion of nonchemical weed control methods, the faster herbicide-resistant weeds appear. Herbicide-resistant crops should be expected to increase the selection of herbicide-resistant weeds due to both higher efficacy and increased frequency of use.

Experience with glyphosate-resistant crops shows that the frequency of application of this herbicide will certainly increase. The recommendations in no-till soybeans are for a preplant, burndown treatment plus two applications during the season and in clean, tilled fields are for two applications during the season. The selection of a glyphosate-resistant weed was slow to occur in nonherbicide-resistant crop situations and was not reported until 20 years after the first use of glyphosate, but the recommendations of repeated applications during the season will increase the possibility of selecting a resistant weed.

Imazamox likely will be applied only once per season; however, weeds with resistance to this herbicide are more likely to occur based on past experience with the imidazolinone and sulfonylurea herbicides. Resistance to the chemical families that inhibit acetolactate synthase (ALS) occurred within 4 years of the registration of these products. There are at least 50 weed species with resistance to ALS inhibitors.

Wheat production systems vary greatly from region to region. Some modifications in these systems will help to reduce the possibility of selecting a herbicide-resistant jointed goatgrass. Wheat with resistance to one herbicide should not be grown continuously in a field. The number of times that the herbicide-resistant wheat should be placed in the rotation will vary on factors such as whether it is an annual cropping system or a wheat-fallow system. Recommendations in a conventional versus a no-till or a minimum-till production system would differ. Jointed goatgrass tends to germinate in the first season and within three years most of the seed has germinated. The best tactic may be to use the resistant wheat 2 or 3 times to reduce the jointed goatgrass populations and then rotate out. In a fallow system, a nonselective herbicide or mechanical control would be used which would decrease the selection pressure. In spring crops where jointed goatgrass populations tend to be lower, alternative control methods may be effective or a herbicide with a different site of action should be used. If jointed goatgrass populations do not occur or are much lower than expected, a grower could choose not to apply the herbicide to the herbicide-resistant wheat or could choose an alternative herbicide to be applied.

Jointed goatgrass is closely related to wheat and hybrids between the two species do occur under field conditions. Growers need to be aware that these hybrids are produced and that the possibility exists that a herbicide resistance gene could move into the jointed goatgrass populations infesting their farms. Only certified seed should be planted in order to prevent the introduction of jointed goatgrass, hybrids, or backcrosses between jointed goatgrass and wheat. Special care will need to be taken to cleanup areas adjacent to herbicide-resistant wheat fields and closely monitor jointed goatgrass that may not have been controlled in the treated field. Hybrids need to be removed as soon as they are identified in and around the herbicide-resistant wheat fields. The herbicide-resistant wheat seed will need to be contained from seeding through harvest. Volunteer resistant wheat should be controlled to prevent outcrossing that could produce hybrids carrying the resistance gene.

There may be some genetic barriers which can be incorporated into the herbicide-resistant wheat that will minimize or prevent gene movement between the species. For example, producing a wheat that has the resistance gene residing on the A or B genome instead of the D genome, may decrease the chance of gene movement. This solution has been suggested but data are lacking as to whether it would really be effective.

Growers need to keep in mind the strategies that are important to prevent or delay the selection of herbicide-resistant weeds, especially the rotation of herbicides with different sites of action and the inclusion of more than one control method. Crop rotation is important and they will need to realize that rotating herbicide-resistant wheat with nonherbicide-resistant wheat or to a different herbicide-resistant wheat is going to be critical. If a jointed goatgrass problem does not appear in a given year, growers should not apply the herbicide but choose a different herbicide for control of other weeds that are present.

Growers should consider herbicide-resistant wheat as one more option in a well planned and managed cropping system. It makes no sense to abandon good management practices to use herbicide-resistant wheat.

THE FUTURE OF THE NATIONAL JGG RESEARCH PROGRAM - DISCUSSION. Darrell L. Hanavan, Chairman, National Jointed Goatgrass Steering Committee, 7700 East Arapahoe Road, Englewood, CO 80112.

Abstract. Nearly 50 wheat industry leaders and state and federal scientists attended the first national "Jointed Goatgrass Meeting" held October 27 to 29, 1993 in Denver. Conference participants recommended that state and federal scientists cooperate in a multi-disciplinary effort to develop sustainable control measures (integrated weed management) based on knowledge of population dynamics and bioeconomics and to transfer this technology. Since that time, Congress has appropriated a cumulative total of $1.9 million dollars through Cooperative State Research Education, and Extension Service (CSREES) to the National Jointed Goatgrass Research Program. Each CSREES dollar spent on this program has been leveraged with nearly three dollars of wheat industry, state and other federal support. This program is a model for efficient and constructive use of federal monies. Participants also established a National Jointed Goatgrass Steering Committee (comprised of wheat producers, wheat commission administrators, extension specialists, and state and federal researchers) to establish priorities, control allocation of funds and ensure coordination of all programs. Research grants have been awarded through a national merit-based competition. There has also been an annual meeting of all investigators and steering committee members to review all research projects and enhance communication. The National Jointed Goatgrass Steering Committee met earlier this week (on Monday) and awarded grants for the sixth year of this program (or for FY 1999). The National Jointed Goatgrass Steering Committee also discussed the life of this program and determined that a five-year program should be developed to begin in FY 2000 and end after the completion of FY 2004. It is also our intent to seek increased Congressional funding during this 5-year period of $500,000 per year (compared to the 6-year average of $327,000). Part of the purpose of this Jointed Goatgrass Symposium is to determine the future direction of the National Jointed Goatgrass Research Program. The National Jointed Goatgrass Steering Committee is seeking your assistance in developing this final 5-year program. Recommendations developed at the Symposium will be provided to a special committee of the National Jointed Goatgrass Steering Committee that will recommend priorities for the final 5-years of funding to the National Jointed Goatgrass Steering Committee for approval by October 1 of this year.

1999 WESTERN SOCIETY OF WEED SCIENCE OFFICERS AND EXECUTIVE COMMITTEE

Front Row (L to R): Rodney G. Lym, Immediate Past President; Wanda Graves, Treasurer/Business Manager; Don Morishita, President-Elect.

Back Row (L to R): Donn Thill, WSSA Representative; Jesse Richardson, Research Section Chair; Jeff Tichota, President; John Orr, Secretary.

Not pictured: Steve Miller, CAST Representative; Gil Cook, Education and Regulatory Section Chair; and Phil Westra, Member-At-Large.

RESEARCH PROJECT MEETINGS

PROJECT 1: WEEDS OF RANGE AND FOREST

Chairperson: Jim Olivarez

Subject: How Do We Institutionalize Weed Prevention Practices?

The topic of discussion was weed prevention practices and strategies. The weed free forage program was discussed as an example of a prevention practice that has been implemented in areas through out the west. These prevention practices are often referred to as Best Management Practices (BMPs). The final topic area was the use and availability of weed free seed. There were 41 people in attendance at the discussion

Deb Hayes gave a brief overview of the weed seed free forage program. A weed free forage program has been instituted on FS lands, in five western states. BLM and other public lands have joined in the program in a number of areas within these states. Currently, closures are under discussion in additional seven states in the west.

Weed Free Forage.

- The program must be a strong partnership with states.
- It is most effective when there are partnerships with other agencies, closures exist on all federal land in cooperation with state lands.
- Must be shown to be of benefit to all participants, both the lands and agencies that require it and the public which is using those lands.
- Cannot pose a financial burden either for producers or the users. Need to keep the cost of producing weed free products down for the producers. In many areas producers are not getting premium prices for the weed free hay. So there is little financial incentive to produce the higher cost product. In other areas producers are receiving a premium price. Weed free hay is also opening up new markets such as, certified hay to dairies and horse operations; for people who want to keep their operations weed free. It is a guarantee of high quality hay and for potential international markets in Canada and Japan.
- Can not pose a financial burden for users of the program. Products must be readily available and at a reasonable cost.
- One of the great utilities of the program is as an education program. It has provided a good platform for getting the message out on noxious weeds. Some areas are putting messages about the weed free program and weeds in general in maps, brochures etc.
- The program must have good reliable inspectors. In Montana, inspection occurs two weeks prior to cutting for straw, and seven days prior to cutting for hay. If it rains in the interim, between inspection and harvest, additional inspections may be necessary.
- Must be enforceable and must be enforced. There was a discussion on whether the program is being enforced on public lands, or is it mostly voluntary compliance. The enforcement varies. For many programs the first 2 years are a phase in period where compliance is voluntary. In some areas where the program has been established warnings and citations are being issued. Many expressed the need for better cooperation with state game wardens, so as they inspect for compliance with hunting laws they also inspect and enforce weed free regulations. Some suggested that the number of inspections, warnings, and citations be reported annually to both federal and state agencies.
- Need to expand the program to neighboring states for both participation and education. Folks in Texas need to be educated on requirements in Colorado before coming to Colorado for recreation.
- There is more and more support for the program in the west. In Colorado weed free hay is being advertised in the *Thirty Nickel*, a free advertisement paper.
- Identification of weed free products continues to be a challenge. Baling twine from Colorado has been a good idea. Individual tags for other products and tagging of individual bales has also been tried. No one universal answer has yet been found.

The group discussed how do you get a program established. All agreed it was a case of the chicken and egg phenomenon. In order to have a weed free program you must have weed free products available. In order for there to be weed free products available, there must be a market for them. Several people related their experiences in putting a program together. All emphasized that it takes time. In Montana it took several years for the program to become established, with the program spreading from county to county.

BMPs, Weed Prevention Practices.

Many state and federal agencies (BLM, FS, Counties, County Weed Boards, State agencies) are implementing some kind of weed prevention strategies and/or practices. Jim Olivarez passed out a list of practices that are being considered in the Northern Region of the Forest Service. While it may not be possible to implement all the practices, all the time, the group agreed it is good to implement as many as possible. Following are points made during the discussion:

- Cooperators, groups, and the public are willing to help with weed problems. BMP's provide a vehicle to translate this cooperative energy into good practices.
- Kniffy Hamilton reported that the BLM is also incorporating BMPs into their field office prevention strategies.
- It is an important education point with private landowners.
- Prevention practices are important not only for federal and state agencies but also for private landowners.
- These practices can be discussed and employed within Weed Management Areas.
- A number of experiences were related on implementing BMPs. It is easier to implement practices when there is an expectation by contractors that all entities will require similar practices.
- We need systematic, compatible weed surveys over a variety of land ownerships
- We need to get as many as people in both the public and private sector, trained in weed identification. This includes county, state and federal agency people whose jobs may not be directly related to weeds, but may have contact with weeds or weed producing activities. Examples are fire fighters, road maintenance crews and recreation workers.
- We need to take the message about prevention practices to all our cooperators, including fire fighters, road maintenance crews and environmental organizations. Some of this cooperation is already occurring.
- We should be doing a better job of soliciting help from the general public for both survey and prevention work. Special interest groups including the Audubon Society, Horseback groups, garden groups, and American Hikers can be great contributors to the effort.
- We need to use a consistent approach to weed surveys, like the current efforts of NAWMA (North American Weed Management Association).
- We need to employ the latest technology in survey work such as GPS and electronic databases, where appropriate and feasible.
- The question was raised on whether we have any information to indicate how effective these prevention techniques are. The group thought that at least some monitoring should be done to answer this question.
- The conclusion of the discussion was that BMPs are a good thing.
- Coordination of BMPs between agencies and governmental entities needs to take place.

Weed Free Seed.

- We need to do a better and more consistent job of seed testing and procurement.
- If you come across a lot of contaminated seed, there needs to be an avenue to tell people about the seed problem. Without some means of telling people, the contaminated seed may just be passed on to some other unsuspecting buyer.
- A basic BMP should be the purchase of weed free seed.
- There are courses and information available on purchasing weed free seed. A seed contractor developed one of the courses federal agencies have been using. The need arose after contaminated seed was used on several large fire rehabilitation projects. The contact called for weed free seed.
- Seed not only has to be certified as weed free, it should also be tested. A number of factors can contribute to a seed lot being labeled as weed free and still contain weed seeds. This could be a different weed list in different states or a small allowable amount of weed seed (99.9% weed free).

◆ It was suggested that certified "weed free seed" should be free of seeds from a weed list agreed upon by all fifty states. It is currently difficult for buyers to ensure that seed mixtures are truly weed free, since state requirements vary widely. We should work to make all the lists the same or at least that the weed seed free requirements should be the same in all states.

Jim discussed the project the FS and the BLM are working on with Peter Rice and the INVADRES database. The project will use the best available information of on species location and attempt to predict the next specie(s), which will threaten the Idaho/Montana Area.

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PROJECT 2: WEEDS OF HORTICULTURAL CROPS

Chairperson: Kai Umeda

Subject 1: Endangered Herbicides on Vegetables, The First Steps Taken for Alternative Chemistries. Now What?

Steve Fennimore, Extension Specialist, University of California, continued the discussion from last year's WSWS Horticultural Crops project session and emphasized that we needed to work together by exchanging ideas and developing common testing protocols. Because of FQPA, IR-4 will become more instrumental in getting new products registered for vegetable crops and PIAP will be important in order to protect the crop tolerances of older chemistries from being canceled by the EPA. Carl Bell, Farm Advisor, University of California Cooperative Extension, reiterated the difficulties of obtaining new product registrations for vegetables and the need to speak out as a group. For example, we need to reply to EPA's health risk comments on bensulide and write an editorial letter to Weed Science to defend any FQPA-listed pesticides for vegetables. Sandra McDonald who coordinates IR-4 and PIAP in Colorado encouraged the 21 participants in the session to screen for "reduced risk pesticides" for vegetable crops and to participate in PIAP's pesticide use survey. This survey will create a crop profile which will summarize the pests and pesticides in each crop. The profile will be used by PIAP to protect existing vegetable pesticides during EPA's PMP(Pesticide Management Program) reviews.

To facilitate dialogue among us, Kai Umeda, Extension Agent, The University of Arizona Cooperative Extension, will set up a mailing list on the internet at vegweeders@ag.arizona.edu. To subscribe to the list serve, send to: majordomo@ag.arizona.edu and type the message: subscribe vegweeders. We can use the mailing list to communicate issues and to coordinate efforts. Participants were encouraged to send to the mailing list his/her name, crops of interest, affiliation, and E-mail address. They were also encouraged to write the above-mentioned letter to EPA and post it on the list serve. Any discussion topic regarding vegetable crops weed control will also be welcome on the list serve.

Subject 2: Integration of Horticultural Crop Disciplines Prospective Linkages Between WSWS and American Society of Horticultural Science, Western Region.

Currently most ASHS members attend the national meeting and skip the Western Region meeting. The pros and cons of creating a horticultural session at WSWS to attract ASHS members were debated. No conclusion or decision was made and we agreed to continue the dialogue.

2000 Officers for Project 2:

Chairperson:	Henry Wu Monsanto Company 1320 E. Everglade Fresno, CA 93720 559-261-0480 c.henry.wu@monsanto.com	Chairperson-elect:	Ed Peachey Dept. of Horticulture ALS 4017 Corvallis, OR 97331 541-737-3152 peacheye@bcc.orst.edu

PROJECT 3: WEEDS OF AGRONOMIC CROPS

Chairperson: Donald Thill

Subject: Herbicide Resistant Crops: Their Regulation and Use.

Dr. Neil Harker, with Agriculture & Agri-Food Canada; Dr. Tom Nickson, with Monsanto Company; and Dr. Klaus Ammann with the University of Bern, Switzerland, made the initial presentations prior to discussion of herbicide resistant crops.

Dr. Harker discussed the rapid adoption by western Canadian growers of herbicide tolerant canola. In 1997, approximately 30% of canola acres were planted to herbicide tolerant varieties. That percentage increased from 50 to 60% in 1998, and is anticipated to increase to about 75% of the 14 million acres of canola in western Canada in 1999. Growers are adopting this new technology in order to control weeds that standard treatments are unable to control such as catchweed bedstraw and redstem filaree. Grower concerns with this new technology include: among no-till growers a concern for weed populations shifts and the development of weed resistance, outcrossing among varieties and to weeds, volunteer control, and restricted markets. Dr. Harker also raised the issue of only one, or a few, companies dominating the herbicide market place and the effect that will have on competition and pricing.

Dr. Tom Nickson discussed the regulatory system for herbicide tolerant crops. Three agencies in the United States are involved in regulations related to genetically modified plants (not plants modified through mutagenesis). The USDA regulates genetically modified organisms (GMOs). The EPA only regulates pesticide use. The FDA does not give formal approval of GMOs unless requested to do so under the food additives petition; however, most companies do consult with the FDA. In Canada, Health Canada administers the novel food law and pesticide use. Agriculture & Agri-Food Canada regulates the release of GMOs into the environment. In Europe, regulation related to GMOs is still being developed. The contentious point in the novel food laws in Europe is labeling. How do you assure 100% GMO free?

Dr. Klaus Ammann discussed the botanical and population genetic issues related to herbicide tolerant crops. He argued that outcrossing is not a certain occurrence among plants and that without a thorough understanding of the details of each circumstance, no global statements on outcrossing can be made. He also discussed the apparent loss of herbicide tolerant genes after 5 to 6 years with no selective pressure for the genes. His point was that not all escapes will be around forever. He also made the point that outcrossing has been around for a long time and is not some new occurrence that has just now evolved with the introduction of transgenic crops. Dr. Ammann's message was that the risks must be weighed against the benefits and that we should be vigilant but not hysterical.

Discussion. A question was asked about what annual economic advantage this technology has brought to US and Canadian farmers. Dr. Harker felt that in terms of canola, there is a large potential for return in fields infested with hard-to-control weeds, in the neighborhood of $10 to $20/A.

The issue of market restrictions was discussed. The canola council and Ag. Canada are very involved in working in Europe to address the issue of market restrictions. Europe is the problem. Japan and Mexico have approved GMOs. Europe's restrictions tend to be short-term, e.g., 2-year, moratoriums to allow for further research and discussion. Strong public opinion in Europe is keeping politicians frightened about the science.

A discussion of GMOs in Canada revealed that Canada registers novel traits. Their registration is not process based and does not differentiate between mutagenesis and transgenics. In response to the question "Why was resistant canola accepted so quickly in Canada?" the response from Dr. Harker was that it was new and it allowed for the control of bedstraw – a difficult to control weed with zero tolerance in seed.

A discussion of the terminator technology followed. Dr. Nickson made the following points about the terminator technology: 1) it could solve the volunteer problem, 2) it should be viewed as gene protection technology, 3) the terminator technology is a concept that has never been put into a plant, and 4) it is probably not an appropriate technology for all of the world.

The discussion then moved on to what industry is doing with GMO technology in third world nations. Monsanto is training third world scientists about this technology and about issues of sustainability. Dr. Nickson felt that Roundup Ready Corn could be used very effectively in Africa to control parasitic striga. The technology also has potential to improve the nutritional value of the staple food crops in the world. Monsanto has an entire sector dealing with nutritive value of products and currently has a program dealing with the allerginicity of rice, which is a huge problem in Japan. There is also a program to develop high vitamin A content in canola oil to fight night blindness in India.

Finally, the group discussed the need for, and the difficulty of, a biological risk assessment of outcrossing. It was pointed out that the fitness of any particular trait is going to vary between biological systems. Therefore, such a study would need to be done on a case-by-case, and region-by-region, basis.

2000 Officers of Project 3:

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PROJECT 4: TEACHING AND TECHNOLOGY TRANSFER

Chairperson: Robert Klein

Subject: New Methods and Equipment for Technology Transfer.

Presentations - Summary List
Robert Klein - WeedSOFT
Ray William - Learning Methods

WeedSOFT - Robert Klein

Weedsoft started as post-emergence weed control program in corn with Dave Mortensen's leadership. Weed Scientists entered the weed efficacy data for various herbicides which in itself was an interesting exercise. There were several contributors across Nebraska.

Ratings by Bob Wilson at Scottsbluff and myself at North Platte on weed control in corn were similar but very different from Eastern Nebraska ratings which were similar amongst themselves. Therefore Western and Eastern Nebraska versions were developed which are applicable in the other part of the state if it is a wet or dry year (Eastern values in the west if it is a wet year, western values in the east if it is a dry year.

Demonstration and application of the program.

1) Advisor (a diagnostic and analytic decision support system to help you select the best management solution to your specific weed)
2) WeedView (picture database for weed identification)
3) Environmental (alerts you to potential environmental issues)
4) MapView (helps evaluate risk of groundwater contamination)

Stage 1
- Enter field data.

Stage 2
- Application information e.g. broadcast vs. bands.
- Add economics - costs of doing operations (e.g. use this to suppress cultivation by making it very expensive), also technology fees can be added in this section.

Stage 3
- Available crops are corn - east/west, sorghum, soybeans, sugarbeets, wheat.
- Record variety, planting date, and growth stage that the crop is at, row spacing, selling price expected and weed free yield in bu/acre.

Stage 4
- Environmental information added - rotations, surface water, groundwater occurrence, soil type, residue, pH , expected moisture at application, erodibility.

Stage 5
- Select weeds you need to control (includes resistant biotypes).
- You select the weed pressure (or you can enter number of weeds).
- Each weed/density class has a yield reduction estimated for it, e.g. kochia, very high yield reduction estimates 22.5 bu/A reduction for a specific yield level and crop and weed growth stage.
- Yield reductions can be modified by stating weed stage growth.
- The yield reductions estimated do actually depend on the number of weeds you select or estimated weed density to allow for this competition between weeds.

Stage 6
- Herbicide price information.
- User can modify as necessary.

Stage 7
- Results screen shows estimates of what treatments to use, what the returns are given the estimated losses due to the weed competition with and without treatment.

Ray William - Learning methods, whole systems approaches to weed management.

The suggestion was made that we could draw a description of pest management systems based on "cognitive adaptive non-linear systems". It has proved fruitful to bring to bear whole systems enquiry point of view to these issues rather than being reductionist. For example by taking en ecological approach to this it can remove participants from pre-programmed systematic thinking. Communication and learning approaches should be based on relational thinking rather than reductionist thinking.

Assessment.

Assessment changes the way we learn - e.g. teachers developing SAT had to learn a new language which isolated them from students so that the learning experience was not linked to the testing. In brief it has been shown that teachers could no longer communicate as effectively with their students.

Does this apply with range ecology and weed science?

Although many practitioners of these disciplines think of them as different there is about 80% of terminology in common between range ecology and weed science.

One question which has proved useful for promoting learning discussions is the "How do you communicate with Rachel Carson when she stops you just as you are about to spray those weeds?". Attendees reaction to this question can be tested before and after trying whole systems learning approaches, and with groups from different backgrounds.

These are new approaches to learning in groups based around asking them what they want to learn about - listing these then grouping the answers in the early stages and judging the group energy for each topic. This is then used to allocate time for each item. It has been noted that in most groups in which these exercises have been tried one or two illegal (off label herbicide) use-examples surface which is effectively corrected by peer to peer pressure rather than disapproval from an authority figure. In these cases the leader of the discussion just facilitates the corrective action by allowing the other participants to explain why these uses should not be adopted.
Cognitive learning approaches.

The learner must create the tension for learning otherwise they don't learn. The drivers for learning change which then changes how you need to learn. There is a need to establish each individuals criteria for learning for themselves. It is noted that there is always a small proportion of the group are there "just for the ride" (e.g. re-certification).

Some pointers.

Be flexible in your approaches to presentation/teaching e.g. moving to the back row with your flip chart to engage those locating themselves far from the front of the room.

Always try to make sure there are two or three take home messages.

Synthesis thinking up front, discuss, then more synthesis. This is a Convergence/Divergence/Convergence learning method.

2000 Officers for Project 4:

Chairperson:	Khosro Khodayari Zeneca Ag. Products Western Research Center 1200 South 47th St., Box 4023 Richmond, CA 94804 510-231-5008 510-231-1235	Chairperson-elect:	Claude Ross FMC 4343 Redbird Ct. Loveland, CO 80537 970-669-3622 claude_ross@fmc.com

PROJECT 5: WETLANDS AND WILDLANDS

Chairperson: Joseph M. DiTomaso

Subject 1: Invasive Weed Information Clearinghouses and Centers.

Discussion Leader: Nate Dechoretz, California Department of Food and Agriculture

There are a number of weed information resources on the world-wide-web on a variety of weed topics. "Resources for Integrated Weed Management," a web-based hand-out, was given to the group (copies available from the Chair-Elect 2000, Scott Stenquist, scott_stenquist@fws.gov). No one site, however, gives the full range of information about the particular weed species including ecology and life history, identification photo(s) at all life stages, and integrated weed management techniques. There is no site for "one-stop shopping for all information" on a particular weed of interest.

In addition, there is no one-site availability for noxious weed classification for the western U.S. Several organizations, e.g., Western Weed Coordinating Committee (WWCC) have discussed the desirability of producing such a world-wide-web site, but there is no one-stop shopping for all information concerning western states' noxious weed lists.

One-stop shopping for weed information (including noxious weed lists) should have these characteristics:

- Ecology, integrated weed management control, and vegetation site management information must be maintained and hosted once the initial information has been entered.
- Information should be available for free or at a very low cost.
- Information must be updated on a periodic basis for maximum usefulness.
- Information demand and timeliness likely a full-time job whether done by academia, government, or contractor.

Some web sites have the state noxious weed information, e.g. Washington/Oregon. Also, the USDA-APHIS CAPS (Cooperative Agriculture Pest Survey) program page is on the web (see: http://ceris.purdue.edu/napis/pests/cwr/index.html) is an example of an information structure.

Such an information site might be best hosted through an established weed group, e.g. WSWS or perhaps WWCC. These groups bring credibility that other local, state, or federal entities may lack.

Subject 2: <u>Development of an Information Weed Management Center for the Western States.</u>

Discussion Leader: Roger Sheley, Montana State University

The science and complexity of an expert-based decision support system requires careful thought and analysis. A full body of knowledge is essential that incorporates the broad spectrum on integrated weed management techniques. Such a system should not only focus on herbicides though they are an important part of an integrated system. In all cases, the complexity of the specific site must be coupled to the larger ecological principles.

Over 114 people have contributed thought and energy to the development of a "noxious weed management center" over a 3-year initial period. Educators, researchers, and agency land managers have been part of this thought process. The job of such a center would be to facilitate such a knowledge team about weed ecology, identification, integrated weed management, and site restoration. Dr. Roger Sheley, Montana State University has been the driving force in the development of such a weed management center. Information can be obtained through e-mail contact with Sheley (rsheley@montana.edu). For the initial establishment of the center it was suggested that one permanent, full time person would be required with a budget of $125,000/yr.

Several important groups would likely be required to provide the initial financial support. These include the Western Governors' Association and the Western Agricultural Experiment Station Directors. Team Leafy Spurge might serve as a model by which a center could provide pertinent and timely information. There apparently has been no WSWS or WWCC official endorsement of such a center at this point.

2000 Officers of Project 5:

Chairperson:	Scott M. Stenquist U.S. Fish and Wildlife Service 911 N.E. 11th Ave. Portland, OR 97232-4181 208-332-8500 scott_stenquist@fws.gov	Chairperson-elect:	Glen M. Secrist Idaho Dept. of Agriculture 2270 Old Penitentiary Rd. Boise, ID 83701 gsecrist@agri.state.id.us

PROJECT 6: BASIC SCIENCES

Chairperson: Peter Dotray

Subject: Management Induced Weed Population Changes: What is our Next Weed?

Approximately 54 people attended the Basic Sciences Project 6 discussion section and participated in the discussion topic entitled "Management induced weed population changes: What is our next weed?" Dr. Alex Ogg, Dr. Bruce Maxwell, and Dr. David Buchena gave brief presentations on the following subjects: An overview of weed changes since 1940's; what will our weeds looks like in 5, 10, and 20 years?; and the economic impact of herbicide resistance weeds.

Historically, weed populations have responded to herbicide selection pressure. For example, before the introduction of 2,4-D, grasses were not a major problem among cereals. In addition, trifluralin use in dry beans and lentils resulted in a shift in the weed spectrum which included nightshades. With the introduction of herbicides, weed diversity has decreased drastically which has stimulated a select few weeds to become major problems in cropping systems. Changes in cultural practices, including narrow crop spacing, tillage reduction, and higher fertilization rates, resulted in an increase in grass and perennial weed populations. With decreasing weed diversity, fewer populations are under increasing selection pressure which has led to herbicide resistance.

With the advent of herbicide resistant crops, weeds of the near future (10 years) will tend to be the crop from the previous year and fewer weeds will be important in the more distant future (20 years). Knowledge of weeds in the future will be better due to improved assessment of weed impacts. Also, with global warming, latitude shifts will result in population shifts of weeds. With increasing selection pressure in herbicide tolerant cropping systems, weed species will invade that have higher phenotypic plasticity which will adapt to more diverse cropping systems and weather conditions. As a result, herbicide resistance evolves at a faster rate. Rates of resistance can be slowed using spatial selective rates instead of broadcast at 100% use rate. This approach reduces overall herbicide costs and increases real profit.

Overall success rate of new herbicide development rests upon economic opportunity. With more herbicides being introduced, there are questions about the decline in new sites of action. Diversity is the key to understanding interaction in the agroecosystem. Herbicides reduce diversity in the field, which releases checks on problem weeds.
2000 Officers of Project 6:

Chairperson:	Kassim Al-Khatib Kansas State University Agronomy - 2004 Throckmorton Manhattan, KS 66506-5501 913-532-6101 913-532-6094 khatib@ksu.edu	Chairperson Elect:	Ian M. Heap Weedsmart PO Box 1365 Corvallis, OR 97339 541-929-6636 541-929-3040 heapian@pioneer.net

1999 WESTERN SOCIETY OF WEED SCIENCE STUDENT PAPER WINNERS
(L to R): Johnny Roberts (1st), Lynn Fandrich (1st), Holli Murdock (2nd),
Matt Schuster (2nd), Ginger Light (3rd), and Martina Murray (3rd)

1999 WESTERN SOCIETY OF WEED SCIENCE STUDENT POSTER WINNERS
(L to R): Dodi Kazarian (1st), Michael Marshall (1st), Darrin Walenta (2nd),
Sandra Shinn (2nd), Tehmina Sheikh (3rd), and Curtis Rainbolt (3rd)

MINUTES OF THE 52nd ANNUAL BUSINESS MEETING
WESTERN SOCIETY OF WEED SCIENCE
DOUBLE TREE WORLD ARENA
COLORADO SPRINGS, COLORADO
MARCH 11, 1999

The WSWS Annual Business Meeting was called to order by President Rod Lym at 7:10 AM on March 11, 1999. Minutes from the 1998 Annual Business Meeting were approved as printed in the 1998 WSWS Proceedings.

Financial Report - Wanda Graves

Registration totaled 371 members including 66 student members and 8 spouses. Preregistration was high at 302 and Graves encouraged members to continue to preregister for the annual meeting.

The WSWS is in good financial standing with a current balance of $334,608.10. Revolving account balances account for $156,244.84 of the total capital. Revolving accounts hold funds to support Weeds of the West ($87,682.70), Noxious Weed Short Course ($17,991.22), and Biological Control of Weeds of the West ($50,570.92). The remaining $178,363.26 in WSWS include funds that are invested in mutual funds ($155,236.87). WSWS income (excluding the Revolving Accounts) averaged $54,500 and expenses (excluding the Revolving Accounts) averaged $38,000 over the last three years.

Immediate Past President - Barbra Mullin

The WSWS Operating Guide will now be maintained by the immediate past president. The guide has been updated and copies made for each officer and the chair of each committee. The officers and committee chairs were asked to please forward the operating guide to the incoming officer at the end of each annual meeting. The Operating Guide will also will be available on the WSWS web site.

Program Committee - Jeff Tichota

A total of 51 posters and 94 papers were presented at the meeting. Tichota thanked Paul Ogg and the local arrangements committee for helping with the sessions. Students from Colorado State University, the University of Wyoming, and the University of Idaho ran the projectors and lights in the sessions.

The Western Weed Coordinating Committee, Western Branch of the American Society of Horticulture, and the Jointed Goatgrass Committee held joint meetings with the WSWS.

Local Arrangements Committee - Paul Ogg

The hotel facilities were excellent and appreciation was expressed to the hotel staff for the friendly service. The local arrangements committee included George Beck, Jim Daniel, Gus Foster (corporate sponsor coordinator), Neal Hageman, Sandra McDonald (graduate student coordinator, lights and projectors), Scott Nissen, Claude Ross, Mack Thompson (signs), Phil Westra, and Bob Zimdahl. The committee was thanked for their work and complimented on the well run meeting.

WSSA Representative - Donn Thill

The 39th annual meeting was held in San Diego, CA on February 7 to 11, 1999 with 713 attendees. The meeting began on Sunday afternoon with the General Session followed by the Presidents reception and ended with the Wednesday evening banquet. The 2000 meeting will be held in Toronto, Canada on February 6 to 10.

WSWS members recognized at the WSSA meeting included Charlotte Eberlein, Mary Guttieri and Jody Steffen-Campbell for the Outstanding Paper Award for *Weed Science*, Charlotte Eberlein was elected vice-president of WSSA, Jodie Holt was appointed as the WSSA Director of Education, Steve Dewey received the Outstanding Extension Award, and Robert Norris, Ian Morrison, and Donn Thill were selected as WSSA Fellows.

Rob Hedberg is the Director of Science Policy representing weed science. Members can contact Rob Hedberg through the Legislative Committee.

WSSA is conducting a member survey to identify member interest in electronic journal format and other issues. The forms were located at the WSWS registration desk. WSWS members were asked to please fill out the survey if have not done so.

CAST Representative - Steve Miller

The CAST Board of Directors met October 9 to 11, 1998 in Kansas City, Missouri and was chaired by David R. Lineback, University of Idaho. The composition of the Board has been changed to one representative per professional society member. Weed Science is well represented on the CAST Board. A symposium was recently held on Global Climate Change and an executive summary will be published. A conference on FQPA will be held in cooperation with the International Society for Regulatory Toxicology and Pharmacology. The next CAST Board of Directors meeting will be held March 24 to 27, 1999 in Washington, DC.

Committee Reports

Awards Committee - Steve Miller

Gus Foster and Phil Westra were selected for the Outstanding Weed Scientist Award for the Private and Public Sectors, respectively.

The Presidents Award for service to WSWS was presented to Celestine Duncan for her efforts on behalf of the Noxious Weed Short Course.

Nominations - Doug Ryerson

Ryerson expressed appreciation to the nominees for their willingness to run for office. The following candidates were elected to office with a return of 152 ballots:

President-Elect: Don Morishita
Secretary: John Orr
Research Section Chair-Elect: Phil Stahlman
Education and Regulatory Section Chair-Elect: Rich Zollinger

Site Selection - Keith Duncan

The 2000 WSWS meeting will be in Tucson, AZ and the 2001 meeting will be at the Coeur d'Alene Resort, ID. The site selection committee will be evaluating locations in southern California for the 2002 annual meeting.

Fellows and Honorary Members - Gary Lee

John Orr and Charlotte Eberlein were selected as WSWS Fellows for 1999. No nominations for Honorary Member were submitted in 1998. Jack Schlesselman will chair the committee next year and will be soliciting nominations from the membership.

Sustaining Membership - Rick Boydston

The society currently has 21 sustaining members who contributed $7,000 in dues to the society in 1998. United Agri Products will become a sustaining member in 1999. The support the sustaining members provide the WSWS in dues and at the annual meeting was acknowledged by the membership.

Finance - Bob Parker

The committee reported that the finances of WSWS are in order, the society continues to be a tax exempt organization, and Wanda Graves provides excellent management to the society.

Necrology - Steven Eskelson

Sam Stedman, Mr. Cotton, died January 29, 1998. Sam served Pinal County, Arizona for 32 years as County Agent, County Director, and State Specialist for Arizona Cooperative Extension.

Loal Vance, Idaho Noxious Weed Coordinator for the Idaho Department of Agriculture, died October 10, 1998.

Herbicide Resistant Plants - Carol Mallory-Smith

The committee will be meeting immediately after the business meeting; members who are interested in being a member of the committee were urged to talk with Jeff Tichota. A summer meeting may be planned with the place and time to be determined.

Resolutions - Joan Campbell

No resolutions were submitted for consideration in 1998. The committee encouraged the membership to forward resolutions. In addition, the committee requests early submissions so that the resolutions can be evaluated prior to the annual meeting.

Student Educational Enhancement - Carl Bell

The program has five participants this summer. The number and interests of the students coincides with the committee membership. The committee encourages students and potential sponsors to participate in the program.

Legislative - Jim Olivarez

The legislative committee was active during 1998 and focused on information and issues relayed by the WSSA legislative committee and Karl Glasener, 1998 AESOP representative. The committee encourages input from WSWS members into the activities of the committee.

Publications - Don Morishita

Barbra Mullin is the incoming chair of the publications committee. The committee completed the operating guide for the committee activities. The WSWS brochure was completed in 1998 by Dave Cudney and Shaffeek Ali. Copies of the brochure can be obtained from Wanda Graves.

A new edition of Weeds of the West is being planned; a subcommittee of the publications committee met in Salt Lake City last year to discuss the content of the revised publication. The committee requests additional input from membership on the proposed content of the new addition. The committee plans to digitize the photographs and is in the process of identifying a source for the work.

Placement - Roger Gast

The placement committee had a desk at the poster session which worked well. Eight individuals submitted position desired forms. There were positions available in the private sector (5), public sector (21), and for graduate research assistantships (16). The placement committee intended to have positions available and positions desired forms in the fall newsletter. Due to an over sight, the forms were not included in the fall newsletter but were in the January newsletter. The over sight will be corrected next year in order to provide people additional time to submit the forms to the committee chair.

Editorial - Barbra Mullin

The editorial committee is an ad hoc committee made up of the newsletter editor, research progress report editor, proceedings editor, and home page editor. Kathy Christianson, interim editor of the Proceedings, estimated the cost of the 1999 Proceedings at $10.80 per copy. Barbra Mullin, Research Progress Report editor, reported that the Research Progress Report was completed in a timely manner and distributed at the meeting. There were 250 copies printed at a cost of $11.80/copy. The goal for the Newsletter is to publish four newsletters per year. Barbra Mullin is the editor and requests information from the membership for the newsletter. The deadline for submissions is April 10 for the spring newsletter and August 7, October 10, and January 10 for the remaining issues. The Web Site editor, Joan Campbell, reported that the newsletters and annual meeting program are currently available on the web site; executive committee and business meeting minutes and the call for papers for the 2000 annual meeting will be posted on the site. A searchable data base for indices is currently being developed.

Poster - Neil Harker

Fifty-one posters, including 19 graduate student posters, were presented at the meeting. The poster committee appreciated the assistance of local arrangements chair, Paul Ogg, in making the poster session successful. The instructions for poster presentations will be posted on the web site next year.

Student Paper Judging - Matt Elhart

There was excellent participation in the paper and poster competition this year. Nineteen papers and 19 posters were presented. The papers and posters were randomly separated into two sections of 9 and 10 presentations each and two sets of awards were presented in each category. All of the student participants were congratulated on their excellent presentations. The presentations and posters were judged by 12 individuals. The judges were thanked for their hard work. The following awards were presented in each group:

Poster Competition - Section 1:
1st place - Dodi Kazarian, Colorado State University
2nd place - Darrin L. Walenta, Oregon State University
3rd place - Tehmina Sheikh, Texas Tech University

Poster Competition - Section 2:
1st place - Michael W. Marshall, Kansas State University
2nd place - Sandra L. Shinn, University of Idaho
3rd place - Curtis R. Rainbolt, University of Idaho

Paper Competition - Section 1:
1st place - John R. Roberts, Oklahoma State University
2nd place - Holli A. Murdoch, Utah State University
3rd place - Ginger G. Light, Texas Tech University

Paper Competition - Section 2:
1st place - Lynn Fandrick, Colorado State University
2nd place - Matthew D. Schuster, Oregon State University
3rd place - Martina W. Murray, New Mexico State University

Public Relations (Affiliations) - Jack Schlesselman

A table was set up near the registration desk for members to sign up for Continuing Education Credit. Most of the states are allowing the use of the standardized Sign-In/Sign-Out forms. Members were reminded to sign out prior to leaving the meeting. The WSWS may try to offer hours for Certified Crop Advisors at the meeting next year.

Education - Celestine Duncan

Two sessions of the noxious weed short course are planned for 1999. The courses filled quickly with 70 attendees and 40 people on a waiting list. The WSWS may try to host an additional short course in Colorado due to the interest in course. The course is financially sound due to the fact that the instructors volunteer their time and that all participants pre-pay for the course. Members of WSWS who are assisting with the course are Steve Dewey, Joe DiTomaso, Celestine Duncan, Rod Lym, Barbra Mullin, and Roger Sheley.

Other educational activities include determining the feasibility of developing a weed biology course for western universities.

New Business

Acceptance of new member States and Provinces - Rod Lym

At the summer meeting, the executive committee approved the request for membership in WSWS by Alberta, Saskatchewan, and Oklahoma. Membership approval is required to change the constitution.

It was moved (Arnold) and seconded (Banks) to accept the proposed changes to the WSWS Constitution.

Discussion included why British Columbia is not included (they did not apply); how states apply for membership in WSWS (a letter of request is sent to the Society; acted on by the Executive Board, and voted on by the Membership); do we have any criteria for membership or limitations on membership (WSWS has been inclusive, not exclusive to date). Rick Arnold called for the question.

The motion to approve the new members passed unanimously.

President Rod Lym introduced the incoming President, Jeff Tichota. Rod passed the copy of Modern Parliamentary Procedures on to Jeff. Jeff presented Rod with numerous "gifts" to commemorate his tenure as President, including a plaque from WSWS in appreciation of his time and service to the society.

Jeff Tichota expressed his appreciation to the local arrangements committee chaired by Paul Ogg and the graduate students who helped in the paper sessions. He encouraged members to volunteer for WSWS committees.

The meeting was adjourned at 8:10 AM.

Respectfully submitted,

Jill Schroeder
WSWS Secretary

1999 WESTERN SOCIETY OF WEED SCIENCE
PRESIDENTIAL MERIT AWARD WINNER
Celestine Duncan

WESTERN SOCIETY OF WEED SCIENCE
YEAR-END FINANCIAL STATEMENT
April 1, 1998 Through March 31, 1999

CAPITAL	
1997-98 Balance Forward	$302,306.24
Current Income	12,757.29
	$315,063.53

DISTRIBUTION OF CAPITAL

Mutual Funds	$155,236.87
Certificate of Deposit	20,880.09
Money Market Savings	89,035.57
Checking Account	49,911.00
	$315,063.53

Revolving Account Balances	
Weeds of the West	$80,116.13
Noxious Weed Short Course	16,861.90
Bio Book	51,375.56
	$148,353.59

Total Capital	$315,063.53
Revolving Accounts	148,353.59
WSWS Funds	$166,709.94

INCOME	1998	1999
Registration & Membership Dues	$ 3,108.49	$ 22,233.00
Proceedings	1,182.29	3,454.00
Research Progress Report	956.30	2,381.50
Bio Weed Control Book	6,781.43	
Noxious Weed Control Short Course	30,125.00	
Weeds of the West Book	155,236.00	
Bank Interest	13,505.29	
Sustaining Membership Dues		7,400.00
		$246,363.30

EXPENSES		
Office Supplies & Equipment	$1,679.74	
Postage	1,729.81	
Telephone	543.04	
Franchise Tax Board & Secretary of State	20.00	
Tax Accountant	200.00	
Network Solutions (Website)	570.00	
CAST Annual Membership	500.00	
CAST Representative Expenses	250.00	250.00
AESOP Representative		1,070.00
Business Manager	6,300.00	
Typist (format mlg list-WSSA)	150.00	
Bio Weed Control Handbook	2,604.25	
Weeds of the West	163,941.07	
Noxious Weed Control Short Course	25,361.49	
Wyoming Weed & Pest Council	2,000.00	
Invasive Weed Video	1,000.00	
Printing		
Brochures, Envelopes	1,115.95	
Programs		1,709.25
Proceedings	3,058.80	
Research Progress Reports		2,950.75
Newsletters, signs	1,118.53	
Student Awards & Plaques	282.28	
Poster Session (poster boards)		481.28
Refund of Registration Fees		265.00
Conference Awards Luncheon		6,918.63
Audio Visual		3,094.43
Conference Speaker Expense	575.00	
Student Awards & Room Subsidy		1,360.00
Executive Board & Committee Mtgs	1,654.93	
Editor's Travel Expense		851.78
		$233,606.01

1999 FELLOW AWARD
WESTERN SOCIETY OF WEED SCIENCE
Charlotte Eberlein

Dr. Charlotte Eberlein is a Professor of Weed Science in the College of Agriculture at the University of Idaho. Charlotte earned a B.S. in Agronomy in 1975 from Washington State University, M.S. in Crop Science in 1978 from Oregon State University, and a Ph.D. in Agronomy in 1981 from the University of Minnesota. She joined the faculty at North Dakota State University in 1981 as Assistant Professor and Extension Weed Specialist. In 1984, Charlotte accepted a position as Assistant Professor at the University of Minnesota and then moved to the University of Idaho in 1989 as Associate Professor of Weed Science. She was promoted to Professor in 1994 and is presently the District III Director for Cooperative Extension at Twin Falls, Idaho.

Dr. Eberlein has amassed an impressive list of contributions to weed science as a discipline. She has taught undergraduate and graduate courses, directed graduate students, initiated and maintained innovative research programs at the three institutions that she has served. Charlotte has published over 34 refereed journal articles and 4 book chapters; as well as 35 extension publications and 33 popular press articles. She is recognized nationally and internationally as an authority in herbicide resistance in plants. She has sought opportunities to work cooperatively with peers in weed science, plant breeding and plant pathology.

Charlotte Eberlein has provided effective leadership to the Weed Science Society of America by serving on 12 committees, serving as Secretary from 1994 and 1996, and recently was elected Vice President that will lead to being President in 2002. Charlotte was inducted as a Fellow Member of WSSA in 1998. She was active in the North Central Weed Control Conference from 1982 to 1988, serving on 6 different committees. However, the Western Society of Weed Science has benefited most from the leadership of this individual. Charlotte has served on 8 committees and held every elected office including President in 1996 to 1997.

A supporting letter states "Suffice it to say that she is one of the shining stars in Weed Science today. She is recognized as an outstanding leader at the regional, national, and international levels. Her superlative work in extension, field research, laboratory research, and professional service activities clearly demonstrates a degree of excellence that deserves recognition by her peers."

1999 FELLOW AWARD
WESTERN SOCIETY OF WEED SCIENCE
John E. Orr

Mr. John E. Orr is a Principal Field Biologist with Zeneca Agricultural Products. He completed a M.S. degree in Agronomy/Weed Science in 1970, at the University of Arkansas. John started his professional weed science career with Diamond Shamrock Corporation in 1969, moved to BASF Corporation in 1971, joined ICI Americas, Inc. in 1983, and has been in his present position since 1987. He works closely with university weed scientists in developing new crop protection products for both major and minor crops grown in the Pacific Northwest. He is dedicated to and supports programs important to regional agriculture.

John has been an active member of WSWS for 27 years. He has served as chairman of the site selection committee and the resolution committee. "John has not been an individual to watch from the sideline" as noted from a supporting letter. He has been "remarkably active in professional and political activities important to weed science and agriculture."

He has provided exceptional leadership within his state of residency, which spreads to surrounding states as well. John has served as president of the Idaho Weed Control Association, president of the Idaho Citizens for Food and Shelter, and serves on the Idaho State Department of Agriculture Noxious Weed Advisory Council and Food Producers of Idaho.

John received the 1995 WSWS Presidential Award of Merit and was honored as the Idaho Weed Control Association's Weed Worker of the Year in 1995.

He administers an extensive product development program, which includes the coordination of both university and private consultant research trials and maintains an active research program of his own. He is recognized for his knowledge of weed control research in seed crops, dry beans, alfalfa, cereals, and orchard crops.

1999 OUTSTANDING WEED SCIENTIST AWARD
PRIVATE SECTOR
Gus Foster

Gus Foster has been a key player in Western agriculture for over 20 years and is truly one of the most innovative product development representatives in the western region. Gus has spent his career in Fort Collins, Colorado with Velsicol, Sandoz and BASF. Though the company he was working for changed names several times, Gus did not and maintained the belief that sound research best serves agriculture. During his career, Gus was instrumental in the development activities with dicamba for perennial weed management in range and non-cropland situations, Marksman herbicide on corn, sorghum and fallow, dimethenamid on corn, dry beans and several minor crops and quinclorac for field bindweed management.

Gus has played a key role in developing cooperative programs between the Ag Chemical Industry and Western Universities. Gus has acted as a facilitator on a wide range of issues and as a mentor and employer of a number of undergraduate and graduate students. This interaction with a scientist working for a private company has been extremely beneficial because it has given us and industry perspective on research and made our weed science discipline more productive and focused.

Our WSWS is today, a stronger organization because of the activities of Gus Foster. He has served the WSWS in a variety of capacities, including President. Gus has helped organize and fund coffee breaks and breakfasts for the benefit of the society. Such involvement and participation was done without fanfare, but with great benefit to our society. Even Gus's special humor is appreciated by most members and has helped all of us not to be too serious about ourselves or our accomplishments.

1999 OUTSTANDING WEED SCIENTIST AWARD
PUBLIC SECTOR
Phil Westra

Since 1985, Dr. Westra has maintained one of the largest and most productive research and extension programs in the western region. His research efforts have resulted in 30 refereed publications, $3.9 million in external grant funding, as well as advising or co-advising 22 graduate students. His untiring effort to seek external dollars for support of weed science programs has allowed CSU to completely renovate the weed science laboratory and greenhouse facilities. In extension, Dr. Westra has been instrumental in providing agent and grower training programs for Colorado and the region. Dr. Westra or his group annually conduct 40 to 50 extension programs, have written 11 extension bulletins, made several videos, and put together several educational slide sets.

Dr. Westra has focused significant energy and resources on regional and national concerns. Herbicide resistance has become a major focus for many university and industry researchers. Dr. Westra directed numerous field and greenhouse research projects to evaluate the level and geographic distribution of herbicide resistant kochia in Colorado and surrounding states. This has provided growers with timely weed management strategies that have saved millions of dollars in yield and harvest losses. In addition, Dr. Westra played pivotal roles in developing regional weed management strategies for field bindweed and jointed goatgrass. Researchers from Kansas, Colorado and Wyoming have worked closely together on these key weeds in the Central Great Plains.

Often research and extension personnel in the public sector are not fully appreciative of the parameters, constraints and decision-making processes private industry has in developing, marketing and stewarding products. Dr. Westra has a strong understanding and respect for both sides of the issue. His ability to see this perspective, empathize with the landscape in which market development decisions are made has allowed him to weld the public and private aspects together for the good of both entities. His ability to generate the levels of outside funding for the weed science program in Colorado is largely due to his abilities to see the biological and market fits and needs.

1999 WESTERN SOCIETY OF WEED SCIENCE FELLOWS
(L to R): Charlotte Eberlein (Public Sector) and John Orr (Private Sector)

1999 WESTERN SOCIETY OF WEED SCIENCE OUTSTANDING WEED SCIENTISTS
(L to R): Gus Foster (Private Sector) and Phil Westra (Public Sector)

1998 NECROLOGY REPORT

The committee received notification of two deaths of friends associated with WSWS this past year. Our thoughts and prayers are extended to the family of Sam Stedman and Loal Vance.

Sam Stedman or Mr. Cotton died January 29, 1998. Sam served Pinal County, Arizona for 32 years as County Agent, County Director, and State Specialist for Arizona Cooperative Extension. Sam introduced integrated pest management to Pinal county, the first cotton module handling system in the country, the first rope wick applicators in Arizona, and the usage of the infrared gun for irrigation monitoring. Sam earned a B.S. degree (1964) in entomology and an M.S. degree (1979) in agronomy and plant genetics. Sam, who is missed by friends and family, was a committed Extension professional who also 'had a life' and a love of trap shooting. Sam is survived by Sonia, his wife of 35 years, daughters Lana and LoriGay, and 5 granddaughters. Sam was an active member of WSWS.

Loal Vance, Idaho Noxious Weed Coordinator for the Idaho Department of Agriculture, died October 10, 1998, of a heart attack while visiting family in Provo, UT. Loal worked as the Noxious Weed Coordinator for 14 years. In that time he worked with many County Weed Supervisors to coordinate the noxious weed management efforts in Idaho.

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AUTHOR INDEX

CROP INDEX

Common and Botanical Name **Page**

WEED INDEX

HERBICIDE INDEX

Common name or Code designation, Trade name and Chemical name **Page**

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