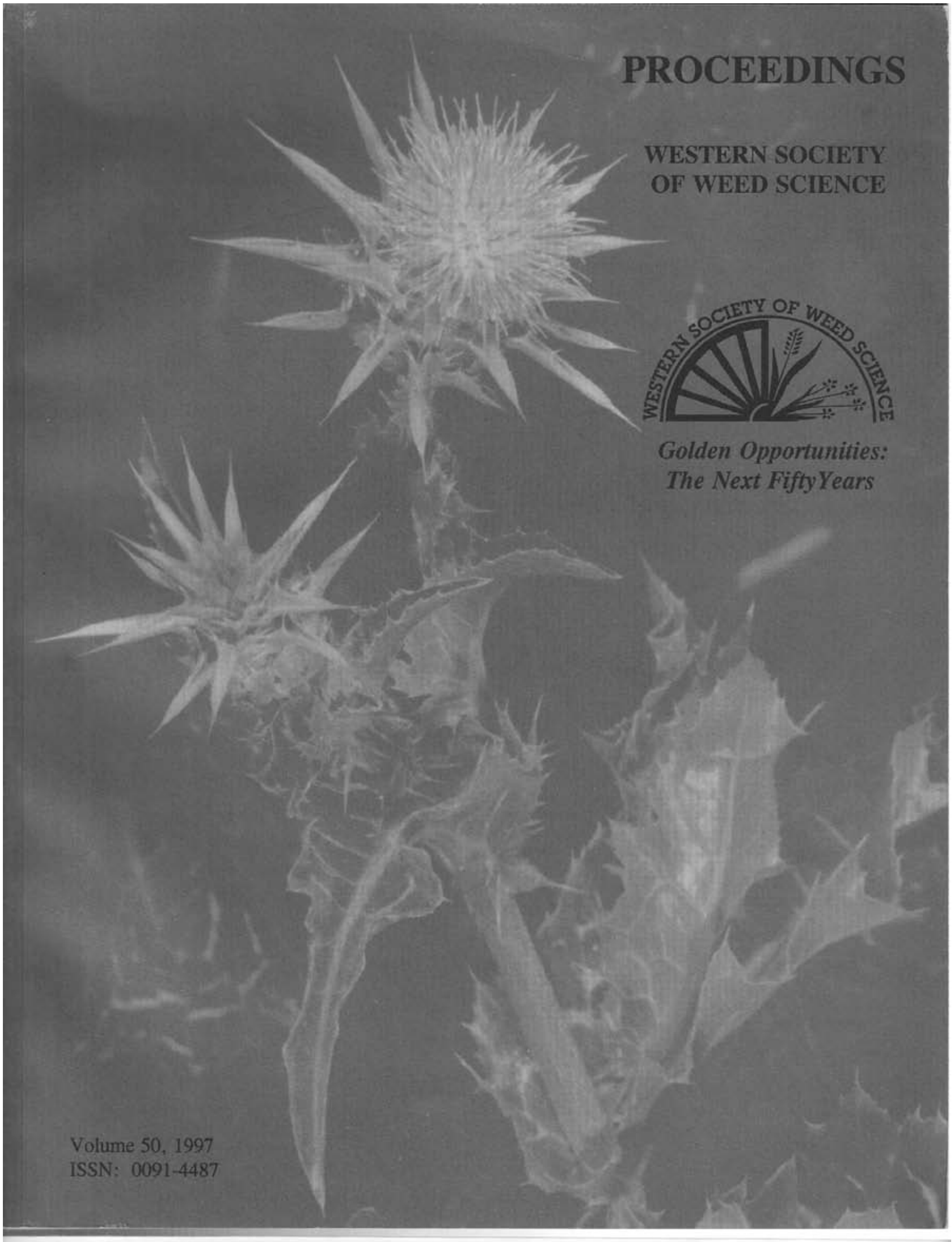

PROCEEDINGS

WESTERN SOCIETY OF WEED SCIENCE

Golden Opportunities: The Next FiftyYears

Volume 50, 1997
ISSN: 0091-4487

WESTERN SOCIETY OF WEED SCIENCE

1997 - 1998

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1997

PROCEEDINGS

OF

THE WESTERN SOCIETY OF WEED SCIENCE

VOLUME 50

PAPERS PRESENTED AT THE ANNUAL MEETING

MARCH 11 TO 13, 1997

RED LION HOTEL - COLUMBIA RIVER

PORTLAND, OREGON

PREFACE

The Proceedings contain the written summary of the papers presented at the 1997 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: Milk thistle [Silybum marianum (L.) Gaertn.]. Photo courtesy of Jack Schlesselman.

Proceedings Editor: Rodney G. Lym

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GENERAL SESSION

PRESIDENTIAL ADDRESS
Charlotte Eberlein
University of Idaho
Aberdeen, Idaho

Good morning!

My talk today will focus on two of Bob Zimdahl's favorite questions about our discipline of Weed Science, namely "Who are we?" and "Where are we going?" And if I can keep my wits about me, I'll even try to shed some light on the third great mystery of Weed Science---how do we get there?

Who are we? We are a diverse group of individuals held together by our common interest in weeds. Some of us grew up on farms and learned the values of hard work and stewardship of the land, and we saw first hand the detrimental effects of weeds on crop growth. Some of us were Peace Corps volunteers or church missionaries in third world countries. We had the opportunity to see how the other half lives, and this provided strong motivation for us to study agriculture. Some of us simply have a love of plants and the outdoors and enjoy the challenge weed management presents us. Others have training in basic sciences like chemistry, genetics, or plant physiology, and Weed Science provides us the opportunity to use our lab skills to solve applied problems.

Our different backgrounds, experience, and training can be a source of great strength for Weed Science because our diversity fosters creativity, facilitates implementation of new programs, helps us to communicate more effectively with groups outside of our discipline, and greatly enhances our ability to adapt to change. Within any diverse group there will be individuals that don't see eye to eye on every issue, but that too can be a strength because we need rigorous, scientific debate on the issues facing Weed Science in order to make sound decisions.

The challenge that we face is to keep our differing viewpoints from becoming a nucleus for divisiveness. In any diverse group there will be some individuals who have no interest in considering any perspective other than their own and no willingness to seek common ground. But when we create barriers and promote exclusion, we limit all of the things that make us productive. We hamper our creativity, we limit our ability to implement new programs and communicate with ourselves and others, and most of all, we profoundly diminish our ability to adapt to change. And these are times of great change for agriculture. Think back to your Biology 101 course...if you are a nearly homogeneous species with a narrow genetic base, will you survive a period of great climatic change? I think not.

So, for our discipline to survive we must be capitalize on our diversity and let it be our strength, be inclusive rather than exclusive, and remember that we really are dependent on each other for success. Imagine for a minute that a great miracle occurs and I am suddenly transformed into a creative and talented modeler. If I write an elaborate model but have no field researchers to validate it and no extension specialist to demonstrate it to growers, what have I accomplished? Weed Science, who are we---we are diverse. And wherever we're going, we need basic scientists, ecologists, and technologists all going there together.

One avenue that weed scientists may choose to explore is site specific weed management. There is the possibility that as more farmers adopt site specific farming techniques, and more combines are equipped with yield monitors, growers will be able to see very clearly for themselves the direct relationship between weed infestations and crop yield. As a result there may be a new interest in developing more refined and perhaps more intensive, weed management systems. We have our "teachable moment" and we need to take full advantage of the opportunity to promote our discipline. We also need to be innovative in developing site specific weed management programs. There has been some nice work at several institutions, including Nebraska, on predicting and mapping weed populations and tying site specific herbicide recommendations to the weed population maps. But we need to move beyond using site specific information just to adjust herbicide rates, and Alex Ogg will cover a number of opportunities for site specific weed management in the special seminar on that topic this afternoon.

Now, I don't want to steal Alex's thunder, but I do want to briefly relate an experience we've had with our potato growers. A group of our very progressive growers came to us 3 years ago to inquire about the possibility of developing site specific cover crop systems for erosion control in potatoes. And they desperately need erosion control systems. For example, this is the view across the American Falls reservoir to the hills beyond on a calm day, and this is the same view in the spring during one of our typical southeastern Idaho dust storms: productive top soil is blowing from our farms into the city of Pocatello---not a good advertisement for agriculture. We have serious wind erosion in the spring because we depend on tillage and herbicides for weed control. But if we could switch to a cover crop plus herbicide system we could nearly eliminate our spring wind erosion problem. And the cover crop system has weed control benefits as well. We found that we could shift the weed community from one dominated by pigweed, lambsquarters, and kochia to one in which only minor infestations of hairy nightshade survive simply by planting potatoes into a winter wheat cover crop. We don't eliminate herbicide use in the system, we still have to chemically kill the cover crop and clean up our nightshade escapes, but we can force a species shift, change the weed control products used, and reduce herbicide input by nearly one-half compared to conventional practices.

And you know, there might even be money in this concept for you in industry. If you work with your biotechnology group to cleverly design cover crop systems that force a species shift away from weeds your compounds don't control, and towards weeds your environmentally safe herbicides or biologicals do control, couldn't this expand your market and be profitable?

But to get back to the topic at hand, site specific management offers us the challenge of dealing with weed management in a system that is no longer treated as a uniform monoculture. To do this, we need to have much more weed biology and ecology information at our fingertips than we've had in the past, and we have to improve our understanding of species and environmental interactions so we can predict how changes in management practices will influence weed populations. Weed Science, where are we going? We're headed for new territory and we're launching weed management systems fueled by Weed Science.

To accomplish this, we're going to have to make some changes in how we train our students and how we update ourselves. We simply must have more emphasis on ecology and plant ecology at the undergraduate level so our graduates are better prepared to deal with the more complex systems they'll be working with in either industry or academia. Weed management prescriptions just aren't going to be as simple as they once were. And we also need to modify our graduate training programs to include a course in community ecology that has a good hands-on field lab. This will give students a good understanding of species interactions and the consequences of making even subtle changes in the system. Students also need a course in applied molecular biology, which is not a hard-core lab course, in order to become familiar with the jargon and techniques used in molecular biology so they can interact with the biotechnologists in their company or institution to develop products that will aid in weed management. An applied GPS/GIS course also is needed to get by in this day and age. And of course, students need a good, solid graduate level weed biology course. One thing I've learned in the past year is that a number of institutions in the West do not offer weed biology courses, and one thing WSWS could do is help facilitate the development of a good video tape or satellite course on weed biology.

How about the rest of us---what do we need? We need journals that are more than vehicles for promotion and tenure. Our journals also should provide us with good review articles on a range of topics, including short reviews of "hot topics" --- new developments important to our field. This is especially critical for industry reps and consultants working out of their homes, who don't have ready access to good libraries or the time to do detailed literature searches. And we need Professional Development Shortcourses on a variety of applied and basic topics to bring us up to speed in new areas.

We also need to have a few more Weed Task Forces like the Leafy Spurge and Jointed Goatgrass Initiatives. These multidisciplinary groups can do a large amount of life history and management research and extension in a relatively short period of time. For example, in the last three years, the jointed goatgrass task force has produced an abundance of information on the biology, impact, and distribution of this weed. They've looked at seedbank dynamics and factors affecting germination and emergence, they've evaluated the effects of a host of cropping practices on seedling survival, they've looked at competitiveness of jointed goatgrass with wheat as several locations, and they've evaluated competitiveness of various winter grain cultivars with jointed goatgrass. There's even a nice study on the formation of hybrids between jointed goatgrass and wheat and the potential for moving genes from wheat to goatgrass---a basic weed genetics study with tremendous relevance to the herbicide industry. And to top it all off, there is an excellent technology transfer program as part of the task force.

Now we don't want to overwhelm ourselves with task forces, but we could use a few more patterned off the Jointed Goatgrass Initiative. They benefit our science by producing basic information useful for developing weed science theories and new weed management practices, and they also benefit our public image. When we can go to the table with groups outside of Weed Science, present a wealth of information on the biology of a weedy species, and show how we can use that information to develop truly integrated options for management, we are perceived as the credible information source that we know in reality we are.

I'd like to finish up this morning by paraphrasing St. Paul---in a completely secular fashion of course. Each of us has unique abilities to offer Weed Science. Some have the gift to do excellent field work; others have the talent for basic laboratory studies. Some have the patience to do detailed studies on the ecology, biology, and genetics of our major weeds. Others have the gift to model. And some have the gift to teach, to pass on the body of information generated by our research to students in the formal classroom setting, or to farmers and ag industry personnel in the field.

The Western Society of Weed Science has been fortunate to have a very talented membership that has shared it gifts and built a productive and progressive Society. Our Golden Opportunities lie in continuing to work together and using our talents to lead Weed Science into the 21st century.

HONOR OUR PAST TO GUIDE OUR FUTURE. Larry C. Burrill, Emeritus Professor, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331-3002.

Socrates wrote: "It is good that we ask the old who have gone along a road we must all travel in our turn the nature of that road."

For the WSWS, the trip on the road to the future starts now. The travel will be challenging, exciting, and new. New yes, but there are those who have gone along such a road before. Are they remembered? Is there a "Society memory?" If so, is it usable and is it used?

Forty nine times, your predecessors came to a city meeting. Denver was first, followed by Berkeley. They came to talk of weeds and weed control.

They met in smoky rooms, halls, and dining rooms; always to talk of weeds. Pioneers then, oddities still; most were wide-eyed and giddy at city life, but they were dedicated to what they did.

There have been some changes. Smoke has been replaced with less obvious pollutants in plastic, air-conditioned rooms. Perhaps in 1997 members are more at home and less giddy in the city. Communication tools are more glamorous. Is the communication better? I don't know.

They accomplished much at these meetings and even more in the months between. They held back weeds that were as relentless as ocean tides. Relentless is the way of nature, and nature abhors empty spots where plants could grow. These early weed people matched wits with an experienced and patient adversary. Did they win? Some battles perhaps but not the war, not yet.

They bought time. They uncovered knowledge. They helped improve old tools and discover new tools of weed management. In fact, they became comfortable with the concept of weed management as they slowly realized that elimination of weeds was rarely possible and probably not desirable. They faced one botanical crisis after another always looking ahead to a new crisis and exciting new tools. As pioneers, there was little time to look back and not much to see anyway.

Forty nine times they came together with themes such as what's new and where do we go from here. Rarely did they stop as a group to look back to ask their collective past to help guide their way through the future. No time, too busy.

No shame, no regrets, they were in a different time. The shame will come if lessons of the past are ignored now in guiding the future.

Socrates wrote of the road we must all travel. One can visualize Socrates, staff in hand, walking on roads of his time; observing, questioning, perhaps recording some thoughts.

We no longer walk in weed science. Our speed is such that images of the future are blurred. We speed along roads where the destination is unclear. Are we going in the right direction? Are we concerned more with speed than direction? Is it not wasteful, negligent, to fail to look in the mirror now and then so that the past can help direct us?

Yes, the WSWS has a rich past filled with data, lessons, and wrong roads. There are chronologically-gifted individuals with abundant experience and wisdom. There are also many younger members with dedication and enthusiasm for weed science.

There is no need for the young to pay homage to those who went before. But the WSWS and its members should make every reasonable effort to make sure that what was learned is both accessible and used. Is there an efficient way to know what was done and reported within WSWS? Of course there is; you are talented people with resources. This voice from your past recommends that you make it happen.

It is crucial to recognize that all of the weed species studied, discussed, and bludgeoned by your predecessors are still with us.

Winston Churchill said "success is the ability to go from one failure to another with no loss of enthusiasm." One could argue that we failed at weed control. The same weed species (indeed many more) remain problematic.

Is it time to try another failure? I think so; and some of you are already looking at weeds in different ways. What should be done about weeds? I don't know, and I'm not sure that you should listen if I offered an opinion. I suggest that within the framework of WSWS you spend less time reporting what can be read and more time talking, listening, probing, and planning. The synergy from group dynamics can be exciting and productive. Regurgitation of what members can read and computers can process is mind deadening and wasteful.

Your discussions, as well as your work should always be guided by a thorough knowledge of the past. To help you know the past, I suggest that you dedicate resources to electronically organizing much of the data in your Research Progress Reports and Proceedings. Certainly, no serious Society member should be without a copy of the book on WSWS history.

I end with a quote by a German poet named Goethe who said "Farming is a very fine thing because you get such an unmistakable answer as to whether you are making a fool of yourself, or hitting the mark." Weed management and weed research are like farming. You know soon if you make a fool of yourself. Careful use of clues from the past and present will greatly improve the chances of hitting the mark.

THE NEXT FIFTY YEARS: INDUSTRY MUST BE MORE LIKE ACADEMIA AND ACADEMIA MUST BE MORE LIKE INDUSTRY. F. Dan Hess, Vice President of Research, Novartis Crop Protection, 975 California Ave, Palo Alto, CA 94304.

Weed science has proven successful in both the private and public research arena over the past 50 years; however, to make this discipline even more productive during the next 50 years, each should strive to capture the strengths of the other. There are research and administrative areas where one has excelled over the other, where both have excelled and where both would benefit from improvement. Managing weeds in the next 50 years will continue to be a significant challenge for agricultural production. Thus, public and private researchers must learn from each other in order to maximize productivity. This manuscript will evaluate research and research management in weed science and suggest where improvement would benefit the never ending task of managing weeds. The discussion of private research will focus on basic manufacturers of herbicides and public research will focus on universities, but many observations are applicable to other private research units such as contract research firms and private consultants and other public research units such as state (e.g., state departments of agriculture) and Federal (e.g., USDA/ARS) programs. The focus of examples is production agriculture, but the same principles apply to forestry, aquatic, and range weed management.

Long-term research. During the past 50 years, university research has done an excellent job of maintaining a significant portion of their research efforts on the long-term horizon. Numerous research projects within university programs are multiple year in nature. Long-term research on topics such as weed biology and weed/crop competition are commonplace in public research portfolios. Research associated with biological weed control using fungi and bacteria have been maintained for more than a decade. Although commercial success has been limited, research continues to identify biological control agents as well as delivery systems which can improve the efficacy of biological weed control. Industrial research programs should commit a portion of their research budget to long-term projects that will increase the overall efficiency of managing weeds while minimizing cost to producers and impact on the environment. For example, a long term commitment by industrial research to fully understand, and then manipulate, seed dormancy could provide an entirely new mechanism for managing weeds. If internal scientific resources within a company are not available to support long term research, funding should be provided to universities or other public research agencies which can generate information of use to all associated with weed management.

Mission oriented research. Both university and industrial research programs have excelled in providing numerous weed control options for agricultural production through a strong commitment to mission oriented research. Few unsolved problems exist in managing weeds and progress to solve remaining problems, such as range and invasive weeds, continues at a rapid pace. Mission oriented research continues to increase the efficiency with which weeds are managed, while increasing the focus on sustainability in agriculture. Mission oriented research must lead weed management practices to a fully sustainable level for future generations, which must rely on the same resources for food and fiber production. University weed management research has delivered a plethora of useful tools, recommendations and information directly applicable to producers. Industrial research continues to deliver a supply of herbicides and adjuvants with an ever better profile in both efficacy and low environmental impact. This mission oriented research must continue in the future even though some claim that weed control is no longer an issue in production agriculture, and thus should not be supported. Weeds are far from being a "non-issue" in agriculture.

Teamwork. Research associated with maximizing productivity of people overwhelmingly concludes that productivity of teams exceeds the additive productivity of individual members. Most management training seminars include exercises where it is easily shown that decisions made in teams are superior to those made by individuals. The most common among these is where participants are asked to select five or so items from a long list to help them survive on a desert island. The group is then divided into random teams and selections are again made, but this time based on team discussion and analysis. The two sets of items are then compared with an optimum list selected by military survival experts. Almost without exception, the items chosen by the teams are more correct than the items chosen by individuals. The facilitator then proudly spends the next several hours expounding on the advantages of teamwork. Most industrial research units have adopted the team approach to research. It is common for synthetic chemists, analytical chemists, molecular modelers, biochemists, as well as laboratory, greenhouse and field biologists to work together on a single herbicide discovery project. All feel accomplishment, and are rewarded, when success is achieved. During the next 50 years, university research should increase their focus on forming research teams to solve complex issues which often encompass several disciplines. Many faculty members resist working within large research teams because the university structure for advancement is often associated with individual productivity where the primary measures of success are number of publications and the amount of research funding obtained. Some university promotion processes go so far as to proportion the authorship of manuscripts, or grant funds obtained, among individual participants by a subjective evaluation of each persons contribution. Efforts must be made to devise measures of success for those faculty who participate in research projects which lend themselves to team approaches.

Systems research. The more learned about weed management, the more clear it becomes that effective weed control requires an understanding of the entire agricultural ecosystem. University and other publicly funded research has excelled in research to increase the understanding of the weed management system which includes the interaction of the soil, crop, weed, terrestrial environment (e.g., light, relative humidity and temperature), as well as the influence of other pests (insects and disease) on competition between weeds and crops. It is essential that research continue to address critical issues such as "threshold" versus "zero tolerance" weed control on the long term agricultural ecosystem. Industrial research needs to increase its emphasis on understanding the weed component of the overall production system. Research must go beyond efficacy trials for new and existing herbicides and include research which considers the overall weed-crop system. For example, research within industry is needed to better understand integrated weed management systems which includes timing and frequency of cultivation coupled to timing and dose of herbicide use.

Training and decision making. Managers within industry have long recognized the value of providing continual training for their research staff throughout their career. Training is in technical areas such as statistics and computer skills as well as in personal skills such as how to deal with difficult people and how to set goals and objectives and then measure performance. Whereas significant cost is involved in these training programs, the benefits far out weigh costs. Many universities are initiating training programs for their research faculty. To maximize long-term productivity, the commitment to training throughout a research career must continue even in light of seemingly impossible budget constants.

Decision making within an industrial research environment often rests with an individual rather than with a committee. Whereas there is risk of error with any individual decision, in nearly every instance the risk associated with a wrong decision is manageable. Whereas decisions by committee may have a lower risk of being incorrect, the cost of a committee decision versus the cost of an incorrect decision must be weighed. If the risk associated with a wrong decision is substantial, then the committee process has value. During the next 50 years, efforts should be made within publicly supported research to empower those lower in the organization to make and implement more decisions. This empowerment is needed in order to minimize overhead associated with research management. Many in publicly supported institutions (e.g., universities and the USDA/ARS) do not like to be compared to a business, but with respect to spending, these organizations have budgets comparable to the research budgets of the major crop protection corporations. In this sense, they are large businesses, and as such, should constantly strive to minimize administrative costs.

Outreach to customers. Whereas industrial organizations pride themselves in "customer service," university applied research and extension faculty in agriculture are the clear champions of customer service. Over the past 50 years these programs have resulted in monumental increases in agricultural productivity to where citizens enjoy one of the most abundant supplies of low cost, high quality food in the world. Historically, it has been difficult for those university faculty involved in mission oriented research, as well as extension outreach programs, to receive equal recognition and rewards as those conducting basic research. Advancement and reward systems within universities must implement programs to compensate those working at the interface between research and implementation in production agriculture. Outreach to customers from industry must be proactive and go beyond the usual objectives of increasing sales and managing complaints. Industry must provide increased training to producers in areas such as managing herbicide resistant weeds and safe use of products to minimize impact on the environment.

Accountability for productivity. In both industry and the university, researchers must be held accountable for productivity throughout their career. The shareholders supporting an industry and the tax payers supporting a university have a right to expect reasonable productivity from all working within these research institutions. Such productivity should not be associated with tenure, which is a means to protect controversial research from political pressure. Continued employment in both industrial and university research should be linked to reasonable productivity. Tenure aside, terminations in industry due to poor performance are no more frequent or less difficult than in academia. Terminations in industry are most often due to business reasons such as company downsizing or merger. Whereas low productivity is infrequent in both industry and academia, less than 2 or 3% in most instances, it is a problem that can amplify itself within an organization. The attitude can become one of "why should I work day, night and weekends for a 3% salary increase when my colleague works less than 40 hours a week and receives a 2% salary increase." Whereas the vast majority of scientists are self-motivated, there are those who need to know the level of performance expected. In a Chronicle of Higher Education article (February 28, 1997, page A12) which reviewed a document titled Public Higher Education and Productivity: A Faculty Voice, prepared by faculty leaders in New York and California, it is stated that if "some faculty members do not work hard enough . . . administrators are largely to blame." "They have failed to establish clear expectations and to evaluate professors accordingly." The same can be said for professionals working in private business. An effective way of optimizing productivity is for managers to set clear expectations through the use of measurable goals and objectives coupled with regular performance evaluations. Performance management programs are commonplace in industrial research and being adopted by colleges and universities in several states. These programs are often difficult to implement and resisted by many scientists, but are very effective if properly implemented and managed. Here, involvement of scientists in the development and implementation process and adequate training about the system are vital for the success of a performance management program.

Time management. The time spent by researchers on activities peripheral to research continually increases. Within universities, researchers spend an ever increasing amount of time writing proposals to fund their individual research programs. Within industry, researchers spend an ever increasing amount of time writing reports and attending meetings. To maintain productivity, researchers must be able to dedicate 80 to 90% of their time to research. For many, the amount of time available for research is less than 50%. Most are yet to realize significant administrative time savings from the "information age" that is so often claimed to increase efficiency. The amount of time available for "hands-on" research must increase to maintain the productivity required for the future, with resources which will no doubt continue to be limited.

Distribution of funding. On the average, industrial research spends approximately 65% of its total budget for personnel expenses. The remainder of the funding provides direct project support for such things as equipment, supplies, maintenance, and travel. Because of the expectation of university researchers to obtain substantial outside funding to support their individual research programs, many departments within universities spend 90% or more of their total budget on personnel related expenses. This places a substantial burden on faculty to obtain the funding necessary for direct expenses associated with their research projects. This is particularly difficult for those conducting research in weed management, where outside funding has historically been difficult to obtain. Whereas new sources of funding are available such as the competitive grants program within the National Research Initiative, the amount of funding available is small relative to number of researchers conducting important research in weed management. Efforts should be made to provide a base level of funding for all faculty within the university system. While this may require fewer faculty per department, the overall productivity of the department may well increase when the remaining faculty receives adequate support for their projects.

The take-home message. Both university and industry research have significant strengths, but there is always room for improvement within any organization. There are places where industry can learn from the academic environment and universities can learn from the industrial environment. To maximize progress in weed management during the next 50 years, it is critical that university and industry scientists, as well as administrators, work together. Agriculture must be more productive to feed an ever increasing world population and must be more sustainable to provide for the agricultural needs of future generations.

IN THE FIELD WITH HERBICIDE RESISTANT CROPS. Philip Westra, Associate Professor, Department. of Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523.

Abstract. A 1 hour panel discussion on Herbicide Resistant Crop (HRC) technology was held during the general session of the 1997 WSWS meeting in Portland, OR. The panel consisted of Dr. Del Harper of Monsanto, Dr. Michael Owen of Iowa State University, Dr. Niel Harker of Ag Canada, and Mr. Craig Shaw, a Canadian farmer. As the moderator of this session, I had asked the panel members to address some or all of the issues listed below. Following the panel presentations, questions or comments were solicited from the audience. This format was in keeping with the WSWS tradition of discussion sessions on topics of current interest. This session provided information of special interest to many members of the audience, and was likely a very educational session for people who have not worked with herbicide resistant crops. While the discussion generated differences of opinion on various aspects of HRCs, the consensus was that this technology is here to stay, and that HRC technology increasingly will enter the food and fiber production systems of the western United States.

1. Is there a yield drag associated with the HR trait?
2. What is the herbicide margin of safety with HRCs?
3. Do HR traits affect food quality?
4. Will HRC technology force producers to pay higher prices for crop inputs?
5. How are HRCs regulated?
6. How many traits can seed producers afford to "stack" in crop varieties?
7. Will HRC technology lead to more herbicide resistant weeds?
8. How will volunteer HRCs be controlled?
9. What technical or other barriers have HRCs posed?
10. What are the benefits of HRCs?
11. Will development of HRCs lead to increased reliance on chemicals?
12. How might consumers react to this technology?
13. Might consumers require HRC labeling on foods made from HRCs?
14. What international trade issues might emerge from HRC technology?
15. What are the obvious benefits to HRC technology?
16. Are transgenic crops a special case?

IN THE FIELD WITH HERBICIDE RESISTANT CROPS: ROUNDUP READY® SOYBEANS. Del Harper, Business Development Director, Monsanto Company, St. Louis, MO 63017.

The commercial introduction of Roundup Ready® soybeans[a] culminates over 10 years of research and development by Monsanto Company and its seed company partners. The development of Roundup Ready® soybeans required that a weed control system be developed, but several additional development issues also needed to be addressed before the system could be commercialized.

The most important element of the system is the herbicide tolerant plant. Prior to the development of the plant, an assessment of the market potential was completed concurrent with an evaluation of the risk associated with the introduction of a tolerant species. Strict criteria were established concerning the level of herbicide tolerance required for commercial weed control, and extensive testing was required to determine the impact of the gene on the soybean. Studies were conducted in numerous genetic backgrounds to ensure the gene has no negative impact on the genetic potential of the soybean.

Regulatory approvals were required for the soybean in addition to the regulatory approval for the application of the herbicide. In the United States, USDA and FDA approvals were required prior to introduction of the plant and

[a]Roundup® and Roundup Ready® are registered trademarks of Monsanto Company, St. Louis, Missouri 63017.

EPA approved the use of Roundup® in Roundup Ready® soybeans. International approvals were also required to allow the soybeans to be imported into Europe and Japan. Commercial agreements also had to be completed with seed companies to ensure an adequate supply of seed in competitive varieties. All of these factors need to come together to launch the product into the market.

The development of the weed control systems required evaluation of the efficacy of glyphosate herbicide as a selective in-crop herbicide. Evaluations were conducted in all tillage systems and in narrow and wide row soybeans. Tank-mixtures and systems utilizing herbicides with soil residual also were evaluated. In addition, an extensive evaluation of the application methods and potential risk of drift from a new use were also studied and training programs initiated to provide the recommendations for the most effective and safe herbicide programs for each soybean producing region.

The 1996 launch of Roundup Ready® soybeans was very successful. Over 10,000 farmers planted the soybeans on over one million acres. Market research conducted with over 1,000 of these growers indicated an overall satisfaction level of 97%. Growers were very satisfied with crop safety, weed control and the yields received from their plantings.

HERBICIDE TOLERANT CANOLAS - RESEARCH PERSPECTIVE. K. Neil Harker, Weed Scientist, Agriculture & Agri-Food Canada, Lacombe, Alberta.

Herbicide tolerant canolas (HTC) have stirred a lot of excitement in western Canada. The ability to control a broad spectrum of weeds, including those previously uncontrollable, in a single herbicide application is rather exciting. There are three groups of HTCs being developed in western Canada. The first two groups are true transgenics with genes inserted into them for herbicide resistance ["Liberty-Link" (tolerant to glufosinate) and "Roundup Ready" (tolerant to glyphosate)]. The remaining group, "Canola Smart" (tolerant to imidazolinones and some other ALS inhibitors including sulfonylureas), is a product of cell culture and more traditional breeding methods.

Each of these HTCs bring their own characteristics to the crop producer's toolbox. Each have unique weed spectrums, phytotoxic action, and residual properties. Currently , it is intended that glufosinate ("group 10") will only be sold in Canada for weed control in Liberty-Link canola. This has very positive implications in terms of weed resistance management. On the other hand, glyphosate ("group 9") and ALS inhibitors ("group 2") are already extensively used in the majority of western Canadian cropping systems, and therefore, there is some concern that their further use in canola, will substantially increase the selection pressure for resistant weeds. Indeed, some are worried that if glyphosate resistance occurs and becomes widespread that critical tools such as zero tillage will be jeopardized.

There is little doubt that each of these canolas will find a market because of their unique qualities and numerous advantages. However, we should make sure that we are active in discussing the implications of using these tools so that they do not jeopardize other tools that I don't think we can afford to lose.

MIDWEST EXPERIENCES WITH HERBICIDE RESISTANT CROPS. Micheal D. K. Owen, Iowa State University, Ames, IA 50011.

The use of herbicide resistant crops (HRC) represents an excellent opportunity to improve weed management, reduce concerns from herbicide carryover, and eliminate crop injury. However, growers must recognize that HRC technologies are only a component of a weed management system and do not represent singular answers to all weed control problems. Experiences in the Midwest indicate that growers have not fully embraced HRC technology;

sulfonylurea soybeans and imidazolinone resistant or tolerant corn has not been widely utilized in agriculture. However, with glyphosate and glufosinate resistant crops on the immediate horizon, the adoption of HRC technology could increase dramatically.

Herbicide resistant crops may be most useful in resolving specific problems such as carryover or the management of specific weeds. For example, imidazolinone resistant corn hybrids will provide some level of protection against ALS inhibitor herbicide carryover. Given the widespread usage of ALS inhibitor herbicides in corn and soybeans, the potential for carryover or the interaction of ALS inhibitor herbicides can be relatively high, depending on the environmental conditions. Planting an imidazolinone resistant hybrid would be an effective strategy to resolve these concerns. Imazethapyr provides excellent control of shattercane and the use of this herbicide in conjunction with an adapted imidazolinone resistant corn would be an effective management program.

Glyphosate and glufosinate resistant crops improve the potential for successful weed management programs in reduced and no tillage production systems. Conservation tillage systems generally provide weeds with an ecological advantage, when compared to crops and increase the variability of efficacy for soil-applied herbicides. The ability to apply a highly efficacious herbicide at any time during the growing season without concerns for crop injury represents an important benefit of HRC.

It is anticipated that growers will rapidly adopt glyphosate and glufosinate resistant crops because of their perceptions of the lower cost when compared to "conventional" herbicide programs, the simplicity of the HRC systems, and the consistency of efficacy. It is suggested that these HRC systems will speed the adoption of no tillage crop production and improve the environmental quality of agriculture, because of grower confidence in the ability to effectively control weeds.

Another benefit that specific HRC technologies represents is the management of resistant weed populations. With glyphosate and glufosinate resistant crops, weeds that are resistant to other mechanisms of herbicide action may be managed effectively throughout the growing season. Other HRC technologies also represent opportunities for resistant weed management, but without the application flexibility of glyphosate and glufosinate. Importantly, ALS inhibitor herbicide resistance in crop may be of limited value for the management of weed resistance given the rapid increase in ALS inhibitor herbicide resistant weed populations. In fact, the use of HRC with the appropriate ALS inhibitor herbicide will likely increase the frequency and speed of development of resistant weed populations.

There are a number of other risks associated with the use of HRC technologies. Many of these are pertinent to glyphosate and glufosinate HRC. Perhaps the biggest concern is the misconception that this technology is simple; growers assume that because they are able to spray one herbicide that will be effective regardless of weed species, size, population, or environmental conditions, the system is easy and simple. While there may be some validity in that assumption, there are many other factors that must be considered for successful control. For example, weed species demonstrate differential tolerance to these herbicides and application rates must be adjusted accordingly. Similarly, larger weeds and environmental conditions that impart stress on plants also requires that the herbicide rate be adjusted. Failure to understand the relationship of weed size and species differences with herbicide rate will increase the potential for poor performance which will result in multiple herbicide applications.

The interaction between weeds and crops must also be considered with the glyphosate and glufosinate HRC technology. Different weed species demonstrate different levels of interference with crops and thus may begin to reduce potential yields at different times. Herbicide application timing must be adjusted accordingly. Weed population also dramatically influences yield potential and should be considered when determining appropriate application timing. Thus, growers must accommodate all aspects of weed biology, crop/weed interactions, and the inherent differences in herbicide tolerance when using HRC technologies.

In many situations, the grower will likely be required to make multiple applications of herbicide in order to achieve an appropriate level of weed control. It is suggested that this HRC system is neither simple nor easy to manage. Cost comparisons will likely demonstrate that the HRC systems with glyphosate and glufosinate are comparable to current "traditional" herbicide strategies.

A final consideration of risk reflects the potential for off-target movement of the herbicide. Herbicide drift is a major issue in the Midwest and is a problem for **all** herbicides and application strategies. However, the focus has been on glyphosate due to the lack of selectivity for glyphosate and the interest in the HRC technology. Drift is an inevitable consequence of current application techniques and while it can not be eliminated, drift can be managed.

The concern for off target movement of herbicides reflects the number of applications and the timing of the application. Applications later in the season may be more prone to drift due to environmental conditions and the equipment used for the application; these applications will be made over the top of larger plants, thus the spray boom will be adjusted higher above the crop and potential for drift increases. Also, temperatures are typically higher later in the growing season and inversions increase drift opportunities. In many instances, HRC strategies with glyphosate and glufosinate will require more than one application which logically increases the potential for off target movement. Corn is the most common plant to be subject to the off target movement of these herbicides and it has a very low tolerance to these products.

In conclusion, HRC technologies can be viewed as a potential benefit to weed management and thus agriculture. However, as with any new technology, there are new skills and strategies that must be utilized with HRC to minimize the risks. HRC technologies do not represent the answer to all weed problems and will require considerable management skills to maximize the benefits of this new weed control tool.

HERBICIDE TOLERANT CANOLA, A FARMER PERSPECTIVE. Craig Shaw, Agricultural Producer, Lacombe, Alberta, Canada T4L 1N8.

I would like to start my presentation by giving some background about my farm because it is important to realize that this new technology has a unique and different fit for every farmer. I run a straight grain farming operation of 1600 A situated in Central Alberta, Canada about half way between Calgary and Edmonton. This area is characterized by: a short growing season of around 90 to 110 days frost free period; high moisture with approximately 8 to 12 inches of growing season precipitation; and high organic soils in the range of 4 to 10%. These factors mean farmers are restricted to shorter season spring crops of barley, wheat, canola, and peas. While this area can produce good yielding crops it can also produce good populations of weeds when herbicide resistance has become a problem. Good market prices and the desire to improve rotations has meant canola has become an important crop in our area.

Today, I have been asked to outline the real benefits seen in the field with the use of herbicide resistant crops and give a realistic assessment of the problems encountered with possible solutions. While I will try to give you answers to these questions, I would like to take the liberty of addressing these issues from the broader perspective of the use of these crops as a farm management tool. Without this broader perspective, I feel we as farmers heighten the risk of letting short term gain lead to future problems that we may have chosen to overlook. With these factors in mind, I would now like to consider the pros and cons of this technology in the context of farm management.

In Canada at present we have three choices in the area of herbicide tolerant canola "Roundup Ready" "Pursuit Smart" or "Liberty Link". The first real benefit to these varieties is in the area of improved broad spectrum weed control with the result of reduced weed competition and lower dockage in the harvested samples. The second major benefit is in the area of control of problem weeds. These weeds have either proven hard to control or for which there are no currently registered herbicides. The third major benefit and this applies in particular to canolas, is the ability to preserve moisture at the soil surface and therefore promote a good seed bed for shallow seeding. This advantage is obviously in comparison with the present most commonly used weed control strategies of using pre-emerge chemicals. An added benefit is the time saved over dual spring incorporations with a time delay window in-between. While these are the most important benefits there are also a number of other possible benefits that relate to farm and cropping management. Farmers may be able to save money, especially in fields with high weed populations, by reducing the number of field operations or the number of herbicides needed. This option may open the window for different cropping practices such as no-till or dormancy seeding. This technology may also provide farmers with more options to combat herbicide resistance.

With all these benefits you would quickly assume that farmers would be clamoring to embrace this new technology. To the credit of farmers, the general feeling of farmers is to approach this technology with guarded optimism. While everyone can see the benefits they can also see that these products can also cause problems if producers are unprepared with the proper management plan. The first limitation that producers can see if they look at the numbers closely, is that present herbicide resistant varieties are generally genetically behind recently released standard varieties. While the gap should narrow quickly, producers with good weed control strategies may be reluctant to switch. Another restriction has been the delays in food safety approvals by other counties and therefore the need for tight control of supplies and distribution until approvals are made. A major concern and one not talked about by the herbicide companies, is that of resistant varieties becoming a weed problem in following crops. This could also be expanded to include the impact these possible weeds could have in no-till or preharvest strategies. While these varieties can offer strategies against herbicide resistance they could also increase our risks for herbicide resistance by increasing the use of certain herbicides. To the credit of the chemical companies there have been presentations to note the shortfalls in terms of weed control by these products. It is easy for producers to fall for the hype that one-pass weed control will eliminate all their weed problems. While these varieties may offer new options such as dormancy seeding (seeding just before freeze in the fall) they may be restricted by the high seed costs and perceived risks involved.

I would also comment on pricing strategies currently being used by chemical and seed companies. While farmers can appreciate the need to recoup development costs there is always a concern of a perceived needed return on investment in the chemical company world and accepted rates of return in the agricultural world. In other words, I would question if what the chemical companies deems an acceptable technology fee, seed cost or chemical cost combination matches what a farmer perceives as the benefit of using this technology. There is also a concern about restrictions and stipulations placed upon growers who sign technology usage agreements. No doubt the adaptation of this technology will relate to the total benefits and the costs involved.

So I would hope as a farmer that the chemical companies would look closely at their products and analyze the fit their products have in the market place. By looking at these products from a farm management perspective you should be able to develop a plan that takes advantage of the traits that are most beneficial to your own operation. Used wisely herbicide tolerant canolas will become an important farm tool. Used poorly they could prove to be a big headache down the road.

POSTER SESSION

INFLUENCE OF ANNUAL MEDICS ON IRRIGATED CORN. Craig M. Alford, James M. Krall, Stephen D. Miller, and William C. Akey, M.S. student, Associate Professor, Professor, Assistant Professor, Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Farmers in the Northern Great Plains have shown an interest in inter-cropping farming systems. Advantages of an inter-cropping farming system which contains a legume species include reduced soil erosion, weed suppression, improved soil fertility and improved forage quality. Many of the farmers in this area graze their corn stalks and are looking at ways to improve the forage quality. However, no information is available on inter-cropping annual medics with corn in the Northern Great Plains. Experiments were conducted at three sites in 1996, Huntley, Lingle, and Torrington, WY, to determine the effects of inter-cropped annual medics on irrigated corn. Two of the sites were under sprinkler irrigation, the other was under furrow irrigation. Plots were 10 by 20 feet with four replications in a split plot design. Eight medic species were evaluated in corn under both a weed-free and weedy situation. In addition, there was a weed and medic free check and a weedy medic free check. Corn yields were reduced by the presence of medics in some treatments, others were comparable to the check yields. For example, *Medicago lupulina* reduced corn yields by 4% whereas *Medicago truncatula* reduced corn yields by 17%. Corn yields were reduced approximately 62% by weeds regardless of medic species. The medics did not appear to significantly suppress weed growth. This study was conducted to select the best adapted medic species for further evaluation in corn as to its ideal seeding date and rate.

COMPARISON OF DRY PEA, SWEET CHERRY, AND GRAPE RESPONSE TO SIMULATED DRIFT OF SULFONYLUREA AND OTHER HERBICIDE CLASSES. Kassim Al-Khatib, Rick Boydston, and Carol Mallory-Smith, Kansas State University, Manhattan, KS 66502; USDA-ARS, Prosser, WA; and Oregon State University, Corvallis, OR 97331.

INTRODUCTION

Herbicides may drift off target during application and cause considerable injury if they contact susceptible plants. Damage to crops from drift depends on many factors, including plant species, growth stage, environmental conditions, herbicide formulation, droplet size, and height above the ground that the spray is applied (1).

In the Pacific Northwest, dry pea, grape, and cherry are grown in close proximity to wheat fields. Damage to these crops by 2,4-D, an auxin-type herbicide, has been reported since the herbicide was first introduced in 1947 (2). However, several other herbicides including sulfonylureas are used extensively to control weeds in wheat. Application of these herbicides usually coincides with early spring growth of dry pea, grape, and cherry. As a consequence, there have been repeated allegations that herbicides drift from wheat fields into dry pea, grape, and cherry causing injury symptoms.

Dry pea, grape, and cherry response to simulated drift rates of sulfonylurea herbicides was studied (3, 4, 5). Unfortunately, previous research was either conducted under greenhouse conditions (3) or evaluated crop injury symptoms and vegetative growth response to sulfonylurea herbicides (4, 5), preventing any conclusions about yield response to simulated drift rates of sulfonylureas.

Visible phytotoxicity ratings have been widely used to evaluate herbicide damage on many crops (4, 5). However, this visual estimate may not accurately predict yield losses because plants frequently recover from herbicide damage with no yield reduction.

The objectives of this study were to: 1) study dry pea yield response to simulated drift rates of thifensulfuron, chlorsulfuron and dicamba applied on pea at early flowering stage, 2) evaluate dry pea response to simulated drift rates of chlorsulfuron, metsulfuron, and clopyralid applied prior to pea planting, 3) determine the effect of simulated drift rates of rimsulfuron, thifensulfuron, and 2,4-D on grape yield, and 4) study the response of cherry to simulated drift rates of chlorsulfuron, thifensulfuron, and glyphosate.

MATERIALS AND METHODS

Dry pea. Dry peas were planted in Mt. Vernon and Ephrata, WA; Rupert and Hayden Lake, ID; and Hillsboro, OR in 1995 and Mt. Vernon, Ephrata, and Walla Walla, WA; Macon, MO, and Hillsboro, OR in 1996 (Figure 1). Planting date, dry pea variety and tillage practices were used based on local recommendations by the cooperative extension service in each state. Herbicide treatments were made when 10% of pea plants were at flowering in 1995 and preplanting incorporated to 5 cm depth in 1996. Herbicides were applied with tractor-mounted, compressed-air sprayer equipped with 8002 flat fan nozzles and calibrated to deliver 178 to 300 L/ha. Rates used were 0.01, 0.035, 0.86, 0.21, 0.52, and 1.36 g/ha for thifensulfuron, 0.035, 0.086, 0.18, 0.52, 1.36 g/ha for chlorsulfuron, 1.56, 3.13, 6.3, 25, 50 g/ha for dicamba in 1995 whereas, rates were 0.001, 0.005, 0.025, 0.1, 0.5, 2.5 g/ha for metsulfuron and chlosulfuron, and 1.75, 3.5, 7, 14, 28, 42 g/ha for clopyralid in 1996. All spray mixtures included nonionic surfactant at 0.25% in 1995. Control plots were sprayed with mixture of water and nonionic surfactant at 0.25% in 1995. Dry pea plants were harvested at physiological maturity, kept at 35 to 40 C for at least 72 h and weighed. Seed moisture content was determined and yield was adjusted to 14% moisture.

Grape. Studies were conducted on a 10 year old Chardonnay vineyard on a loam sand soil near Royal City, WA and an 11 year old white Reisling vineyard on a sandy loam soil near George, WA (Figure 7). Treatments in each study consisted of six rates of thifensulfuron, rimsulfuron, 2,4-D and nontreated control. Herbicides were applied at full bloom (when 50% of calyptra had fallen) on June 15, 1995. Herbicides were applied with an ATV sprayer, equipped with a boom with two 8004 flat fan nozzle positioned above the treated row, and calibrated to deliver 154 L/ha. A 6.3 m length of row was treated in each plot and a 6.3 m buffer was left unsprayed between plots. Grapes were harvested by hand from 3 m of row in the center of each plot. Chardonnay grapes were harvested in October 1995 and 1996. White Reisling grapes were harvested in October 1995 and October 1996.

Cherry. Studies were conducted at Salem, OR. Two year-old cherry trees were treated with herbicides after full bloom (50% of petal fall) on April 25, 1995.

Data analysis. Experiments were conducted as randomized complete block designs. Treatments were replicated five to six times. The data were analyzed using regression analysis.

RESULTS

Dry pea. Pea plants responded differently to various herbicides. Foliar application of thifensulfuron reduced yield only at the highest rate in two locations (Figure 2), whereas chlorsulfuron reduced yield at the three highest rates in Ephrata study and the higher two rates in Hillsboro and Rupert studies. Yield was reduced only by the highest rate of chlorsulfuron in Mt. Vernon whereas yields were not reduced by any rate in Hayden Lake study (Figure 4). Yield reduction by dicamba was similar to chlosulfuron except in Rupert study where pea yields were not reduced by dicamba (Figure 3 and 4).

Pea plants also responded differently to soil applied chlorsulfuron, metsulfuron, and clopyralid. Chlorsulfuron reduced pea yield only by the highest rate in all locations except Mt. Vernon, WA (Figure 4). Metsulfuron injured pea plants more that chlosulfuron in Ephrata, WA; Macon, MO; and Mt. Vernon, WA. However, pea yields were not reduced by any rate in Hillsboro, OR and Walla Walla, WA (Figure 5). In general, clopyralid reduced yield more than chlosulfuron and thifensulfuron. These results clearly showed that yield is not any more sensitive to simulated drift rate of sulfonylurea than to simulated drift rate of other herbicide classes.

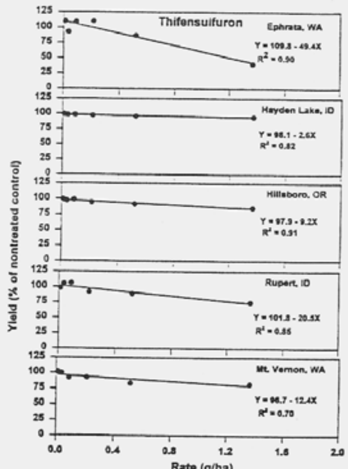

Figure 1. Dry pea yields as affected by a foliar application of thifensulfuron in 1995.

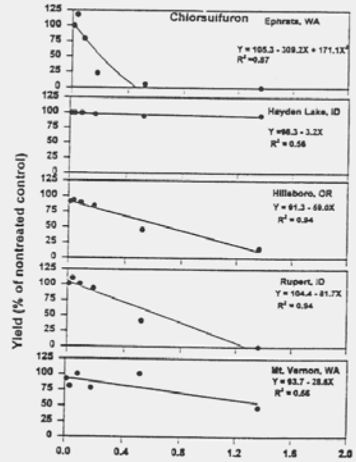

Figure 2. Dry pea yields as affected by a foliar application of chlorsulfuron in 1995.

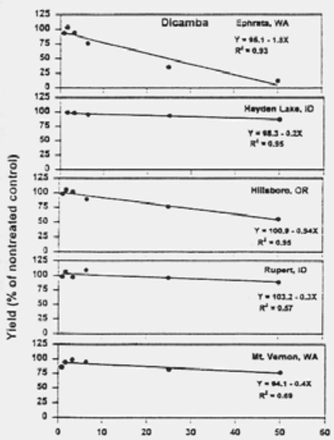

Figure 3. Dry pea yields as affected by a foliar application of dicamba in 1995.

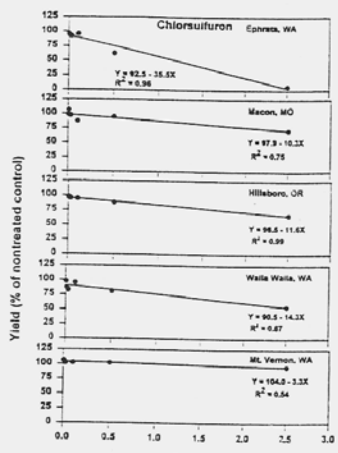

Figure 4. Dry pea yields as affected by chlorsulfuron applied preplanting in 1996.

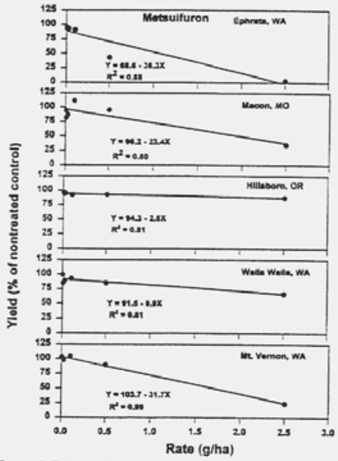

Figure 5. Dry pea yields as affected by metsulfuron applied preplanting in 1996.

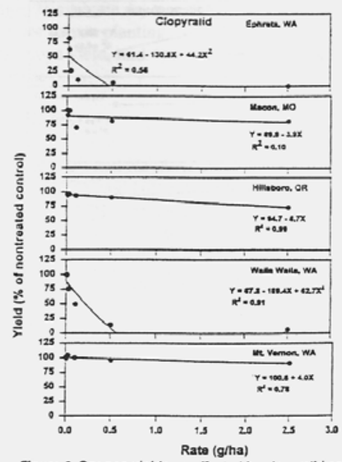

Figure 6. Dry pea yields as affected by clopyralid applied preplanting in 1996.

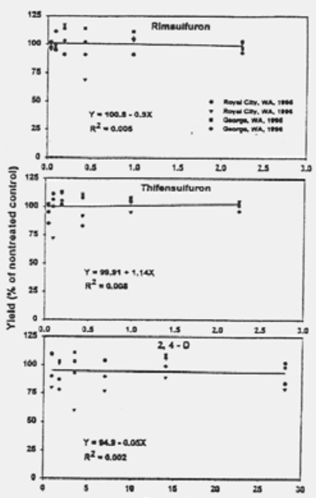

Figure 7. Grape yields as affected by herbicides applied in 1995. Grapes were harvested five months and one (1996) year after treatment

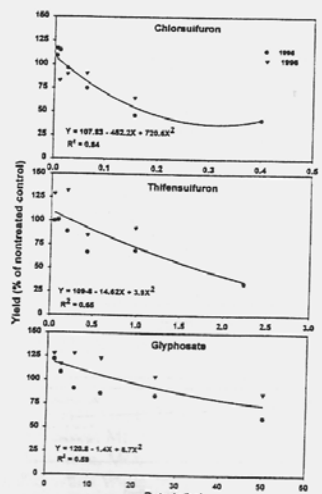

Figure 8. Cherry yields as affected by herbicides applied in 1995. Cherries were harvested 5 weeks and one (1996) year after treatment

Grape. Thifensulfuron and rimsulfuron caused slight visual injury symptoms on grape leaves in the year of treatment. 2,4-D caused from slight to severe injury symptoms on grape leaves in the year of treatment with the higher rate resulting in the most injury. None of the herbicides reduced grape yield in the year of treatment or in the year following treatment (Figure 7). The number of grape fruit clusters the year after treatment was also not affected by any of the herbicides.

CONCLUSIONS

Dry pea, grape, and cherry yields were not more sensitive to simulated drift rates of sulfonylurea herbicides than simulated drift rates of other herbicide classes. Foliar application of thifensulfuron slightly reduced yield at the highest rate in two locations, whereas chlorsulfuron and dicamba reduced yield in four locations. Yield reduction was higher with chlorsulfuron than with dicamba. The order of yield reduction in dry pea by soil-applied herbicides was clopyralid > metsulfuron > chlosulfuron. Grape and cherry yields were not more sensitive to simulated drift rates of sulfonylurea than drift from other herbicide classes.

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RESISTANCE OF COMMON SUNFLOWER TO IMAZETHAPYR. Kassim Al-Khatib, Dallas Peterson, and Neal Hoss, Assistant Professor, Associate Professor, and Lab Technician, Agronomy Department, Kansas State University, Manhattan, KS 66506.

INTRODUCTION

Common sunflower is a troublesome weed species that is spread throughout North America. This species grows in distúrbed areas such as ditches, cultivated fields, and pastures. Common sunflower, which is noncultivated, is very similar to cultivated sunflower. However, common sunflower has more morphological variability than its cultivated counterpart. Plant height and branching as well as inflorescence size can vary significantly between biotypes.

Many field crops including corn, soybean, wheat, and sugarbeet, are often infested by common sunflower in the Midwest. Common sunflower competes strongly with crops for water, nutrients, light, and carbon dioxide, reducing yield and quality. Soybean yields were reduced by 19% and 95% when infested with 0.3 and 4.6 sunflower plants/m^2, respectively (1). In sugarbeet, yield was reduced 70% by 1.5 sunflower plants/m^2. Common sunflower was five times more competitive than velvetleaf. The increased competitiveness was attributed to greater early season vigor, height, and leaf area of common sunflower (2).

Managing common sunflower in soybean and corn is difficult because the plants are warm season annuals and have similar ecological requirements. Before the introduction of acetolactate synthase (ALS) inhibitor herbicides, control of sunflower in soybean and corn was difficult and labor intensive. However, good control has been achieved in the past with ALS inhibitor herbicides such as imazethapyr, imazaquin, chlorimuron, thifensulfuron, and primisulfuron. As a result of its success, ALS inhibitor herbicides have been used extensively over large areas of Kansas. However, growers in northeast Kansas have recently experienced difficulty in controlling common sunflower in soybean with imazethapyr. Those growers have been using imazethapyr continuously for several years, and sunflower appeared to have developed resistance to the herbicide.

The objectives of this study were to determine if common sunflower biotypes had developed resistance to imazethapyr and to evaluate cross-resistance of imazethapyr-resistant common sunflower to other ALS inhibitor herbicides.

MATERIALS AND METHODS

Seed sources. Seed heads of imazethapyr-susceptible common sunflower were collected in the fall of 1996 from the Konza Prairie, a natural habitat near Manhattan, KS where no herbicides were applied in the last 25 years. Seed heads also were collected from a site of suspected imazethapyr resistance west of Rossville, KS which has a 7 year history of imazethapyr use (Table 1).

Table 1. History of soybean field from which common sunflower seeds were collected.

Year	Crop	Herbicide use
1990	Soybean	Alachlor (s)[a] + imazethapyr (f)
1991	Soybean	Alachlor (s) + imazethapyr (f)
1992	Soybean	Imazethapyr (f)
1993	Soybean	Imazethapyr (f)
1994	Soybean	Imazethapyr (f)
1995	Soybean	Alachlor (s) + Trifluralin (s) + imazethapyr (f)
1995	Soybean	Alachlor (s) + Trifluralin (s) + imazethapyr (f)

[a]'s' = soil applied and 'f' = foliar applied.

Common sunflower seeds were clipped and vacuum infiltrated for 15 min with a solution of 2 μM gibberellic acid. Seeds were planted in 11-cm-diameter plastic pots containing 0.5 kg soil. Plants were grown in the greenhouse at 26/23 C (day/night) with a 16 h photoperiod.

Plant response. Plants were sprayed at the 3-leaf stage with 0, 0.25X, 0.5X, 1X, 2X, 4X, 8X, 16X and 32X of the normal use rate of imazethapyr, imazamox, chlorimuron, and thifensulfuron. Herbicide use rates were 69.9, 43.7, 10.5, and 4.4 g/ha for imazethapyr, imazamox, chlorimuron, and thifensulfuron, respectively. Herbicides were applied with a bench-type sprayer calibrated to deliver 187 L/ha at 138 kPa. Herbicides were applied with 0.25% (v/v) non-ionic surfactant (NIS). The nontreated control was treated with water and NIS.

Two weeks after herbicide application, visible plant injury ratings were determined and plants were harvested. Plants were dried at 72 C for 48 h. A dose response curve was established by plotting use rate vs. plant injury and dry weight. The rate required to cause 25% visible injury and dry weight was determined (3). The experiments were a completely randomized design including five replications, and were repeated twice.

RESULTS

Imazethapyr resistance. Growth of susceptible biotype of common sunflower was reduced by imazethapyr at 0.25X of the use rate whereas the resistant biotype survived 32X of the use rate. The imazethapyr rates required to cause 25% visible injury (GR_{25}) were 3.6 and 753 g/ha for susceptible and resistant biotypes, respectively (Figure 1). Common sunflower dry weight reduction by imazethapyr showed similar trends to visible injury (data not shown).

Cross resistance. Imazethapyr resistant common sunflower biotype was also resistant to imazamox. The GR_{25} values for visible injury were 4.1 and 1236 g/ha for susceptible and resistant biotypes, respectively (Figure 2). However, the imazethapyr resistance biotype was slightly resistant to chlorimuron and thifensulfuron. The GR_{25} values for visible injury were 0.48 and 1.54 g/ha for thifensulfuron and chlorimuron in susceptible biotype and 1.30 and 1.7 g/ha for thifensulfuron and chlorimuron in resistant biotype (Figure 3 and 4). Again, dry weight reduction by herbicides showed similar trends to visible injury (data not shown).

CONCLUSIONS

The common sunflower biotype collected from a field with a history of imazethapyr use is resistant to imazethapyr. In addition, this biotype is also resistant to imazamox. The ratio of GR_{25} of resistant to susceptible biotype were 211 and 301 for imazethapyr and imazamox, respectively. However, this biotype showed slight resistance to chlorimuron and thifensulfuron. The ratios of GR_{25} of resistant to susceptible biotype were 1.1 and 2.1 for chlorimuron and thifensulfuron, respectively.

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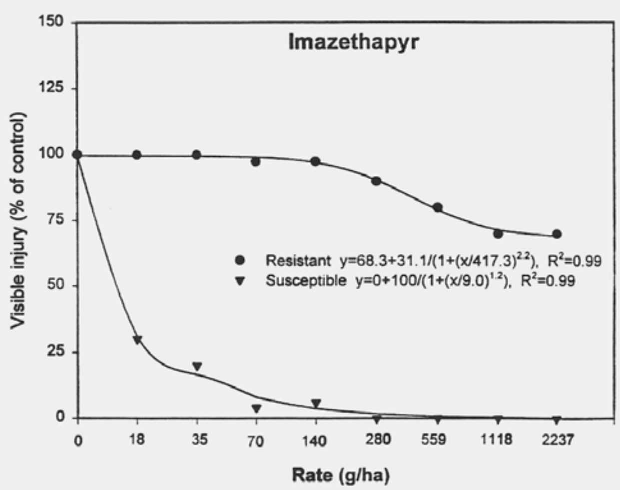

Figure 1. Visible injury of two common sunflower biotypes as affected by imazethapyr.

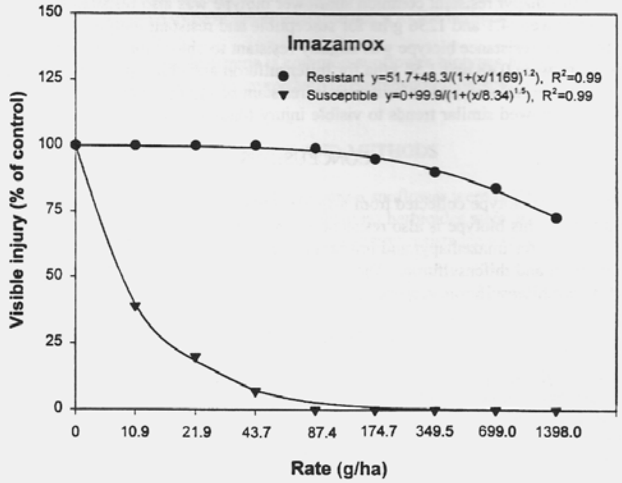

Figure 2. Visible injury of two common sunflower biotypes as affected by imazamox.

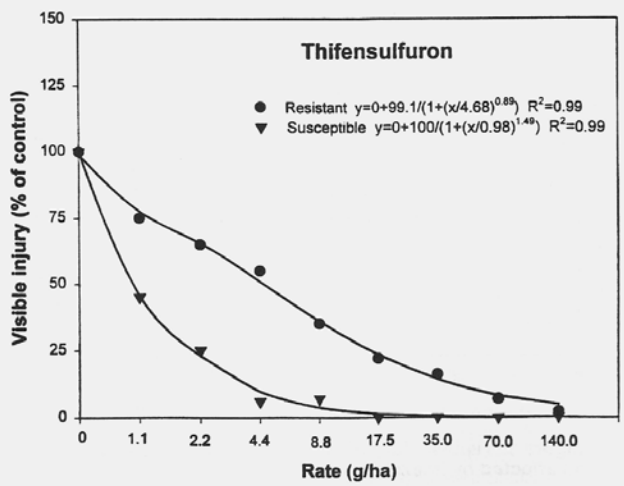

Figure 3. Visible injury of two common sunflower biotypes as affected by thifensulfuron.

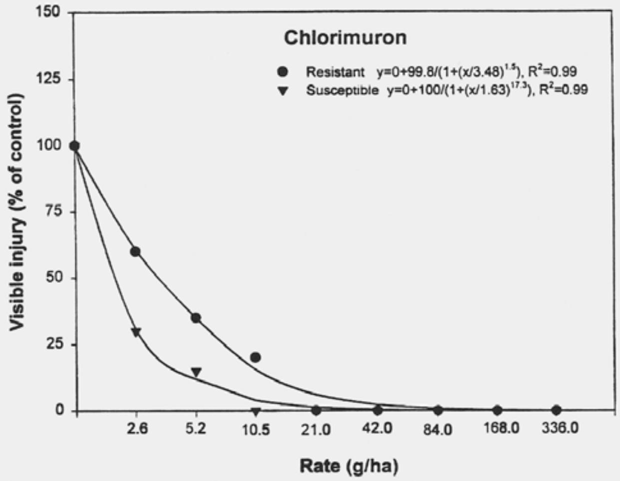

Figure 4. Visible injury of two common sunflower biotypes as affected by chlorimuron.

SUPPRESSING LEAFY SPURGE INFESTATIONS IN NATIVE PRAIRIE SITES INCORPORATING GEOGRAPHIC INFORMATION SYSTEMS AND INTEGRATED PEST MANAGEMENT STRATEGIES. Roger J. Andrascik, Steven R. Hager, and Paula J. Andersen, Resource Management Specialist, Geographic Information Systems Specialist, and Biological Science Technician, Theodore Roosevelt National Park, Medora, ND 58645.

Abstract. Leafy spurge is a troublesome invasion nonnative plant on the northern Great Plains of the United States. Current research shows that leafy spurge is a serious invader into the Theodore Roosevelt National Park (South Unit). This aggressive invasion has displaced many native plant species. In addition to destroying the rich species diversity unique to the badlands, significant ecological impacts have resulted. Infestations within the park have grown from 13 ha in 1972 to an estimated 728 to 1,700 ha. Intensive management is required to reduce and contain these infestations while comprehensive and integrated approaches are needed to restore the habitat. Geographic Information Systems (GIS) technology has been utilized to map and develop various types of Integrated Pest Management (IPM) control techniques for the park. Leafy spurge is managed on a watershed sub-basin level. IPM approaches including herbicide treatment and various biological control agents are used to suppress infestations and restore native habitat.

ANNUAL GRASS AND BROADLEAF WEED CONTROL IN DRY BEANS WITH DIMETHENAMID APPLIED POSTEMERGENCE AT THE 1ST, 3RD, AND 6TH TRIFOLIOLATE LEAF STAGE APPLIED BEFORE OR AFTER CULTIVATION. R. N. Arnold, E. J. Gregory, and D. Smeal, Pest Management Specialist, Professor, and Agriculture 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 bean growers usually preplant incorporate one or

two herbicides in combination and then follow with one mechanical cultivation for annual weed control. Weeds compete vigorously with dry beans and yield reductions exceeding 70% have been recorded. A field experiment was conducted in 1996 at Farmington, NM to evaluate the response of pinto beans (var. Bill Z) and annual grass and broadleaf weeds to dimethenamid applied postemergence at the 1st, 3rd, and 6th trifoliolate leaf stage and applied before or after cultivation. Individual treatments were applied with a compressed air backpack sprayer calibrated to deliver 30 gpa at 30 psi. Ethalfluralin was applied preplant incorporated over all plots on May 22 at 0.75 lb/A. Dimethenamid was applied postemergence at the 1st, 3rd, and 6th trifoliolate leaf stage on June 12, June 27 and July 8. Visual evaluations of crop injury and weed control were July 29 for the 1st and 3rd trifoliolate leaf stage treatments and August 6 for the 6th trifoliolate leaf stage treatments. No crop injury was observed in any of the treatments, All treatments gave good to excellent control of both grasses and broadleaf weeds. A trend was noticed that applying dimethenamid postemergence at either the 1st, 3rd, and 6th trifoliolate leaf stage after cultivation resulted in approximately a 2 to 7% increase in black nighthshade control. Yields were 1630 to 3060 lb/A higher in herbicide treated plots than the check.

BROOM SNAKEWEED SEEDLING ESTABLISHMENT AND SURVIVAL IN THE CHIHUAHUAN DESERT OF NEW MEXICO. Barbara L. Barnett and Kirk C. McDaniel, Research Assistant and Professor, Department of Animal and Range Sciences, New Mexico State University, Las Cruces, NM 88003.

Abstract. Above average precipitation (1.5 times above normal of 6.2 cm) on the Chihuahuan Desert Rangeland Research Center (CDRRC) from November 1994 to February 1995 provided excellent conditions for broom snakeweed germination. From March 1995 to May 1996, precipitation was drastically reduced (65% below normal), providing an opportunity to study broom snakeweed seedling survival under drought conditions. Vegetation on the CDRRC is typical of the northern Chihuahuan desert with black grama considered to be an indicator of a high seral stage, and mesquite/mesa dropseed indicative of low seral communities. Drought and livestock grazing are generally noted as major reasons for loss of black grama and increases in low seral plants, such as broom snakeweed, in this ecosystem.

In early June 1995, study locations were established in grazed and non-grazed (exclosure) areas within four seral stages of Chihuahuan desert vegetation. The four stages were named by the dominant plant in each layer and included black grama grassland (BGG), mesa dropseed grassland (MDG), black grama-mesquite mixed (BGM), and mesa dropseed-mesquite mixed (MDM).

At each site, four 100 m parallel transect lines were established and the broom snakeweed parent plant nearest to each 10 m mark was selected for a total of 40 plants per site. Each parent was flagged and a 2 m diameter circular frame was centered over the canopy. One axis of the frame was marked to facilitate replacement through time. The number of broom snakeweed seedlings in each frame was counted and marked on a pantograph to determine direction and distance from the parent plant. In October 1995, and again in June 1996, seedling survival was determined by replacing the frame and marking the location of the survivors on the pantographs. Density and cover of associated plants within the frames were also recorded.

Aerial herbage cover was less than 15% on all sites, whereas bareground comprised 80% and litter up to 15% of the total ground cover. When broom snakeweed seedling counts began in June 1995, the grazed sites averaged 10.9 seedlings/m^2 and non-grazed sites averaged 5.1 seedlings/m^2, irrespective of vegetation type (Table). While there were significant differences in the number of seedlings counted within different vegetation types, there was no clear pattern indicating an affinity for establishment. The highest number of seedlings were recorded in the grazed BGM (19.3 seedlings/m^2) and the lowest number were counted in the non-grazed BGG (0.7 seedling/m^2).

All parent plants and the majority of broom snakeweed seedlings (80%) died during the 1995 summer growing season, probably because of drought. Approximately 30% of seedlings surviving through the summer died the next winter. Thus by June 1996, the number of new broom snakeweed plants on each study site was roughly equivalent to the original 1995 parent plant population (Table).

Table. Number of broom snakeweed seedlings associated with the parent plants on the Chihuahuan Desert Research Center, Las Cruces, NM.

Grazing treatment	Vegetation type[a]	Parent plants June 95	Seedlings around parent plants[b] June 95	October 95	June 96
		(no./m^2)			
Grazed	BGG	0.1	13.2^{b}	0.5^{c}	0.4^{c}
	BGM	0.8	19.3^{a}	6.3^{a}	4.0^{a}
	MDG	2.1	$8.9^{b,c}$	3.4^{b}	2.7^{b}
	MDM	3.0	2.3^{d}	1.0^{c}	1.6^{c}
	Overall	1.7	10.9^{1}	2.8^{1}	2.2^{1}
Non-grazed	BGG	0.2	0.7^{d}	0.2^{c}	0.1^{c}
	BGM	0.8	7.4^{c}	0.9^{c}	0.6^{c}
	MDG	3.4	7.9^{c}	1.5^{c}	0.9^{c}
	MDM	2.5	$4.5^{c,d}$	1.0^{c}	0.8^{c}
	Overall	1.4	5.1^{2}	0.9^{2}	0.4^{2}

[a]BGG=black grama grassland; MDG=mesa dropseed grassland; BGM=black grama-mesquite mixed; MDM=mesa dropseed-mesquite mixed.
[b]Means in the same column followed by the same letter or number are not significantly different at $\alpha = 0.05$.

THE EFFECTS OF *WALSHIA MISCECOLORELLA* FEEDING ON SWAINSONINE CONCENTRATIONS IN SILKY CRAZYWEED. M. C. Campanella, T. M. Sterling, and D. A. Thompson, Undergraduate Student and Associate Professors, Department of Entomology, Plant Pathology and Weed Science, New Mexico State University, Las Cruces, NM 88003.

Abstract. Locoweeds are known to cause a chronic neurological disease in livestock. This disease, called locoism, is thought to be induced by the indolizidine alkaloid, swainsonine. Symptoms of locoism in livestock include a desire to consume only locoweed, an impairment of the nervous system, and higher abortion rates. Silky crazyweed is a common species of locoweed growing on rangelands across the western United States and is the most abundant and destructive locoweed in New Mexico. Because of the weed's toxic effects to livestock, methods to control locoweed, including biological control, are being tested. Caterpillars of the small moth, *Walshia miscecolorella* are native to New Mexico and feed on the roots of silky crazyweed. Because plant stress can alter levels of secondary plant products such as alkaloids in plants, the effect of caterpillar feeding on the level of swainsonine production was measured. If caterpillar feeding increases swainsonine levels, making the plants more toxic to cattle, the potential for biological control of these weeds would be reduced. Ten plants infested by caterpillars and 10 plants of similar size free of caterpillars were collected from five sites in New Mexico. Leaf samples were ground using a wiley mill to pass through a 20 mesh screen. Swainsonine was extracted from leaf tissue using methanol in a Soxhlet extraction. Swainsonine concentrations were then determined using an ∝-mannosidase assay. Swainsonine standards with concentrations ranging from 125 to 8000 ng/ml were prepared and tested along with the sample dilutions. Forty µl of extract were placed in a multi-well plate with 95 µl of 1 mM p-nitrophenyl-∝-D-mannopyranoside and 20 µl of the enzyme

∝-D-mannosidase (210 units) mixed with 5 ml of 0.2 M acetate buffer (pH=4.5). The plate was incubated for 30 minutes at 39 C, followed by the addition of 100 µl of 0.25 M glycine buffer (pH=10.6) to stop the reaction. The amount of swainsonine was then determined using a microplate reader which read the absorbance of the mixtures at 405 nm. A two-way ANOVA was used to compare swainsonine concentrations. There was no interaction between sites and caterpillars. However, a positive correlation between higher swainsonine concentrations and plants with caterpillars was found. Also, there were differences between collection sites. The higher swainsonine concentrations in plants with caterpillars could be a response to wounding from the caterpillars. Further tests are necessary to determine if caterpillars are inducing higher swainsonine concentrations.

WEED CONTROL IN SUGARBEETS WITH DIMETHENAMID AND COMBINATIONS. Robert W. Downard and Don W. Morishita, Support Scientist and Associate Professor, Department of Plant, Soil and Entomological Sciences, University of Idaho, Twin Falls, ID 83303.

Abstract. Sugarbeets require good weed control through the season to optimize yields. This may be accomplished through three or four herbicide applications prior to and during the growing season. They may be applied all postemergence or as a combination of preplant incorporated or preemergence and postemergence applications. There is a need to reduce the number of applications for economic and environmental reasons. Dimethenamid a new herbicide has been tested previously in sugarbeets as a preplant incorporated and preemergence treatment and has reduced stands. In another field experiment, it was tested as a postemergence treatment to determine crop tolerance and weed control. Dimethenamid was applied alone, lay-by, and tank mixed with a premix formulation of ethofumesate, desmedipham, and phenmedipham (ethfmst&desm&phen). Weed species evaluated for control were kochia, common lambsquarters, and redroot pigweed. Field trials were conducted in 1995 and 1996 at the University of Idaho Research and Extension Center, near Kimberly, ID. Individual plots were 4 rows by 30 feet arranged in a randomized complete block design with four replications. Herbicides were applied in a 10 inch band with a bicycle-wheel sprayer at 20 gpa, 3 mph, and 38 psi. Herbicides were applied at the sugarbeet cotyledon, 1- to 2-leaf, 3- to 4-leaf growth stage, and lay-by. The lay-by application was incorporated with 0.5 inches of water through sprinkler irrigation. In 1995 ethfmst&desm&phen at 0.33 lb/A applied at the cotyledon growth stage and followed 7 days later by ethfmst&desm&phen at 0.33 lb/A plus dimethenamid at 1.17 lb/A severely injured the crop. This early crop injury did not reduce yields partially due to low weed densities and excellent growing conditions in 1995. The severe injury from this treatment in 1995 was not seen in 1996. Ethfmst&desm&phen at 0.33 lb/A applied at the cotyledon growth stage followed by ethfmst&desm&phen at 0.33 lb/A plus dimethenamid at 1.17 lb/A 7 days later had good weed control and root yields both years. Sugarbeet root yields were not different among herbicide treatments. Good weed control and high sugarbeet root yields were accomplished by two postemergence herbicide applications when dimethenamid was added to the last application.

BRASSICA GREEN MANURE SYSTEMS FOR WEED, DISEASE, AND NEMATODE CONTROL IN POTATOES. Charlotte V. Eberlein[1], Rick Boydston[2], Kassim Al-Khatib[3], James R. Davis[1], Mary J. Guttieri[1], Gerald S. Santo[4], and William Pan[5], Professor, Plant Physiologist, Associate Professor, Professor, Support Scientist, Professor, and Associate Professor, [1]Department of Plant, Soil, and Entomological Sciences, University of Idaho, Aberdeen, ID 83210; [2]USDA/ARS, Prosser, WA 99350; [3]Agronomy Department, Kansas State University, Manhattan, KS 66506; [4]Plant Pathology Department, Washington State University, Prosser, WA 99350; and [5]Crop and Soil Sciences Department, Washington State University, Pullman, WA 98164.

Abstract. Alternative pest control practices are needed to convert potato production from a high-input, synthetic chemical-based system to a lower input system. Brassica green manures have shown potential for providing biological control of several common potato pest problems, including soil borne diseases, nematodes, and weeds.

Brassica species contain glucosinolates, sulfur containing compounds that are enzymatically hydrolyzed to toxic compounds when plant cells are disrupted. Degradation products include isothiocyanates, thiocyanates, and nitriles, some of which have allelopathic, fungicidal, and/or nematicidal properties. Multidisciplinary studies to evaluate pest control in a *Brassica* green manure system were conducted at Aberdeen, ID, Prosser, WA, and Mt. Vernon, WA. Three pest management systems were compared in a split plot design at each location. Main plots were low, medium or high pest control input levels, and subplots were green manure treatments: no green manure, *Brassica napus*, or *Brassica hirta*. Low input plots received no additional nematode, weed, or soil-borne disease treatment, medium input plots received a low rate, postemergence application of rimsulfuron plus metribuzin for weed control; and high input plots received a spring fumigation treatment for nematode and soil-borne disease control and a standard, full rate, preemergence rimsulfuron plus metribuzin application.

Weed response to green manure incorporation varied by location. At Mt. Vernon there was no effect of green manure treatments on weed populations or late season weed biomass. At Aberdeen, early season weed densities were similar for all low input treatments, but late season hairy nightshade biomass was reduced 87% in both *Brassica* treatments compared to the no green manure control. At Prosser, early season redroot pigweed and hairy nightshade densities were lower in *B. napus* plots than in the no green manure weedy control. Late season common lambsquarters biomass was reduced 83% by *B. napus* incorporation compared to the no green manure control.

At all three locations, weed control with the combination of an incorporated green manure plus a low rate, postemergence application of rimsulfuron plus metribuzin was equal to the high input, standard practice treatment. There were no differences in U.S. No. 1 yields among low, medium, or high input treatments at Prosser, but at Aberdeen and Mt. Vernon U.S. No. 1 yields were higher in the high input treatment than in the low input treatment.

There were no differences in U.S. No. 1 yield among green manure subplot treatments at Prosser or Mt. Vernon, but U.S. No. 1 yields were 43% lower in the *B. napus* green manure treatment than in other treatments at Aberdeen. N released after incorporation of the *B. napus* green manure substantially delayed tuber initiation, which resulted in lower U.S. No. 1 yields. Tuber initiation also was delayed in *B. napus* plots at Prosser, but final yield was not affected. Prosser has a longer growing season than Aberdeen, with more time for recovery from delayed tuber initiation.

PROSPECTS AND CHALLENGES FOR GOATSRUE ERADICATION. John O. Evans, Caleb D. Dalley, and Matt R. Larson, Professor, Graduate Research Assistant, and Research Technician, Plants, Soils, and Biometeorology Department, Utah State University, Logan, UT 84322-4820.

Abstract. Goatsrue (*Galega officinalis L.*), a noxious and toxic plant species, was targeted for eradication nationally through a program funded by USDA/APHIS starting in 1981. Herbarium surveys discovered specimens dated from 1890 to 1960 for locations in 10 continental states and the District of Columbia. It is an introduced esoteric plant brought into the US about a century ago as a potential forage plant. Native to central and southern Europe and western Asia, goatsrue was considered to be of considerable promise as a forage and green manure crop and it may have been used for religious, medicinal and ornamental purposes.

Goatsrue is an aggressive weed that infests cropland, pastures, wetlands, and waterways and, undisturbed, will spread throughout the intermountain region causing agricultural, wildlife, aesthetic, and recreational losses. It is highly toxic to livestock, wildlife, game birds and perhaps humans. Dense infestations of goatsrue form monocultures crowding out native plants used by animal and wild fowl for food and nesting habitats. Geese, ducks and wetland animals will not inhabit areas infested with this species because their preferred plants disappear and it is fatal if inadvertently ingested or if they are forced to consume it.

The current eradication program is highly successful and scheduled to be completed within 5 years. Principle obstacles at this point include, severe curtailment of federal support funds for goatsrue, a potential for land managers within the goatsrue infestation to direct attention towards other goals, and massive reproductive crowns of some plants that are particularly difficult to kill. An enormous depletion of the goatsrue population has occurred during the past dozen years of eradication effort. About 95% of the original weed population has been removed, but goatsrue seed reserves provide seedling populations annually throughout most of the original infested area. Crop rotation, tillage, mowing, digging, and chemicals are employed in an integrated approach to eliminate goatsrue. If seedpods are formed before control methods occur, they are hand clipped to prevent further development and viable propagules are incinerated.

THE DISSEMINATION OF WEED SEED BY SURFACE IRRIGATION WATERS. C. Fiore and J. Schroeder, Undergraduate Student and Associate Professor, Department of Entomology, Plant Pathology, and Weed Science, New Mexico State University, Las Cruces, NM 88003.

Abstract. Elephant Butte Irrigation District (EBID) maintains a 960 kilometer, gravity-flow irrigation network of earthen canals, laterals and drains. Canal banks support growth of many weed species, controlling bank-side erosion. EBID controls weeds with a mowing and herbicide program. Mowing along the canals is on about a 6-week rotation. Herbicides are limited to spot treatments on areas inaccessible to the mowers or distant from canals. Locally, growers believe that the weeds growing along the canals cause increased weed problems in the field. The study objectives were to examine this assumption by collecting data over the 1996 growing season to determine if weeds on canal banks correlated with: a) weeds germinated from cropland soil samples; b) seeds from canals; c) weeds in cropland fields and d) weeds growing along canals.

The study comprised two cotton fields in Doña Ana County, New Mexico. Field soils were classified as a Harkey medium loam at the RJT Field and an Anapra silt loam at the S Field. Soil samples were obtained with an 816 cm^3 soil auger on February 23, 1996 prior to planting, post-irrigation on March 31 and post-growing season on October 6. Four core samples were obtained from the area around each irrigation gate into the fields. The samples from two gates (eight cores) were placed in 34 by 50 cm or 22 by 32 cm trays lined with paper towels. The trays were placed in a greenhouse under natural lighting at 22 to 28 C air temperature. Weed seedlings were identified, counted, and removed. Soil samples were kept moist until seedling emergence ceased. The soils were air dried, mixed and remoistened two times until emergence ceased. Irrigation samples were taken with seed traps at the surface, middle and bottom strata of the canal water. The irrigation samples were taken from canals directly maintaining each field or from larger canals providing water to the field irrigation systems. The samples were placed in sterile potting media in 15 cm pots. The emerging plants were identified and counted. Weeds along the canal banks were identified in the flowering stage. We also sampled August 22, 1996 to test the effectiveness of the seed traps. A junglerice-infested canal was sampled as above during irrigations by well and by EBID. Mulch cloth (1 m by 1.5 m) was placed in front of a field irrigation gate. After the irrigation, the material was collected and seeds counted.

The cropland soil samples yielded 18 monocot and 10 dicot species. Carolina lovegrass was the most abundant monocot to germinate; Palmer amaranth the most abundant dicot. This did not reflect the densities of these species found on the canal banks. The seed germination was very low from irrigation samples, with no germination from most of the samples. The few seeds that did germinate were not the same as predominant species found in the fields or along the canal banks. Weed germination from irrigation samples may have been influenced by seed dormancy. Weeds in the cropland fields were controlled by herbicides and cultivation which may have contributed to the low correlation. Palmer amaranth, London rocket, spurred anoda and barnyardgrass were the most common species identified in the fields. Weed species growing along the canals were more diverse than the species in the fields. At the Rincon test site all of the collection traps collected a large number of the junglerice seeds yet only 23 of 837 seeds germinated in the greenhouse.

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

Abstract. Alfalfa is New Mexico's leading cash crop, accounting for approximately 20% of the state's crop income. Weeds compete vigorously with spring-seeded alfalfa for light, nutrients, and moisture. Some weeds, when harvested with alfalfa, may reduce quality. Hay quality, particularly protein content, is an important consideration in feed rations in some markets, such as the dairy and horse racing industries. A field experiment was conducted in 1996 at Farmington, NM to evaluate the response of alfalfa (var. Champ) and annual broadleaf weeds to postemergence applications of AC 299,263 and imazethapyr. All treatments except EPTC, were applied postemergence with SUN-IT II at 1 qt/A when alfalfa was in the second trifoliolate leaf stage and weeds were small. AC 299,263 applied at 0.12 lb/A caused significantly more injury (stunting only) than any other treatment. Black nightshade, redroot and prostrate pigweed control were excellent (>97%) with all treatments except the check. The check plot yielded significantly more tons per acre than any other treatment. This is possibly attributed to the high weed content when harvested. All treatments had a significantly higher protein content than the check.

INTERNATIONAL SURVEY OF HERBICIDE-RESISTANT WEEDS. Ian M. Heap, WeedSmart, P. O. Box 1365, Corvallis, OR 97339.

INTRODUCTION

The utility of herbicides is being threatened by the appearance of herbicide-resistant weeds. The purpose of the "International Survey of Herbicide-Resistant Weeds" is to monitor the evolution of herbicide-resistant weeds and assess their economic impact throughout the world. In 1995 and 1996, surveys were sent to weed research and extension specialists around the world, and to date over 340 survey forms have been returned. Survey questions were aimed at identifying resistant weed species and the herbicide involved, the location and year that resistance was first identified, the crop or vegetation management situation, the number of sites and area infested, the economic impact of resistance, and how resistance was confirmed. Resistant weeds are not recorded in this survey if respondents did not indicate that a side by side comparison of resistant and susceptible plants of the same species was used to confirm resistance. Results of the survey are briefly summarized in this paper. For a full and current list of herbicide-resistant weeds, please refer to the "International Survey of Herbicide-Resistant Weeds" web site at http://www.pioneer.net/~heapian/, or contact the author for a booklet of herbicide-resistant weeds. If you can improve the quality of data in the survey or you know of new cases of resistant weeds please contact the author.

CONFIRMED CASES OF HERBICIDE RESISTANT WEEDS WORLDWIDE

There are currently 183 unique herbicide-resistant weed biotypes (Table 1). The discovery of triazine-resistant common groundsel by Ryan (1970) is often cited as the first case of herbicide resistance. However a few weeds had evolved resistance to 2,4-D prior to 1968. Hilton (1957) had identified populations of spreading dayflower resistant to 2,4-D after repeated use of 2,4-D in Hawaiian sugar cane fields. One population of spreading dayflower was over 5 times more resistant to 2,4-D when compared to a susceptible population. Also, in 1957 populations of wild carrot had evolved 2,4-D resistance on sections of Canadian highway rights-of-way regularly treated with 2,4-D (Switzer, 1957; Whitehead and Switzer, 1963). Weed scientists became interested in the phenomena of triazine resistance in the 1970's and there was a large (and sustained) increase in the number of new resistant weed biotypes reported in the late 1970's.

Since 1978, the number of new cases of herbicide-resistant weeds has increased at a relatively constant rate, averaging 9/year (Figure 1). In the 1970s and early 1980s triazine-resistant weeds accounted for approximately 70% of all herbicide-resistant weed biotypes. This proportion changed as other herbicide modes of action were brought to market in the late 1970s and early 1980s. There are 61 weed species that have evolved resistance to triazine herbicides, approximately one third of the total number of all herbicide-resistant weed biotypes. The majority of triazine-resistant weeds have been identified in corn production in North America or Europe, or in orchards in Europe. The most commonly reported triazine-resistant weeds are common lambsquarters (16 countries) and redroot pigweed (10 countries).

Weeds have rapidly evolved resistance to herbicides that inhibit the enzyme acetolactate synthase (ALS inhibitors) and the enzyme acetyl-coenzyme A carboxylase (ACCase inhibitors). Because of the widespread usage and ease that weeds evolve resistance to ALS inhibitors, weed species are evolving resistance to ALS inhibitors at a greater rate than for any other herbicide mode of action.

Thirty-three weed species have evolved resistance to ALS inhibitors in a total of 11 countries (Table 1). Worldwide ALS inhibitor resistant weeds are problematic in cereals, corn/soybean rotations, rice, highway rights-of-way, and forestry. Of particular concern in the Pacific Northwest are ALS inhibitor-resistant populations of kochia, Russian thistle, and prickly lettuce. ACCase inhibitor-resistant grasses threaten cereal production throughout the world. ACCase inhibitor-resistant *Alopecurus*, *Avena*, *Lolium*, *Phalaris*, or *Setaria* species have appeared in Australia, Canada, Chile, France, Mexico, South Africa, Spain, the United Kingdom, and the United States. The large areas infested with rigid ryegrass in Australia, and wild oat in Australia, Canada, and the USA make ACCase inhibitor-resistant weeds a serious economic problem.

Although 27 weed species have evolved resistance to bypyridil herbicides, and 14 weed species have evolved resistance to synthetic auxins, the situations, area infested, and availability of alternative herbicides have kept their impact minimal. Isoproturon-resistant little seed canary-grass from wheat fields in India, and chlortoluron-resistant *Alopecurus japoniens* from wheat fields in China have the potential to seriously affect food production in these developing countries.

The most challenging and least predictable resistant weeds are black-grass from the United Kingdom and rigid ryegrass from Australia because these weed biotypes the ability to resist numerous unrelated herbicide chemistries as a result of enhanced herbicide metabolism. The recent discovery of glyphosate-resistant rigid ryegrass from Australia confirms that weeds are capable of evolving resistance to glyphosate. This is a timely reminder for farmers in the Mid-west to avoid using glyphosate on glyphosate resistant crops year after year, without utilizing other herbicide modes of action or weed control strategies. Despite a long history of extensive use of glyphosate only rigid ryegrass has evolved glyphosate resistance. Glyphosate is considered a "low risk for resistance" herbicide and glyphosate resistant crops will be an effective tool to manage herbicide-resistant weeds if used in conjunction with other herbicides and weed control strategies.

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Table 1. Occurrence of resistant-weed biotypes to different herbicide groups.

Herbicide group	WSSA[a] Code	HRAC[b] Code	Example	Resistant weed biotypes Dicots	Monocots	Total	Number of countries
ACCase inhibitors	1	A	Diclofop-methyl	0	13	13	11
ALS inhibitors	2	B	Chlorsulfuron	26	7	33	11
Dinitroanilines	3	K1	Trifluralin	1	5	6	4
Synthetic auxins	4	O	2,4-D	12	2	14	11
Triazines	5	C1	Atrazine	43	18	61	20
Nitriles	6	C3	Bromoxynil	1	0	1	1
Phenylurea/amides	7	C2	Chlortoluron	5	11	16	13
Thiocarbamates	8	N	Triallate	0	2	2	3
Glycines	9	G	Glyphosate	0	1	1	1
Triazoles	11	F3	Amitrole	1	3	4	2
PPO inhibitors	14	E	Oxyfluorfen	0	1	1	1
Chloroacetamides	15	K3	Metalochlor	0	2	2	2
Benzoflurans	16	N	Ethofumesate	0	1	1	1
Organoarsenicals	17	Z	MSMA	1	0	1	1
Bypyridiliums	22	D	Paraquat	20	7	27	12
			Total	110	73	183	

[a]Weed Science Society of America herbicide classification
[b]Herbicide Resistance Action Committee herbicide classification

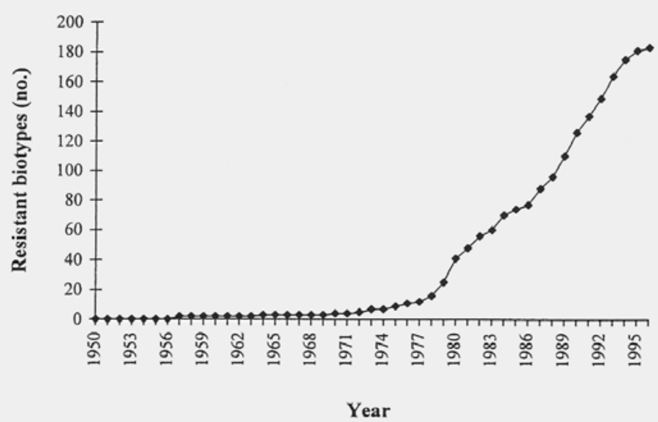

Figure 1. The chronological increase in the number of unique herbicide-resistant weed biotypes worldwide.

THE CURRENT STATUS OF CLASSICAL BIOLOGICAL CONTROL EFFORTS AGAINST EXOTIC RANGELAND WEED PESTS IN WYOMING.
David J. Kazmer, Kiana Rogers, John L. Baker, and Tim McNary, Assistant Professor, Wyoming CAPS Program, Department of Plant, Soil, and Insect Science, University of Wyoming, Laramie, WY 82071; Supervisor, Fremont County Weed and Pest, Lander, WY 82520; and Quarantine Officer, USDA/APHIS/PPQ, Cheyenne, WY 82001.

Abstract. Since 1975, 30 natural enemy species have been released in Wyoming for the control of exotic rangeland weeds. Twenty seven of these species are now established in one or more counties. Local land managers representing private, county, state, and federal agencies are active in the Wyoming biological control program. In 1996 alone, local land managers released or redistributed over 3.8 million insect natural enemies representing 28 species against 11 target weeds. Innovative techniques used to facilitate redistribution efforts include the use of prison inmates to harvest insects from field insectories and helicopter release to access large tracts of inaccessible terrain. Qualitative observations suggest that released natural enemies are having significant impacts on musk thistle and leafy spurge.

ALTERNATIVE SEEDING DATES WITH HERBICIDE TOLERANT(HT) CANOLA.
Kenneth J. Kirkland and Eric N. Johnson, Weed Scientist and Extension Specialist, Agriculture and Agri-Food Canada, Scott, Saskatchewan, Canada, S0K 4A0.

Abstract. Spring canola is the most important oilseed crop produced on the Canadian prairies with 4 to 5 million ha grown annually. Traditional seeding dates vary by region but generally occur in the mid-late May period. With the short growing season experienced over much of the region fall frost injury and the associated reductions in yield and quality is a concern to growers. Earlier reports (Austenson and Kirkland 1975) indicated that seeding spring canola in late October to lie dormant over winter could successfully extend the growing season. They also reported that winter annual weeds were both abundant and highly competitive making this seeding date impractical. The introduction of herbicide tolerant canola and the associated herbicides which effectively control a range of weeds including winter annuals could make the late October seeding of spring canola possible.

The objective of this study (1994 to 1996) was to compare the effect of late (LF), early spring (ES) and mid-May (mM) seeding dates on maturity, yield and quality of glyphosate tolerant canola. Canola seeded in late-October emerged in late-April and demonstrated excellent tolerance to spring frosts. Glyphosate applied at 440 g/ha at the 3- to 4-leaf stage of the canola provided excellent control of winter annual and early germinating summer annual weeds. Later germinating summer annual weeds were not competitive with fall seeded canola.

Canola seeded in late-October (FS) and late-April (ES) was harvested approximately 15 and 10 days earlier, respectively than mid-May (mM) seeded canola. Yield from LF and ES seeding was 10% greater than the mM seeding, and oil content ranged from 1% to 2% higher.

In summary, changing canola seeding date from mid-May to late October or late-April increases the crops ability to compete with weeds, advances maturity and improves quality. Other possible advantages include; the fit into direct seeding systems, soil conservation, reduced risk of insect and disease attack, utilization of June precipitation and cool temperature for seed set, improves weed management options, and spreads growers workload.

THE EFFECT OF PHENOLOGICAL STAGE ON DETECTABILITY OF YELLOW HAWKWEED AND OXEYE DAISY WITH REMOTE MULTISPECTRAL DIGITAL IMAGERY. Lawrence W. Lass and Robert H. Callihan, Support Scientist and Professor Emeritus, Department of Plant, Soil and Ent. Sciences, University of Idaho, Moscow, ID 83844-2339.

Abstract. Many upland pastures and forest meadows in the western United States contain significant infestations of yellow hawkweed and oxeye daisy. Documentation of infestations is necessary in order to plan and assess control tactics. Previous work with an airborne charge coupled device (CCD) with spectral filters indicated that flowering yellow hawkweed with at least 30% cover was detectable at 1 m resolution. A single image of a large area may not capture all plants in the flowering phase, and multiple images are costly. The objective of this research was to assess the accuracy of images recorded at different phenological stages. We compared three methods of classification: unsupervised classification of a three-principal component-analysis image, supervised classification of a three-principal component-analysis image, and supervised classification of a composited image consisting of four bands and normalized-difference nir/red band. Regardless of the classification method, images of yellow hawkweed and oxeye daisy in full bloom had lower classification error than at early bloom or post-bloom. The percent error for yellow hawkweed classification was about twice as high at post-bloom than at full bloom, but varied slightly depending on the method of classification and cover class. The ability to detect discrete colonies of yellow hawkweed was not affected by phenological stage, but the ability to measure the area of each cluster differed among stages. Less than one-third of the pixels classified as yellow hawkweed or oxeye daisy in the early-bloom image remained in the same class in the full-bloom image. About half the pixels in the full-bloom image remained in the 90 to 100% cover class at the post-bloom image. Seasonal growth of the grasses masked some yellow hawkweed and oxeye daisy plants, and accounted for differences in classification among phenological stages.

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

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

The pinto beans (Bill Z variety) were planted at a depth of 1.5 inches on July 8, 1996. On July 8 and 9, the experimental area received 0.5 inches of rainfall after PRE treatments were applied. At the unifoliate stage of growth, the number of bean plants per meter of row were counted in three sections of each of the two middle rows. Control of green foxtail (PPI experiment) and redroot pigweed and common lambsquarters (PRE experiment) was evaluated 4 and 6 weeks after planting. Plants were harvested after an early frost on September 27 and pod yields obtained. Yields for the PPI experiment were not obtained due to a heavy bindweed infestation.

Green foxtail control was 100% 4 weeks after planting in all treatments. Dimethenamid at 1.5 lb/A with 0.5 inch incorporation provided 85% foxtail control compared to less than 93% control for all the other treatments 6weeks after planting. Both chloroacetamide herbicides provided excellent (93 to 100%) control of redroot pigweed and common lambsquarters at both evaluation dates regardless of the incorporation method. Rainfall immediately after treatment application may have maximized the activity of the herbicides. The dimethenamid treatments, regardless of incorporation depth, and the surface applied metolachlor reduced plant stands in the PPI experiment. Metolachlor had no affect on plant stand in the PRE study. Dimethenamid, at both rates and 0.25 or 0.5 inch ('surface scratch' or 'aggressive') incorporation, reduced plant stands while surface applied dimethenamid only reduced stands when applied at the 2X rate. However, dry bean yield was not affected by any dimethenamid treatment. The results are contrary to what was expected. The rainfall immediately after treatment may have moved the herbicides into the soil profile decreasing the differences among incorporation treatments and increasing crop injury from surface and surface scratch treatments.

COMPARISON OF ACTIVATED CHARCOAL RATES FOR SULFOMETURON AND IMAZAPYR DEACTIVATION IN SOIL. D. W. Morishita and R. W. Downard, Associate Professor of Weed Science and Weed Science Support Scientist, University of Idaho, Twin Falls R&E Center, Twin Falls, ID 83303.

Abstract. Long residual soil-applied herbicides have been used for many years for long-term weed control in noncrop, vacant property, and industrial locations. Occasionally, situations arise where a landowner chooses to remediate an area previously treated with a soil sterilant for the purpose of establishing vegetation. When this happens activated charcoal is often recommended as a means of herbicide deactivation. Sulfometuron and imazapyr are two herbicides used for long-term weed control. Like other sulfonylurea herbicides, sulfometuron is applied at low rates; relative to other soil sterilants. Imazapyr, an imidazolinone herbicide, is applied at rates higher than sulfometuron, but lower than other commonly used soil sterilants. Most activated charcoal product labels recommend applying 112 kg/ha for each 1.12 kg/ha active ingredient applied to the soil with a minimum rate of 336 kg/ha activated charcoal. Since sulfometuron and imazapyr are applied at lower rates than other soil sterilant herbicides an experiment was conducted to determine how much activated charcoal would be needed to deactivate these herbicides. Sulfometuron and imazapyr were applied to bare ground at 0.315 and 1.12 kg/ha, respectively. Activated charcoal was applied at rates of 112, 224, 336, 448, and 560 kg/ha. Each activated charcoal rate was applied in 1 liter of water to each plot and incorporated 10 cm deep with a roto-tiller. Soil samples from each plot were collected 16 hours after the activated charcoal was incorporated and frozen immediately. Experimental design for this study was a randomized complete block with four replications. Tame oats were planted into 100 cm^2 pots filled with the soil samples. Plants were harvested when the oats in the untreated checks were beginning to tiller and dried at 60 C for 24 h. Dry shoot weight of the oats was reduced with all rates of activated charcoal used compared to the untreated check. At the two lowest activated charcoal rates, sulfometuron reduced shoot dry weight 85 to 88% while imazapyr reduced shoot dry weight about 75%. Shoot dry weight reduction at the 336 and 448 kg/ha charcoal rate was 67 to 77% for both herbicides. At the highest activated charcoal rate, dry shoot weight was reduced 53 and 60% with sulfometuron and imazapyr, respectively. The dry shoot weight of oats in this study indicate that the recommended activated charcoal rate for deactivating sulfometuron and imazapyr treated soils are far below the amount needed.

RESPONSE OF NINE COTTON CULTIVARS TO PYRITHIOBAC TREATMENT. 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 an acetolactate synthase (ALS) inhibitor that became registered in 1995 for use postemergence over-the-top (POT) on Upland cotton (*Gossypium hirsutum* L.) to control broadleaf weeds.

Upland cotton generally has excellent tolerance to pyrithiobac applied POT. However, there is evidence that Pima cotton (*G. barbadense L.*) may be more sensitive to pyrithiobac and application is not recommended on this type of cotton at this time. The objective of this research is to compare the response of nine cotton cultivars to POT-applied pyrithiobac. The cultivars include three Upland (Acala 1517-91, Acala 1517-95, TM-1), four Pima (S-6, S-7, Conquistador, 3-79), and two Sea Island (*G. barbadense*) (NMSI 1331, NMSI 1601) cottons. Seeds were pregerminated and planted in 20.3-cm-diameter pots containing a 1:1 (v/v) mixture of Belen clay loam and washed sand with a final analysis of 57:20:23 sand:silt:clay, and 1.2% organic matter. Plants were subsequently thinned to five plants per pot. Plants were maintained under greenhouse conditions, with average maximum and minimum temperatures of 35 C and 17 C, respectively. At the 2- to 4-leaf stage of growth, plants from each cultivar were treated POT with one of three rates of pyrithiobac, representing one, two, and four times the recommended rate (0.07, 0.14, or 0.29 kg/ha). One pot of each cultivar was left untreated as a control, and each treatment and control was replicated four times. Three weeks after treatment, the plants were rated visually for injury on a scale of 1 to 10 (1= no injury, 10= no survival), and the shoots and roots were harvested, dried, and weighed.

There were significant differences among cultivars in response to pyrithiobac, with no cultivar by rate interaction detected. Based on visible injury, shoot growth and root growth averaged across all application rates, there were no significant differences in response among Acala 1517-95, Pima S-6, Pima 3-79, and TM-1, and Acala 1517-91 and Acala 1517-95 showed little or no injury or growth reduction for all measured parameters. NMSI 1331 and Conquistador were among those showing the greatest injury or growth reduction, though even among these cultivars visible injury symptoms were not severe (≤ 3). The greatest average reduction in shoot growth was in Conquistador (average 31.7% reduction), which was more than all other cultivars except NMSI 1331. There was no difference in average shoot growth among the other seven cultivars. Acala 1517-91 showed more root growth, averaged across application rates, than other cultivars. There was no significant difference in average root growth among Acala 1517-95, TM-1, Pima S-6, Pima 3-79, and Conquistador, or among TM-1, Pima S-6, Pima 3-79, and Conquistador. NMSI 1331, NMSI 1601, and Pima S-7 root growth decreased most. These results indicate that there are differences in tolerance to pyrithiobac among cotton cultivars and that some, but not all, *G. barbadense* cultivars may be more sensitive to pyrithiobac application. These differences in pyrithiobac tolerance were found in the early stages of growth; however, and may not affect crop yield.

BROOM AND THREADLEAF SNAKEWEED RELATIVE SUSCEPTIBILITY TO A NATURAL INFESTATION OF THE LONG-HORNED BEETLE. R. E. Parreira, T. M. Sterling, D. A. Thompson, and L. W. Murray, Research Assistant and Associate Professors, Department of Entomology, Plant Pathology, and Weed Science, Associate Professor, Department of Experimental Statistics, New Mexico State University, Las Cruces, NM 88003.

Abstract. Broom and threadleaf snakeweed are problem rangeland weeds due to their highly competitive nature with perennial grasses and toxicity to livestock. The herbicides used to control these weeds are many times not economical for range application. Alternate methods of control are being investigated including biological control. One biological control method is to manage for increased densities of destructive stem and root borers. The long-horned, root-boring beetle *Crossidius pulchellus* Le Conte, is a solitary root borer that hollows out large portions of the snakeweed roots during its larval stage. Broom snakeweed populations were collected from eight locations in New Mexico (Des Moines, Clovis, Corona, Bayard, Tatum, Lovington, San Simon Sink, and Las Cruces). Threadleaf snakeweed was collected from one location in New Mexico (Las Cruces) and one location in Arizona (Sasabe). A common garden was established in 1992 from cuttings of these plants. The garden was designed as five replications of 20 genotypes from 10 different populations, arranged factorially, in a randomized complete block design. A natural infestation of the long-horned beetle occurred in the fall of 1992. Damage from the infestation, in the garden was apparent 1 year after it became established. Therefore, differential susceptibility to the root borer among populations and between species was assessed by visually evaluating necrosis monthly, from March to October in 1994, 1995, and 1996. Once plants were 100% necrotic,

plants were harvested, crown diameters measured and roots examined for beetle damage. Necrosis was analyzed using a three-way factorial with four response categories (0%, 1 to 25%, 26 to 75%, and 76 to 100%) in a categorical model. Test statistics for these categories were asymptotic Chi-square statistics. Mortality was analyzed using standard analysis of variance for a randomized block design. LS means were calculated by year and cumulative over 3 years. In 1994, necrosis was low in all populations. Necrosis shifted to higher percent damage categories in successive years, for most populations of broom snakeweed. Broom snakeweed populations Des Moines, Tatum and Lovington had the largest increase in the 76 to 100% damage category in 1996. Threadleaf snakeweed populations showed an increase in the 1 to 25% damage category, but was low in all other categories for 1995 and 1996. Mortality due to the beetle was less than 3% in both threadleaf snakeweed populations for all 3 years. Mortality due to the beetle in broom snakeweed populations showed significant differences among populations and increased over the 3 years. The highest percent mortality, over all 3 years was in broom snakeweed populations Des Moines (68%), Tatum (61%), and Lovington (59%) and lowest percent mortality in populations San Simon Sink (8%), and Las Cruces (5%). Results indicate that broom snakeweed has differential susceptibility to the long-horned beetle, and threadleaf snakeweed has limited susceptibility to the long-horned beetle.

SURVEY OF TERBACIL RESISTANT COMMON LAMBSQUARTERS AND PIGWEED. Farid M. Sardar and Carol A. Mallory-Smith, Graduate Student and Assistant Professor, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331-3002.

Abstract. A survey was conducted to determine if herbicide resistance was responsible for decreased terbacil control of common lambsquarters and pigweed. Greenhouse experiments were conducted in 1996 at Oregon State University to determine the effect of terbacil on common lambsquarters and pigweed. Common lambsquarters and pigweed seeds were collected from sites in Central Oregon and the Willamette Valley. Common lambsquarters was collected at 17 sites and pigweed at 40 sites. The sites had a history of terbacil use and reports of poor control. Seeds were tested in a randomized complete block design with four replications. Five rates of terbacil (0, 0.025, 0.05, 0.1, 0.2, and 0.4 1b/A) were used in these experiments. All of the common lambsquarters samples tested were resistant to terbacil. About half of the pigweed samples were resistant to terbacil. More samples with resistant pigweed were found in Central Oregon than in the Willamette Valley. The seeds were collected from fields with suspected resistance, so the number of samples with resistant weeds was higher than would be expected if random samples had been collected. However, these results indicate that terbacil resistance is widespread and that growers need to be aware of the problem.

CUCUMBER RESPONSE TO SELECTED SULFONYLUREA HERBICIDES. Jill Schroeder and Gary P. Hoxworth, Associate Professor and Research Assistant, Department of Entomology, Plant Pathology, and Weed Science, New Mexico State University, Las Cruces, NM 88003.

Abstract. Field experiments were conducted in 1995 and 1996 to determine the response of cucumbers 'Marketmore 76' to low rates of selected sulfonylurea herbicides applied POST and PPI, respectively. Both experiments were established in a randomized complete block design with six replications on a Belen clay loam soil (20:46:34 sand:silt:clay, 2.2% O.M., pH 7.7). Cucumbers were planted on July 13, 1995 for the postemergence study and hand weeded throughout the season. Postemergence treatments included thifensulfuron and bensulfuron applied at five rates from 0.035 to 2.24 g/ha; 2,4-D amine applied at five rates from 0.875 to 28 g/ha; and 3 controls. All treatments included a 0.25% v/v nonionic surfactant and were applied when the cucumbers initiated vines. Preplant incorporated treatments were applied prior to planting cucumbers on July 2, 1996. Treatments included metsulfuron and chlorimuron applied at six rates from 0.001 to 2.5 g/ha; atrazine applied at six rates from 35 to 1120 g/ha; and 3 controls. The experiment was hand-weeded, cultivated and

treated with labelled herbicides to remove weeds during the season. Data each year included yield from three harvests and grade (Super Select or grade No. 1, Select or grade No. 2, and culls) of cucumbers.

Yield data were highly variable both years. Yields of individual harvests showed the same trend as analysis of the combined yield or no difference due to herbicide treatment. The yield of the three control plots did not differ significantly either year. Grade of cucumbers was not affected by any treatment. Yield of cucumbers, regardless of grade, was not affected by the POST treatments except thifensulfuron applied at 2.24 g/ha which reduced yield nearly 50% compared to the controls. Yield of cucumbers was reduced 25% or more by atrazine applied at $\geq$ 280 g/ha PPI in 1996. Visually, none of the POST applied herbicides, thifensulfuron, bensulfuron or 2,4-D, affected cucumber growth and development. The no observable effect level for the PPI applied herbicides was 0.5 g/ha metsulfuron or chlorimuron and 70 g/ha atrazine. Results indicated that low rates of these sulfonylurea herbicides have minimal affect on field grown cucumbers.

PURPLE NUTSEDGE, YELLOW NUTSEDGE, CHILE PEPPER, AND SOUTHERN ROOT-KNOT NEMATODE INTERACTIONS. A. N. Sultana[1], J. Schroeder[1], S. Thomas[1], L. Murray[2], Carmella Martinez[2], and E. Higgins[1], Research Assistant, Associate Professor, Associate Professor, Associate Professor, Graduate Student, and Research Specialist, [1]Department of Entomology, Plant Pathology, and Weed Science and [2]University Statistics Center, New Mexico State University, Las Cruces, NM 88003-0003.

Abstract. Previous research in New Mexico has demonstrated that chile peppers grown with purple nutsedge (PNS) and Southern root-knot nematode (*Meloidogyne incognita* (Kofoid & White) Chitwood, host race 3; RKN) host higher levels of RKN and produce less biomass than chile peppers and weeds grown alone. The objectives of this research, which was part of a larger experiment, were to determine the population dynamics of RKN on PNS and yellow nutsedge (YNS) grown alone, with each other, and in association with chile, and also to determine PNS and YNS tuber production for nutsedge grown alone, with each other, and with chile in the presence of RKN. A field microplot experiment was conducted from 1994 through 1996 at the Leyendecker Plant Science Research Center near Las Cruces, NM. The experimental design was a randomized complete block with four replications with the plots blocked reflecting initial RKN levels. Each of the fiberglass microplots contained an Anthony-Vinton fine sandy loam soil (pH 7.9, 0.8% O.M.) and measured 76 cm in diameter and 65 cm in depth. Plants were established in 12 pairs (YNS, PNS, chile plus YNS, chile plus PNS, PNS plus YNS, and chile plus YNS plus PNS) per plot in March of each year. Plants were destructively sampled at 1 month intervals following chile pepper establishment by removing a 12 by 18.4 cm cylinder of soil surrounding the base of one plant pair per plot. The natural log of RKN egg production per gram of subsoil biomass per species and nutsedge tuber production were determined at each sample date. Data were analyzed by analysis of variance and contrasts on plant treatment combinations. Means and standard errors were also calculated.

RKN reproduction on PNS and YNS growing with chile in all combinations [P(CP), Y(CY), P(CYP), Y(CYP)] was greater than RKN reproduction on both species when growing alone [P, Y, P(YP), and Y(YP)] in 1995 and 1996 ($\alpha \leq 0.08$). This was probably due to the higher levels of RKN present on chile and agreed with 1989 and 1990 greenhouse results which demonstrated that chile hosted significantly higher RKN levels than PNS and YNS. In addition, 1993 and 1994 field studies demonstrated that chile hosted higher levels of RKN when grown in the presence of PNS than without PNS. When RKN reproduction on PNS and YNS grown alone and together with chile [P, Y, CP, and CY] was contrasted to RKN reproduction on both nutsedge species grown together and with chile [P(YP), Y(YP), P(CYP), and Y(CYP)], RKN reproduced more on nutsedge growing in combination with chile. However, RKN reproduction on either nutsedge did not differ when grown alone plus or minus chile [Y, Y(CY) contrasted to P, P(CP)].

Multiple nutsedge species in the field may elevate RKN levels in soil more than just a single nutsedge species. Chile by nutsedge interactions were generally not significant. Chile consistently suppressed tuber production of YNS and PNS. When both nutsedge species grew together in the presence of RKN tuber

production was suppressed compared to each species growing alone. Overall, for plants infested with RKN, YNS growing alone and with chile produced more tubers than PNS growing alone and with chile. However, YNS and PNS tuber production was similar when both species grew together. Chile by nutsedge interactions were not significant for tuber production. These data imply that YNS tuber production may be a more serious problem when RKN is present in the field and support 1995 and 1996 greenhouse studies which showed that YNS tuber production increased in direct proportion to RKN eggs extractable from YNS subsurface biomass when RKN reproduction is good.

CLOPYRALID UPTAKE, TRANSLOCATION AND ETHYLENE PRODUCTION IN RESISTANT AND SUSCEPTIBLE YELLOW STARTHISTLE PLANTS. Juan Valenzuela-Valenzuela[1], Norman K. Lownds[1], and Tracy M. Sterling[2], [1]Dept. of Agronomy and Horticulture, [2]Dept. of Entomology, Plant Pathology and Weed Science, New Mexico State University, Las Cruces, NM 88003.

Abstract. Resistance to the auxinic herbicide picloram has been reported in a yellow starthistle population growing in Washington. In addition, this population is cross-resistant to clopyralid, another auxinic herbicide. To understand the mechanism of cross-resistance to clopyralid, studies were conducted to determine uptake and translocation and to characterize clopyralid-induced ethylene production in the susceptible (S) and resistant (R) biotypes. R and S yellow starthistle plants were grown under ambient greenhouse conditions until full rosette stage and then transferred to a growth chamber (14 h photoperiod, 25C, 200 μmol m^{-2} s^{-1}) 48 hr before treatment. Radiolabel solutions were prepared from ^{12}C and ^{14}C clopyralid. Each treatment in the uptake experiment contained 0.009 μCi (20,000 dpm), and in the translocation experiment 0.225 μCi (500,000 dpm). Clopyralid 11.7 mM (420 g/ha) solutions were applied as six, 0.5 μl droplets to the adaxial surface of completely expanded leaves using a microsyringe. Radioactivity was quantified by liquid scintillation spectrometry. Uptake was determined at specified times after treatment. Almost all clopyralid uptake occurred within the first 2 hr, with no differences between the two biotypes. The amount of clopyralid translocated was 2.4, 40.2 and 50.7% of that absorbed at 2, 24 and 96 hr after treatment, respectively, but was not different between biotypes. Clopyralid induced about ten times greater ethylene production in S than in R. Ethylene production was followed by epinasty and chlorosis. Cross-resistance to clopyralid seems to be higher than the level of resistance to picloram. It is not possible to explain cross-resistance on the basis of differential clopyralid uptake or translocation.

THE EFFECTS OF FERTILIZER PLACEMENT ON JOINTED GOATGRASS IN WINTER WHEAT. Stephen M. Van Vleet and Stephen D. Miller, Research Associate and Professor, Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Jointed goatgrass is a winter annual grass related to winter wheat and has a direct correlation to large annual wheat yield losses in the western U.S. With increased use of nitrogen and shorter wheat varieties, jointed goatgrass infestations have increased. Information has not been available on jointed goatgrass response to fertilizer application method. The objective of the following research was to evaluate the competitive ability of jointed goatgrass with winter wheat as influenced by fertilizer placement. Experiments were conducted at the research and extension center, Archer, WY from 1994 to 1995 and 1995 to 1996. Winter wheat (var. Buckskin) was planted at a rate of 45 lb/A and jointed goatgrass at a rate of 50 viable seed/m^2. Plots were 10 by 40 feet with four replications arranged in a split-plot randomized complete block design. Fertilizer placement treatments consisted of applying 40 lb/A nitrogen in a deep band 2 inches below and 1 inch to the side of the wheat row, broadcasting on the soil surface or spoke wheel injecting fertilizer 4 inches deep and 2 inches to the side of the wheat row. Fertilizer placement consisted of spoke wheel injecting a 28-0-0 liquid nitrogen source, broadcasting and deep banding a 50/50 mixture of 34-0-0 dry ammonium nitrate and dry 46-0-0 urea. In addition, an unfertilized check was included as a reference.

Jointed goatgrass populations and joints/spike were not influenced by fertilizer placement; however, spikes/plant, joints/spike, height, biomass production and dockage were highest in the broadcast fertilizer treatment. The presence of jointed goatgrass decreased winter wheat spikes/plant, seed/spike, 200 seed weight, height, grain yield and biomass with all fertilizer placement treatments. Winter wheat was less competitive with jointed goatgrass in the broadcast treatment compared to the spoke wheel or deep band treatment.

WEEDS OF RANGE AND FOREST

JUNIPER CONTROL WITH A BASAL - WATER TREATMENT CONTAINING PICLORAM. John H. Brock, Professor, Environmental Resources Program, School of Planning and Landscape Architecture, Arizona State University, Tempe, AZ 85287-2005.

Abstract. Juniper control can be important to increase forage production, to open areas for better animal access, increase vision across landscapes, and remove juniper's physical presence around range facilities such as working pens and watering sites. Utah juniper (*Juniperus osteosperma*) was treated with picloram herbicide applied in water and with a surfactant by a basal spot technique. The plants were treated in mid summer of 1995 in anticipation of the summer thunderstorm season characteristic of ecosystems of the basin and range geologic province. Treatments included picloram herbicide in 10, 15 and 20% water solutions alone and with 0.125% surfactant. Mortality ratings were made at 5 and 12 months after treatment. In both evaluations, the data showed a positive dose response. The additive tended to decrease the size of the basal spot, and a slight increase in canopy mortality. Canopy reductions ranged from 46 to 83%. Approximately 40 days passed from the time of treatment until a rainfall event which could have initiated herbicide activity was experienced. Rainfall in 1995 and most of the summer of 1996 was well below normal which may have limited the initial effectiveness of the treatments.

HERBACEOUS WEED CONTROL IN DOUGLAS-FIR PLANTATIONS IN WESTERN OREGON USING MIXES OF SULFOMETURON AND HEXAZINONE. Byron D. Carrier and Bruce R. Kelpsas, Weyerhaeuser Company, Springfield, OR 97478 and Northwest Chemical Corporation, Aurora, OR 97002.

Abstract. Herbaceous weed competition is a common problem in the period of time from planting a new Douglas-fir forest until the seedlings are old enough to be free of the competitive effects at age 5 or 6 years. Herbaceous competition, which on most western Oregon forest sites is comprised of assorted grasses, groundsels, thistles, ferns, and a myriad of other plants, is very effective in competing for soil moisture in the drier summer months. This competition is typically targeted for removal in the first 2 years of plantation establishment. Several trials were installed in the spring of 1996 to determine which rates of each herbicide in a tank mix where the most effective for herbaceous weed control.

A five by five factorial design was used to give a range of herbicide treatments that would encompass rates that would be used or considered by field personnel for control of herbaceous competition. The rates for sulfometuron were 0, 0.75, 1.5, 2.25, and 3 oz/A. and the rates for the hexazinone were 0, 0.5, 1, 1.5, and 2 lb/A. Two newly planted sites were selected in April of 1996. All individual treatments were applied to pre-marked strips, that were 10 feet wide by 50 feet long. There were three replications of each treatment, at each installation. All spraying was with a gas operated backpack sprayer and handheld six-nozzle boom calibrated to deliver 10 gpa with 8002 spray tips. Competition was evaluated using an ocular estimate of percent cover at 3 and 4 months after treatment.

A cover prediction equation and response surface were developed to predict the amount of herbaceous cover remaining when using variable rates of sulfometuron and hexazinone. The threshold for herbaceous weed control was set at 70%. This study showed that using tank mixes at lower rates of sulfometuron and hexazinone gave as good a result as using either herbicide alone at the highest labeled rate. The mix of commonly used rates of 1.5 oz/A of sulfometuron and 1 lb/A of hexazinone controlled 78% of the herbaceous vegetation on the study sites. The study showed that there are tank mix rates with these herbicides that are probably more cost effective than the 1.5 oz/A of sulfometuron and 1 lb/A of hexazinone.

SEED GERMINATION OF YELLOW STARTHISTLE AND SPOTTED KNAPWEED AFTER TREATMENT WITH PICLORAM OR CLOPYRALID. Vanelle F. Carrithers, Dean R. Gaiser, Celestine Duncan, and Denise Horton, Technical Service & Development, DowElanco, 28884 South Marshall, Mulino, OR 97042; Vegetation Management Specialist, P.O. Box 610, Newman Lake, WA 99025; Weed Management Consulting Services, P.O. Box 9055, Helena, MT 59604; and Technician, Seed Laboratory, Department of Agronomy, Johnson Hall, Washington State University, Pullman, WA 99164.

Abstract. Four trials were established to determine the seed germination potential after herbicide treatments. Two trials on yellow starthistle were established in separate years, one each in 1995 and 1996, around Grangeville, ID. Two trials on spotted knapweed were established in 1995 around Athol, ID, one using picloram or picloram plus 2,4-D and the other using clopyralid or clopyralid plus 2,4-D. Treatments were applied at the same three timings for both weed species: rosette, bud and flower. On yellow starthistle and in one spotted knapweed trial treatments were: picloram at 0.125, 0.25, or 0.375 lb/A; picloram plus 2,4-D at 0.125 plus 1, 0.25 plus 1, 0.375 plus 1 lb/A and an untreated control. In the other spotted knapweed trial treatments were: clopyralid at 0.125, 0.25, and 0.375 lb/A; clopyralid plus 2,4-D at 0.125 plus 1, 0.25 plus 1, and 0.375 plus 1 lb/A, and an untreated control. At the rosette stage only the picloram alone treatments were applied. Seed were collected 1 week after full flowering for spotted knapweed and 2 weeks after full flowering for yellow starthistle.

Yellow starthistle seed viability was significantly reduced with all treatments compared to the untreated controls at the bud and flower stage (Table 1). At the bud stage, the addition of 2,4-D significantly reduced viable seeds only with 0.125 lb/A rate. At the flower stage, seed viability was reduced 16 to 35% over untreated plants even though plants did not appear to be controlled and flowering was not reduced. The most effective treatments for seed viability reduction (90 to 100%) were applications made at the bud stage, except picloram at 0.125 lb/A.

No spotted knapweed seeds were formed at bud stage treatments except picloram at 0.125 lb/A and clopyralid at 0.125 lb/A (Tables 2 and 3). Seeds were 6 and 23% viable, respectively. Flower stage treatments did not appear to control plants but all rates of both products did significantly reduce the viability of seeds produced. At flower stage, seed viability was reduced 52 to 76% by picloram and 52 to 64% by clopyralid over the untreated control seed. Bud stage was again the most effective seed viability reduction treatment timing except for the lowest rates.

Treatments of picloram and clopyralid applied at bud stage significantly reduce seed formation and viability in spotted knapweed and yellow starthistle. Applications at the flower stage will reduce seed viability, however, this reduction is not enough for a thorough noxious weed control program. The addition of 2,4-D increased control of yellow starthistle at the bud stage but the seed viability was not effected. There was no difference between picloram or clopyralid for seed viability reduction.

Table 1. Percent yellow starthistle viable seed after treatment with picloram or picloram plus 2,4-D in the season of application.

Treatment	Rate	Bud	Bud	Flower	Flower
	(lb/A)	Ave. total seeds	% viable seeds	Ave. total seeds	% viable seeds
Picloram	0.125	116	20	411	68
Picloram	0.25	103	4	497	61
Picloram	0.375	89	1	500	57
Picloram + 2,4-D	0.125 + 1	37	8	516	61
Picloram + 2,4-D	0.25 + 1	9	0	504	52
Picloram + 2,4-D	0.375 +1	32	1	525	53
Untreated		448	81	448	81

Table 2. Percent spotted knapweed viable seed after treatment with picloram or picloram plus 2,4-D in the season of application.

Treatment	Rate	Bud	Bud	Flower	Flower
	(lb/A)	Ave. total seeds	% viable seeds	Ave. total seeds	% viable seeds
Picloram	0.125	41	6	198	34
Picloram	0.25	0	0	196	17
Picloram	0.375	0	0	188	32
Picloram + 2,4-D	0.125 + 1	0	0	205	19
Picloram + 2,4-D	0.25 + 1	0	0	212	32
Picloram + 2,4-D	0.375 +1	0	0	215	17
Untreated		191	70	191	70

Table 3. Percent spotted knapweed viable seed after treatment with clopyralid or clopyralid plus 2,4-D in the season of application.

Treatment	Rate	Bud	Bud	Flower	Flower
	(lb/A)	Ave. total seeds	% viable seeds	Ave. total seeds	% viable seeds
Clopyralid	0.125	NA	23	185	30
Clopyralid	0.25	0	0	170	25
Clopyralid	0.375	0	0	191	32
Clopyralid + 2,4-D	0.125 + 1	0	0	158	24
Clopyralid + 2,4-D	0.25 + 1	0	0	151	30
Clopyralid + 2,4-D	0.375 +1	0	0	170	26
Untreated		138	67	138	67

CONTROL OF GEYER LARKSPUR AND DRUMMOND MILKVETCH WITH VARIOUS HERBICIDES. Mark A. Ferrell, Thomas D. Whitson, and Larry E. Bennett, Extension Pesticide Coordinator, University Extension Educator, and Professor, Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. This research was conducted north of Cheyenne, WY to evaluate Geyer larkspur and Drummond milkvetch control with applications of various herbicides. Plots were 10 by 27 feet with four replications arranged in a randomized complete block. Herbicide treatments were applied broadcast with a CO_2 pressurized hand-held sprayer delivering 30 gpa at 30 psi on June 23, 1995 (air temp. 70 F, soil temp. 0 inch 84 F, relative humidity 40%, wind north at 4 mph, sky clear). The soil was a sandy loam (57% sand, 24% silt, and 19% clay) with 4% organic matter and a 6.7 pH. Larkspur was in bud and 6 to 12 inches in height. Milkvetch was in full bloom and 12 to 14 inches in height. Infestations were heavy throughout the experimental area. Plant counts of the entire 10 by 27 foot plot were made June 16, 1995 immediately before herbicide application and July 16, 1996; 389 days after treatment. Pretreatment counts were compared to post-treatment counts to obtain percent control.

Picloram at all rates and 0.5 lb/A of dicamba provided 90% or better control of Geyer larkspur. Picloram at 0.375 lb/A and 0.5 lb/A or 1 lb/A 2,4-D plus 0.125 lb/A picloram gave 90% or better control of Drummond milkvetch. Other herbicides alone or in combination provided good to poor control of both species.

Table. Geyer larkspur and Drummond milkvetch percent control.

Treatment[a]	Rate	Weed control[b]	
		Geyer larkspur	Drummond milkvetch
	lb/A	%	
Picloram[c]	0.125	93	53
Picloram[c]	0.25	94	69
Picloram[c]	0.375	98	95
Picloram[c]	0.5	99	90
2,4-D[d]	1	79	29
2,4-D ester[c]	1	69	17
2,4-D[d] +picloram	1+0.125	95	92
2,4-D[d]	2	82	24
Picloram+2,4-D ester[c]	0.25+0.5	85	86
Picloram+ 2,4-D ester[c]	0.25+1	90	73
Metsulfuron[c]	0.019	89	70
Metsulfuron[c]	0.008	73	84
Metsulfuron+2,4-D ester[c]	0.008+1	82	67
Metsulfuron+picloram[c]	0.008+0.38	87	81
2,4-D[d]+metsulfuron[c]	0.5+0.008	89	86
Dicamba[c]	0.5	90	62
Dicamba[c]	1	80	75
Dicamba+ 2,4-D ester[c]	0.5+0.5	54	49
(LSD 0.05)		22	31
(CV)		19	35

[a]Treatments applied June 23, 1995.
[b]All plants were counted in the 10 by 27 feet plots immediately before herbicide application and July 16, 1996; 389 days after treatment. Pretreatment counts were compared to post-treatment counts to obtain percent control.
[c]X-77 added at 0.25% v/v.
[d]Mixed amine formulation - Hi-Dep.

MANAGEMENT OF WOOLLY DISTAFF THISTLE IN OREGON. Kenneth A. French and Dennis L. Isaacson, Weed Control Agronomist and Program Supervisor, Noxious Weed Control Program, Oregon Department of Agriculture, 635 Capitol St. N.E., Salem, OR 97310.

Abstract. Woolly distaff thistle was first detected in Oregon in 1987. The Oregon Department of Agriculture (ODA) declared the weed a Class "A" noxious weed and initiated a management program in 1988. The goals of the program were to detect and contain all distaff thistle infestations in the state, eradicating infestations if it were possible.

Control methods included herbicide treatments with picloram, glyphosate and 2,4-D, and pulling. Distaff thistle is typically a winter annual which may germinate, grow, flower and mature over an extended period, so crews made as many as six separate passes over each infestation about 3 weeks apart annually; plants were sprayed early in the

season, and pulled, bagged and removed late in the season if there was risk of seeding. Amounts of tank mix applied and the numbers of plants pulled were recorded for each treatment pass at each infestation. Contract labor crews and landowners assisted ODA employees in treatment of large sites.

Public support of detection efforts was solicited by publication and distribution of identification pamphlets, "Wanted" posters, and articles in local newspapers. Presentations on identification and the importance of containing distaff thistle were given to livestock producer group meetings and public land management agency personnel. Possible sightings of the weed were channeled to the local ODA Weed Control Agronomist. Reports were followed up by phone, and if justified, by site visits. Aerial observations were conducted by helicopter.

More than 25 individual infestations, ranging in size from a single plant to 400 A, were detected and are currently under management, all in Douglas County in southwestern Oregon. Most infested sites are under active management for livestock forage production. Control treatments typically have been successful in reducing distaff thistle densities by 90% or more within 5 yr of detection, and no seeding is known to have occurred at any site. No individual site is yet regarded as eradicated, and open field burning and seasonal rainfall appear to markedly influence germination of distaff thistle seed. Burning is being considered as an additional management tool in exhausting seed banks.

Containment at individual sites has been shown to be feasible, but little is known of the original sources of the distaff thistle infestation. Several counties in California have extensive infestations, and some are not under treatment.

EFFICACY OF PICLORAM OR CLOPYRALID APPLICATIONS AT THREE TIMINGS ON SPOTTED KNAPWEED OR YELLOW STARTHISTLE. Dean R. Gaiser, Vanelle F. Carrithers, and Celestine Duncan, Vegetation Management Specialist, P.O. Box 610, Newman Lake, WA 99025; Technical Service & Development, Dow Elanco, 28884 South Marshall, Mulino, OR 97042; and Weed Management Consulting Services, P.O. Box 9055, Helena, MT 59604.

Abstract. Four trials were established to determine the efficacy of picloram on spotted knapweed and yellow starthistle, and the efficacy of clopyralid on spotted knapweed. Two trials on yellow starthistle were established in separate years, one each in 1995 and 1996, around Grangeville, ID. Two trials on spotted knapweed were established in 1995 around Athol, ID, one using picloram or picloram plus 2,4-D and the other using clopyralid or clopyralid plus 2,4-D. Treatments were applied at three timings for both weed species, rosette, bud and flower. On yellow starthistle and in one spotted knapweed trial treatments included picloram at 0.125, 0.25, and 0.375 lb/A, picloram plus 2,4-D at 0.125 plus 1, 0.25 plus 1, and 0.375 plus 1 lb/A, and an untreated control. In the second spotted knapweed trial treatments included clopyralid at 0.125, 0.25, and 0.375 lb/A, clopyralid plus 2,4-D at 0.125 plus 1, 0.25 plus 1, and 0.375 plus 1 lb/A, and an untreated control. At the rosette stage only the picloram alone treatments were applied.

Picloram applied at the rosette yellow starthistle growth stage controlled most of the sprayed plants when applied at 0.25 and 0.375 lb/A (Table 1). The lowest rate, 0.125 lb/A, did not control plants. Regrowth was significant in the 0.125 lb/A plots with delayed seed head development compared to untreated plants. Bud stage treatment results were better when 2,4-D was added to picloram. Plants were not controlled with flower stage applications.

Herbicides applied at the rosette and bud stages of spotted knapweed prevented 75 to 100% of seed head development (Tables 2 and 3). Control of rosettes was excellent with both products at all rates. At bud stage, again both products had the same results with excellent control at the higher 2 rates when applied alone and all rates when 2,4-D was added.

Picloram had better efficacy on spotted knapweed than on yellow starthistle. Control of spotted knapweed with picloram and picloram plus 2,4-D at rosette and bud stages was excellent in the season of application and 1 year after treatment, except with picloram at 0.125 lb/A at the bud stage (Tables 2 and 3). The addition of 2,4-D with picloram at 0.125 lb/A did increase control of spotted knapweed.

Control of yellow starthistle was good to excellent in the season of application with 0.25 and 0.375 lb/A at rosette. At the bud stage control was improved with the addition of 2,4-D. One year after treatment control was good to excellent at bud and flower stages with all rates except picloram at 0.125 lb/A.

Control of spotted knapweed with clopyralid was equal to picloram at the same rates. The addition of 2,4-D also increased control with clopyralid at 0.125 lb/A. One year after application control was not as good as picloram treatments. The addition of 2,4-D did not change the control of yellow starthistle in the year after treatment.

Table 1. Yellow starthistle percent control after treatment with picloram or picloram plus 2,4-D in the season of application and 1 year after treatment.

		Growth stage and time after treatment					
Treatment	Rate	Rosette 4 MAT[a]	Rosette 1 YAT[a]	Bud 1 MAT	Bud 1 YAT	Flower 3 WAT[a]	Flower 1 YAT
	(lb/A)	% control					
Picloram	0.125	24	5	46	74	0	84
Picloram	0.25	88	71	70	91	0	93
Picloram	0.375	97	77	84	99	0	100
Picloram + 2,4-D	0.125 + 1	NA[b]	NA	78	86	0	87
Picloram + 2,4-D	0.25 + 1	NA	NA	91	96	0	90
Picloram + 2,4-D	0.375 +1	NA	NA	98	96	0	95
Untreated		0	0	0	0	0	0

[a]MAT = months after treatment, YAT = year after treatment, WAT = weeks after treatment.
[b]NA=applications were not applied at this plant stage.

Table 2. Spotted knapweed percent control after treatment with picloram or picloram plus 2,4-D.

		Growth stage and time after treatment					
Treatment	Rate	Rosette 4 MAT[a]	Rosette 4 YAT[a]	Bud 2 MAT	Bud 1 YAT	Flower 1 WAT[a]	Flower 1 YAT
	(lb/A)	% control					
Picloram	0.25	100	98	99	100	0	100
Picloram	0.375	100	100	99	100	0	100
Picloram + 2,4-D	0.125 + 1	NA[b]	NA	99	97	0	100
Picloram + 2,4-D	0.25 + 1	NA	NA	99	99	0	100
Picloram + 2,4-D	0.375 +1	NA	NA	100	100	0	100
Untreated		0	0	0	0	0	0

[a]MAT = months after treatment, YAT = year after treatment, WAT = weeks after treatment.
[b]NA=applications were not applied at this plant stage.

Table 3. Spotted knapweed percent control after treatments with clopyralid or clopyralid plus 2,4-D.

Treatment	Rate	Rosette 4 MAT[a]	Rosette 1 YAT[a]	Bud 2 MAT	Bud 1 YAT	Flower 1 WAT[a]	Flower 1 YAT
		Growth stage and time after treatment					
	(lb/A)	% control					
Clopyralid	0.25	199	62	100	59	0	42
Clopyralid	0.375	100	161	99	59	0	44
Clopyralid + 2,4-D	0.125 + 1	NA[b]	NA	100	61	0	43
Clopyralid + 2,4-D	0.25 + 1	NA	NA	99	57	0	44
Clopyralid + 2,4-D	0.375 +1	NA	NA	99	56	0	45
Untreated		0	0	0	0	0	0

[a]MAT = months after treatment, YAT = year after treatment, WAT = weeks after treatment.
[b]NA=applications were not applied at this plant stage.

PLANT GROWTH REDUCTION AND SEEDHEAD SUPPRESSION OF UNIMPROVED TURF WITH AC 263,222. Pamela J .S. Hutchinson, John O. Evans, and Tim C. Vargus, Field Research Agriculturist, American Cyanamid Company, Meridian, ID 83642; Professor, Department of Plant, Soils and Biometerology, Utah State University, Logan, UT 84322-4820; and Research Director, Varco Ag Incorporated, Jerome, ID 83338.

Abstract. Studies were conducted on wheatgrass species in 1995 and 1996 in Utah and Idaho. In 1995, AC 263,222 at 0.094, 0.125, 0.156 or 0.188 lb/A was applied alone or in combination with 2,4-D to crested wheatgrass. In 1996, 2,4-D was applied alone and AC 263,222 was applied at 0.063, 0.094 or 0.125 lb/A alone or in combination with 2,4-D to intermediate wheatgrass. Slight color loss of both wheatgrass species was observed early season in all treatments both years compared to the untreated check. However, color improved as the season progressed. In 1995, crested wheatgrass in untreated checks appeared less green than wheatgrass in the treated plots at the end of the season. AC 263,222 treatments provided significant plant growth reduction and seed head suppression of both wheatgrass species at all sites compared to the untreated check. When 2,4-D was tank-mixed with AC 263,222, growth and seed head suppression were less compared to AC 263,222 applied alone.

EFFECT OF A NATIVE RUST ON POPULATION DYNAMICS OF DYERS WOAD. Erin G. McConnell[1], Steven A. Dewey[1], Sherman V. Thomson[2], and Eugene W. Schupp[3], Graduate Research Assistant, Professor, Professor, and Assistant Professor, [1]Department of Plants, Soils and Biometeorology, [2]Department of Biology, and [3]Department of Rangeland Resources, Utah State University, Logan, UT 84322.

Abstract. Dyers woad, a member of the mustard family, is an invasive alien infesting numerous acres of rangeland in the intermountain west. It is an aggressive perennial well suited to the dry, rocky, often disturbed soils of the region. *Puccinia thlaspeos* is a native rust specific to the mustard family, and is pathogenic to dyers woad. The possibility of *P. thlaspeos* as a biocontrol agent for woad infestations shows promise. The objectives of this study were to see if it is possible to inoculate natural wood stands in the field, and to monitor effects of the induced rust infection on the population dynamics of dyers woad.

Three populations of dyers woad were chosen in the mountains of northern Utah. Four paired plots measuring 2 m^2 at each site were delineated, each pair consisting of an inoculation plot and a control. Each site was inoculated once with dry, crushed infected woad leaves in the first week of July 1995. In May 1996, symptoms of infection were evident in all inoculation plots, averaging 38%, 28%, and 6% at sites 1, 2, and 3 respectively. Mortality rates of infected plants were not significantly different from uninfected plants across all sites.

Seed production by infected plants was significantly reduced. Many infected plants died in the bolting stage. The number of seed produced on surviving infected plants was reduced but seed viability was not diminished. Since dyers woad spreads by seed, a reduction in seed production could greatly affect population dynamics of the weed, and will likely be an important factor in developing a successful weed control strategy.

EFFECT OF FALL APPLIED PICLORAM AND 2,4-D ON *APHTHONA NIGRISCUTIS* POPULATION.
Jeff A. Nelson, Rodney G. Lym, and Calvin G. Messersmith, Graduate Research Assistant and Professors, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Abstract. *Aphthona nigriscutis* has reduced the density of leafy spurge at many locations. However, there are locations where *A. nigriscutis* has not established or is found at densities too low to be effective. Therefore, it may be necessary to integrate biological and chemical control to reduce leafy spurge to satisfactory levels. The objective of this experiment was to determine the effect of picloram and 2,4-D fall-applied in the field on *A. nigriscutis* population.

Experiments were conducted at two locations, Chaffee and Fort Ransom, ND which averaged 90 and 63 leafy spurge stems/m^2, respectively. Approximately 350 *A. nigriscutis* adults were released into 1.8- by 1.8- by 1.8-m cages on June 22, 1995. An additional 100 *A. nigriscutis* adults were released on July 14, 1995. The herbicides picloram plus 2,4-D at 0.56 plus 1.1 kg/ha were applied on four dates, August 15, September 1, and 15, and October 1.

The effect of picloram and 2,4-D on *A. nigriscutis* population was estimated by counting the number of adults emerging from soil cores harvested October 30, 1995 and May 28, 1996 and adults collected in the field in June and July 1996. A golf cup cutter was used to harvest soil cores which were 10.8-cm diameter to a depth of 15 cm, and sample harvested in October were held at 3 C for 75 d. Each sample was then placed into a 2 L paper container and covered by a trap chamber, which was a clear plastic cylinder with a mesh top. Trap chambers with soil cores were maintained in the laboratory at 21 C with a 16 h photoperiod until A. *nigriscutis* adults emerged. Soil cores harvested in May were placed directly in trap chambers and treated identically to soil cores harvested in October. An insect sweep net was used to collect *A. nigriscutis* from the cage area and portions of the border which totaled 4.5 m^2.

Leafy spurge density averaged less than 1 stem/0.25 m^2 on June 5, 1996 regardless of herbicide application date or location. The number of *A. nigriscutis* adults emerging from soil cores obtained in fall and spring was similar regardless of herbicide application date or location. An average of 2 *A. nigriscutis* adults were recovered from each soil core harvested in the fall compared to only 1 per core from spring harvested samples, which indicates overwintering mortality. Peak field emergence of *A. nigriscutis* adults averaged 33/4.5 m^2 on July 10 at Chaffee and 7/4.5 m^2 on July 18 at Ft. Ransom. The number of *A.* nigriscutis collected in the field was similar regardless of herbicide application date at each location.

INFLUENCE OF SITE PREPARATION METHOD ON GROWTH OF FOUR SPECIES OF CONIFER IN COASTAL BRUSHFIELD RECLAMATION. Michael Newton, Bruce R. Kelpsas, and Elizabeth C. Cole, Professor, Oregon State University, Corvallis, OR 97331; Forester, Northwest Chemical Corp., Salem, OR 97205; and Senior Research Assistant, Oregon State University College of Forestry, Corvallis, OR 97331.

Abstract. Four methods of site preparation were used for reclamation of an established brushfield on a highly productive site in the Coast Range of Oregon. Data reflect 12 years of growth for transplant Douglas-fir, grand fir, Sitka spruce and western hemlock plantings after site preparation by scarification, aerial broadcast application of glyphosate, aerial broadcast application of picloram plus 2,4,5-T followed by broadcast burning, and aerial broadcast application of picloram plus 2,4,5-T followed by crushing with a bulldozer.

The selection of species influenced the comparative efficacy of the treatments. For Douglas-fir, height growth and survival were greatest on scarified sites, but height growth on burned and crushed sites was not significantly different from scarified. Glyphosate-only led to less growth than the other methods. Hemlock growth was best on the crushed and glyphosate-only sites and poorest on scarified sites, but differences were not significant. Grand fir and Sitka spruce were much smaller at 12 years than the Douglas-fir or hemlock; Sitka spruce had the best over-all survival of all species, but height development was severely influenced by the terminal shoot weevil, *Pissodes sitchensis.* Hemlock survival was poorest. Survival did not differ greatly for any species among treatments. Overall, treatments that removed tall cover during the first 5 years of seedling growth led to greatest height growth.

THE EFFECT OF PICLORAM ON PLAINS PRICKLYPEAR WHEN APPLIED AT THREE GROWTH STAGES. William R. Taylor and Tom D. Whitson, University Extension Educator and Extension Weed Specialist, University of Wyoming, Laramie, WY 82071.

Abstract. Plains pricklypear, a perennial cactus is common throughout the western U.S. It reproduces by spreading pads through mechanical pasture renovation or by seed. It becomes a dominant species when rangeland is heavily overgrazed or when it has been heavily used by burrowing animals. Moisture competition with perennial grasses is often small but range and pastures are often poorly utilized in areas infested with plains pricklypear. Grazing does not occur above pricklypear or in close proximity to plants. Some rangeland has over 30% of the surface area infested with plains pricklypear which is then lost to grazing.

Six experiments were established on the Matt Perino Ranch near Newcastle, WY; three in 1993 and three in 1994. Treatment dates in 1993 included June 10, early bud stage, June 24, midbloom stage, and September 15, following the first killing frost. Treatment dates in 1994 included June 9, 30% bloom, June 17, late bloom, and October 10, following a killing frost. Herbicides were applied in 30 gpa at 41 psi. Soils were clay with 25% sand, 30% silt and 45% clay with 1.8% OM and a 7.7 pH. Evaluations were made by counting live pricklypear plants in each treatment area and comparing counts to the original inventory before herbicides were applied.

With most perennial weeds of rangeland maximum control is obtained by the second year following herbicide application but maximum pricklypear control with low rates of picloram occurs the third year after application. Applications made at the prickly pear bloom stage provided considerably higher control in areas treated in 1993 than in 1994. Picloram at the 8 oz rate applied in the bloom stage in 1993 controlled 100% of the plains pricklypear three years after applications were made. Control should last 15 years or longer depending on the management of the rangeland and prairie dog activity. Tordon 22K® is currently labeled at the 16 oz/A but Grazon® P+D, a combined package mix of picloram plus 2,4-D can be applied at 1 qt/A or 0.13 lb picloram/A, which is equal to 8 oz of picloram/A. This will reduce herbicide costs by approximately $3.00/A.

Table 1. The comparison of six rates of picloram applied in 1993 at three pricklypear growth stages and evaluated in August 1996 by counting pricklypear plants and comparing numbers to the original inventory to calculate percent control.

		Plant growth stage at application		
Herbicide	Rate	Vegetative	Bloom	Fall dormancy
	oz/product/A	% control		
Picloram	2	42	72	45
Picloram	4	62	93	65
Picloram	6	83	89	68
Picloram	8	75	100	87
Picloram	16	91	100	80
Picloram	32	89	99	97
Check		27	23	27
Mean		67	92	74

Table 2. The comparison of six rates of picloram applied in 1994 at three pricklypear growth stages and evaluated in August 1996 by counting pricklypear plants and comparing numbers to the original inventory to calculate percent control.

		Plant growth stage at application time		
Herbicide	Rate	Vegetative	Bloom	Fall dormancy
	oz/product/A	% control		
Picloram	2	48	55	48
Picloram	4	52	55	47
Picloram	6	45	63	48
Picloram	8	48	90	57
Picloram	16	85	82	80
Picloram	32	85	99	72
Check		38	52	38
Mean		61	74	59

EFFECTS OF HERBICIDES ON GRASS SEED PRODUCTION AND DOWNY BROME. Tom D. Whitson[1], M. E. Majerus[2], R. D. Hall[3], and Jay D. Jenkins[4], Professor, Dept. of Plant, Soil and Ins. Sci. Dept., Asst. Mgr., N.R.C.S. Plant Materials Center, Coord., Seed Cert. Service, and Extension Educator, [1,3,4]University of Wyoming, Laramie, WY 82071 and [2]N.R.C.S. Plant Materials Center, Bridger, MT 59014.

Abstract. Control of downy brome in cool-season perennial grasses grown for seed production must be done prior to seed harvest because its seed cannot be effectively separated from the cool-season grass seed. Twelve herbicides were applied at two locations as semi-dormant treatments in October and November, 1994 and 1995 and two herbicides were applied following early emergence of perennial grass seed fields in April, 1994 and 1995. In the semi-dormant treatment area, downy brome had not emerged but was in the 4- to 6-leaf stage during the non-dormant treatment. Trials were conducted on western wheatgrass, slender wheatgrass, beardless wildrye, thickspike wheatgrass and meadow bromegrass. The semi-dormant treatments providing excellent downy brome control and not resulting in perennial grass damage included: oxyfluorfen plus metribuzin at 1.1 plus 0.28 kg/ha and metribuzin at 0.42 kg/ha. Perennial grass injury was 13% with metribuzin applied at 0.6 kg/ha. Early spring applications of paraquat at 0.83 kg/ha controlled 100% of the downy brome but suppressed perennial grass growth 75%.

Glyphosate applied in early spring at 0.28 kg/ha controlled 37% of the downy brome while perennial grass suppression was 16%. Seed yield reductions occurred when beardless wildrye, thickspike wheatgrass and meadow brome were treated with glyphosate at 0.28 kg/ha. Thickspike wheatgrass yields were reduced with the application of metribuzin at 0.6 kg/ha. Metribuzin at 0.42 kg/ha and the combination of metribuzin plus oxyfluorfen at 0.28 plus 1.1 kg/ha controlled 97% and 95% of the downy brome and did not affect seed viability or grass yield.

WEEDS OF HORTICULTURAL CROPS

WEED CONTROL WITH SULFENTRAZONE IN SPEARMINT AND ASPARAGUS. Rick A. Boydston, Plant Physiologist, USDA-ARS, Irrigated Agriculture Research and Extension Center, Prosser, WA 99350.

Abstract. Sulfentrazone was tested for weed control in established furrow-irrigated native spearmint and Scotch spearmint from 1993 to 1996 and in newly planted asparagus crowns and established asparagus in 1995 and 1996. In six separate trials conducted from 1993 to 1996, sulfentrazone applied preemergence to spearmint at 0.25 to 0.5 lb/A did not reduce spearmint hay or oil yields compared to a standard treatment of terbacil. Sulfentrazone applied to emerged spearmint caused necrosis and stunting, but spearmint recovered and grew normal. Sulfentrazone controlled redroot pigweed, common lambsquarters, and kochia greater than 98%. In trials on Scotch spearmint, sulfentrazone applied preemergence at 0.5 lb/A followed by bentazon applied postemergence twice reduced final yellow nutsedge biomass by greater than 90% in 1995 and 1996 compared to nontreated checks. In 1995 and 1996, sulfentrazone was tested on newly planted asparagus grown on a Warden sandy loam soil containing 1% organic matter. Sulfentrazone applied preemergence at 0.5 and 1 lb/A to newly planted asparagus crowns in 1995 controlled common lambsquarters and common groundsel 100%, but severely injured asparagus by late June and July. Sulfentrazone applied preemergence to newly planted asparagus crowns at 0.25 and 0.5 lb/A in 1996 controlled common lambsquarters greater than 98% and did not injure asparagus. Sulfentrazone applied preemergence at 0.5 and 1 lb/A to sprinkler-irrigated established asparagus in 1995 and 1996 did not injure asparagus or reduce asparagus yield compared to a standard treatment of trifluralin plus metribuzin in 1995 or trifluralin plus linuron in 1996. In 1995 and 1996, sulfentrazone applied at 0.5 and 1 lb/A controlled common lambsquarters, hairy nightshade, common groundsel, and Russian thistle from 94 to 100%.

FIELD DODDER CONTROL WITH A BIOCONTROL ORGANISM AND RIMSULFURON IN TOMATOES. W. Thomas Lanini and Gene Miyao, Extension Weed Ecologist, Department of Vegetable Crops, University of California, Davis, CA 95616 and Farm Advisor and County Director, University of California Cooperative Extension, Woodland, CA 95695.

Abstract. In 1996, a series of studies were initiated to evaluate a biocontrol agent, rimsulfuron, and a tomato variety suspected to be tolerant of dodder. The biocontrol agent consisted of *Alternaria conjuncta/infectoria*, *Fusarium tricinctum*, or a combination of these two organisms. These organisms were formulated as a granule for preemergence treatments, or in liquid suspensions for postemergence applications. Rimsulfuron was evaluated alone or in combination with *A. conjuncta/infectoria* as a postemergence treatment. Two processing tomato varieties, Halley 3155 (susceptible) and Heinz 9492 (resistant) were also evaluated. Measurements were made on the number of dodder plants attached, growth rate of dodder, flower and seed production of dodder, and tomato yield and maturity for each treatment. Preemergence applications of either biocontrol organism reduced the number of dodder plants by over 50%. Dodder surviving these treatments was reduced in size by over 35% and flowering and seed production were reduced by over 60% compared to untreated controls. Tomato yields averaged over 83,000 kg/ha where dodder was controlled compared to 61,000 kg/ha where tomatoes were infested with dodder. Postemergence biocontrol treatments did not control dodder. Rimsulfuron applied at the rate of 15 g/ha stunted dodder for several weeks after treatment but dodder growth resumed after three weeks. The resistant variety, Heinz 9492, had 52% less dodder attacks, and dodder growth, flowering and seed production were reduced on this variety compared to Halley 3155.

EFFECTS OF ORGANIC SOIL AMENDMENTS ON BROCCOLI, CORN, AND WEED GROWTH.
Timothy J. O'Brien, John Luna, and Carol Mallory-Smith, Graduate Research Assistant, Assistant Professor, and Assistant Professor, Department of Horticulture, Oregon State University, Corvallis, OR 97331.

Abstract. Economic and environmental pressures clearly necessitate the use of alternatives to herbicides in some vegetable cropping systems. Two greenhouse studies were conducted in 1996 to evaluate the effects of the surface application of two agricultural by-products (meadowfoam meal and hydrolyzed corn gluten) on the biomass accumulation of broccoli (direct seeded and transplanted), sweet corn, barnyardgrass, and pigweed. The addition of meadowfoam meal to sterile greenhouse potting mix significantly reduced broccoli biomass (direct seed by 34% and transplanted by 50%) when compared to controls (α=0.05). Hydrolyzed corn gluten significantly reduced sweet corn biomass by 46% when compared to controls (α=0.05). Results suggest that hydrolyzed corn gluten and meadowfoam meal inhibit the biomass accumulation of barnyardgrass and pigweed. Additional research is being conducted in the greenhouse and field to fully document these effects.

CONTROL OF YELLOW NUTSEDGE WITH PREEMERGENCE APPLICATIONS OF THIAZOPYR.
John T. Schlesselman, Randy L. Smith, L. Douglas West, and Harvey A. Yoshida, Rohm and Haas Company, 1520 East Shaw Avenue, Suite 119, Fresno, CA 93710.

INTRODUCTION

Field testing of thiazopyr by Rohm and Haas Company began in California during the fall of 1994. Thiazopyr is one of the pyridine compounds purchased from Monsanto Company. It has been evaluated under two experimental numbers; RH-123652 (Rohm and Haas Company) beginning in 1994, and MON13200 (Monsanto Company) prior to 1994. There are currently two trade names for thiazopyr; Mandate™ for the eastern U.S., and Visor™ for the western U.S. Thiazopyr is formulated as a 240 gm/L emulsifiable concentrate.

Thiazopyr is probably best known as an excellent preemergence annual grass herbicide. It also has considerable activity on many small-seeded annual broadleaf weeds. On February 21, 1997, thiazopyr was granted a registration by the EPA for preemergence applications in permanently established grapefruit, orange, tangelo, and tangerine groves.

During July 1996, a temporary tolerance for the preemergence use of thiazopyr in nutcrops (almonds, pecans, pistachios and walnuts) was granted. There are currently over 20 grower-applied EUP nutcrop trials being conducted throughout California under various climatic and edaphic regimes.

Yellow nutsedge (*Cyperus esculentus*) is a major weed problem in most agricultural crops. Considerable research has been conducted during the past two years to determine the activity of thiazopyr on yellow nutsedge in California. This work has centered around differences in nutsedge activity based on amount of rainfall following thiazopyr application. Differences in soil type was also a consideration in determining the preemergence activity of thyiazopyr on yellow nutsedge.

MATERIALS AND METHODS

Most trials conducted from 1994 to 1996 were established as small-plot CO_2 backpack trials in various crops such as grapes, apples, almonds, walnuts, and stonefruit, as well as on some fallow ground. Thiazopyr at 0.28 to 1.12 kg/ha were generally used. The plots were of sufficient size to encompass a large weed spectrum, and each treatment had four replications. Rainfall records were maintained at all locations, as well as an analysis of the soil characteristics. Evaluations for crop response and preemergence weed control were made periodically throughout the season.

RESULTS AND DISCUSSION

During 1994 to 1995, only one trial had a sufficient yellow nutsedge population to obtain meaningful results. This trial, conducted in Tulare County, was in a sandy loam soil. The trial was evaluated 6 months after application. Thiazopyr at 1.12 kg/ha provided the best yellow nutsedge control at 91%, but was not significantly better than the 82% control obtained with norflurazon at 2.24 kg/ha (Table 1). Even the 0.56 kg/ha rate of thiazopyr was 73% effective, which was not significantly less than the nutsedge activity of norflurazon. Norflurazon has been the "commercial standard" in controlling/suppressing yellow nutsedge, but many growers are reluctant to use it because of the phytotoxicity potential to their trees and vines. Thiazopyr has not resulted in any adverse response by any of the perennial crops tested. The remaining two herbicides in this trial, pendimethalin and oryzalin, were ineffective in controlling yellow nutsedge.

Rainfall incorporation has played an important part in the yellow nutsedge activity of thiazopyr. Several trials in 1995 and 1996 were designed to determine the activity of thiazopyr based on application timing; a fall versus a spring application. It was thought that a spring application timing (but still prior to the emergence of nutsedge) might reduce the possible "breakdown" of thiazopyr and result in better nutsedge control. The results were quite opposite the expectations. Thiazopyr activity on yellow nutsedge at 0.84 to 1.12 kg/ha averaged 34% better control with the fall application (Table 2). It appeared as if the winter rains (32.61 cm) following the fall application were necessary to move the thiazopyr down to the nutlet germination zone. The spring treatment received only 2.41 cm of rainfall following application.

Table 1. Preemergence activity of thiazopyr in controlling yellow nutsedge.

Treatment	Rate	Preemergence yellow nutsedge control[a]
	kg/ha	——%——
Thiazopyr	0.45	62 c
Thiazopyr	0.56	73 bc
Thiazopyr	1.12	91 a
Pendimethalin	6.72	13 e
Oryzalin	4.48	7 e
Norflurazon	2.24	82 ab
Control	0	0 e

[a]Letters to the right of ratings indicate DMRT at the 0.05 significance level.

Table 2. Influence of application timing and rainfall on the preemergence activity of thiazopyr for the control of yellow nutsedge.

Treatment	Rate	Application timing[a]: Fall 32.61 cm rain	Application timing[a]: Spring 2.41 cm rain
	kg/ha	——%	——
Thiazopyr	0.56	56 bcd	53 bcd
Thiazopyr	0.84	71 ab	40 d
Thiazopyr	1.12	85 a	48 bcd
Control	0	0 e	0 e

[a]Letters to the right of ratings indicate DMRT at the 0.05 significance level.

Soil type was also important in understanding the yellow nutsedge activity of thiazopyr. Seven of the trials conducted from 1995 to 1996 had adequate populations of nutsedge. These trials conducted throughout California were divided into two soil types; sandy loam (four trials that averaged 57% sand, 32% silt, 11% clay, and 1.0% organic matter) and clay loam (three trials that averaged 33% sand, 40% silt, 27% clay, and 1.6% organic matter). Yellow nutsedge evaluations were made about 6 months after the fall applications. Thiazopyr averaged 30% better nutsedge control in the sandy loam soil compared to the activity in the clay loam soil (Table 3). Thiazopyr at 0.84 to 1.12 kg/ha in the sandy loam soil also provided significantly better nutsedge control than norflurazon.

Two of these seven thiazopyr trials with yellow nutsedge were nearly identical, (conducted in non-bearing grapes) located only 13 miles apart in San Joaquin County, applications were made within 24 hours of each other, and similar amounts of rainfall following application (24-33 cm). The only difference was with the soil types; loamy sand at the Lodi site (84% sand, 12% silt, 4% clay, and 0.6% organic matter) versus clay loam at the Stockton site (30% sand, 38% silt, 32% clay, and 1.3% organic matter). Increased yellow nutsedge control with thiazopyr in lighter coarse soil (loamy sand) compared to a heavier fine soil (clay loam) (Table 4). Thiazopyr provided 56% to 85% control in the loamy sand soil compared to only 30% to 54% control in the clay loam soil. These differences were significant with each rate of thiazopyr.

Table 3. Preemergence activity of thiazopyr on yellow nutsedge based on soil type 6 months after treatment.

Treatment	Rate	Preemergence yellow nutsedge control[a] Sandy loam	Clay loam
	kg/ha	%	
Thiazopyr	0.56	55 bcd	24 ef
Thiazopyr	0.84	68 abc	42 cde
Thiazopyr	1.12	80 a	48 b-e
Norflurazon	2.24	37 de	42 cde
Control	0	0 f	0 f

[a]Letters to right of ratings indicate DMRT at the 0.05 significance level.

Table 4. Influence of soil type on the preemergence activity of thiazopyr on yellow nutsedge.

Treatment	Rate	Preemergence nutsedge control[a] Loamy sand	Clay loam
	kgha	%	
Thiazopyr	0.56	56 bc	30 d
Thiazopyr	0.84	71 ab	46 cd
Thiazopyr	1.12	85 a	54 bc
Control	0	0 e	0 e

[a]Letters to the right of ratings indicate DMRT at the 0.05 significance level.

CONCLUSIONS

Based on the results from the 1995 and 1996 research conducted in California, three conclusions can be made. Thiazopyr applications made prior to the winter rains provided better yellow nutsedge control compared to treatments made later in the spring. Better yellow nutsedge activity was obtained with thiazopyr in sandy loam soil than in clay loam soil. Optimum rates for good yellow nutsedge control with thiazopyr were 0.84 to 1.12 kg/ha.

ADJUVANT COMBINATIONS WITH QUIZALOFOP FOR WILD OAT CONTROL IN PEPPERMINT.
Bob N. Stougaard, Assistant Professor, Northwestern Agricultural Research Center, Montana State University, Kalispell, MT 59901.

Abstract. Field experiments were conducted at Kalispell, MT to determine the optimum adjuvant combination for wild oat control in peppermint with quizalofop. Quizalofop was applied to 4- and 8-leaf wild oat plants at 20 and 50 g/ha with either a nonionic surfactant (NIS) or methylated seed oil (MSO) alone or in combination with 28% urea ammonium nitrate (UAN) liquid fertilizer. Differences among adjuvants were most apparent when quizalofop was applied at the lowest rate. MSO was more effective than NIS for enhancing quizalofop activity. Quizalofop efficacy with both adjuvants increased when applied with UAN. Greater than 90% wild oat control was obtained with the lowest rate when applied with MSO plus UAN to 4-leaf wild oat plants. These results demonstrate the potential to improve the consistency of weed control when applied with the proper adjuvant combination.

EVALUATION OF POSTEMERGENCE HERBICIDES FOR MELON WEED CONTROL. Kai Umeda,
Extension Agent, Maricopa County Cooperative Extension, University of Arizona, Phoenix, AZ 85040.

Abstract. Melon production in the desert southwest begins with planting the spring crop in January to March and ends with harvesting the fall crop in November. Spring cantaloupes and watermelons may be planted by direct seeding or transplanting under furrow irrigation with or without plastic mulch or irrigated with subsurface drip systems. A banded application of preemergence herbicide and several cultivations provide marginal weed control until the vines begin to spread on typical 80-inch beds. Fall melons may be directly seeded into pre-irrigated mulched beds or sprinkler irrigation may be used to germinate the crop. Following emergence of the crop in the early spring or early fall, hand-hoeing is the only effective method to eliminate hard to control weeds in the seed row. Several field tests were conducted in Central Arizona to evaluate postemergence herbicides for potential use in melon weed control. Bentazon at 0.5 to 2 lb/A, halosulfuron at 0.025 to 0.1 lb/A, and pyridate at 0.25 to 1.5 lb/A were applied postemergence on cantaloupe and watermelon.

Bentazon was marginally safe on cantaloupes and controlled purslane and pigweeds. Morningglory and Wright's groundcherry were not effectively controlled by bentazon. Bentazon appeared to be less injurious to watermelons relative to cantaloupes. Halosulfuron was safe on both cantaloupes and watermelons (<15% injury). Halosulfuron at greater than 0.05 lb/A was effective in controlling only Hyssop spurge and London rocket. In one test, halosulfuron gave acceptable control (85%) of morningglory. Purslane and groundcherry were not controlled by halosulfuron. Pyridate was not safe on cantaloupes causing severe crop stand reduction. Pyridate was safer on watermelons and caused marginally acceptable injury, however; weed control was not effective against groundcherry, spurge or London rocket. Pyridate appeared to give acceptable control of morningglory in one test.

ANNUAL WEED CONTROL IN TREEFRUIT, NUT AND VINE CROPS WITH THIAZOPYR.
L. Douglas West, John T. Schlesselman, Randy L. Smith, and Harvey A. Yoshida, Rohm and Haas Company, 1520 East Shaw Avenue, Suite 119, Fresno, CA 93654.

Abstract. Thiazopyr was evaluated in 33 trials in treefruit, nut and vine crops in 1995 and 1996 in California. Application rates ranged from 0.14 to 1.12 kg/ha. Thiazopyr was tested on more than 30 species of annual grasses and broadleaves, and was compared to oryzalin, pendimethalin and oxyfluorfen. Combinations of thiazopyr and oxyfluorfen were compared to oxyfluorfen plus oryzalin and oxyfluorfen plus pendimethalin. Thiazopyr had greater activity on grass species than on broadleaves, but did provide control of a number of broadleaves. The soil residual activity of the material was, generally, 5 to 7 months. Thiazopyr was more effective on annual grass species than oryzalin and pendimethalin, and significantly more active on a kilogram to kilogram basis. The thiazopyr plus oxyfluorfen combinations had equivalent or better activity than those of oxyfluorfen plus oryzalin and oxyfluorfen plus pendimethalin.

QUACKGRASS CONTROL IN WINTER WHEAT WITH MON 37500. Sheldon E. Blank, Local Development Manager, Monsanto, the Ceregen Unit, Kennewick, WA 99336.

Abstract. MON 37500 is a new selective herbicide being developed in North America for the control of grass and broadleaf weeds in wheat. Although the major focus of this new product has been control of *Bromus* species in wheat, initial probes in Europe revealed the product may have utility for selectively treating quackgrass.

From 1994 to 1996, four trials were established in Washington state to evaluate the efficacy of MON 37500 on quackgrass in winter wheat. Spring applications of MON 37500 at 0.012 to 0.031 lb/A applied postemergence to quackgrass infested winter wheat resulted in 90 to 98% control, respectively. Quackgrass growth stage varied between years from 3- to 4-leaf stage up to 6- to 7-leaf stage. No winter wheat injury was observed and MON 37500 treatments increased grain yield 28.5 bu/A over untreated check areas.

SAN 1269H: PERFORMANCE PROFILE IN FIELD CORN. Steven Bowe, Dan Westberg, and Gary Schmitz, Sandoz Agro, Inc., 1300 E. Touhy Ave., Des Plaines, IL 60172.

Abstract. SAN 1269H is a unique herbicide discovered and developed by Sandoz Agro for broad spectrum postemergence weed control in field corn. SAN 1269H has been extensively tested in over 200 field trials since 1991. SAN 1269H is a synergistic combination of herbicides possessing auxin transport inhibition (SAN 835H) and auxin agonist (dicamba) modes of action. SAN 1269Hs broad spectrum efficacy and modes of action will allow it to be an important tool for weed resistance management.

SAN 1269H contains the sodium salts of SAN 835H and dicamba in a 1:2.5 acid equivalent ratio, formulated as a 70% WG. This ratio provides broad spectrum postemergence and in-season residual broadleaf weed control with annual grass suppression at a use rate range of 200 to 300 g/ha. Higher rates of 250 to 400 g/ha can be used to extend residual effect and control certain perennial weeds, while lower rates of 100 to 200 g/ha may be useful for situations where short residual postemergence control is desired. SAN 1269H provides excellent control of all important annual broadleaf weeds including common cocklebur, common lambsquarters, annual morningglories, pigweeds, ragweeds, velvetleaf, perennial broadleaf weeds such as Canada thistle and suppression of annual grasses such as foxtail, *Panicum* spp., and shattercane. No weed size/soil dependent rate restrictions are expected with early to mid post applications. SAN 1269H should always be applied with a non-ionic surfactant plus ammonium fertilizer adjuvant combination or modified crop oil concentrate for best performance.

Field corn has demonstrated excellent tolerance to SAN 1269H applied for postemergence weed control at pre-plant burndown, early post and mid-post timings. Future development will focus on use pattern refinement, development of additional uses and utilization with herbicide resistant crop technologies.

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

Abstract. BAY FOE 5043 plus metribuzin is a new herbicide premix product under development by Bayer Corporation and will be marketed in corn and soybeans under the trade name AXIOM®. Across the United States, the product has demonstrated excellent soil applied activity against many major annual grasses and certain small-seeded broadleaf weeds. It is formulated as a 68%DF and controls weeds at much lower use rates than the present

soil applied graminicides. Field studies conducted in the Western United States with BAY FOE 5043 plus metribuzin alone at 0.5 to 1 lb/A confirm selective control of many regionally important grasses and broadleaf weeds in field corn, including red-root pigweed, common lambsquarters, barnyardgrass, kochia, Texas panicum, common purslane, Russian thistle and green foxtail. BAY FOE 5043 plus metribuzin offered similar levels of annual grass control and superior broadleaf weed control as compared to the standard soil-applied graminicides. Tankmixtures of BAY FOE 5043 plus metribuzin and broadleaf herbicides such as atrazine provided broadspectrum annual grass and dicot control.

TOLERANCE OF ROUNDUP READY® COTTON TO GLYPHOSATE APPLIED AT VARIOUS GROWTH STAGES. Peter A. Dotray[1], J. Wayne Keeling[2], and B. Scott Asher[1], Assistant Professor, Associate Professor, and Research Assistant, [1]Department of Plant and Soil Science, Texas Tech University, Lubbock, TX 79409-2122 and [2]Texas Agricultural Experiment Station, Lubbock, TX 79401-9757.

Abstract. Cotton producers on the Texas Southern High Plains face increasing numbers of annual and perennial weeds that are not effectively controlled by preplant incorporated and preemergence herbicides. Glyphosate applied postemergence topical to cotton may control many of these problem weeds, but any cotton injury would be unacceptable. Field experiments were conducted in 1996 to evaluate Roundup Ready® cotton tolerance to glyphosate applied at the 0- to 1-leaf stage, 4-leaf stage, 9- to 10-node stage, or the 14-node stage. Preharvest treatments were applied 2 weeks past first bloom to 60% open boll. All glyphosate applications were made with a tractor-mounted plot sprayer delivering 7.5 GPA and the methods of application varied depending on cotton growth stage. All plots were kept weed-free. Roundup Ready® cotton exhibited excellent tolerance to glyphosate. No differences in visual injury, plant mapping, yield, or quality were observed following any glyphosate application. Other experiments conducted to evaluate a systems approach to weed management indicated that glyphosate improved silverleaf nightshade, Russian thistle, and kochia control over conventional weed management programs.

EVALUATION OF QUINCLORAC FOR MANAGEMENT OF FIELD BINDWEED IN A WHEAT FALLOW ROTATION. Stephen F. Enloe, Phil Westra, and Scott Nissen, Graduate Research Assistant, Associate Professor, and Assistant Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523.

Abstract. Field bindweed is a very persistent, perennial weed in most dryland agricultural areas of the United States. Its extensive root system makes it an excellent competitor for moisture and very difficult to control. Several herbicides have been successful in controlling bindweed topgrowth, but few have provided long term control without the increased risk of crop injury.

Four field studies were established in the fall of 1994 to compare the long term control of field bindweed in a wheat-fallow rotation with quinclorac, picloram, dicamba, 2,4-D, and glyphosate plus 2,4-D premix. First year treatments were applied in September 1994 as a fall application in fallow. Second year treatments were applied in August 1995, approximately 45 days prior to wheat planting. All treatments were applied with a CO_2 pressurized backpack sprayer at 15 gpa. Wheat was harvested in July 1996 and field bindweed control was evaluated 12 months after the second year application. Visual evaluations (0=no control; 100=total control) and bindweed biomass (g/m^2) were used to determine herbicide efficacy. Third year treatments were applied in late September to early October 1996.

Due to an extremely dry fall and spring, wheat yields were taken at only two locations in the study. Wheat yields were nearly doubled by all herbicide treatments at Ft. Collins, CO, with no significant differences between them. Quinclorac and picloram increased wheat yields by 50% over the 2,4-D, dicamba, and glyphosate plus 2,4-D treatments at Loveland, CO. Quinclorac and picloram consistently provided the highest level of field bindweed

control over all four locations. Field bindweed control was significantly higher with picloram than quinclorac at only one location. 2,4-D, dicamba, and glyphosate plus 2,4-D provided much more variable control, generally ranging from 30 to 60%.

RESULTS FROM THE MON 37500 EXPERIMENTAL USE PERMIT. Neal R. Hageman, Sheldon E. Blank, Gary L. Cramer, Paul J. Isakson, Jeffrey A. Koscelny, and Douglas K. Ryerson, Local Development Managers, Monsanto, the Ceregen Unit, 800 North Lindbergh Boulevard, St. Louis, MO 63167.

Abstract. MON 37500 is a new herbicide being developed in North America for the control of grass and broadleaf weeds in wheat. An Experimental Use Permit (EUP) was granted in September 1995, by the Environmental Protection Agency for fall applications of MON 37500 in winter wheat. The EUP was approved for 250 A across 11 states. Most applications were made with commercial equipment and the treated area at individual sites varied from 1 to 10 A.

Bromus species were the primary weed targets in the EUP. MON 37500 at 0.031 lb/A achieved 87% control of downy brome across 48 sites and 90% control of cheat across 11 sites. In addition, weed control information was gathered on several other weeds. Among the broadleaf weeds evaluated in the EUP, MON 37500 gave 93% control of pinnate tansymustard, 97% control of tumble mustard, 95% control of field pennycress, 98% control of bushy wallflower, 90% control of mayweed chamomile, 90% control of catchweed bedstraw, and 88% control of tarweed fiddleneck. At one site, MON 37500 provided 95% control of quackgrass.

Wheat yields were also an important part of this EUP. Where possible, wheat yields were taken with large scale commercial equipment. Averaged across 29 sites where yields were taken, MON 37500 achieved a 12.8 bu/A wheat yield increase over the untreated check.

EFFECT OF SURFACTANTS ON DOWNY BROME CONTROL WITH PRIMISULFURON. Paul E. Hendrickson and Carol A. Mallory-Smith, Graduate Student and Assistant Professor, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331-3002.

Abstract. Primisulfuron is registered for control of downy brome in Kentucky bluegrass. Studies have suggested that using a methylated seed oil with primisulfuron may increase weed control compared to other surfactants. Greenhouse experiments were conducted to evaluate the influence of four surfactants (organosilicone, nonionic, crop oil concentrate, and methylated seed oil) on downy brome control. Primisulfuron at 1.25, 2.5, and 5 g/ha was applied alone or with organosilicone and nonionic surfactants at 0.25% v/v, a crop oil concentrate at 1% v/v, and a methylated seed oil at 1.75 L/ha. Response to primisulfuron was determined by measuring above ground biomass. Top growth was harvested 3 weeks after treatment and dried at 65 C for 96 hours. The addition of surfactants significantly decreased biomass when combined over all herbicide rates (Table). The least biomass reduction was measured when the organosilicone was included. Biomass reduction was greater with the addition of the crop oil concentrate and methylated seed oil than with the other two surfactants. Field studies are being conducted to determine if similar results will be observed under natural conditions.

Table. Biomass reduction over all primisulfuron rates.

Treatment	Biomass reduction[a]
	—— % ——
Primisulfuron alone	13 a
Primisulfuron + organosilicone	45 b
Primisulfuron + nonionic	66 c
Primisulfuron + crop oil concentrate	75 d
Primisulfuron + methylated seed oil	82 d

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

EFFICACY OF ISOXAFLUTOLE APPLIED PREEMERGENCE IN CONVENTIONAL TILLAGE CORN. Charles P. Hicks and Dwight G. Mosier, Senior Field Development Representatives, Rhone-Poulenc Ag Company, Research Triangle Park, NC 27709.

Abstract. Isoxaflutole is a member of a new class of isoxazole herbicides from Rhone-Poulenc Ag Company which disrupts pigment biosynthesis in susceptible plants. Isoxaflutole is formulated as a 75% water dispersible granule. It does not tie up on surface trash nor does it photodegrade when left on the soil surface. In the field, isoxaflutole provides appropriate residual activity, but dissipates within a growing season with no carryover into following crops.

Isoxaflutole was evaluated in 1995 and 1996 in 370 preemergence conventional tillage field trials conducted by Rhone-Poulenc in the United States. Results from these trials have shown that isoxaflutole provides excellent selective control of both grass and broadleaf weeds in corn at low use rates. Field trials conducted on light textured, high pH soils of the west, have demonstrated that isoxaflutole, applied alone preemergence at 53 g/ha controls important weeds, including: redroot pigweed, common lambsquarters, kochia and barnyardgrass. Applications of 79 g/ha were needed for control of wild proso millet and field sandbur. Tank mixtures of isoxaflutole at 53 to 79 g/ha with half rates of metolachlor, acetachlor or atrazine provided excellent control of most annual grass and broadleaf weed species.

On heavier textured soils of the midwest, isoxaflutole applied preemergence at rates of 79 to 105 g/ha provided excellent control of velvetleaf, common ragweed, smooth pigweed, Pennsylvania smartweed and fall panicum. Applications of 132 g/ha were needed for control of tall waterhemp, giant foxtail, yellow foxtail, green foxtail and wooly cupgrass.

JOINTED GOATGRASS COMPETITIVENESS IS INFLUENCED BY WINTER WHEAT SEEDING RATE. Brady F. Kappler, Drew J. Lyon, Stephen D. Miller, Phillip W. Stahlman, and Gail A. Wicks, Graduate Research Assistant, Department of Agronomy, University of Nebraska-Lincoln, 362 Plant Sciences Hall, Lincoln, NE 68583-0915; Associate Professor, University of Nebraska-Lincoln, Panhandle Research and Extension Center, 4502 Avenue I, Scottsbluff, NE 69361-4939; Professor, Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY 82071; Professor, Kansas State University, Hays Agricultural Research Center, 1232 240th Avenue, Hays, KS 67601-9228; and Professor, University of Nebraska-Lincoln, West Central Research and Extension Center, Route 4, Box #46A, North Platte, NE 69101-9495.

Abstract. Jointed goatgrass is a troublesome weed in winter wheat. Winter wheat seeding rates are easily adjusted by growers and have been shown to reduce competition from some weeds. Field experiments were initiated in the fall of 1994 and completed during 1996 at Hays, KS; Sidney, NE; and Torrington (1994 to 1995) and Archer (1995 to 1996), WY to determine the effect of wheat seeding rates (ranging from 33 to 101 kg/ha) on jointed goatgrass competitiveness. Jointed goatgrass densities averaged 25 plants/m^2 at Kansas and Wyoming, while Nebraska densities averaged 30 plants/m^2. Winter wheat plant densities, 42 days after planting, increased as the wheat seeding rate increased. The presence of jointed goatgrass did not affect winter wheat plant densities. Jointed goatgrass reproductive tiller density at harvest, spikelet production, and biomass were all decreased as wheat seeding rates were increased at the Wyoming locations. Wheat seeding rate did not affect jointed goatgrass reproductive success at Nebraska or Kansas. The ability of jointed goatgrass to reduce winter wheat reproductive tiller density at harvest decreased as wheat seeding rates were increased at Nebraska and Wyoming. Winter wheat grain yield increased as wheat seeding rate increased at Wyoming and at Nebraska during 1996, but otherwise grain yield was not affected by wheat seeding rate. Jointed goatgrass reduced wheat grain yield at all locations, but the extent of the loss was not influenced by wheat seeding rate. Wheat grain yield was least affected by jointed goatgrass interference at Wyoming.

Selecting higher wheat seeding rates never reduced winter wheat grain yields, but did show promise for reducing jointed goatgrass reproductive success. Wheat seeding rates can play a role in integrated jointed goatgrass management systems.

CARFENTRAZONE-ETHYL WITH 2,4-D AND 28% NITROGEN FOR CONTROL OF BROADLEAF WEEDS IN WINTER WHEAT. Robert N. Klein, Jeffrey A. Golus, and Gail G. Stratman, Professor, and Extension Research Technologist, University of Nebraska West Central Research and Extension Center, North Platte, NE 69101 and FMC Market Development, Lincoln, NE 68521.

Abstract. A study was conducted 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% water-50% 28% N were used as carriers.

Plots were laid out in 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 inch spacing) on May 22. All treatments contained carfentrazone-ethyl at 0.023 lb/A plus 2,4-D at 0.25 lb/A, with the exception of one treatment that contained only 28% N at 20 gpa. Extended range Flat Fan nozzles were used at 5, 10, and 20 gpa with 28% N added at 2% v/v and water being the carrier. Turbo TeeJet nozzles were also used in this manner. 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. Five gpa treatments were applied with 11002 XR and TT11002 VP nozzles at 20 psi and 5.54 mph. Ten gpa treatments were applied with 11002 XR and TT11002 VP nozzles at 20 psi and 2.8 mph. Twenty gpa treatments were applied with 11004 XR and TT11004 VP nozzles at 20 psi and 2.8 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 rated 1 and 2 weeks after treatment. Weed control rated 4 and 6 weeks after treatment.

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

	Rate	Application method	Crop injury 29 May	Crop injury 6 June	Kochia 17 June	Kochia 5 July	Russian thistle 17 June	Russian thistle 5 July
	lb/A		% control					
Carfentrazone-ethyl + 2,4-D + 28% N	0.023 + 0.25 + 2%	5 gpa flat fan	0	3	84	81	73	74
Carfentrazone-ethyl + 2,4-D + 28% N	0.023 + 0.25 + 2%	10 gpa flat fan	0	5	91	89	80	81
Carfentrazone-ethyl + 2,4-D + 28% N	0.023 + 0.25 + 2%	10 gpa flat fan	0	5	93	92	84	85
Carfentrazone-ethyl + 2,4-D + 28% N	0.023 + 0.25 + 2%	5 gpa trboTjet	0	0	83	79	73	73
Carfentrazone-ethyl + 2,4-D + 28% N	0.023 + 0.25 + 2%	10 gpa trboTjet	0	4	90	89	81	80
Carfentrazone-ethyl + 2,4-D + 28% N	0.023 + 0.25 + 2%	20 gpa trboTjet	0	5	91	90	81	84
Carfentrazone-ethyl + 2,4-D + 28% N[a]	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 5%			3	3	7	8	8	8

[a]28% N used as carrier
[b]10 GPA water and 10 GPA 28% N

The greatest crop injury occurred with 28% N as the carrier, although a small amount occurred with 28% N at 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. 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.

MON 37500: A NEW SELECTIVE HERBICIDE TO CONTROL ANNUAL WEEDS IN WHEAT. Jeffrey A. Koscelny, Gary L. Cramer, Sheldon E. Blank, Neal R. Hageman, Paul J. Isakson, Douglas K. Ryerson, and Scott K. Parrish, Local Development Managers, Monsanto, the Ceregen Unit, 800 North Lindbergh Boulevard, St. Louis, MO 63167.

Abstract. A sulfonylurea herbicide, MON 37500, is currently being developed for selective control of many grass and broadleaf weed species in wheat. The objective of this research was to evaluate MON 37500 efficacy on *Bromus* species in winter wheat.

MON 37500 at 0.031 lb/A applied preemergence, fall postemergence, and spring postemergence controlled *Bromus* species 90, 93, and 84%, and increased wheat yield 12, 19, and 11 bu/A, respectively in small-plot replicated trials. Results were similar in large plot strip trials where MON 37500 at 0.031 lb/A applied preemergence, fall postemergence, and spring postemergence controlled *Bromus* species 89, 88, and 73%, and increased wheat yield 11, 14, and 9 bu/A, respectively. Italian ryegrass was also controlled with fall applications of MON 37500 at 0.031 lb/A. MON 37500 has excellent activity on many broadleaf weeds in wheat. Tansymustard, tumble mustard, and field pennycress were controlled 95, 98, and 89%, respectively with an application of MON 37500 at 0.031 lb/A. MON 37500 represents a breakthrough for wheat producers and will provide broad spectrum broadleaf weed and grass control, including *Bromus* spp.

GLUFOSINATE HERBICIDE FOR WEED CONTROL IN TRANSGENIC SUGARBEET. Dean W. Maruska, Jim F. Stewart, Kevin J. Staska, Kevin B. Thorsness, and Paul G. Mayland, Field Development, AgrEvo USA Company, Wilmington, DE 19808.

Abstract. Weed control is an important aspect of sugarbeet production. The current herbicides labeled for use in sugarbeet are limited by their weed spectrum and in some cases weed size at application. Glufosinate is a non-selective postemergence herbicide with no soil residual and is being developed by AgrEvo USA Company for use on transgenic sugarbeet. This sugarbeet has been genetically altered by insertion of the phosphinothricin-acetyltransferase (pat) gene and is tolerant to glufosinate. The pat gene encodes for an enzyme that detoxifies glufosinate in the transformed sugarbeet plant. Field experiments were conducted in 1995 and 1996 at various locations to evaluate weed efficacy and tolerance of transformed sugarbeet to glufosinate applications. Glufosinate at 200 to 500 g/ha was applied to 2.5, 7.5 and 12.5 cm weeds and applications were repeated 2 times when newly germinated weeds reached the original application size. Weed species present in the trials were redroot pigweed, common lambsquarters, kochia, wild oat, green foxtail, and barnyardgrass. The plots were not cultivated or hand weeded. Weed control with glufosinate was better when applied to 2.5 cm weeds compared to 7.5 or 12.5 cm weeds. Glufosinate at 200 and 250 g/ha gave 85 and 90% overall control of 2.5 cm weeds, respectively. However, glufosinate at 300 to 500 g/ha gave greater than 95% overall control of 2.5 cm weeds. Glufosinate applications to transformed sugarbeet did not cause any visible injury. Glufosinate will provide sugarbeet growers with a tool to produce sugarbeet without hand labor and with less or no cultivation.

ALTERNATIVES FOR PURPLE AND YELLOW NUTSEDGE MANAGEMENT. Milton E. McGiffen, Jr.[1], David W. Cudney[1], Edmond J. Ogbuchiekwe[1], Aziz Baameur[2], and Robert L. Kallenbach[3], [1]Extension Specialists and Staff Research Associate, University of California, Riverside, CA 92521-0124; [2]Farm Advisor, University of California Cooperative Extension, Moreno Valley, CA 92557-8708; and [3]Farm Advisor, University of California Cooperative Extension, Blythe, CA 92225.

Abstract. Yellow and purple nutsedge are problem perennials that resist most common control measures. High temperatures, irrigation, and relatively non-competitive crops combine to greatly increase the severity of nutsedge infestations in the Southwest. We compared the growth and susceptibility of purple and yellow nutsedge to chemical and cultural control measures at several locations in southern California. When not controlled, low initial populations of either species led to heavy infestations later in the season. Herbicides tested included imazethapyr, dimethenamid (SAN 582 H), glyphosate, norflurazon, halosulfuron, and EPTC. Most of the herbicides tested were more effective against yellow than purple nutsedge. However, purple nutsedge was far more prolific in both tuber production and above ground growth than yellow nutsedge in an irrigated field in the low desert. Summer crops with dense canopies can severely decrease nutsedge shoot and tuber growth. Cool season crops planted into heavy nutsedge infestations in the fall are generally unaffected because nutsedge soon enters dormancy and ceases growth. Solarization, or pasteurization of the upper soil layers, was effective in decreasing tuber formation.

ROTATIONAL CROP RESPONSE TO MON 37500, METSULFURON, PROSULFURON, TRIASULFURON AND TRIBENURON PLUS THIFENSULFURON. Patrick A. Miller, Phil Westra, and Scott J. Nissen, Graduate Research Assistant, Associate Professor and Assistant Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523.

Abstract. Sulfonylurea herbicides can persist in the soil environment for several months following initial application. In addition, plant species vary in sensitivity to members of this herbicide family. As a consequence, rotational crop response is a concern where sulfonylurea herbicide carryover is likely. For this reason, a study was initiated at the Agricultural Research, Development and Education Center (ARDEC) in Ft. Collins, CO.

The objective of the study was to evaluate the plant response of several sulfonylurea herbicides applied alone and in combination with MON 37500. The rotational crops evaluated were corn, sorghum, winter and spring barley, winter oilseed rape, sunflower and sugarbeet. The bioassay species were planted on 7 Aug 1996 and evaluated for plant height 21 and 36 days after treatment (DAT).

A number of herbicide concentrations were necessary to detect differences in bioassay species susceptibility to members within this herbicide family. As such, we used a CO_2 pressurized log-sprayer calibrated to deliver 84.7 L ha^{-1} and provided a series of 0.5x dilutions across the plot area. The sprayer was calibrated to deliver each 0.5x dilution at approximately 3 meter intervals. Each plot contained 9 (0.5x) herbicide dilutions, beginning with an initial concentration of 2x and ending with a final concentration of 0.0078x. The 1x dosage for MON 37500, metsulfuron, prosulfuron, triasulfuron, and tribenuron plus thifensulfuron was 78.4, 6.3, 25.5, 22.2, and 28.4 g ha^{-1}, respectively. The plots were 3 by 30 meters with three replicates and the study was arranged as a randomized, complete block design.

In general, the treatments containing MON 37500 were more active at a given herbicide dilution, than the other treatments. In addition, no antagonistic or synergistic plant responses were observed in the treatments containing MON 37500 with an added ALS herbicide. Use of the log sprayer allows for the estimation of herbicide residues remaining in the soil at some future point in time (assuming dissipation is linear with time and follows first-order kinetics). Based on the herbicide concentration required for a specified level of crop injury, the number of days necessary to delay planting of a rotational crop can be calculated.

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

Abstract. Defoliation of sugarbeet by mid-season hail storms opens the field up for late season weed invasion. This research was conducted at the Torrington Research and Extension Center in 1995 and 1996 to develop weed management guidelines for sugarbeet fields that have been defoliated in mid-season. Sugarbeet plot areas were treated as a production field with best management practices until layby herbicides were applied and included: planting sugarbeet to stand, preplant incorporated herbicide and post emergence herbicide application. Three replications were arranged in a split-plot randomized complete block design. Defoliation date treatments were split to include application timing and herbicide treatments. Herbicides were applied layby and after defoliation and included dimethenamid, EPTC and trifluralin. Weed populations were nearly five times higher with early season defoliation than when sugarbeets were not defoliated. Weed control with post defoliation treatments was 8 to 15% higher than with layby treatments. Dimethenamid provided the best weed control in 1995 but EPTC plus trifluralin was better than dimethenamid in 1996. Sugarbeet returns were 30% less with mid-August defoliation than when sugarbeets were not defoliated.

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

Abstract. A field experiment was conducted in Ft. Collins CO, to evaluate the competitive effect of lambsquarter on grain corn. This research is part of a regional research project (NC-202) designed to develop locally sensitive weed economic thresholds for a number of important weeds in corn. Evaluation of economic threshold studies in a number of states will allow assessment of the stability of interference coefficients for these weeds. Corn was planted at a density of 5 to 6 plants/m of row on 6 May 1996 and common lambsquarter on 8 May 1996 at densities of 0, 1, 3, 9, and 18 plants/m of row. Non-destructive corn and lambsquarters growth data was recorded every

15 days after emergence. Corn yield, weed biomass and weed seed production were recorded and analyzed using regression analysis. Evaluations for 3 months after planting showed reduced corn height, leaf number per corn plant and N content in corn leaves with increasing weed density. Weed density did not affect lambsquarter height or branch number during this time period. Corn yield declined at the highest lambsquarter densities, suggesting that weed density is an important component of the competitive effects of this weed in corn. Corn yields were reduced from 157 bu/A in the untreated control plots to 105 bu/A at the highest lambsquarter density. The yield reduction response was best described by a linear regression line with a r^2 of 0.72. Total (100%) ground cover occurred only at the highest lambsquarter density. Lambsquarter at the highest density produced more than 80,000 seeds/m of corn row.

VOLUNTEER BARLEY CONTROL IN WINTER WHEAT WITH MON 37500. Sandra L. Shinn and Donald C. Thill, Graduate Research Assistant and Professor, Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83344-2339.

Abstract. Spring barley often is grown in rotation with winter wheat. However, some volunteer barley plants can overwinter in the subsequent winter wheat crop and reduce winter wheat grain yield and quality. A study was established during March, 1996 in a winter wheat field in southeastern Washington state to evaluate control of 'Steptoe' volunteer spring barley with MON 37500. The experiment was designed as a randomized complete block with four replications. Individual plots were 2.4 by 8.2 m. MON 37500 was applied at 0.018, 0.026 and 0.035 kg/ha in March and April when volunteer barley plants were in 2- to 4-tiller and 4-tiller to joint-stages, respectively. All rates of MON 37500 controlled volunteer barley 98% or more at both application times. Volunteer barley density ranged from 0 to 2 plants/m^2 in MON 37500 treatments compared to 65 plants/m^2 in the untreated control plots. After harvest, each winter wheat grain sample was cleaned and graded. Dockage was 0.1 to 0.9%, primarily in the form of volunteer barley kernels, in grain samples from plots treated with MON 37500 and 2.7 to 8.6% in grain samples from the untreated control. Grain samples from MON 37500 treatments were grade number one compared to the untreated control sample which were grade number four. Cleaned grain yield in MON 37500 treatments averaged 7264 kg/ha and grossed $1675/ha Portland, OR port price on August 15, 1996 compared to the untreated control which yielded 6909 kg/ha, but grossed only $1439/ha.

WINTER ANNUAL GRASS CONTROL IN WINTER WHEAT WITH MON 37500. Phillip W. Stahlman, Francis E. Northam, and Patrick W. Geier, Research Weed Scientist, Research Associate, and Research Assistant, Kansas State University Agricultural Research Center-Hays, Hays, KS 67601.

Abstract. A field experiment was conducted at the Kansas State University Agricultural Research Center near Hays, KS in 1995 to 1996 to determine the effects of MON 37500 applied POST at three times on the growth and reproductive capacity of winter annual grass weeds. MON 37500 plus NIS at 0.031 lb/A plus 0.5% v/v was applied in the fall and two times in the spring. Fall-POST treatments reduced cheat, downy brome, and Japanese brome plant densities greater than or equal to 90% compared with about 40% reduction for jointed goatgrass. Spring-POST treatments reduced downy brome and Japanese brome densities by up to 40% and 50%, respectively, but killed few (< 20%) cheat or jointed goatgrass plants. However, MON 37500 applied in the spring reduced the number of cheat spikelets/panicle by 33 and 56% and germination by 59 and 74%; effects were greater for the earlier application. Spring-applied treatments reduced Japanese brome spikelets/panicle greater than or equal to 80% and germination about 40%. MON 37500 did not effect jointed goatgrass spikelet production, but reduced germination by 13 to 24%. Downy brome germination was not affected.

HOE 6001 - A NEW GRASS HERBICIDE FOR USE IN WHEAT, BARLEY, AND DURUM. James F. Stewart, Terrel W. Mayberry, and Kevin B. Thorsness, Field Development Representatives, AgrEvo USA Company, Wilmington, DE 19808.

Abstract. Control of grass weeds in cereal crops is an important aspect of cereal production. NDSU research has shown that wild oat and foxtail populations of 172 plants/m^2 will reduce spring wheat yields approximately 40% and 15%, respectively. Postemergence herbicides that control both wild oat and foxtails in wheat, barley and durum wheat are limited.

HOE 6001 is a new postemergence herbicide that is a premix of fenoxaprop-p-ethyl and a new safener (HOE 108892-06H) and is being developed by AgrEvo USA Company. HOE 6001 controls wild oat, green and yellow foxtails, foxtail millets, proso millet, volunteer corn, barnyardgrass, blackgrass, and windgrass in wheat, barley, and durum wheat.

The objectives of this research were to evaluate spring and winter wheat, spring barley, and durum wheat tolerance to HOE 6001 at 45, 117, and 234 g/ha (0.5 X, X and 2X rates) applied at the pre-tiller (Zadoks 13), tillering (Zadoks 22) and jointing (Zadoks 31) growth stages and to evaluate wild oat control with HOE 6001 at 133.5 g/ha alone and tank mixed with various broadleaf herbicides when applied to pre-tillered (Zadoks 13), tillering (Zadoks 22) and jointed (Zadoks 31) wild oat. Experiments were conducted at several sites in North Dakota, Idaho, and Washington in 1996. Percent visual crop injury was evaluated 14 and 28 days after harvest (DAT) and pre-harvest. Percent visual wild oat control was evaluated 28 DAT and pre-harvest.

Percent visual crop injury 14 DAT with HOE 6001 at 0.5 X, X and 2X rates at the pre-tillering, tillering and jointing growth stages was acceptable (10% or less) on all varieties tested regardless of the crop. Percent visual crop injury was similar to diclofop or imazamethabenz plus Scoil at 14 DAT and was minimal to non-detectable in all varieties 28 DAT with HOE 6001 regardless of rate or growth stage at application. Yield of spring and winter wheat, spring barley, and durum wheat treated with HOE 6001 at 0.5X, X and 2X rates applied at the pre-tillering, tillering, and jointing growth stage was equal to diclofop or imazamethabenz plus Scoil.

Percent visual wild oat control at pre-harvest was 92% or greater with HOE 6001 at 133.5 g/ha applied to 1- to 5-leaf wild oat. HOE 6001 tank mixed with bromoxynil, bromoxynil plus MCPA ester, and MCPA ester gave wild oat control equal to or greater than imazamethabenz plus bromoxynil plus MCPA ester plus Scoil regardless of the wild oat stage at application. Thifensulfuron plus tribenuron plus MCPA ester tank mixed with HOE 6001 caused unacceptable antagonism of wild oat control.

WEED CONTROL AND CROP SAFETY WITH BAY FOE 5043 PLUS METRIBUZIN. Jim Anderson, Philip Westra, and Tim D'Amato, Bayer Product Development, Greeley, CO 80631 and Assoc. Professor, and Research Associate, Dept. of Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523.

Abstract. BAY FOE 5043 is an experimental oxyacetamide herbicide that is being developed as a premix with metribuzin under the name of Axiom® for use in field corn. Several studies were conducted in Colorado over 2 years to evaluate weed control and crop safety with this compound. BAY FOE 5043 is a 68% dry flowable premix of FOE 5043 (54.4%) plus metribuzin (13.6%). BAY FOE 5043 has been tested in numerous herbicide screening trials in field corn at several locations in Colorado from 1994 to 1996 to evaluate pre and ppi applications. Visual evaluations have shown BAY FOE 5043 to provide effective broad spectrum weed control. Weed species tested have been *Setaria viridis, Kochia scoparia, Amaranthus retroflexus, Chenopodium album*, and *Solanum sarrachoides*. Crop safety has been good when rate was properly adjusted for soil type.

FALLOW PRACTICES FOLLOWING 1996 WHEAT HARVEST. Gail A. Wicks and Robert N. Klein, University of Nebraska Extension Specialists, Department of Agronomy, North Platte, NE 69101.

INTRODUCTION

Research has been conducted on using herbicides to control weeds in a fallow situation for about 50 yr. Torlies S. Aasheim, a Project Supervisor for the SCS at Havre, MT is credited with being the first scientist to work on controlling weeds in fallow situation involving winter wheat stubble in the spring of 1948 (1). His group used "Dow General" (DNBP or dinoseb) and 2,4-D and called this practice chemical fallow. Later, 2,4-D and dalapon were used to obtain better grass control (2). Phillips from Kansas State University at Hays, KS did the first research on using atrazine following wheat harvest in 1961 and planting grain sorghum the next spring (4). In Nebraska, we began an extension program in 1972 to reduce soil erosion and improve dryland grain yields. Industry had tried to make chemical fallow a successful program in the 3-yr rotation but it never caught on with Nebraska farmers. Therefore, we decided to coin a new name to describe a conservation practice that would be beneficial to dryland crop production. We wanted farmers to be more aware of the benefits of crop residue for ecology purposes which also increased crop yields and be an economic benefit. The term ecofallow fit. Soon we found that a term was needed to encompose the entire rotation not just the 10 to 14 month fallow period. The term chosen was ecofarming which would entail using the best crop management techniques throughout the rotation.

Ecofarming is a no-till or reduced tillage system for controlling weeds and managing crop residues throughout the crop rotation with less tillage. This crop management system reduces soil erosion while increasing weed control, water infiltration, water conservation, and crop yields in semiarid regions of the central Great Plains. It employs several methods of integrated crop and pest management. It is essential that a good crop of winter wheat is established. To do this one starts with the prewheat-fallow period before winter wheat planting. To increase the chances that sufficient soil water is available for wheat seed germination and growth, weeds must be timely controlled and wheat planted into a firm seedbed. The period between wheat harvest and planting the summer crop is called the ecofallow period. In Nebraska the summer crops include corn, forage sorghum, grain sorghum, proso millet, soybean, and sunflower. Corn and grain sorghum are the most popular crops to use in rotations with winter wheat.

Several methods of weed management are used in the winter wheat-fallow and winter wheat-corn or grain sorghum-fallow rotations. Cultural practices that improve weed management include crop rotation, competitive varieties, narrow rows, and planting sufficient winter wheat seed to ensure optimum stands of wheat to suppress weeds. Winter wheat must be fertilized timely to increase the competitiveness of wheat. Fertilizing too late in the spring favors the summer annual weeds and increases weed problems after wheat harvest. Increasing fertilizer rates increases crop biomass and improves weed control. However, increasing nitrogen rates beyond the optimum reduces grain yields. Harvesting crops efficiently reduces seed loss and lessens potential weed problems. Crop rotations include winter crops (winter wheat) rotated with summer crops (corn and grain sorghum). The most critical management input in the 3-yr rotation is weed control. Herbicides are used during the prewheat-fallow and the ecofallow periods to control weeds and reduce crop residue losses caused by tillage.

A 3-yr rotation is the most cost effective rotation in the 17 to 23 inch precipitation areas of the central Great Plains. Westcentral, southcentral, and southwest Nebraska; western Kansas; and eastern Colorado are the areas where this system of crop production is predominantly used. Farmers in the winter wheat producing areas in southcentral South Dakota also use this crop production practice. In southwest Nebraska in 1989, 28% of the wheat stubble fields to be planted to corn, sorghum or wheat the following year were sprayed after wheat harvest compared with 8% in the southern panhandle (3). In 1994, 20% of wheat stubble fields in the winter wheat-fallow rotation were sprayed following harvest in southwest Nebraska and northwest Kansas (7). In 1994 in the winter wheat-corn or sorghum-fallow areas, 75% of the fields were sprayed in southwest Nebraska and 55% in northwest Kansas (7). A similar survey in Nebraska in 1991 showed that 65% of the wheat stubble fields were sprayed (6).

In the 3-yr rotation, herbicides should be applied within 30 days after wheat harvest to reduce soil water usage by weeds and prevent weed seed production. Then in the following spring, herbicides and nitrogen are applied preplant. Corn or grain sorghum is planted no-till into the standing wheat stubble in late April to late May. The crop is harvested late September to early November. The following spring and summer the fields are fallowed and planted to winter wheat in September. Weeds are controlled in the prewheat fallow with crop residue, herbicides, and cultivation.

Winter wheat-fallow is the most common rotation used in the 14 to 18 inch precipitation areas. The prewheat-fallow period is necessary to store water in the soil profile for the following winter wheat crop.

Weeds must be controlled timely with herbicides and/or sweep tillage during the prewheat-fallow period. The crop residue is left on the soil surface until the latter part of June or first part of July to protect the soil from water erosion. Then tillage is used to manage the crop residue and prepare the seedbed. Sufficient crop residues also must remain to protect the soil and newly seeded winter wheat from wind erosion during fall and winter months when wheat is small. Keeping the soil protected from wind and water erosion with residues is vital for the future of this fragile land.

Winter wheat and corn or grain sorghum stubble are the keys to successful crop production without soil erosion during the 3-yr crop rotation. Weed-free winter wheat stubble protects the soil during the row cropping period. During the prewheat-fallow period, herbicides are needed during April to July to control weeds before they use soil water and nutrients and produce seed in the corn or sorghum stubble. Usually one application of glyphosate plus dicamba or glyphosate plus 2,4-D in April will control winter annual weeds. Another application of glyphosate maybe needed to control later germinating weeds in late May or June. Stubble mulch equipment is used during late June, July, and August to control weeds, and keep crop residues on the soil surface. A rodweeder is the final tillage tool used to prepare a firm seedbed for winter wheat. The wheat must be planted at the optimum planting date to reduce the incidence of root and crown rot and reduce winter injury. Early planted winter wheat is more susceptible to root and crown rot, has less yield and more weeds than wheat planted at the optimum time. With this system the only time the ground is subject to erosion is during the prewheat fallow period and establishment period for winter wheat.

Ecofarming practices have been used in Nebraska since 1972. Periodic surveys were taken on the usage of ecofallow over the years. A survey was taken across the state in September and October of 1996. These surveys are necessary to learn how what soil conservation practices are being used and what crop production problems need to be improved. The 1996 survey was initiated because of the drought stress on the winter wheat before mid-May and the high rainfall following. Two questions concerning post-harvest weed control were raised when wheat harvest was delayed. One, would herbicides control tall weeds satisfactorily, and two, what changes in after harvest management practices would farmers make.

MATERIAL AND METHODS

Between September 7 and October 7 a survey of winter wheat stubble fields was made across Nebraska to determine the after harvest management practices used by farmers. These practices included using a sweep plow, a tandem-disk harrow, sprayed with herbicides, or doing nothing. In addition weed control in sprayed fields were rated excellent, good, and fair. Excellent means that fields had 12 inches or higher stubble, excellent weed control (95 to 100%), sprayed timely with no dead weeds appearing above the stubble. A good rating says that fields had poor wheat stands in places, weed control was 95 to 100%, spraying was late as weeds were 10 to 20 inches above the stubble, and weeds probably produced seed before spraying. Fair ratings indicate that too many weeds were not killed by the herbicide treatment or volunteer wheat was not controlled. Major weed species missed by the herbicides or tillage were identified. Fields disked and planted back to winter wheat before the survey were not included. Winter wheat may have been planted back to wheat in some fields that were disked or sprayed after the survey. Sufficient subsoil moisture was available for continuous wheat.

Winter wheat harvested in center pivot corners were also surveyed. Only the first corner of the pivot was recorded. The counties surveyed included Box Butte, Chase, Cheyenne, Clay, Custer, Dawes, Dawson, Deuel, Dundy, Fillmore, Franklin, Frontier, Furnas, Gage, Gosper, Harlan, Hayes, Hitchcock, Keith, Jefferson, Lancaster, Lincoln, Logan, Morrill, Perkins, Red Willow, Thayer, and Webster.

RESULTS AND DISCUSSION

Winter wheat crop. The 1995 to 1996 winter wheat crop was under drought conditions in the fall of 1995. Many areas had insufficient or lack of timely rains to aid the germination and growth of the winter wheat. So, winter annual weeds such as downy brome, jointed goatgrass, field pennycress, and tansy mustard seeds did not germinate before wheat seeding. Normally, the final seedbed tillage operation kills emerged seedlings before wheat planting. Therefore, these weeds emerged after planting and fields had greater winter annual weed densities in the winter wheat than normal. In addition, wheat in some areas had to be planted deep to reach moist soil. Heavy fall rains silted in the wheat or crusted the soil so the wheat emergence was poor. Wheat was replanted. Poor winter survival was common in many areas with late planted winter wheat. The drought continued in the spring of 1996. In many areas the growth of the wheat was slowed. Then in the middle of May it started to rain. Some areas received 24 to 26 inches of rain during a three-month period. This delayed harvest and weeds in thin wheat flourished. Since wheat harvest was delayed, weeds grew larger and interfered with harvest. Following harvest rain continued, and fields could not be sprayed timely.

This survey involved 1379 winter wheat fields across 26 counties in western and southern Nebraska (Table 1). In the 17 to 23 inch precipitation area, 33% of the fields were sprayed after wheat harvest in the 2-yr rotation and 78% 3-yr rotation (Table 2). This was an increase of 12% since 1989 and 13% since 1991 in the percent of fields sprayed (3, 6). Tillage was down 14% from previous years, probably because soils were too wet or more farmers are switching to ecofallow. As one moves eastward in the state the percentage of fields sprayed after wheat harvest decreased (Table 2). Why? Various reasons exist. Less emphasis is placed on conserving soil water in eastern Nebraska because of more precipitation. In wet springs it is more difficult to plant into untilled wheat stubble. Fewer custom applicators want to move into this market. Less extension efforts are made to promote ecofallow because farmers fallow less in higher precipitation areas. They are more interested row crop rotations. Often winter wheat is grown continuously and these fields could have been planted before the survey began.

Twenty-eight to 40% of the wheat stubble fields were rated excellent for weed control (Table 3). Summer annual grasses were the most difficult weeds to control with herbicides after harvest (Table 4). Barnyardgrass and longspine sandbur in the west and as one move east yellow foxtail, fall panicum, and crabgrass were the problem grasses. For the most part, fields that had good wheat stands had excellent weed control. Fields with poor stands or sprayed too late had poorer control than when sprayed earlier or had better wheat stands. Wheat variety, planting date, seedbed preparation, and poor weed control during the prefallow period affected wheat stands. More volunteer wheat existed this year because excess rain delayed wheat harvest; then rain, hail, and wind increased shattering (Table 4). When atrazine was used it was not as effective probably because the soil surface pH (6 or less) may have been low enough to tie-up the atrazine. Also, dense stands of wheat seedlings were difficult to control because of competition for atrazine. Examples are wheat growing from wheat heads or small seed passing through the combine. In addition atrazine rates are less than a few years ago which increases the amount of volunteer wheat that escapes. Also, more fields were sprayed with glyphosate alone. In a dry season, these fields would have remained relative free of volunteer wheat but in a wet year wheat seed continued to germinate. This trend, occurred more in the 2-yr rotation area and in eastern Nebraska where they did not use atrazine. In the wheat-fallow area only 1 lb/A of atrazine can be used, while in the east soybean maybe planted next year instead of corn or sorghum.

Triazine-resistant kochia was a problem in westcentral and central Nebraska. More atrazine is used in these areas so triazine-resistant kochia is more prevalent. Shattercane, velvetleaf, and wild hemp were found and could be a future problem. Efforts need to be made to prevent seed production in these fields. Also, weeds in surround areas need to be controlled timely.

In general, the weed control was similar with a survey taken in 1986 (5). Tall weeds and weeds cut off with the combine were difficult to control. Barnyardgrass still is a difficult weed to control as well as crabgrass and fall panicum. Applicators were doing a better job of spraying in 1996 compared with 1986 as there were fewer sprayer skips.

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Table 1. Number of fields surveyed in 1996.

Rotation	Total
	No. of fields
Winter wheat-fallow	397
Winter wheat-corn or sorghum-fallow	640
Winter wheat-sorghum-soybean	125
Center pivot corners	217
Total	1379

Table 2. Stubble mulch management practices following winter wheat harvest across precipitation areas in Nebraska in 1996.[a]

	Precipitation areas				
	17 to 23 inches/rotation				
Operation	2-yr	3-yr	24 to 27 inches	28 to 30 inches	Center pivot corners[b]
	%				
Sprayed	33	78	52	14	31
Tandem-disk harrow	22	10	39	14	48
Sweep plow	11	0	0	0	0
Nothing	34	12	9	12	21

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

Table 3. Evaluation of fields for condition of wheat stubble and weed control.

	Precipitation areas				
	17 to 23 inches/rotation				
Operation	2-yr	3-yr	24 to 27 inches	28 to 30 inches	Center pivot corners[a]
	%				
Excellent[b]	35	40	28	38	31
Good[c]	13	34	28	38	48
Fair[d]	52	26	44	24	21

[a]Only the first corner of the pivot was included.
[b]Excellent wheat stubble and weed control.
[c]Weeds were dead but large enough to produce seeds before spraying. Many of these fields had poor stands of winter wheat.
[d]The fair fields had weeds missed by the herbicides.

Table 4. Weed species not controlled with herbicides.

Operation	Precipitation areas: 17 to 23 inches/rotation 2-yr	3-yr	24 to 27 inches	28 to 30 inches	Center pivot corners[a]
	% of fields				
Summer annual grass	14	50	25	50	42
Kochia[b]	15	11	19	--	8
Volunteer wheat[c]	71	35	56	50	48
Others[d]	0	4	0	0	0

[a]Only the first corner of the pivot was included.
[b]Includes TR kochia and ALS kochia.
[c]The high percentage for volunteer wheat probably means that these fields were sprayed with glyphosate or glyphosate-2,4-D. These fields may have to be sprayed again to kill the volunteer wheat this fall or next spring or planted to corn, sorghum, sunflower, or soybean next spring.
[d]Includes shattercane, velvetleaf, and wild hemp.

PURPLE NUTSEDGE CONTROL WITH VARYING RATES OF METHAM AND SPRAY APPLICATION IN COTTON. Steve Wright and Manuel Jimenez Jr., Farm Advisor and Staff Research Associate, University of California Cooperative Extension, Visalia, CA 93291.

Abstract. Nutsedge is a serious weed pest and very difficult weed to control in cotton. Metham has provided some suppression of both purple and yellow nutsedge in commercial applications. Control has been erratic and in some cases cotton injury has been observed. The objective of this study was to see if rates of metham could be lowered and still maintain good nutsedge control by using an improved method of application. Metham was applied on April 5, to evaluate the effect of application techniques with varying rates. The field had good moisture from a preirrigation and rain. Beds were mulched prior to application. Disc hillers and large sweeps were used to cover the treated zone with a 5 to 6 inch soil cap. All treatments were applied at 90 gpa. Cotton was planted on April 22, 1995. Plots were 2 to 30 inch rows by 1200 feet.

Nutsedge tuber counts were taken at different depths. Nutsedge tubers were distributed in the soil profile as follows: (0 to 4 inch depth)-33.7%, (4 to 8 inch depth)-39%, (8 to 12 inch depth)-19.5%, (12 to 16 inch depth)-0.06%, and (16 to 20 inch depth)-.02%. All metham treatments gave excellent control of nutsedge in the seedrow for 21 days following application. All three application techniques gave comparable weed control. Only the 65 gpa rate gave approximately 70 to 75% control for 44 days. No visible cotton injury was observed. Increasing rates of metham reduced seedling disease and increased shoot weights and seedling height. Metham at all rates reduced mycorrhiza counts. Although there were no visible injury symptoms, Metham at 65 gpa reduced yields under the conditions of this study. Metham treatments reduced seedling and shoot phosphate levels even though soil P levels were high (22 ppm). By first bloom there were no differences. Differences in N, K, and Zn levels were minor with no clear trends. There were also no clear differences in plant population or plant mapping parameters.

Table 1. Purple nutsedge control, seedling disease, mycorrhiza, and lint yield from metham and application techniques.

Treatment	Metham	Purple nutsedge control/DAT 21	29	36	44	50	Seedling disease	Mycor. infect	Lint yield
	gpa	%					0 to 4 scale[a]	- % -	lbs/A[b]
SSB[c]	25	89	44	25	19	14	2.34	4.11	1282
SSB[c]	45	96	73	55	36	38	1.96	11.65	1114
SSB[c]	65	100	89	81	73	59	1.54	2.52	1085
Fert. knives[d]	25	93	46	20	11	5	2.23	----	1088
Fert. knives[d]	45	96	81	58	51	35	1.69	----	1177
Fert. knives[d]	65	99	88	78	70	61	1.72	----	1086
TSB[e]	25	91	55	26	23	13	2.16	----	1138
TSB[e]	45	91	69	56	48	33	2.08	----	1094
TSB[e]	65	96	86	83	75	69	1.84	----	1129
CHECK	----	0	0	0	0	0	2.43	19.14	1222
LSD		9	11	12	18	16	.52	10.91	136

[a]Disease Rating 0 = No seedling diseases, 4 = severe seedling diseases.
[b]Yield based on 2 to 30 inch rows by 18 feet and 3 replications.
[c]SSB = Single spray blade (8 inch band).
[d]TSB = Triple spray blade (8 inch band).
[e]Three tiered fert. knives = fertilizer knives 2 per row (8 inch band)

TEACHING AND TECHNOLOGY TRANSFER

THE HERBICIDE SELECTION GUIDE AND WEED-PRO WEED MANAGEMENT COMPUTER PROGRAMS. Richard K. Zollinger, Terry Gregoire, Steve Wegner, and David Schwartz, Associate Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105-5051; Area Extension Specialist, North Dakota State University Extension Service, Devils Lake, ND 58310-0140; and Whetstone Software, Inc., Fargo, ND 58106.

Abstract. The Herbicide Selection Guide is a DOS based computer program developed for growers and agricultural professionals to aid in weed control and effective herbicide use. The program was developed through cooperation between Whetstone Software, Inc. and North Dakota State University Extension Service as a DOS based program but can be run from Windows as a DOS icon. The Herbicide Selection Guide displays possible herbicides based on selection from 1 of 27 crops at various growth stages and at least 50 weeds species. The program simulates field conditions by allowing the user to select a crop and one or more weeds after which the program displays herbicides, herbicide pre-mix, and herbicide tank-mix options listed in order of weed control efficacy from greatest to least. The program also displays cost per acre of each treatment listing. Herbicide performance of each product on each individual weed can be evaluated by scrolling through all labeled herbicides and herbicide combinations. As a result, the most effective and economical treatments can be selected. F keys shown around the outside of the screen allow the user to access information on other weeds controlled, herbicide rates, carryover potential, other labeled crops, and crop growth stages. Compiled applied information has been added showing herbicide mode of action, grazing restrictions, rainfall intervals after herbicide application, managing herbicide residues, and adjuvant selection. F1 "Help" feature is available in all screens. Word search capability allows the user to type in any word and is then forwarded to text files where the word is found. The program was developed for North Dakota. However, the program allows full editing to regionalize the program for other areas. For example, herbicide prices can be changed, and individual state supplemental and emergency labels can be added.

Weed-Pro is a computer program developed by North Dakota State University Extension Service and is based on the North Dakota Weed Control Guide. Weed-Pro is included in The Herbicide Selection Guide or is available as a separate program. Weed-Pro used alone or within The Herbicide Selection Guide provides an extensive amount of weed control and herbicide use information presented in a rapid-information-access and easy-to-use format.

The program contains detailed information on herbicide use for at least 40 cropping systems used in North Dakota. Information on herbicides include herbicide classification, cost, drift, incorporation, mode of action, carryover, combination with other additives, prepackaged mixtures, rates, effectiveness, rain-free interval, and storage temperatures. Information on adjuvants include classification, mode of action, cost, herbicide enhancement, water quality and pH modifiers. Information on herbicide use on crops and weeds include crop grazing, feeding or haying restrictions following herbicide use and resistance.

The program also contains herbicide and integrated control strategies for control of noxious and troublesome weeds. The program contains herbicide label information specific for North Dakota. A distinguishing feature of Weed-Pro are several data bases containing summaries of North Dakota State University weed control research over several years. The Herbicide Selection Guide and Weed-Pro are available through the North Dakota State University Extension Service.

SURVEY OF JOINTED GOATGRASS CONTROL PRACTICES BY WINTER WHEAT PRODUCERS.

Brian M. Jenks, National Jointed Goatgrass Extension Coordinator, University of Nebraska, Scottsbluff, NE 69361.

Abstract. Winter wheat producers with jointed goatgrass infestations were surveyed to identify current control practices used in the central Great Plains. Approximately 150 interviews were conducted to gather information and document examples of successful management strategies and production. Surveys were sent to 30 extension agents in NE, CO, WY, and KS for initial grower interviews. Follow-up telephone interviews were conducted to fill information gaps. The control method most frequently cited was crop rotation. Rotating out of wheat for at least two years to crops such as corn, sunflower, or proso millet allowed producers to reduce jointed goatgrass populations. Other methods included planting jointed goatgrass-free seed, elimination of seed production during the non-wheat period, plowing, fertilizer placement, border control, spot spraying, and burning. The objective of the survey was to make use of winter wheat producers' years of experience and incorporate new ideas into current jointed goatgrass research and best management practices.

THE NATIVE THISTLES OF NORTH DAKOTA. Rodney G. Lym and Katheryn M. Christianson, Professor and Research Specialist, Plant Sciences Department, North Dakota State University, Fargo, ND 58105.

Abstract. Nine species of thistle are in North Dakota, of which five are native and one is considered rare. North Dakota has a relatively low population of native thistles compared to most western states, which commonly have 25 or more native thistle species. Some plants referred to as thistles such as perennial sowthistle (*Sonchus arvensis* L.) and Russian thistle (*Salsola iberica* Sennen) are not true thistles, but rather are plants with poorly chosen common names. Most native thistle species go unnoticed. Only a few introduced thistles have become weedy pests. There are approximately 160 native thistle species in North America, with at least 110 species north of Mexico and 50 in Latin America south of the Mexican border.

Of the five native thistle species found in North Dakota, Flodman thistle [*Cirsium flodmanii* (Rydb.) Arthur] and wavyleaf thistle [*Cirsium undulatum* (Nutt.) Spreng.] are perennials, while tall thistle [*Cirsium altissimum* (L.) Spreng], field thistle [*Cirsium discolor* (Muhl. ex Willd.) Spreng.], and swamp thistle (*Cirsium muticum* Michx.) are biennials. Flodman thistle is the most common of these plants and is found in all North Dakota counties, while tall thistle is considered rare and is on the threatened/endangered species list in some regions.

Flodman thistle is more competitive than most other native species, has the potential to infest large areas, and is found throughout North Dakota. Flodman thistle is tolerant to high salt concentration in soil but grows best under moist conditions, as most thistles do. Flodman thistle can survive under drought conditions which gives it a competitive advantage on semi-arid rangeland. The stems of Flodman thistle can be peeled and eaten and were part of the Native American diet.

Wavyleaf thistle is often confused with Flodman thistle but is a larger plant and generally is found in drier locations than those occupied by Flodman thistle. Various Native American tribes used wavyleaf thistle to treat gonorrhea and syphilis. The remedy involved drinking a tea made from the plant and then elevating the body temperature to induce sweating. If the patient were male, he had to run 1 mile then wrap himself in a blanket. A female patient just sat bundled in a heavy blanket to induce sweating. A tea from the roots can be made to treat diabetes and stomachache. The roots were also boiled and used in soup.

Field thistle has only been documented to occur in extreme eastern North Dakota although it is quite common in Minnesota and most of eastern North America. Field thistle is found by roadsides, in clearings and openings in wooded areas, and in moist but not marshy locations. It generally grows 6 to 7 feet tall in North Dakota, but can reach heights up to 10 feet. The tall plant and leaves that resemble oak leaves are two good characteristics for identification of this plant in North Dakota. Field thistle is closely related to tall thistle. North Dakota is on the border of the ranges of both species. While they have been found in the state, they are considered uncommon.

As its name implies, swamp thistle is found in moist low-lying woodland areas, thickets, and near rivers and especially wet meadows. It is found in eastern and north central North Dakota. Swamp thistle is an elegant long-stemmed flowering plant that usually grows 3 to 6 feet tall. Swamp thistle has very few and weak spines on the leaf margins and no spines around the flower head, which is an easy way to tell it apart from field thistle and tall thistle. The swamp metalmark butterfly will lay eggs only on swamp thistle which is the caterpillar's only food source.

Tall thistle is closely related to field thistle and can be difficult to distinguish. Tall thistle is found in Nebraska where field thistle does not occur, and only field thistle, not tall thistle, is found in Canada. Although both species have been found in North Dakota they are considered uncommon and the characteristics that are used to distinguish these two species blur in the northern Great Plains. Tall thistle is commonly found near woods, in open lowlands, and near ditches and roads. It occasionally occurs on the slopes of open prairies. The leaves of tall thistle more closely resemble dandelion leaves, compared to the oak-leaf shape of field thistle.

The remaining four thistles species in North Dakota are introduced. Canada thistle [*Cirsium arvense* (L.) Scop] is common throughout the state, while musk thistle (*Carduus nutans* L.) is isolated to a few counties. Plumeless thistle (*Carduus acanthoides* L.) is found only in the eastern part of the state. Bull thistle [*Cirsium vulgare* (Savi) Tenore] is found in the northern and eastern counties of the state but generally grows singularly or only scattered in pastures and wooded areas. Only Canada thistle and musk thistle are on the North Dakota noxious weed list.

DESIGNING TARGETED EXTENSION WEED SCIENCE PROGRAMS: INFERENCES FROM WEED IDENTIFICATION SUBMISSION PATTERNS IN IDAHO. Timothy W. Miller and Robert H. Callihan, Extension Support Scientist and Professor Emeritus, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83844-2339.

Abstract. Since 1984, plants from various sources have been submitted to the University of Idaho's Weed Diagnostic Laboratory (WDL) for identification. These sources include county weed control superintendents, county extension educators, agricultural consultants, farmers, ranchers, homeowners, and University of Idaho weed scientists. Many of these submissions have been common weed species, long known to exist in Idaho; many have been desirable ornamental or forage plants that were not truly weedy; many have been plants native to the state or the Pacific Northwest; many have been new alien weed species not previously documented as growing in the region, state, or county; all were submitted because they were unknown. A total of 2424 specimens have been submitted to the WDL since its inception, and detailed records have been maintained on these weed identification requests. While nearly all of Idaho's 44 counties have submitted plants for identification, most requests have been received from relatively few counties. Additionally, submission of non-weedy plant specimens is closely correlated to whether that county has an active Master Gardener program. By observing these and other patterns in submissions, extension weed scientists may gain insight into the level and type of weed science training required to tailor effective statewide weed control programs for agricultural professionals.

MONUMENTAL WEEDS: UNRECOGNIZED UNWANTED PLANTS? Robert F. Norris, Associate Professor, Weed Science Program, Vegetable Crops Department, University of California, Davis, CA 95616.

Abstract. Weeds are often defined as plants that are growing where they are not wanted. It would appear that there are many plants that are capable of growing on or in man-made structures, and which are capable of causing considerable economic and aesthetic damage. Are these plants weeds? What is the cost of plants growing on ruins of 1000+ year-old buildings? Examples range from the Forum in Rome to the Mayan temples of Copan. What is the value of the ornate carving to a medieval building that has plants growing in the cracks; examples include the cathedral parapets in Segovia, the leaning tower of Pisa, and the church gate at Sandringham (country residence of the British Queen). What is the economic impact of plants that clog the drain systems of buildings, such as the

houses of Parliament in Canberra to the gutters on your neighbor's house? Walls are built to protect property, but their integrity is degraded and longevity is often shortened by plants growing between the blocks, such as fleabane in the retaining wall for the Tiber River in Rome. Areas are paved around buildings to permit easy passage yet plants growing in the paving create hazards and accelerate disintegration of the materials. The ultimate irony is, perhaps, the dandelion growing on the monument to Thomas Coke, one of the founders of modern agriculture, in Norfolk in England. In all these situations the plants introduce organic matter into mechanical parts of the structure causing loss of integrity. When the plant dies the decaying organic matter will tend to reduce the pH of the surrounding mortar or stone and leads to accelerated decomposition of the mineral structure. Roots of most plants create considerable forces as they grow, which will pry apart joints between stones or even 'lift' stone slabs. Roots of the birch tree growing over the gate to the entrance of the Chateau at Fontainbleu in France are certainly causing structural damage to the masonry and will shorten its life. I argue that more attention needs to be paid to unwanted plants growing in association with man-made structures. They are 'monumental' weeds. Weed management on buildings and monuments should be a component of their preservation.

WEEDS OF AQUATIC, INDUSTRIAL, AND NON-CROP AREAS

EFFECT OF MOWING HEIGHT, TIMING AND FREQUENCY ON YELLOW STARTHISTLE CONTROL.

Joseph M. DiTomaso, Carri Benefield, Mark Renz, and Guy Kyser, Weed Specialist, Graduate Research Assistant, Graduate Research Assistant, and Staff Research Associate, Weed Science Program, Department of Vegetable Crops, University of California, Davis, CA 95616.

Abstract. Yellow starthistle is the most widespread and important non-crop weed in California, particularly in the northern counties. Although there are several options for the control of this weed, many are either expensive, impractical in most areas, marginally or largely unsuccessful, or present potential environmental hazards. When used properly, mowing offers an economical and environmentally safe option for the control of yellow starthistle. In this study, we examined the phenological development of yellow starthistle flowers, and the effect of mowing height, repeated cuttings, timing of mowing, and growth form on recovery and seed production. Our findings indicate that viable seeds are produced 9 days after flower initiation. In addition, the ideal mowing period occurs when approximately 2 to 5% of the spiny heads have initiated anthesis. Thus, a 1 to 2 week window of opportunity exists for utilizing mowing as a yellow starthistle management strategy. Plants mowed at earlier stages of growth recover quickly, whereas mowing at later stages of flowering results in significant seed production. Additional evidence indicates that mowing between 2 and 8 inches above the soil surface does not dramatically affect the efficacy of mowing. Most importantly, however, when yellow starthistle plants occur in the absence of competition with grasses, individual plants are large and rounded in outline, with numerous decumbent stems branching from near the base of the plant. Regardless of the stage of development or the number of repeated cuttings, mowing was ineffective in controlling these plants. By comparison, in competition with grasses or in areas with less fertile soil conditions, nearly all individual starthistle plants were more erect with little basal branching. Under these conditions, a single mow at the early flowering stage was shown to be very effective for the control of yellow starthistle. Thus, the successful application of mowing as a yellow starthistle control strategy depends upon both proper timing and an understanding of the physical form of the plants.

TOXICITY OF HALOSULFURON, GLYPHOSATE, AND MSMA ON PURPLE NUTSEDGE (*CYPERUS ROTUNDUS* L.).

Gerardo Martinez-Diaz and William T. Molin, Graduate Student and Associate Professor, Plant Sciences, The University of Arizona, Tucson, AZ 85721.

Abstract. Purple nutsedge reproduces by tubers and rhizomes. Therefore, any approach to control purple nutsedge has to focus on reducing tuber viability. The objective of this work was to study the effects of three herbicides that differ in their mode of action on the viability of tubers. Two field experiments were performed at the University of Arizona in 1996. The treatments were glyphosate 2.2 and 5.8 kg/ha, halosulfuron 0.072 kg/ha, MSMA 2.2 kg/ha, and the control. The treatments were distributed in a completely randomized block design with four replications. Basal bulbs and tubers were collected 1 month after the application at 0 to 20 and 20 to 40 cm depth and were planted in sand at 1 to 2 cm. Shoot emergence was monitored at weekly intervals. Halosulfuron caused leaf blade chlorosis of the basal parts of the leaves, MSMA caused partial necrosis of the leaves while glyphosate 5.8 kg/ha caused a complete foliar necrosis. The number of living tubers was not altered by the herbicides. Nevertheless, halosulfuron delayed shoot emergence in both basal bulbs and underground tubers. Glyphosate 2.2 kg/ha did not delay shoot emergence but did at 5.8 kg/ha. On the contrary, MSMA stimulated shoot emergence. The best control of purple nutsedge was achieved with glyphosate 5.8 kg/ha.

BASIC SCIENCES, ECOLOGY, BIOLOGY, PHYSIOLOGY, GENETICS AND CHEMISTRY

PURPLE NUTSEDGE COMPETITION WITH COTTON IN GREENHOUSE AND FIELD CONDITIONS.

R. Cinco-Castro and W. B. McCloskey, Graduate Student and Extension Weed Specialist, Department of Plant Sciences, University of Arizona, Tucson, AZ 85721.

Abstract. Greenhouse addition series experiments were conducted at the Tucson Campus Agricultural Center of the University of Arizona to study the effects of water stress, plant density, and species proportion on the competition between purple nutsedge and cotton. One addition series experiment was conducted in well watered conditions in 1994 using five densities of each species (0, 1, 3, 6, and 9 cotton seeds or purple nutsedge tubers per pot) resulting in 24 combinations of densities and species proportions. The plant propagules were planted in 19 L pots and plants were harvested at 7 weeks after planting (WAP). In 1996, two complete addition series were conducted using two soil moisture regimes, well watered and moderate to severe water stress regimes, with four densities of each species (0, 1, 3, and 6 propagules per pot) resulting in 15 possible density and proportion combinations for each water regime. The wet treatments were monitored with micro-tensiometers and irrigated when soil water potential reached -0.04 MPa. The dry treatments were monitored with resistance blocks and irrigated when soil water potential reached -1.0 MPa. Plants were harvested at 6 WAP. The 1996 experiments were conducted using larger pots (30.5 cm in diameter by 60 cm in depth) than were used in 1994. A similar addition series experiment was also conducted in the field at the Maricopa Agricultural Center of the University of Arizona in 1995 in order to assess the applicability of greenhouse results to field situations. The field experiment was arranged in a split plot design with six blocks. The two irrigation regimes were the main plot treatments and the various purple nutsedge-cotton densities were the subplot treatments. The wet and dry irrigation regimes were maintained by irrigating when 35% and 65%, respectively, of the total soil moisture was depleted. Soil moisture depletion was monitored using a neutron probe. The plants were harvested at 10 WAP.

Biomass production per plant changed in response to changes in plant densities and species proportion. As cotton density increased or as the starting nutsedge tuber density increased, the reciprocal yield of individual cotton plants increased (i.e., biomass per plant decreased) in 1994. The reciprocal yield of cotton was more severely increased by increasing nutsedge density than by increasing cotton density. Two-species reciprocal yield equations were used to calculate coefficients of intra- and interspecific competition (Table 1). The ratio of the coefficients B_{ii}/B_{ij} were used to evaluate the importance of intra- and interspecific competition in determining the biomass produced by the two species. Interspecific competition with nutsedge was more important than intraspecific competition in predicting the effect of density and species proportion on cotton biomass production as indicated by a value of 0.39 B_{ii}/B_{ij} for cotton. In contrast, intraspecific competition was more important than interspecific competition with cotton in predicting the effect of density and species proportion on nutsedge biomass production as indicated by a value of 3.23 B_{ii}/B_{ij} for nutsedge.

In 1996, the effect of intraspecific competition was more important than the effect of interspecific competition on nutsedge biomass production (Table 2), however, the ratio B_{ii}/B_{ij} was about half that in the 1994. In contrast to the 1994 data, in the 1996 greenhouse experiments, intraspecific competition was more important than interspecific competition in determining cotton biomass production. The difference in the cotton data between 1994 and 1996 was that bigger pots were used and the larger pots allowed cotton to partially escape competition from nutsedge through deeper root growth. Under dry conditions, intraspecific competition was more important than interspecific competition as in the wet treatment but the drier conditions further reduced the importance of interspecific competition.

The results of the 1996 field experiment were similar to those obtained in the 1995 greenhouse experiments in both wet and dry conditions with moisture stress again reducing the relative importance of interspecific competition between nutsedge and cotton (Table 3). The results of all three experiments indicate that greenhouse

addition series competition experiments can be applicable to field conditions provided the experimental design takes into account the biological characteristics of the species being studied. In these experiments, this meant using larger, taller pots that allowed the tap root of cotton to develop more normally than it does in a small pot.

Table 1. Reciprocal yield equations for interactions between purple nutsedge and cotton in well watered greenhouse conditions in 1994.

Species	1/w =	B_{io}[a] +	B_{ii}[b] N_i +	B_{ij}[c] N_j	R^2	B_{ii}/B_{ij}[d]
Nutsedge wet	1/w =	0.0056 +	0.0055Nn +	0.0017Nc	0.75	3.23
Cotton wet	1/w =	0.0369 +	0.0073Nc +	0.0186Nn	0.55	0.39

[a]B_{io} = Reciprocal of theoretical maximum size of an individual.
[b]B_{ii} = Describes the influence of intraspecific competition.
[c]B_{ij} = Describes the influence of interspecific competition.
[d]B_{ii}/B_{ij} = Describes the relative importance of intra- and interspecific competition.

Table 2. Reciprocal yield equations for interactions between purple nutsedge and cotton in wet and dry greenhouse conditions in 1996.

Species	1/w =	B_{io}[a] +	B_{ii}[b] N_i +	B_{ij}[c] N_j	R^2	B_{ii}/B_{ij}[d]
Nutsedge wet	1/w =	0.0223 +	0.0183Nn +	0.0106Nc	0.66	1.72
Cotton wet	1/w =	0.0141 +	0.0101Nc +	0.0058Nn	0.64	1.74
Nutsedge dry	1/w =	0.0527 +	0.0127Nn +	0.0044Nc	0.40	2.89
Cotton dry	1/w =	0.0613 +	0.0269Nc +	0.0087Nn	0.39	3.00

[a]B_{io} = Reciprocal of theoretical maximum size of an individual.
[b]B_{ii} = Describes the influence of intraspecific competition.
[c]B_{ij} = Describes the influence of interspecific competition.
[d]B_{ii}/B_{ij} = Describes the relative importance of intra- and interspecific competition.

Table 3. Reciprocal yield equations for interactions between purple nutsedge and cotton in field conditions at the Maricopa Agricultural Center in 1995.

Species	1/w =	B_{io}[a] +	B_{ii}[b] N_i +	B_{ij}[c] N_j	R^2	B_{ii}/B_{ij}[d]
Nutsedge wet	1/w =	0.100 +	0.041Nn +	0.027Nc	0.56	1.52
Cotton wet	1/w =	0.038 +	0.021Nc +	0.018Nn	0.62	1.17
Nutsedge dry	1/w =	0.466 +	0.077Nn +	0.026Nc	0.43	2.96
Cotton dry	1/w =	0.072 +	0.040Nc +	0.028Nn	0.69	1.40

[a]B_{io} = Reciprocal of theoretical maximum size of an individual.
[b]B_{ii} = Describes the influence of intraspecific competition.
[c]B_{ij} = Describes the influence of interspecific competition.
[d]B_{ii}/B_{ij} = Describes the relative importance of intra- and interspecific competition.

GROWTH ANALYSIS OF PURPLE NUTSEDGE AND COTTON IN GREENHOUSE EXPERIMENTS.
R. Cinco-Castro and W. B. McCloskey, Graduate Student and Extension Weed Specialist, Department of Plant Sciences, University of Arizona, Tucson, AZ 85721.

Abstract. The interaction of the biological characteristics of purple nutsedge and cotton to influence competitive outcomes is not well understood. It has been reported that propagule weight and photosynthetic capacity are important characteristics for allowing purple nutsedge to compete effectively with cotton. Two growth analysis experiments were conducted to measure species characteristics and physiological processes that affect the competitive success of these species. Greenhouse experiments were arranged using a randomized complete block design with six blocks in 1994 and 1996. Either one cotton seed or nutsedge tuber were planted in a 19 L pot and the pots were harvested at 3, 5 and 7 weeks after planting (WAP) in 1994. In 1996, the seeds or tubers were planted in bigger pots (30.5 cm in diameter by 60 cm in depth) and plants were grown in wet and dry moisture regimes. Moisture levels were monitored with microtensiometers in the wet treatment which was irrigated when soil water potential reached -0.04 MPa and with resistance blocks in the dry treatments which were irrigated when the soil water potential reached -1.0 MPa. Plants were harvested 2, 4, 6 and 8 WAP in 1996.

In 1994, the total biomass production of purple nutsedge was four times higher than cotton at 3 and 5 WAP, and two times higher at 7 WAP indicating that the nutsedge had a higher absolute growth rate (AGR) than cotton during the early seedling stage. The relative growth rate (RGR) was higher in cotton than in purple nutsedge at 3 and 7 WAP but the RGR were similar at 5 WAP. In the 1996 experiment, purple nutsedge produced more total dry weight than cotton under wet conditions but produced less total dry weight than cotton under dry conditions at 8 WAP. As expected, the AGR was greater in the wet treatment than in the dry treatment for both species. The AGR of purple nutsedge and cotton were similar in the wet treatments at all harvests. However, in the dry treatment, the AGR of cotton was greater than the AGR of nutsedge at the end of the experiment (8 WAP). Cotton had a higher RGR than purple nutsedge in both the wet and dry treatments. Moisture stress in the dry treatment resulted in increased root/shoot ratios for both species. In general, nutsedge had higher root/shoot ratios than cotton in both treatments because of the production of rhizomes and tubers. Cotton photosynthetic rates were similar over a range of leaf water potentials (LWP) between -0.7 to -2.5 MPa in both the wet and the dry treatments. The photosynthetic rates of nutsedge were greater than those of cotton under well watered conditions but nutsedge photosynthetic rates were reduced more than cotton photosynthetic rates under water stressed conditions. Under well watered conditions, purple nutsedge maintained a higher LWP than cotton but under water stressed conditions the reverse was true. Water stress affected leaf expansion more than photosynthesis in cotton. The leaf area produced in the dry treatment was reduced by 38% in cotton and 49% in purple nutsedge at 8 WAP compared to the wet treatment. In summary, purple nutsedge was more productive than cotton in the absence of water stress but cotton produced more dry weight than nutsedge when water was limiting. These productivity differences were related to differences in the way the two species responded to water stress.

ISOLATION AND CHARACTERIZATION OF A cDNA ENCODING A SMALL MONOMERIC GTP-BINDING PROTEIN FROM *AVENA FATUA*.
Harwood J. Cranston, Russell R. Johnson, and William E. Dyer, Graduate Research Assistant, Postdoctoral Research Associate, and Associate Professor, Department of Plant, Soil and Environmental Sciences, Montana State University, Bozeman, MT 59717-0312.

Abstract. Our laboratory has been searching for dormancy related mRNAs in imbibing seeds using differential display. Dormant seeds are known to progress through the rapid uptake and lag phases of development during imbibition, and yet for unknown reasons cell elongation does not occur and progress toward germination ceases. We reasoned that mRNAs that are highly expressed in dormant seeds during this time may be involved in dormancy maintenance. In contrast, abundant mRNAs found in nondormant seeds may participate in the initial events of embryonic axis elongation and germination. We now report the isolation of cDNA AF*sar1* from nondormant wild oat embryos that fulfills these latter criteria. DNA sequence of the full-length 801 bp AF*sar1* cDNA is 92% identical to an *Arabidopsis thaliana* mRNA encoding a small GTP-binding protein termed *sar1p*. The calculated molecular weight of AF*sar1* (24 kDa) and conservation of the four GTP-binding domains provide strong evidence

that AF*sar1* encodes a GTP-binding protein in *A. fatua sar1p* is a member of the ras-like GTPase subfamily that forms complexes with several rab proteins to promote ER vesicle bud formation and vesicle transport to the Golgi apparatus. These proteins are known to be involved in many cellular functions and thus are good candidates for performing critical steps in the germination process. The *A. fatua SAR1* gene is up-regulated to a greater extent in nondormant than dormant embryos during the early stages of imbibition. However, when dormant and nondormant seeds were imbibed in 1 mM GA_3, mRNA transcript levels and percent germination of nondormant seeds remained constant while in germinating dormant seeds transcript levels were similar to those in nondormant seeds imbibed in water. The results indicate that imbibition in GA_3, may lead to the derepression of AF*sar1* transcription in dormant seeds which may be linked to removal of a block to germination. We are currently examining AF*sar1* regulation in other plant tissues and during other developmental stages.

ESTIMATION OF INBREEDING COEFFICIENTS IN FIELD POPULATIONS OF KOCHIA. Mary J. Guttieri, Charlotte V. Eberlein, and Edward J. Souza, Research Support Scientist, Professor, and Associate Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Aberdeen, ID 83210.

Abstract. The mating behavior of kochia is non-obligate allogamous. The stigma protrude and are receptive prior to anther development, but there is no barrier to successful pollination of stigma by pollen from earlier-maturing flowers from the same plant. Previous work has demonstrated that kochia pollen is carried in wind and can successfully pollinate flowers on plants 30 m away. The objective of this study was to characterize the relative contributions of self-pollination and cross-pollination to gene flow in field populations of kochia.

Seed were collected from lateral branches of each of 300 maternal kochia plants at each of nine locations in southeastern Idaho. Seedlings were screened for susceptibility to postemergence application of chlorsulfuron at 35 g/ha. Phenotypic frequencies within a seed lot from an individual maternal plant were used to assign maternal genotypes. Resistance allele frequencies and Wright's inbreeding coefficients were calculated for each population using maternal genotypic frequencies. Five of the nine populations had low but detectable frequencies of the resistance allele (p_{Csr} = 0.007 to 0.044). The inbreeding coefficients for four of the five low frequency populations were approximately 0, indicating that the populations were random-mating. One of the low-frequency populations had an inbreeding coefficient of 0.319, indicating partial selfing. Four of the nine surveyed populations had much higher frequencies of the resistance allele (p_{Csr} = 0.243 to 0.680). In one population, no susceptible maternal genotypes were detected, consistent with a recent selection event. Two of the high frequency populations had inbreeding coefficients near 0, indicating random-mating. One of the high frequency populations had a slightly negative (-0.185) inbreeding coefficient, indicating either heterozygote advantage or a recent selection event affecting part of the population.

The results of this study indicate that field populations of kochia are random-mating. The implication of random mating in kochia is that imigrant resistance alleles will move through a population independently of any unlinked deleterious alleles.

SENSITIVITY TESTING OF MODELS PREDICTING WINTER WHEAT YIELD LOSS AS A FUNCTION OF JOINTED GOATGRASS AND WINTER WHEAT DENSITY. Marie Jasieniuk[1], Bruce D. Maxwell[1], Randy L. Anderson[2], Brian M. Jenks[3], Drew J. Lyon[3], Stephen D. Miller[4], Don W. Morishita[5], Alex G. Ogg[6], Steven Seefeldt[6], Philip W. Stahlman[7], Philip Westra[8], and Gail Wicks[9], [1]Montana State University, Bozeman, MT 59717; [2]USDA-ARS, Akron, CO 70720; [3]University of Nebraska, Scotsbluff, NE 69361; [4]University of Wyoming, Laramie, WY 82071; [5]University of Idaho, Twin Falls, ID 83301; [6]USDA-ARS, Pullman, WA 99164; [7]Kansas State University, Hays, KS 67601; [8]Colorado State University, Ft. Collins, CO 80523; and [9]University of Nebraska, North Platte, NE 69101.

Abstract. Standard negative hyperbolic models, which predict crop yield loss as a function of weed and crop density, were fit to winter wheat/jointed goatgrass data from field experiments conducted at Colorado, Idaho, Kansas, Montana, Nebraska, Washington, and Wyoming over several growing seasons. Model parameters, including percent yield loss per jointed goatgrass tiller per unit area as goatgrass density approaches zero, percent yield loss per winter wheat tiller per unit area as wheat density approaches zero, and the upper limit to percent yield loss as goatgrass density becomes very large, varied significantly among sites and years. To determine how much influence particular parameters had on predictions of the models, a sensitivity analysis was conducted by varying the parameters by 10, 20, and 40% and determining the impact of these changes on winter wheat yield losses. Preliminary results indicate that variations in the parameter describing the upper limit to percent yield loss as weed density becomes very large, has the most influence on yield loss predictions.

COMPARTMENTAL ANALYSIS OF DIFENZOQUAT EFFLUX IN RESISTANT AND SUSCEPTIBLE *AVENA FATUA* L. SUSPENSION CELLS. Anthony J. Kern and William E. Dyer, Graduate Research Assistant and Associate Professor, Department of Plant, Soil, and Environmental Sciences, Montana State University, Bozeman, MT 59717-0312.

Abstract. The mechanism of difenzoquat resistance in wild oats is not well understood. We previously reported that difenzoquat becomes rapidly and irreversibly bound to an unknown cellular fraction in resistant (R) but not in susceptible (S) plants. To further characterize this difference, we conducted compartmental analysis of difenzoquat efflux from suspension cells derived from R and S wild oats. Suspension cells were incubated in the presence of ^{14}C-labeled difenzoquat, and after 2 hours, cells were washed and the incubation medium replaced with difenzoquat-free medium. At various timepoints thereafter, cells were flash spun, and effluxed radioactivity determined by liquid scintillation counting of the supernatant. In S cells, three different "compartments" of difenzoquat efflux could be identified, most likely corresponding to herbicide effluxing from the cytoplasm, vacuole, and cell wall. These compartments contained 57%, 39%, and 4%, respectively, of the cellular difenzoquat. Greater than 75% of difenzoquat was effluxed from S suspension cells within 60 minutes. In contrast, only two compartments were identified in R cells, most likely corresponding to the cytoplasm and cell wall compartments. These compartments contained 68% and 32% of the total radioactivity, respectively. In marked contrast to S cells, efflux of >75% of difenzoquat from R cells required 1200 minutes. We hypothesize that resistance is associated with a substantial increase in the cell wall binding activity of difenzoquat in R wild oats.

EFFECTS OF ALLELOPATHIC COMPOUNDS FROM PURPLE NUTSEDGE (*CYPERUS ROTUNDUS* L.) ON COTTON (*GOSSYPIUM SP.*). Gerardo Martinez-Diaz and William T. Molin, Graduate Student and Associate Professor, Plant Sciences, The University of Arizona, Tucson, AZ 85721.

Abstract. Greenhouse and laboratory studies were conducted to determine the allelopathic potential of extracts from purple nutsedge on germination and growth of two cotton species. Hexane extracts caused the greatest inhibition of hypocotyl, radicle and secondary root elongation. Growth reduction occurred at 250 ppmw. Hypocotyl and radicle length of both species of cotton were affected similarly by the extracts, but the growth of secondary roots was more affected in Pima S-7 than in DP 5415. Seedlings exposed to soils treated with the hexane extracts from fresh tubers

showed root leakage. Root leakage was observed at 100 ppmw. Electrolyte leakage was greater for Pima S-7. The hexane extracts from purple nutsedge tubers contained sesquiterpenes which agrees with previous publications. It is possible that under natural conditions the sesquiterpenes are released to the soil environment which causes interference with root functions of cotton. As a result cotton may not compete efficiently for the soil resources with purple nutsedge.

ROOT LEAKAGE AND WATER RELATIONS OF COTTON SEEDLINGS (*GOSSYPIUM BARBADENSE* VAR. PIMA S-7) AS AFFECTED BY ALLELOPATHIC EXTRACTS FROM PURPLE NUTSEDGE.
Gerardo Martinez-Diaz and William T. Molin, Graduate Student and Associate Professor, Plant Sciences, The University of Arizona, Tucson, AZ 85721.

Abstract. Experiments were conducted to elucidate whether the allelopathic extracts from purple nutsedge would cause a change on cell membrane permeability from roots of cotton seedlings. The effects of the allelopathic extracts on water relations of cotton seedlings were also studied. The hexane extracts were soluble in water and caused root leakage at concentrations above 50 ppm. The extracts caused cell membrane damage as soon as they were in contact with the roots independently of the water potential of the solutions in the range from 0 to 0.6 MPa. Cotton seedlings transplanted to soil treated with the extracts at 125 ppmw experienced a decrease in water potential, leaf water content and osmotic potential. These responses were detected 24 h after transplanting. A decrease in water potential was also detected in plants transplanted to soil previously infested with purple nutsedge. The results suggest that the sesquiterpenes may be soluble in water at concentrations that damage cell membrane of cotton roots. The decrease of water potential of cotton seedlings may be a consequence of the cell membrane damage caused by the allelopathic compounds extracted from the tubers. Under field conditions, cotton infested with purple nutsedge may experience water stress due to the presence of allelochemicals in the soil environment.

THE INFLUENCE OF EPICUTICULAR WAX ON PICLORAM PHOTODEGRADATION. Roland L. Maynard and Tracy. M. Sterling, Graduate Assistant and Associate Professor, New Mexico State University, Las Cruces, NM 88003.

Abstract. Photolysis is an important mechanism for picloram degradation but has not been studied on leaf surfaces. The photodegradation of analytical picloram in methanol, water (KOH added to pH 10.0), and methanol (equimolar KOH added) as well as Tordon® was studied on chloroform-extracted epicuticular wax of Afghan pine (*Pinus eldarica* Medw.). The wax solution of pine and each of the four solutions of picloram was dried and exposed to solar radiation for 0, 6, or 24 h, both in summer and winter. The effect of Afghan pine epicuticular wax thickness on picloram photodegradation was also investigated using Tordon. Picloram and photodegradation products were then extracted out of the wax layers using a chloroform/water partition and analyzed for picloram and picloram photodegradation products using reverse phase HPLC. Potential volatile photodegradation products were trapped using Tenax® chemical sorbent. Photodegradation products and volatiles were analyzed using GC-MS. Analytical picloram in methanol degraded slower than Tordon® on glass while both behaved similarly in wax. The photodegradation rate of picloram in methanol with KOH added was higher than picloram in methanol in both wax and glass in summer while no difference was seen in winter. Wax increased the rate of photodegradation in the two solutions with the methanol carrier. Accumulation of photodegradation products over time depended on picloram solution and presence of wax for picloram in methanol and picloram in water. Results of the wax thickness study and the identification of photodegradation products using GC-MS will be presented.

DICAMBA RESISTANCE IN KOCHIA (*KOCHIA SCOPARIA* L. SCHRAD): PRELIMINARY STUDIES.
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Abstract. Extensive use of the herbicide dicamba (3, 6-dichloro-2-methoxybenzoic acid) in small grain crops has selected for dicamba-resistant kochia. Preliminary dose response studies show that resistant (R) plants are 2- to 3-fold more tolerant to dicamba than susceptible (S) plants. We are interested in the mechanism(s) of resistance to this auxinic herbicide and in determining if resistance is related to alterations in indoleacetic acid perception or signal transduction. To begin characterizing the resistance mechanism(s), R and S kochia seedlings were treated with ^{14}C dicamba and harvested after 12, 24, 48, 60, 96, or 168 hours. Seedlings were dissected and the plant parts analyzed for uptake and distribution patterns of radioactivity. Preliminary results indicate that ^{14}C dicamba uptake is similar in R and S seedlings up to 48 hours after treatment. Likewise, herbicide translocation patterns are similar, although less translocation occurs in R plants after 48 hours. HPLC was used to detect dicamba and its metabolites, 5-hydroxydicamba and dichlorosalicylic acid (DCSA) in treated leaves and whole plants. Rates of dicamba metabolism were equal in R and S plants up to 60 hours after treatment. Thereafter, treated R leaves contained significantly more 5-hydroxydicamba than S leaves, although no differences were seen between R and S apical meristems. DCSA was not detected in extracts from either R or S plants. These preliminary results indicate that alterations in herbicide metabolism may be involved in dicamba resistance, although the relatively slow appearance of differences between R and S is not consistent with the lack of epinasty and rapid injury symptoms on R plants. We are currently examining the fate of ^{14}C dicamba in microsomal fractions in order to more precisely compare R and S metabolism rates shortly after herbicide treatment.

APPROACHES TO UNDERSTANDING TRIALLATE/DIFENZOQUAT RESISTANCE IN WILD OATS: IS GIBERELLIC ACID INVOLVED? John T. O'Donovan, Abdur Rashid, and Aziz Khan, Research Scientists, Alberta Research Council, Postal Bag 4000, Vegreville, AB, Canada 1T4.

Abstract. Wild oat populations from numerous farms in Alberta have simultaneously developed resistance to recommended rates of two very dissimilar herbicides, triallate and difenzoquat. Triallate, a thiocarbamate, is applied preemergence, and affects the growing point of emerging wild oat seedlings. Difenzoquat (sometimes classified as a bipyridillium) is applied postemergence at the 4 to 5 leaf stage, and inhibits the growing point of the more mature plant. Studies on the mechanism of action of triallate and other thiocarbamates at the sub-cellular level indicated that the herbicides were metabolized to more active sulphoxides that affect the biosynthesis of very long chain fatty acids (> C18) by specifically inhibiting the fatty acid elongation system. Virtually all of this specific target-site information on the thiocarbamates has been generated from studies on crop species. Little is known about the fatty acid composition of the shoot tissues of wild oat seedlings during the early growth phase, a stage when triallate is most effective. The specific mechanism of difenzoquat action is less clearly understood. Unlike the thiocarbamates, difenzoquat is not metabolized in susceptible species.

We conducted dose response experiments in petri dishes to better characterize the effects of triallate, difenzoquat, and two other thiocarbamates, EPTC and cycloate on emerging shoots of several R and S populations. The results indicated that difenzoquat as well as triallate inhibited shoot length more in susceptible (S) than in resistant (R) seedlings. However, within both R and S groups, there was considerable heterogeneity among the populations in the response of wild oat shoots to the herbicides suggesting that the evolution of resistance to recommended field rates of these herbicides may have been a gradual process involving a shift to more homogeneous populations with reduced genetic variability. There was slight cross-resistance to cycloate but none to EPTC. Among the thiocarbamates, there appeared to be a strong correlation between resistance and degree of water solubility of the herbicides. Wild oats were most resistant to triallate which was the least soluble and most susceptible to EPTC which was the most soluble.

To understand the basis of the herbicidal effect of triallate in the early growth phase of wild oats and the possible cause(s) of triallate and difenzoquat resistance, we investigated the profile of fatty acid chains in young shoot tissues

of selected S and R populations grown in petri dishes, and the effect of triallate and difenzoquat on the profiles. The composition of fatty acid moieties was similar in young shoot tissues of both S and R populations. Gas chromatographic analysis of fatty acid methyl esters showed that these tissues contained fatty acids of chain length C14 to C24, but the major components were C18 (C18:2, C18:3, C18:1) and C16 chain lengths. Since all other fatty acid chains (> C18:3) were present as very minor components (< 2%) it is unlikely that elongation to very long chain fatty acids is the primary biochemical site of triallate action in wild oats. Triallate caused a significant ($P<0.05$) reduction in the level of all major fatty acids in the S populations, but not in the R populations. However, difenzoquat did not significantly affect the fatty acid composition of shoot tissues in either S or R populations. This coupled with the lack of significant cross-resistance to other thiocarbamates suggests that the resistance is not related to the precise mechanisms of action of these herbicides at the sub-cellular level.

In other experiments, the effects of giberellic acid (GA3) on the response of susceptible wild oat shoots to increasing rates of triallate and difenzoquat was determined in petri dishes. In some cases, GA3 dramatically overcame the inhibitory effects of triallate and difenzoquat on shoots of the emerging seedlings, particularly at relatively low concentrations of the herbicides. At relatively high herbicide rates, the presence of GA3 had little effect. Shoot growth of untreated wild oat seedlings was also stimulated by the presence of GA3.

The ability of exogenously applied GA3 to overcome the inhibitory effects of both triallate and difenzoquat by stimulating growth of wild oat shoots indicates that the plant hormone may be involved in conferring resistance to these herbicides. It is possible that resistant wild oats have faster growing meristems than susceptible populations, and that this faster growth is due to enhanced levels of endogenous giberellins and/or enhanced giberellin biosynthesis capacity. The enhanced growth may preclude sufficient herbicide reaching its site of action in the meristem. While the evidence is so far circumstantial, it is consistent with several observations. Many of the original R wild oat seed collected from farmers' fields tended to have low dormancy and rapid shoot emergence relative to seed from S populations. These processes have been shown to be governed by giberellins. Experiments are currently underway to quantify giberellin levels in R and S populations.

JOINTED GOATGRASS COMPETITION IN WINTER WHEAT. Todd A. Pester, Philip H. Westra, Tim J. D'Amato, and Kirk A. Howatt, Graduate Research Assistant, Associate Professor, Research Associate, and Graduate Research Assistant, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523.

Abstract. Jointed goatgrass is a problem weed in winter wheat production, infesting some 2 million hectares in the Central and Western United States. Once established in a field, jointed goatgrass is capable of reducing wheat yields by as much as 80%, and currently there are no selective herbicides available to control jointed goatgrass. Therefore, identifying a wheat cultivar which is more competitive against jointed goatgrass would be beneficial for maintaining wheat yield while reducing jointed goatgrass seed production. Field experiments were conducted during the 1994 to 1995 and 1995 to 1996 growing seasons using 10 common winter wheat cultivars grown with and without jointed goatgrass. The wheat cultivars were Akron, Halt, Lamar, Laredo, Sandy, Scout 66, TAM 107, TAM 200, Vista, and Yuma. Wheat was planted at 46 kg ha^{-1} in 5, 30 cm rows by 18 m long with jointed goatgrass planted in half of each plot and replicated 3 times. The jointed goatgrass in these studies caused severe wheat yield reductions ranging from 53% (Vista) to 78% (Sandy). Winter wheat height appeared to be related to competitiveness with jointed goatgrass. In 1995, the four tallest wheat cultivars (Akron, Lamar, Sandy, and Scout) reduced jointed goatgrass biomass an average of 20% more than the other cultivars.

PHENOLOGY PREDICTIONS OF COMMON ANNUAL WEEDS IN CALIFORNIA. Scott J. Steinmaus, Jodie S. Holt, and Timothy S. Prather, Postdoctoral Plant Ecologist and Associate Professor, Department of Botany and Plant Science, University of California, Riverside, Riverside CA 92521 and Regional IPM Advisor, Kearney Agricultural Center, 9240 S. Riverbend Ave., Parlier, CA 93648.

Abstract. Seeds were collected in the vicinities of UC Riverside and Kearney Agricultural Center of weeds that were common at each location. Current collections at each location include several weeds from each of 10 or more plant families. Many of the species are found in both collections. Germination experiments were conducted on all seeds in the collections to determine percent and rate of germination at 25 C. These data were used to select the species to be studied further, and to determine the number of seeds to plant in field experiments. Further germination experiments were conducted on a temperature gradient bar that ranged 15 C to 37 C, using three species at a time from both locations. Four conventional indices and a repeated probit analysis were utilized to determine lower and upper temperature thresholds of germination for each species from the gradient bar data. Summer annual species tended to have higher thresholds than the winter annuals.

The first of several field experiments was planted in November, 1995, using the same species in two locations to quantify vegetative and reproductive phenological events. Identical experiments were also planted in April, July, and October of 1996. Experiments were planted in a randomized complete block design with six blocks. Weed species constituted the treatments; nine species were planted in the first experiment, including members of five plant families. Plots were sprinkler irrigated, and unwanted plants were controlled by hand weeding. Data collection was made at 2 or 3 day intervals and included time to emergence, time to 1 to 10 leaves, time to 1 to 10 branches or tillers, time to flowering, and time to first seed set. Because the data was right censored (i.e. the experiment ended before all plants could set seed) and was of a non-parametric nature, survival analysis was utilized to provide robust estimates of expected times to the different phenological events. These event times were converted to cumulative degree days (C day^{-1}) for each species using the simple sine method which is based on daily maximum and minimum temperatures as well as the species-specific temperature thresholds determined from the gradient bar experiments.

In the fall 1995 field experiment, there was a nearly simultaneous flush of all weed species. Seedling mortality was high for the summer annuals such as prostrate and tumble pigweed, purslane, and barnyardgrass. Of those surviving, most ceased growth until February, 1996, when daily temperatures began to rise. These species produced mature seed by about mid March, 1996. Species such as shortpod mustard and common sowthistle tended to emerge slightly sooner than the summer annuals. They, however, did not cease growth, and were capable of producing mature seed by February, 1996.

This research will generate information about the phenology of important annual weeds in California. Predictions of emergence, growth, and reproduction of weeds could help growers plan cultivations and post-emergence herbicide applications in order to control the greatest number of weed species with the least amount of herbicide. Information about weed emergence can also be used to choose the crop planting dates when weed germination is not likely to occur, to improve timing of seedling management or seedbed preparation, and to exploit the competitive advantage of early crop establishment. Furthermore, accurate weed phenology predictions can assist integrated pest management programs by identifying potential hosts of beneficial insects, alternate hosts of pestilent insects, and hosts of insect vectored diseases.

A LEAF DISC ASSAY FOR EVALUATING POTENTIAL ANTAGONISTIC AND SYNERGISTIC TANK MIXES WITH CARFENTRAZONE-ETHYL. W. Mack Thompson, Scott J. Nissen, and Claude G. Ross, Graduate Research Assistant and Assistant Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523 and Sr. Research Biologist, FMC Corp., Loveland, CO 80537.

Abstract. Carfentrazone-ethyl is a new protoporphyrinogen oxidase (Protox) inhibitor for postemergence, broad spectrum broadleaf weed control in wheat. Selectivity to carfentrazone-ethyl appears to be based on the crops ability to rapidly metabolize the herbicide to non-phytotoxic metabolites. Compounds that affect cytochrome P450 activity, flux of the chlorophyll biosynthetic pathway, or oxygen radical detoxifying system could alter the selectivity and

activity of carfentrazone-ethyl. Leaf disc assays utilizing electroconductivity (EC) measurements are a common method for evaluating electrolyte leakage caused by Protox inhibitors. We have developed an automated leaf disc assay based on a seed analyzer system. This assay is useful in identifying potential antagonistic tank mix partners, safeners, or conditions that may lead to poor weed control or crop injury. The system can simultaneously analyze 100 samples and record the data according to a programmed time schedule.

Velvetleaf cotyledon leaf discs, 3 mm in diameter, are soaked in isotonic treatment solutions (1% sucrose buffered with 1 mM MES adjusted to pH 6.5 with NaOH, 30 μM carfentrazone-ethyl) in the dark for 20 h. Discs are then rinsed in distilled water and placed in a clear acrylic sample tray with 100 wells (4 ml). Three discs are placed in each sample well containing 3.5 ml distilled water. The lid of the seed analyzer is placed on the tray with a pair of electrodes extending into each well and an initial EC reading is taken. The tray is then illuminated from below with 500 $\mu E\ m^{-2}\ s^{-1}$ of light and the EC of each cell recorded hourly for 6 h. The tray and its contents are then frozen and final EC measurement is taken after thawing. The data are normalized by dividing the recorded EC for each cell by the final EC measurement of each cell after freezing.

Rate studies were used to determine the I_{50} concentration [herbicide concentration at which electrolyte leakage (EC) was 50% of the maximum observed] of carfentrazone-ethyl for velvetleaf. The I_{50} concentration was used in subsequent experiments to evaluate the effects of several pesticides on the performance of carfentrazone-ethyl.

COMPETITION AND GROWTH ANALYSIS OF JOINTED GOATGRASS GROWING WITH A TALL AND SHORT WINTER WHEAT VARIETY. Philip Westra, Zewdu Kebede, and George Beck, Associate Professor, Research Graduate Assistant, and Associate Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523.

Abstract. Greenhouse studies were used to compare the growth of jointed goatgrass (JGG), Baca (a tall wheat) and TAM 107 (a short wheat). Germinated wheat and jointed goatgrass seeds were vernalized at 4 C in the dark for 6 weeks prior to transplanting into pots. Mixtures of 0:8, 3:5, 5:3, and 8:0 (JGG/wheat) were used. Six harvests were made beginning 2 weeks after transplanting. Data collected included plant height, leaf area, biomass, tiller number, and seed yield. Yield was obtained at final harvest. The study was repeated and data combined due to homogeneity of variance. Baca had higher dry weight than JGG. Relative crowding coefficients for Baca were 3.13 and 2.51 at 5 and 3 plants while relative growth rates were 0.325 and 0.401 at 8 and 3 plants; these values were always higher for wheat than for JGG. Baca also produced greater leaf area than JGG. TAM 107 generally produced lower values than Baca for growth parameters in the greenhouse, but its growth was greater than for JGG. JGG always produced significantly more reproductive tillers than either wheat variety, suggesting that it has a great plastic ability to adapt to available resources to quickly infest a wheat field. In greenhouse competition studies, Baca grew 6 cm taller than TAM 107, but both varieties were an average of 10 cm taller than JGG. Baca had a higher relative competitive ability (9.5) against JGG than TAM 107 (6.5) for biomass production. Thus, both wheat varieties were more competitive than JGG on a per-plant basis. In the field, harvest data showed in 1 year that maximum wheat yield reduction due to JGG in Baca was 40% compared to 60% for TAM 107. In a second year of research, yield reduction was similar for both varieties. Increasing the density of both wheat varieties caused a reduction in the amount of seed produced by jointed goatgrass.

CONCEPTS OF COMPUTERIZED ANALYSIS OF SEED BURIAL STUDIES. David W. Wilson, Stephen D. Miller, and Patrick Mees, Research Scientist, Professor and Programming Technician, Department of Plant, Soil and Insect Science, University of Wyoming, Laramie, WY 82071.

Abstract. Design parameters for seed burial studies inherently require a prolonged chronological scale of several years. Most weed seed burial studies are conducted over a time frame of 10 or more years. The extended time period for a seed burial study creates serious problems in standardizing seed viability analysis of the project. A

single project may have multiple researchers and technicians conducting viability analysis throughout it's extended study period. For many years, the 2,3,5 triphenyl tetrazolium chloride (TZ) test for seed respiration activity has provided an acceptable standard of quantifying embryo viability in seed longevity studies. A problem with the tetrazolium test is the variability of individual human color perception and estimation of the red fomazan stained embryo tissues. Errors in color interpretation, between different individuals cause additional errors from one annual analysis to the next. High resolution computer scans and computerized, high definition, color analysis of scans may prove to be a simple method of standardizing tetrazolium testing analysis. Seed analysis hardware requirements include an IBM compatible computer and a low vibration, single pass, high resolution, 24-bit flatbed scanner with applicable software. The software must be designed to include multiple platform and scanner model support, seed bank totalization, seed/embryo size selection and discrimination, TZ viability color quantification, and data archivability. The archiving of 24-bit color files circumvents hardware obsolescence, due to future improvements and advances in computer scanner technology. Archived files provide a permanent record of a normally biodegradable data set and enable comparability with previous, current or related studies. Archived files allow data exchange over the Internet, as well as the printing of individual scans through a color printer. Computerized color recognition decreases the time required to analyze tetrazolium generated embryo coloration gradients. Miscounts are eliminated with quantified automatic data analysis. Costs related to fees from commercial or government seed testing facilities are eliminated. Computerized analysis of seed burial studies is a promising technique for standardizing weed seed viability and longevity assessment.

FOLIAR ABSORPTION OF MON 37500 IN TWO BROME SPECIES. Patrick A. Miller, Phil Westra, and Scott J. Nissen, Graduate Research Assistant, Associate Professor and Assistant Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523.

Abstract. Surfactants are specialized spray additives formulated to improve the emulsifying, dispersing, spreading and leaf surface absorbing properties of herbicides. Surfactants are categorized into one of five chemically distinct categories, with each of these surfactant classes providing a varying level of leaf absorption.

The objective of the study was to assess the influence of surfactant and nitrogen on the foliar absorption of MON 37500 in *Bromus tectorum* (BROTE), and *Bromus japonicus* (BROJA). The brome species were treated 10 to 14 days after planting (DAP) and were approximately 8 to 12 cm in height. Treatments consisted of esterified seed oil, (ESO); nonionic surfactant, (NIS); crop oil concentrate, (COC); and organosilicone surfactant, (OS). The surfactants were added to pH 7 buffered water at concentrations of 0.625, 0.25, 0.625, and 0.25% v/v, respectively. Treatments containing nitrogen consisted of one of the surfactants previously mentioned with urea ammonium nitrate (UAN) at a rate of 2.5% v/v of a 28% solution, or ammonium sulfate (AS) at a rate of 2.5 kg ha^{-1}. A randomized complete block experimental design was used with four replications per treatment and was repeated.

Treatments were made by pipetting 4 (0.5µL) droplets (~1000 Bq $plant^{-1}$) of ^{14}C MON 37500 (specific activity, 1020 MBq μmol^{-1}) onto the uppermost, fully-expanded leaf. Following a 24 or 48 hour absorption period, leaf washes were performed by vortexing the treated leaf for 30 s in 5 ml of 90% water, 10% methanol, and 0.25% v/v X-77. Ten mL of scintillation cocktail were added to the leaf wash solution, and the samples were analyzed for radioactivity via liquid scintillation spectroscopy. Herbicide absorption was calculated as the difference in ^{14}C MON 37500 applied minus ^{14}C MON 37500 recovered in leaf washes following the foliar absorption period.

Experimental results indicate the uptake of ^{14}C MON 37500 was greater in BROJA (60%) than in BROTE (50%). Averaged across species and nitrogen addition, OS and ESO provided the greatest foliar uptake of ^{14}C MON 37500 (>60%), followed by NIS (60%), and COC (30%). Averaged across species and surfactant class, UAN provided the greatest foliar uptake of ^{14}C MON 37500 (>70%), followed by AS (60%), and no nitrogen addition (30%). The differences in ^{14}C MON 37500 absorption among surfactant classes was dramatic, as were the differences in ^{14}C MON 37500 absorption of surfactants containing nitrogen. Although UAN generally provided the greatest increase in the foliar absorption of ^{14}C MON 37500, additions of AS to treatment solutions were also effective in increasing the foliar absorption of ^{14}C MON 37500.

These results indicate that the addition of appropriate surfactant or nitrogen-surfactant blend can be an effective means of increasing the foliar absorption of weakly acidic herbicides such as MON 37500. Additional research in this area will investigate the effect of droplet drying time on herbicide deposition and crystallization on plant leaf surfaces, and explore the chemical and physical composition of leaf surfaces.

THE FUNDAMENTALS OF PHOTOGRAPHY. John T. Schlesselman, Rohm and Haas Company, 726 E. Kip Patrick Drive, Reedley, CA 93654.

INTRODUCTION

The use of photography in weed science, or agriculture in general, should be a rewarding experience that can add immeasurably when documenting field research. Photography may also be used to visually record various agricultural situations that will help understand what was happening. These slides or photographs can be used in many ways; in conjunction with an oral presentation to better understand the subject matter, stock photography to be used by a company or university to put together slide sets of various crops and/or pest management problems/situations, and private industry may use these slides/photographs in advertising literature. No matter how it is used, photography is a useful "tool" in agriculture and bringing a camera along while at work can also make a job more interesting.

Understanding the basic principles in photography is important in order to capture the image as the photographer wants others to see it. In this day of "auto-everything" cameras, it sometimes takes the creativity away from the photographer and leaves the image completely up to the whim of the camera. Realizing that most results from a completely automatic camera will be satisfactory much of the time, there is still a need to understand what is going on when a photograph is "shot". Separating a "photographer" from a "picture-taker" sometimes means switching that camera from automatic to manual and understanding what is going on when you depress that shutter button. A knowledgeable photographer will also make the right decision when choosing the appropriate lens and film to obtain that desired result.

With a basic understanding of certain photographic concepts such as exposure and depth-of-field, an individual may be challenged to take the camera off the automatic mode and attempt some creativity by manually operating the camera.

EXPOSURE

In everyday photographic terms, **exposure** means the picture taken on a roll of film (ie: a 36-***exposure*** roll). Defined another way, exposure is a quantity of light or the amount of light (intensity x time) that reaches the film, reproducing a desired image. Exposure is a function of three variables; film speed, shutter speed, and aperture. An almost infinite combination of these variables will produce the quantity of light necessary for a correct exposure. The photographer has the freedom to decide how these variables will be used. Of course today's high tech automatic camera is programmed to decide for the photographer the best all around exposure, but a whole new photographic world is opened up when that same camera is switched to manual. Creativity is what separates the photographer from the picture-taker.

Film speed. The film speed is based on the film's sensitivity to light and is identified by an "ISO" number. Fast films (high ISO numbers) are more light-sensitive than slow films (low ISO numbers). Fast films require less light to expose the film. Slow films usually have an ISO rating up to 100 (ie: Kodachrome 25, Kodachrome 64, Sensia 50). A medium speed film would be from ISO100 to ISO200 and would include Elite II 100 and Sensia 100. Films that are considered fast have ISO numbers between 200 to 400, and the extra-fast films are above ISO400.

The sensitivity of ISO400 film is twice that of ISO200 film and requires 50% of the light to obtain an equivalent exposure. For example; if ISO400 film requires a 1/500 second exposure, then the ISO200 film would require a 1/250 second exposure, and an ISO100 film would have successful results with a 1/125 second exposure.

Selection of the right film speed depends on the intent of the photographer. Films of medium speed (ISO100 to ISO200) are the most common for everyday photography. Films with faster speeds (>ISO200) are generally used under low light conditions.

Shutter speed. The shutter speed is the length of time the camera's shutter remains open, exposing the film. Typical shutter speeds are usually indicated by the reciprocal number in seconds; 1000 = 1/1000 second, 500 = 1/500 second, 250 = 1/250 second, 125 = 1/125 second, etc. Slow shutter speeds would be effective to show movement (ie: the blurred walnuts or almonds as they are being shaken from the tree at harvest). A fast shutter speed could include a stop-action shot of a crop duster. Most cameras also have a bulb (B) setting for timed exposures. In the case of the bulb setting, the shutter remains open for a predetermined amount of time based on manually holding in the shutter button or a preprogrammed time on an automatic camera.

Aperture. The aperture is simply the lens opening, and is commonly referred to in "f/stops". A typical range of apertures for a lens would be f/22, f/16, f/11, f/8, f/5.6, f/4, f/2.8, and f/2. For these apertures, f/22 is the smallest opening and f/2 is the largest. There is also a direct correlation between apertures; the amount of light received doubles at each f/stop increase. If one unit of light passes through the f/22 aperture, two units of light would pass through the f/16 aperture, four units of light would pass through the f/11 aperture. Based on this scenario, by the time the lens was opened up to an aperture of f/2, 128 units of light would pass through the lens.

Remember that when changing one of the three exposure variables like aperture, there must be a corresponding change of the shutter speed and/or film speed to obtain an equivalent exposure. Of course the camera may already have done that automatically.

DEPTH-OF-FIELD

When viewing photographs, some appear to be in sharp focus from front to back, while others only part seems to be sharp. This is called the depth-of-field, and it is the distance range where everything will be in sharp focus. The depth-of-field is variable and directly related to the lens aperture. **The smaller the aperture, the greater the depth-of-field.** For example, with a standard 55 mm lens focused on an object 10 feet away, the depth-of-field at the f/2 aperture will total only two feet (9.5 to 11.5 feet from the camera), at f/11, the depth-of-field is 16 feet (7 to 23 feet from the camera), whereas at the f/22 aperture, the depth-of-field will be from 5 feet to infinity. Depth-of-field is one of the most important considerations in photography. It appears that in many photographic situations, maximum depth of field is preferred. That means being aware of the aperture, and making sure to use the smallest aperture possible.

If maximum depth-of-field is the objective in a scene out to objects at "infinity" as indicated on the camera lens, there is a way to insure that depth-of-field is maximized. It's called **hyperfocal distance**. When the lens is focused at infinity, the near limit of depth-of-field for the preset aperture is called the hyperfocal distance (There is usually a depth-of-field scale shown on the lens barrel with markings for the various apertures). By moving the focus to that distance will result in the maximum depth-of-field for that aperture. If maximum depth-of-field is preferred and this hyperfocal distance technique can't be remembered, there is an easy way to obtain the best sharpness possible rather that just guessing: Set the camera on the smallest aperture possible and focus about 30% into the field of view. This technique should result in pretty good depth-of-field in most situations.

As stated earlier, the smaller the aperture, the greater the depth-of-field. However, the depth-of-field for a given aperture will vary depending on the focal length of the lens. For a given aperture, a wider angle lens offers a greater depth-of-field. For example, at an aperture of f/16, the depth-of-field for a 135 mm lens is from 50 feet to infinity, whereas the depth-of-field for a 28 mm wide angle lens is from 3 feet to infinity.

In close-up photography, where the subject is being magnified, the depth-of-field becomes very limited and critical. At a 0.1X magnification using a f/16 aperture, the total depth-of-field is 104 mm. However, when a subject is magnified to 1X (life-size), the total depth-of-field is down to only 2 mm.

Manipulating the depth-of-field is important to obtain the desired result. Maximum depth-of-field may not always be wanted. By using **selective focus**, a large aperture will narrow the depth-of-field and highlight a sharp subject from an otherwise confusing picture. By focusing only on the subject (ie: weed seedling) and blurring the cluttered background, the subject will stand out and therefore be easily identified.

SLIDE FILMS

Only slide film is being discussed for two reasons: First, most individuals in weed science research will use slides more often than photographs. Secondly, photographs are easily and relatively economically made from slides. The most common and readily available slide films on the market are Kodak's Kodachrome 64 (ISO64) and Elite II 100 (ISO100). Fuji's Sensia 100 (ISO100) is also a very popular slide film that has only been on the market for a couple of years, but has become one of the industry standards.

Kodachrome 64. It seems like this film has been around forever, at least 40+ years. Although the colors are somewhat muted, they are quite consistent whether in full sunshine or used under overcast skies. This film can definitely use a polarizing filter to help exhibit some brighter color. Flesh tones are true with Kodachrome 64 and it is not too contrasty. Kodachrome 64 is a good all around slide film, but not very exciting.

Elite II 100. This new Ektachrome film shows promise. Comparison tests have shown this film to have excellent bright color qualities, but should be underexposed (about ½ f/stop) to match the bright colors found in Fujichrome film. Color suffers slightly under overcast skies, but results are still acceptable. Elite II 100 is not hampered by too much contrast. It is an excellent choice and readily available.

Sensia 100. This is a fairly new film, replacing the colorful Fujichrome 100. It's dramatic color is no match for the Kodak films. However, it does tend to be quite contrasty, and the flesh tones can come out rather red. Under overcast skies, the color shifts to a cool "blue", indicating the need for a warming filter (No. 81A). Even though there are some problems (although correctable) associated with Sensia 100, it is still the first choice for many outdoor photographers.

CAMERAS AND LENSES

Anyone who has visited a camera store or browsed through a photography magazine recently has to be overwhelmed at the number of cameras on the market. Just 20 years ago it seemed like each manufacturer had a small line of cameras and they looked and worked just like their competitors. But today, with all the high tech gadgetry, there are a myriad of choices that boggles the mind. Viewfinder cameras have come a long way since they were all fixed focal length and usually resulted in photographs of marginal quality. These cameras don't "see" through the lens, but have a straight through area to view the subject. The current viewfinder cameras have elaborate zoom lenses that range from 28 mm to 140 mm, and have many features, resulting in good photographs. There are a couple of problems with this type of camera. They are not very good for close-up photography since a person can't see exactly what's in the lens and that is important for proper composition. Another problem with viewfinder cameras is that since there's no manual override, results are at the mercy of the automatic mode, and that might not be what is desired. They can also be quite expensive for what they do.

If there is a choice in selecting a camera, the single lens reflex (SLR) is the only way to go. It's important to see exactly what the picture area will be and through-the-lens viewing is what a SLR is all about. Interchangeable lenses is a big plus when comparing SLRs to viewfinder cameras. No serious photographers would limit themselves to only one lens (well, maybe a full-range zoom, which may have questionable quality considerations). These new cameras have auto-everything, which is fine, especially the auto-focus for people whose eyesight is beginning to become somewhat unreliable. Generally, the auto-everything cameras will give very good results most of the time, but there still should be a manual override for those who really want to get creative.

Lens selection is as important as the SLR camera body being purchased. Wide angle lenses (35 mm, 28 mm, and even the super-wide 20 mm) are very effective in encompassing areas so a person doesn't have to back up several hundred feet to get everything in the photograph. Wide angle lenses are also good for that low angle, dramatic shot of a harvester, sprayer or whatever the photographer wants to capture. Since there can be considerable distortion with the wider angle lenses, care should be taken to not overdue it. The telephoto lens (105 to 200+ mm) can be useful, but is not used nearly as much as a wide angle lens. A telephoto lens is good for photographing people when approaching them too close may result in losing that "candid" effect. Telephoto lenses are useful when a spraying is in operation and getting too close may result in unwanted spray deposits on the camera and photographer.

Compressing subjects are easily attained with a telephoto lens. Using a long lens to photograph a nearby subject with mountains in the background will result in a picture that looks like the subject is almost touching the mountains. A zoom lens, like a 28 to 105 mm or 35 to 135 mm will probably encompass most needs of a photographer in the weed science field. Using a zoom lens is also a lot easier than continually changing lenses.

The final lens in the photographer's arsenal should be some kind of close-up lens, to allow for photographing small subjects like weed seedlings, insects, and close-ups of plant diseases. Some zoom lenses have "macro" stamped on the barrel or state "close-up" on their advertising literature, but in reality only magnify a little larger than the standard lens, which isn't much. For real close-up work, a lens should be capable of magnifying up to somewhere between 50% to full life-size (in other words, filling the viewfinder with a subject up to the size of the film (1 by 1.5 inches). Generally these are fixed focal length close-up lenses of anywhere from 50 mm to 105 mm. The 50 mm lens forces the photographer to be just inches away from the subject, whereas the 105 mm lens allows more working distance from the subject. A problem with a larger working distance between lens and subject is there's more area for unwanted clutter to interfere with getting a clear shot of the subject.

CONCLUSION

Understanding the basics of photography is important if the photographer wants to capture the subject on film exactly as desired, with the right lens, film, lighting, and composition. This is also very important in purchasing the right equipment for what and how subjects are to be photographed. Probably the most important factor in great photographic results is time. If a person doesn't want to or can't take the time necessary for quality results, then they become just a person taking pictures and can't expect many eye-catching results.

TECHNIQUES IN FIELD PHOTOGRAPHY. Clyde L. Elmore, University of California, Weed Science Program, Davis, CA 95616.

INTRODUCTION

Photographs are a major teaching tool in delivering information to audiences in weed science. Many of us use slides (photographs) in presentations to tell a story or make a point to students in the classroom. We also use slides to document various occasions, weed problems, weed species, changes of the environment, experimental treatments and results from the field or greenhouse. Thus, photography is a useful "tool" in agriculture and as you are working, there is often a "once in a lifetime" occurrence or a "photo op" that you want to remember, make a point, and/or share with others.

Achieving the best photograph to tell the story is often easier than one may think. How often have you thought "if I had a picture of that, it would be a lot better, and much easier than trying to explain"? There are a lot of techniques that can help us obtain these good photographs. In the previous presentation you have learned the fundamentals of using the camera, films and lenses. Hopefully, you have the appropriate equipment (everyone has a wish list) to take the pictures that you want to "capture".

What I plan to present are some methods that I feel will help to make photographs and thus presentations, better. These techniques are used by many of us as we shoot but often need conscious effort to make sure we think of them, rather that be a "snap-shooter". Good photographs take planning and time.

PREPLANNING

There are several things that can be done to improve photographs before ever taking the picture itself. Plan a photographic shoot. Plan a day in your schedule to take photographs. Take a camera with you when you work; if you don't have a camera with you, you can't take a picture. Most of us take a camera along with us, but we don't plan on other gear. Using a tripod will help immeasurably to achieve sharp pictures. A tripod allows us to shoot at slower shutter speeds (assuming the wind isn't blowing) and obtain better depth of field, thus giving better photographs. It also allows us to choose if we want something out of focus and keep certain parts sharply focused. This can highlight certain objects or bring them to the foreground while having a background out of focus. The next presentation will tell about another method (using flash) to improve depth of field. Plan ahead if you want to use different lenses, filters, flash, cable release or different films so you can have them with you, before you leave on the shoot. Having all your gear together in a single backpack case or camera bag will decrease the chance of leaving something behind that you need.

What do you plan for the picture? When you take a photograph, what do you plan to use it for? In a presentation, a slide is often used to "Set the stage!", "Make a point!", "Tell a story!", publish, document a weed, the stage of growth of a weed or crop, identify a weed problem, a control method, or a comparison of one treatment to another. All of these can be planned. Often if the picture is shown from a different view than would be seen with the eye it will be more appealing, or at least it will catch the viewer's attention. Maybe you just happen to find something interesting you want to document while you are out. Stop the vehicle and take some photographs, a "photo op".

Determine composition. Choose the part of a scene that will best tell the story. Tighten the picture to eliminate all extra material. The normal view of an object as your eyes see it, will be shown with a 50 mm lenses. A wide angle lenses (20 to 35 mm) can be used to give a broader view or set the stage of the location. It also allows you to get closer to the object without having to back several feet or yards away. This is helpful if there is little room to work or if you are shooting trees in orchards or vines in vineyards. A wide angle lenses is not good for closeup photography. If you want to crunch the scene together or bring the background into the scene then a telephoto lenses would be helpful (105 to 200+ mm). If busy people are in the picture (such as a work scene or running equipment), a telephoto will keep you far enough away from the action that you are not so conspicuous and will lose the action of the moment. A zoom lenses (35 to 70 mm, 70 to 300 mm) can be helpful to "see" the composition of the picture that you want by adjusting the focal length to achieve the desired photograph.

A photograph can be taken from a different height or angle to the object. An overhead shot using a ladder or the hood of a car (a cherry picker in extreme) will give a different view from the normal. Conversely, a low angle photograph gives a different perspective by increasing the size of mid-size plants to look almost like trees and small weeds to look like mature weeds. Shooting at an angle with beds or tree rows may be more interesting than shooting down the row.

Keep undesirable objects out of the picture. Objects other than the photograph that you want are sometimes difficult to keep out of the photograph. Electric or telephone lines are sometimes difficult to keep out of the photograph. Objects like your shadow, or a vehicle in the foreground or background, or a finger over the lenses can be removed by planning ahead. It is more difficult to keep a shadow out of the photograph when using a wide-angle lenses, or shooting early in the morning or evening when the light for photographs are the best, but the shadows are longer. Just be aware of where shadows are in the area you are photographing. Also bright objects that reflect light can be very distracting, because they draw your eye to them in a photograph. In preparing for a photograph, remove unwanted paper, leaves, dead flowers, and other unwanted objects. What you see in a single lenses reflex (SLR) camera is what you will see in the photograph. Most cameras today will give you the full view and not cut the edge of the photograph, compared to what you see through the viewfinder.

Use light to accentuate the object. Often the best light to take photographs are in the early morning and late afternoon or early evening. Light is soft at these times, but is very harsh during the middle of the day. Also most of us have been told to have the sun coming over our left shoulder or from behind us to shoot. Often this gives a true color, relatively flat light on the subject. A way to increase contrast may be to backlight an object. Backlighting is placing yourself so the light is behind the subject. One does have to be careful to not get the sun shining directly on the lenses or a starburst effect will be observed. Shade the lenses with a lenses shade and/or the hand or a hat to keep the sun off the lenses. Watch so the hat does not show in the photograph.

Unfortunately we are often stopping for lunch after working in the field all morning and decide "I better take a picture before I leave here", which may be the worst time to take the photograph. At this time the film can not read the full range of the light and the photo is often washed out of any detail. Flat light of slightly overcast days can also be a very uniform light giving a pleasant picture, unless shadows are wanted. If shooting under trees or vines or some other plant canopy, it may be too dark and artificial light from a flash may be needed. Use low light conditions to make objects stand out and saturate the color of the objects. Row patterns of beds, vegetables or vines can be improved by using low light in the afternoon or early morning instead of noon-time light, purposefully using the shadows to increase contrast.

ADVANTAGES AND DISADVANTAGES OF USING SIGNS OR EQUIPMENT

Depending upon the use to be made of the photograph a sign in the plot can be useful or be a disadvantage. If products that are still numbered are photographed, the slides will have limited use. Use a common name or if the primary audience are growers, use a trade name (maybe one should have a picture of each for different uses). The same is true for equipment (John Deere doesn't want a picture of a Ford tractor in their advertising). It limits the use. The size of the sign can also cause problems. A large sign in the foreground may not be the main subject that you want to show. The sign should be roughly in the front one-third of the plot so the sign can be in focus, and the front of the plot also will be in focus. Signs in the background often cannot be read easily (If you can't read them, don't show them). Try not to use any red on the sign, it tends not to show well in a photograph. Depending on where the photograph will be shown, you may need rates in metric (kg/h) or English units (lb/A). A photograph that is to be published, should not have a sign.

If taking a photograph of a plot, try to have the plot fill the slide. Often one tries to take many plots in one shot and all get lost and almost become part of the background. If there are a long row of plots a telephoto lenses can stack the plots close together to see more plots without loss of all detail. "Fill the frame" is a common saying for photographs.

Action shots. Using an equipment slide or some other action shot can enhance a presentation. A photograph of the equipment, in action, is better than having the equipment standing still. Try to get the equipment close enough to you to not make it look small in a large field. A shot with a wide angle lenses will make the equipment appear small, unless you are standing next to the equipment. Using a telephoto lenses is helpful here. It allows you to be out of the way of the equipment and make it appear closer than it actually is in the field. Use a telephoto lenses to get close to the working mechanism. If only an overall shot of equipment in the field is desired, then a normal lenses may be the best lenses.

Landscape compared to a vertical photograph. Most photographs are taken in a landscape or horizontal plane. People are accustomed to this angle. An interesting shot using plants however, is to periodically use a vertical shot. This gives a feeling of height (it also represents a portrait of plants that can be excellent in a presentation. When using either, watch carefully so that the horizon of the field is level. Also if the sky is in the photograph, try to keep it at one-third of the photograph or less. Often one-half of the frame with sky in bright light will fool the light meter in the camera and the bottom one-half will be underexposed. The comments by the previous speaker on using manual light control (selectively focusing on a gray card or the back of the hand) will help remedy this problem. Since our main subject is what we want to emphasize, we do not want a lot of the sky as part of our photographs.

Other problems or needs sometimes encountered. Other objects that are sometimes found in slides include the use of a ruler or some other common object to show scale (coin, pencil, hand, people). Most of the time, these objects attach a time or period to the slide as well as drawing attention away from the subject, and it is undesirable. This is especially true of cars, pickups and other equipment.

In forensic botany there is sometimes a need for exact documentation of a time. Some cameras have a date utility or a data back that will allow a date to be placed on the slide. This will date the visiting a location or an exact recording of the event. Often it seems that it doesn't matter as much what the photograph looks like, as whether it is proven that the date is correct. Under normal use, this date in a slide is a distraction for photographs and should not be used.

Cameras with built-in flash units can be used beneficially for relative closeup work, but are ineffective for "normal" work and often is not effective for "fill" flash. Fill flash is where a small amount of artificial light is used to lessen shadows behind a subject, and to give more detail in the background. The next presentation will go into more detail on this subject.

CONCLUSION

There are many techniques for improving field photography. I have touched on a few of them. Often the best way to learn techniques is to work with someone who is an excellent photographer, or take classes. Also, being in the field and being aware of what you are currently doing when taking photographs, then review the work and determine how to improve, will go far in improving your photographs. Another point to remember is to critically cull slides. A bad slide will not improve your presentation. Remember someone said "A picture is worth a thousand words" and we are in the age of picture media.

CLOSE-UP PHOTOGRAPHY-TECHNIQUES FOR EVERYBODY. Jack Kelly Clark, Principal Photographer, DANR Communication Services, University of California, Davis, CA 95616.

INTRODUCTION

The term "close-up" is a bit of a throwback to the past. When photographers and movie makers of yesteryear wanted an image with greater detail, they had to move the camera in close to the subject to achieve the desired results. Modern optics allow us to achieve the same "close-up" results, often without having to position the camera very close to the subject. By choosing the appropriate focal length lens, a photographer can dictate the amount of working distance (the space between the front of the lens and the subject) he desires to produce a particular image scale.

"How close will this camera focus?" is one of the questions often asked at the camera shop when contemplating a purchase. The question that really needs to be asked are: "What is the maximum image scale produced by this lens at it's near limit or close focus setting?" This paper will try to clarify some of the language of close-up photography and present some usable techniques that will be helpful to both rank amateurs and seasoned pros.

DEFINITION OF CLOSE-UP

Since close-ups can be produced from many different distances, a more quantitative definition of a close-up has evolved over the years. The photographic community now accepts that the term close-up applies to photographs produced on the film in the camera at image ratios between 1:10 and 1:1. Another way to express this range is one-tenth life size to life size, or 0.1X to 1X.

Image ratio is simply the ratio of the image size to the actual size of the object. The dimensions of a 35 mm slide or negative are 24 mm by 36 mm. For field work, round that up to 1 by 1.5 inches. If you photograph a subject with dimensions of 0.75 by 0.75 inches and the resulting image has identical dimensions on the slide, you have shot that image at a image scale of 1:1, definitely a close-up. If you photograph a subject that is about 10 inches across on its short dimension, and it's about 1 inch on the film, then you have shot that image at 1:10, and it also qualifies as a close-up.

Just about every lens in your camera bag has a set of close-up capabilities. This is the range of close-up image scales that can be produced by a particular optic. For example, if you own a 55 mm f/2.8 Micro Nikkor lens, without any attached accessories it has close-up capability range of 1:10 to 1:2. It is very advantageous to know the close-up capabilities of the various lenses you use.

Images produced on the original film that are greater than life size (e.g., 2X, 10X, etc.), and not produced with a compound microscope enter into the realm of photomacrography (macro for short). Photomacrography techniques are beyond the scope of this paper.

METHODS TO GET CLOSE

The least expensive way to produce a close-up photograph is to use your existing equipment at its near limit or closest focus setting on the lens. If this produces an image scale that is acceptable to your imaging needs, then you may not want or need to invest in more elaborate equipment. Most medium zoom lenses available today will produce usable close-up image scales between 1:5 and 1:10. For example, the Canon EF 28-105 mm f/3.5-4.5 USM zoom lens will produce a maximum reproduction ratio of 1:5 (0.20X) at its near limit focus setting. The field of view, or amount of real estate photographed at that image scale is about 5 by 7 inches.

If you don't want to spend a lot of money, but still want good results, the relatively new, double element close-up diopters available from Canon (250D & 500D) and Nikon (5T & 6T) are an easy alternative to more expensive macro lenses. These coated optics screw into the front of your lens just like a filter, don't increase the amount of expose needed and produce high quality close-up images. For example, the above mentioned Canon zoom lens will produce a maximum image scale of 0.45X (almost one-half life size) with the addition of the Canon Close-up Lens 250D.

Extension tubes will increase the range of close-up capabilities of most lenses. Extension tubes attach between the lens and camera body and extend the lens out away from its normal operating position. The result is a larger, more spread out, dimmer image reaching the film. Because the image is dimmer, some exposure compensation will be required to achieve acceptable results. Since similar results can be achieved with the close-up diopters mentioned above, I don't recommend the use of extension tubes for close-up work unless it is a dedicated tube designed to work with a particular macro lens to achieve a 1:1 image ratio.

Macro lenses for modern 35 mm single lens reflex (SLR) cameras are the best way to produce close-up photographs. These lenses can focus from infinity to either 1:2 or 1:1. These lenses are some of the highest quality 35 mm optics available today. Some of the older designs require a dedicated extension tube to achieve the 1:1 image ratio. Newer models from Nikon and Canon can be set at all close-up image scales without having to attach any extension tube. Another big advantage of owning one of these lenses is that the close-up image scale settings are imprinted on the lens barrel, an important consideration for scientific documentation.

THE CRAFT OF MAKING CLOSE-UPS

I divide the process of making a close-up photograph in to four basic steps: Find It, Frame It, Light It and Shoot It. We'll examine each of these four steps separately, with emphasis on lighting, since good lighting is one of the most important ingredients for a successful photograph.

Find it. Little or no discussion is necessary here. This audience is composed mostly of professional biologists who know exactly which subjects they need to photograph as close-ups.

Frame it. Field of view at any particular reproduction ratio is the actual area photographed. For example, at 1:1 the field of view is 24 mm by 36 mm or about an inch by 1 by 1.5 inches. At 1:2 the field of view is about 2 by 3 inches. At 1:8 the field of view is about 8 by 12 inches, and so on. However, you don't need to memorize a table of image scales and field of views.

Here's an easy method to quickly frame your close-up subject. First, try to think rectangular. It's best to do this with an aspect ratio of 1 by 1.5 inches in mind (the proportions of a 35 mm slide). Two, draw a mental rectangle around the subject so that it is nicely framed the way you would want it to be framed in a slide, then estimate the dimensions of that rectangle. Three, take the short dimension and use that number to set the appropriate image scale on your lens. Then, with the camera up to your eye, frame the subject and focus by moving the entire camera toward and away from the subject until it comes into sharp focus. If it is not framed to your liking, readjust the image scale up or down to achieve the desired results.

It is important to do most of your focusing by moving the camera system to and fro. At close-up reproduction ratios, major adjustments to focus with the lens barrel create large changes in image scale, often an undesirable effect. Use the lens barrel focus adjustment like you would use the fine focus adjustment on a microscope-use it to touch up the rough focus you achieved with the to and fro movement of the entire camera. Some photographers use the image scale settings as calibration points for manual flash exposures.

Light it. Good lighting is paramount to successful photography. The easiest way to light a close-up subject is to utilize the natural light already illuminating that subject. Natural light can be beautiful. However, often there is not enough to allow use of the optimum camera settings that will produce a good close-up photograph. Those optimum settings are in the range of f/11 to f/22 with a shutter speed fast enough to stop both subject and camera movement. With slow, fine grain film, f/stops in that range dictate longer shutter speeds which can allow subject or camera movement to degrade the image. This dictates the use of a tripod. Tripods are necessary tools, but they can be quite cumbersome for many close-up shooting situations in the field.

Artificial light in the form of through the lens (TTL) exposure controlled electronic flash is the best way to consistently produce high quality close-up photographs, no mater what ambient conditions exist. The duration of the flash is most often faster than 1/1000 second. When used as the primary or main source of light, this quick burst becomes the actual exposure time, thus allowing for hand held close-ups shot at apertures between f/11 to f/22. The sharpness factor of your close-up photography will increase quickly.

TTL flash is a form of metered flash that is quite accurate in producing properly exposed photographs. A separate metering system in the camera reads the amount of flash illumination striking the film. When that ISO setting receives enough light, the camera shuts off the flash, the shutter closes and the exposure is completed. Changing the f/stop or shutter speed will not affect the results of TTL flash exposure. Use a smaller or larger f/stop, and the flash intensity will adjust to still give you the proper exposure. The shutter speed does not affect flash intensity. The shutter just needs to be open during the flash exposure (in sync). TTL flash exposures can be bracketed (made lighter or darker) by changing the film speed setting on the camera or using the camera's flash compensation dial.

For beginners, let the TTL flash be the main light source. Set your camera in manual mode, set the shutter speed at the highest sync speed possible, choose an aperture between f/11 and f/22. Make sure the flash is set on TTL mode. Fill the frame with as much subject as possible and shoot a roll of film. Try bracketing exposures by changing the ISO setting or changing the flash compensation dial. To see clearly visible changes in your brackets, do them in one half or two thirds stop increments.

A single TTL flash on the hot shoe of the camera can produce acceptable results if a wide angle setting on the flash's beam angle control is used to spread the light down onto the subject in front of the lens. This will produce a dark shadow always in the same location, but if you only occasionally shoot closeup photos, this technique may be a workable alternative to purchasing and carrying around more photo equipment. Use this technique with focal length lenses of 100 mm or longer. Shorter lenses may not allow enough working distance for the light to angle down on the subject. A shadow from the front of the lens may get into the photograph. As in any new photographic situation, some preliminary tests are in order before you begin shooting important subjects.

Many of the new models of SLR cameras come with a small, built-in TTL controlled electronic flash. These flash units are not very powerful, but when used at distances encountered with the most common close-up situations, better than adequate results are possible with very little effort. The flash angle is fixed, but not as oblique as the first technique above. The resulting shadow is smaller. Again, to avoid the shadow of the lens in your photograph, it's best to not use this technique with focal lengths of less than 100 mm. Do some tests before attempting serious work.

TTL ring flashes are easy to use and predictable. One drawback, similar to the two techniques above, is that the flash angle is fixed-i.e., the shadows always look the same. It is often said that ring flashes are shadowless, but this is not really true. A small shadow is often visible all around the subject. Sometimes this can be distracting and sometimes it is not noticeable at all. The effect varies with the subject. Their other drawback is that the light is quite flat in nature. However, ring flashes are easy to set up, lightweight and the TTL controlled flash produces consistent results.

One TTL flash unit off camera, i.e., not attached directly to the hot shoe atop the pentaprism, produces a single hard shadow that can be varied by changing the angle of the light relative to the axis of the lens. A dedicated TTL off camera cord is necessary to tie the flash to the metering system in the camera body. This technique can be practiced with the flash being hand held, but this produces extremely variable results. A bracket can be employed to hold the flash in position. However, if you are going to go to that much trouble to attach one flash off camera, you might as well employ two and get genuinely professional results.

Two flash units off camera is the best way to produce close-up photographs with electronic flash. One light serves as the main light, with the second light, decreased in intensity by one f/stop, serves as the fill light. The fill light lightens the shadows created by the main light without eliminating them and it helps even the illumination across the field of view. When used on a decent bracket system, these two lights can be manipulated to produce a number of variations of shadow angle and lighting ratio to bring out the most detail in a particular subject. It is a miniaturized, two light studio. This system can be used with almost any focal length lens. The flash units should be identical models, and the appropriate TTL cabling is necessary to tie both units to the TTL flash meter inside the camera. The intensity of the fill light can be reduced by simply placing a piece of one stop neutral density acetate or a piece of diffusion material over its lens. Even setting the fill at a wider beam angle will reduce its intensity for fill light purposes.

The above are the six basic ways to light 35 mm close-up photographs ranging from natural light through five different methods that employ small electronic flash units.

Shoot it. All that is left to do now is to make the exposure. In practice, these four basic steps blend together and become somewhat seamless, especially the framing, focusing and lighting.

A word about depth of field. Depth of field is that zone of acceptable focus that exists in front of and behind the plane of sharp focus. Small apertures increase this zone while larger lens openings decrease it. Increasing the image scale decreases the depth of field. For example, at an image scale of life size (1:1) and an aperture of f/16, the depth of field is limited to about 2 mm. Use f/16 but assume that you have no depth of field. Then practice making the film plane parallel with the plane of the subject. Use the back of the camera as a film plane indicator. Also, make sure the most important part of your subject is in sharp focus.

CONCLUSIONS

Technology has made photography relatively easier, and close-up photography has followed suit. However, I call your attention to this quote from Ansel Adams, written in 1948 in his book The Negative: "The photographer must not hesitate to make tests-many times, if necessary. If his work means anything to him, it is worthy of constant investigation and evaluation. The curse of contemporary photography is the frantic effort of the manufacturer to make it "simple." It is no simpler than any other art-nor is it more complicated. Ultimate achievement taxes the capacity of the artist, whatever his medium may be. However, the photographer can be more certain of his results, and therefore make better use of his energies, if he establishes reliable procedures for achieving the desired expression."

Close-up photographs are a very effective communication tools for portraying a variety of life science subjects both in the field and in the lab. Mastering some of the basic skills to increase the quality of your close-up photos can pay big dividends in the conveyance of ideas and concepts. Additionally, the improvement of these skills pays big dividends in personal satisfaction.

MAKING YOUR RESULTS COME ALIVE: SLIDE IMAGING AND IMPORTING PICTURES INTO A PRESENTATION. Dave Cudney, Extension Weed Scientist, University of California, Riverside, CA 92507.

Abstract. There are several tools that can be very helpful in preparing slide presentations. The following will contain a review of some of the equipment that is available and found to be useful. The use of computers directly "plugged" into slide presentations will not be discussed. This method of presentation, although efficient at providing immediate or late-breaking information, is not as portable or simple as bringing a tray of slides to a program for presentation. With a computer presentation one is also at the mercy of ones technology should anything go wrong. The following equipment is necessary to produce slide presentations:

Computer. A computer (cost about $2,000 to $4,000) is the back-bone of the system. Whether one prefers a "Mac" or a "Windows" or "DOS" machine is not important. What is important is that the machine have a relatively fast processor and enough memory to run the graphics software needed to prepare a slide presentation. Currently the most popular system is a Pentium processor with a clock speed of at least 100 megahertz, 32 megabytes of RAM memory, high quality video out-put and monitor, a hard disk with 2 gigabytes of memory, a CD drive, and a large capacity removable storage device such as a "zip" drive or a read/write CD. The storage devices are necessary to store images and graphics files. These files are often 10 to 20 megabytes in size. A "zip" drive ($200) disk can hold 100 megabytes and a read/write CD drive (about $600) disk can hold 650 megabytes. The "zip" disks (about $15 ea.) or CDS (about $10 ea.) can be transferred from computer to computer (e.g. the slide imager may be on one computer and the slide presentation may be prepared on another).

Scanners. Scanners are helpful to create digital images which can then be printed or imported into graphics software like PowerPoint for preparation of presentations. Slide scanners can be obtained for about $2000. Slide scanners can be used to digitize and archive valuable slides for later use. Slide scanners can be obtained that have stack feeders for digitizing large batches of slides. Flat bed scanners are useful for scanning prints and page graphics (about $900). There are many formats for storing scanned images. One has to be careful in selecting a format which makes the most efficient use of memory while still compatible with the intended graphics software. It is relatively easy to have some files of more than 25 megabytes.

Digital cameras. These cameras are still relatively new. A digital camera can be purchased which will produce images of 640 by 480 pixels resolution for $600. Images from these cameras can be viewed directly on the camera screen, projected on TV screens, printed on a color printer, or imported into a graphics software package and used in a slide or computer presentation. The resolution is not nearly as good as an ordinary slide, but, the key is the speed and ease with which images can be taken and imported. This is much easier than taking a 35 mm shot, developing the image, digitizing the image, and then importing it into the graphics software. It is also much cheaper given the cost of slide digitizers. There are high resolution digital cameras available but their cost is, as yet, quite high.

Other sources of images include video tape, stored images on CDS, and the Internet. Images may be downloaded from these sources and inserted into slide presentations.

Color printers. The price of color printers is relatively low (about $500) and they can be used for preparing color "prints" of digitized images or slide presentations. This is particularly useful in the preparation of posters. Color posters can be made as a large, one-sheet, printout on expensive large-scale color printers. These posters are easily transported to meetings and merely tacked to the poster board as a single sheet. This makes poster presentations considerably simpler. Unfortunately the large-scale printers are very expensive. However, if one has access to one through a commercial print shop or a university or government shop, they make excellent use of graphics software.

Slide imager. The slide imager (about $5,000) is a device that allows the computer to print the graphics that have been produced by graphics software to a camera in order to produce 35 mm slides for presentation. There are several that are available. Polaroid and Montage are two of the brands available. Generally the higher the resolution, the higher the cost of the imager. A resolution of 4,000 lines or better gives good results.

Development. Slide development equipment is usually not necessary as "1 hour" or at least over-night developing is available in many areas. Should one need to develop and mount slides, a good developing system can be purchased for about $1,000. After purchase of the equipment, slide development costs are about $4 a roll with mounts. Slide developing and mounting with such a system usually takes about 1 hour. The system we have develops two rolls at a time.

Success depends on the user. All of the equipment discussed will give one the potential for preparation of some very nice and sometimes sophisticated slide presentations. Experimentation with the graphics software should produce desirable backgrounds, interesting ways to present data, excellent talk outlines, and imported pictures to augment the presentation. Thorough familiarization with the software manual should allow one to realize what the potentials are. A little work and a lot of imagination can result in beautiful presentations.

ORAL PRESENTATIONS: HOW TO PUT TOGETHER A PRESENTATION THAT THE AUDIENCE REMEMBERS AND ACTUALLY LEARNS SOMETHING. Larry C. Burrill, Emeritus Professor, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331-3002.

The primary message presented in this paper is that speakers at technical meetings face an audience of individuals with poorly developed listening skills and with no commitment to help the speaker communicate. Thus, speakers who are truly concerned about communicating must and will find a way. The choice of technical aids to communications is less important than is the determination to communicate. My comments are more about mind-set than about tools.

The scene is familiar. Speakers at technical sessions of the WSWS seem convinced that their obligation ends with the presentation of colorful title slides, enthusiastic descriptions of experimental design and number of replications, and crowded, multi-colored, tables of data embellished with mind-deadening statistical hieroglyphics. You now have a perfect formula for intellectual formaldehyde.

My comments target the speakers while it is known that effective communication is a two-party activity. Someone must be listening. I regret to say that listening skills of the average person in any audience are poor at best. The speaker should not expect much help from the audience.

Speakers, the challenge is yours. I prefer to consider it an opportunity. After all, unless yours is an invited speech, it was you who decided that you have something you wish to say. Speakers must embrace the challenge of talking to an audience of people suffering from boredom, distraction, sleep deprivation, and the previous speaker.

How do you discourage people in the audience from pushing the mental "mute" button? First, I must remind readers that there is no substitute for a relaxed and prepared speaker. Only work and experience will bring you to that point.

While working to master your fears and subject or having done so, the next step is the big one. You must recognize that your goal is to communicate rather than give a speech. Then you must care enough to make it happen in spite of barriers put up by people in the audience who go into a trance whenever a projector is turned on. Also, you must resist the temptation to make all of your talks fit a certain mold so that you can do more with less effort and less planning.

The remaining steps are simple. Listing them is useful only to speakers accepting responsibility for communicating.

1. Get a mind-set that you are going to tell a story, not just give a report. Then you must care enough to plan so that you have good photographs when it's time to tell the story.

2. Use good slides to help your audience understand what you did and why. Tell the story. It will help them stay interested.
   a. show the problem
   b. show some research techniques and tools
   c. show results more graphically than with numbers now and then
   d. show people

3. Unless your talk is about statistics, keep it out of your data slides and comments.

4. How print slides are prepared is not important. How they look is important. Simple is good. Brightly colored computer-generated slides of tables meant for a publication may be good art, but they don't help you communicate. Leave some of the colors and some of the boring part of the story to go in the written version. This allows simpler slides and more time for interesting stuff.

Yes, these things take time to prepare and take time from your story. But they also help you keep the attention of the audience so you can communicate. You may cover less ground in your talk, but your audience will stay with you. Teach less so they will learn more. This is an important concept. One that we used successfully in our teaching and training courses. We were not paid to lecture; we were paid to teach. Teaching implies learning. Giving a speech may help us feel busy, but is there communication? It is difficult to drink from an open fire hydrant. One can drink fully from a trickle. Tell an interesting story and the audience may remember and learn.

BASIC GUIDELINES FOR POSTER PRESENTATIONS. Joyce Payne Bowers, Entomologist, 3700 #B Arkansas Drive, Anchorage, AK 99517.

INTRODUCTION

The poster presentation has become a popular means for conveying information at professional meetings. There are multiple reasons for this popularity. A broader range of information can be presented in a poster than in an oral presentation, contact with the audience is enhanced, and for many presenters the poster presentation is less stressful than the oral presentation.

Visual presentations have their own set of guidelines. Basic guidelines for the design and layout of posters are presented in this paper, as well as suggestions for targeting specific audiences and solving common spacial problems. A good poster design will attract viewers and allow information to be dispersed to a wider audience.

POSTER DESIGN

Preliminary information. Preliminary information needs to be gathered before beginning a poster design. This includes the size allocated for the poster presentation, the mounting surface type (determines the type of hangers to be used), and the poster number placement (poster number placement needs to be incorporated in the poster design). The target audience should also be considered before designing a poster. Adaptations for presenting posters to professionals within a discipline, professionals outside a discipline, and non-scientific groups are presented under applicable subsections.

Initial decisions about which elements and headings are to be included in a poster and other design decisions are made after the preliminary information has been gathered. The subsections listed below address these decision areas.

Element headings. The following headings are normally included in a poster: Abstract, Introduction, Materials and Methods, Results, and Conclusion/Discussion. Other text headings that may be included are: Objectives, Citations, Future Directions, and Acknowledgments.

Visual elements. These are important elements in a poster because they attract viewers. They include photographs, graphics, graphs, charts, and tables. Photographs of new apparatus are relevant when presenting posters to professionals within a discipline. Photographs of uncommon apparatus are relevant when presenting posters to professionals outside a discipline. Include photographs of the material and methods steps when presenting to non-scientific groups. Photographs of before and after results and the plant/target organisms are applicable to all three target audiences.

Spacial sequencing. People view new information using known spacial sequences. There are three basic choices for the spacial sequencing of a poster: vertical (read from top to bottom in columns), horizontal (read from left to right in rows), and the flow chart (viewer is guided through the poster by the use of directional lines). Only one spacial sequence should be used in a poster.

Fonts and point size. When printing out text and headers, select a font that is easy to read. Use the same font emphasis on all headers, subheaders, and text throughout the poster, e.g. all text in the same font. More that one point size will be used in a poster. The same point size emphasis should be used throughout the poster, e.g. all text the same point size and all headers the same point size. For most posters the following point sizes will be sufficient: 18 to 24 point for text and subheaders (bold), 24 to 36 point for headers (bold), and 72 to 96 point titles (bold). Increase the point size uniformly throughout the poster if the poster can not be read easily from approximately 3 to 4 feet.

Title, header, and text formatting. Word processing programs offer four text alignment choices: center, left, justify, and right. Titles and headers (i.e. Abstract, Introduction, etc.) should be centered. Either the left alignment (text has an even margin on the left side and breaks differently for each line on the right margin) or the justified alignment (text is aligned between the left and right margin evenly) is used for the text. Right alignment is not normally used in posters. All of the text elements should have the same alignment. Text elements should also have a even margin of white space around the printed text, usually 0.38 to 0.5 inches will be sufficient. When presenting a poster to professionals within a discipline, write the text in the same manner as a journal article. If the poster is being presented to professionals outside a discipline, be sure to define/explain technological terms specific to the discipline when writing the text. Keep the text simple and to the point when presenting posters to non-scientific groups and present details as supplements rather than in the body of the poster.

Color formatting. The following areas fall into this category: paper choice, photographs, graphics, graphs, and mounting board. White paper with black text provides the best contrast for viewers. The use of medium tone papers lowers the contrast in the text elements making them more difficult to read and less attractive visually to viewers. If colored paper is going to be used in a poster, pastel colors are more appropriate. Select corresponding and complementary colors from photographs to use in graphics and graphs and for the mounting board color. If the poster does not contain photographs, select a color used in graphics or graphs for the mounting board color.

POSTER LAYOUT

Layout of the poster starts after initial decisions have been made about which elements and headers are to be included in the poster. It is important to layout the poster on a vertical surface (e.g. wall, chalk board, etc.). Posters are not presented on table tops. Many spacial problems can be avoided by simply working vertically. Measure out the allocated poster space on the vertical surface. Take printed copies of text elements, photographs, graphs, charts, etc. and arrange them within the allocated space. Fill the allocated space but do not cram it full. Disperse the visuals throughout the poster. Visual elements help to guide the viewers eyes through the poster. Move elements around until a visually pleasing arrangement is achieved. Edit text elements for typographical and spelling errors. Formatting should be consistent throughout the poster, e.g. all text is aligned the same and the same point size, all headers are bold and the same point size. Print out corrected copies of the elements and mount the poster. Hang up the mounted poster and review all of the elements. Create a map of the completed poster as an assembly guide. Pack the poster, poster map, and hanging implements for transportation.

SPACIAL PROBLEM SUGGESTIONS

Spacial problems occur regardless of the amount of experience a person has in poster design and layout. The following suggestions should help solve the most common spacial problems encountered when designing a poster.

Poster elements do not fill allocated space. Has all of the necessary information been included in the text elements? Changing the text alignment, left/justify, will occupy different amounts of space. Text and visual elements, e.g. Future Directions and Acknowledgment sections, can be added. The overall outer poster dimension can be decreased.

Too many elements for allocated space. Remove unnecessary information from text elements. An element can be moved out of the body of a poster and made available as a supplement. The size of photographs can be decreased or crop photographs and group them on the same piece of mounting board.

Move Headers. The placement of your headers, Introduction, etc., can occupy or free up space. Headers can be mounted separately from the text or mounted on the same board with the text.

SYMPOSIUM

NEW TECHNOLOGY AND ITS APPLICATION: A CHRONOLOGY OF DEVELOPMENT. Bruce D. Maxwell, Associate Professor, Plant, Soil and Environmental Sciences Department, Montana State University, Bozeman, MT 59717.

Abstract. Site specific weed management has received increasing attention in the last 5 years with the increased availability of weed detection/herbicide application technology, geographic positioning systems (GPS) and geographic information system (GIS) software. Significant economic savings can be accomplished by restricting application of management practices to the specific location of the weeds. Initial developments in site specific weed management were centered on plant detection devices based on spectral reflectance which activated a herbicide sprayer. This technology has been refined to recognize different plant species and therefore selectively activate herbicide application to weeds and not the crop. GPS has offered another approach to site specific weed management based on development of maps that can be used for future weed management. Sampling and data analysis is the current focus of the development of the mapping technology. Application of this technology is highly dependent on predicting the future location of weeds based on a sample. Research is in progress that will identify the mechanisms which regulate weed spatial dynamics. Site specific weed management has been almost entirely centered on increasing the efficiency of herbicide application to control weeds. However, there may be ways for these new technologies to be an important aspect of integrated weed management. For example, other practices may be used such as variable crop seeding rates, row spacing and variety changes to increase competition with weeds, variable fertilization regimes to create a resource environment in favor of the crop rather than the weed, selection of tillage practice (no-till vs. conventional), restriction of weed dispersal mechanisms.

REDUCED HERBICIDE USING PHOTOELECTRONIC DETECTION. Jim Beck, Founder, Director, Patchen Inc., Los Gatos, CA 95030.

INTRODUCTION

Selectively spraying agricultural chemicals in a way that causes them to contact only foliage and not the bare ground or open air is not a new idea. Successful "selective application" of chemical materials, sometimes referred to as "spot spraying" or "intermittent spraying", has been limited in the past to a person visually observing the plant to be treated and then manually directing a spraying device. Devices which attempt to automatically sense plants, either mechanically or through the use of electrical conductivity, sonar, light or infrared radiation have not been widely accepted. Previous attempts, without exception, have had serious performance or cost disadvantages. Some examples include a weed sprayer which uses a horizontal light beam which is interrupted by weeds which are taller than the crop plants. The limited usefulness of this approach is obvious. Other examples include orchard sprayers which use sonar to detect the presence of trees, then attempt to avoid spraying spaces between trees. Mixed results have been reported with the sonar device, indicating that maintenance and cost effectiveness are issues left to be improved upon.

At least one herbicide application device has become available which relies upon the unique spectral reflectance of living plant tissue to detect the presence of weeds. It uses optical filters and silicon photodetectors to separate two critical wavelengths, then compares the signals representing these wavelengths using electronic circuitry. The usefulness of this device is limited by the use of naturally occurring ambient light as the radiation source. Relying upon sunlight presents the difficulty that the sun's spectral distribution changes dramatically as the sun sweeps across the sky.

Spectral variations as well as intensity variations are relatively unnoticeable to human eyes but have dramatic implications to analytical radiometric sensing devices. This sunlight based equipment is able to compensate somewhat for large shadows by directing a second photodetector pair to the sky as a differential reference. Additionally, the unpredictable effects of changing sun angle and cloud cover can be partially compensated for by continual operator adjustments. However, the lack of tolerance for localized shadows combined with a somewhat large (8 by 24 inches or 200 mm by 600 mm) field-of-view and high detection threshold, make this equipment totally ineffective in perennial crops or under the canopy of row crops.

TECHNOLOGY

It is well known that chlorophyll bearing plant tissue has a very unique spectral reflectance in the upper visible wavelengths and in the near infrared (NIR). Figure 1 shows reflectance comparisons between typical growing plant tissue, dead leaves, mineral soil and a certain parasitic weed. Comparing the reflected energy in the near infrared (NIR) to that reflected in the chlorophyll absorption band (approximately 670 nm) makes the plant tissue color signature unique. Earlier inventions attempted to use reflected sunlight, passing through optical filters to separate these two wavelengths in an attempt to distinguish between these objects. Spectral variations and shadows from trees, buildings or in fact the spray vehicle itself render a device using sunlight inconsistent at best.

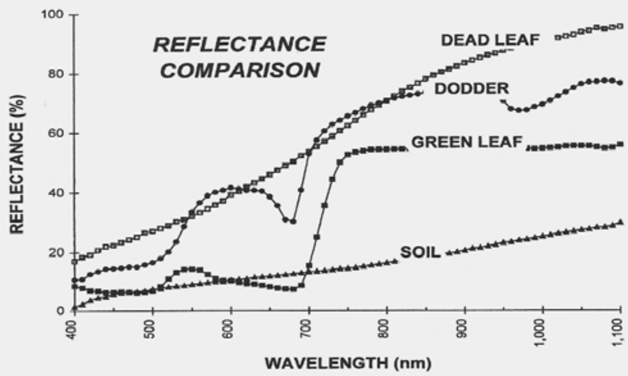

Figure 1.

The technology recently developed specifically for this application uses an approach which allows the device to work equally well in bright sunlight, in shadows or in total darkness. The WeedSeeker® generates its own light from solid state light emitters which are RF modulated. The detector circuitry is tuned to the modulation frequency which has the effect of isolating this light from the sunlight.

High efficiency and precise wavelength gallium aluminum arsenide light emitters are focused precisely in a narrow band on the ground, under the sprayer and perpendicular to the vehicle direction of travel. They are powered by an internal power source and modulated under the control of a microcomputer which is also contained within the module. These devices have sufficient bandwidth to allow modulation frequencies in excess of 1 MHz. Phase shift and frequency modulation techniques have pronounced advantages in this type of application since virtually all potentially interfering noise sources are predominantly amplitude varying. The sun has no coherent phase or frequency noise which could interfere. Since discriminating between chlorophyll bearing plant tissue and all other objects can be done with only two wavelengths a bi-phase modulation technique is very effective. The demodulation can be done using a quadrature detector of the type used in FM radio since the phase angle of the current in the detector is directly proportional to the ratio of the two wavelengths being detected. Applications requiring three or more wavelengths as a means of discriminating between plant species or making absolute identification of certain objects use the familiar synchronized emitter-detector-pair technique or tone coding/decoding.

The modulated optical and infrared energy is selectively reflected back to the module in a ratio which is dependent upon the presence of chlorophyll bearing foliage in the field of view. Silicon PIN photodetectors are mounted in the module; precisely aligned behind an optical system which efficiently shapes and captures the light energy.

To enhance the equipment's ability to detect cotyledon size weeds, the field-of-view (FOV) of the system is constrained in both axes. In the axis perpendicular to the direction of vehicle travel, the reflected beam is masked by an aperture having a shape and physical placement which allows a constant beam width to strike the detector independent of height variations above the ground. Since naturally occurring ambient light is ignored by the system, the detector image is confined by the width of the reflected modulated light beam in the direction of vehicle travel. Constraining the shape of the reflected image being allowed to strike the detector provides more than an order of magnitude improvement in the size of weeds being detected as compared to previous sunlight systems.

The detectors and associated demodulation circuitry convert the photo energy into low level analog currents which contain the color signature of the objects in the field-of-view. Demodulation and analog to digital conversion is used to make the information compatible with the internal computer.

Each module contains its own microcomputer which takes into account the color signature of the objects in the field-of-view along with information about the background lighting and the speed of the vehicle. Software stored in an Erasable Programmable Read Only Memory (EPROM) allows the computer to make a decision about the disposition of an object in the field of view and command the sprayer heads to take the appropriate action. When the computer decides that a weed is present, one or more of the selectively controlled spray heads emits a short burst of herbicide directly onto the foliage and specifically avoids spraying the surrounding area. This design approach has eliminated the problems associated with earlier attempts to accurately detect the presence of small amounts of plant tissue using spectral reflectance.

PRODUCTS

The first of these new products, introduced in 1992, is an eight channel device having nozzles and detectors with two inch spacing. It is directed primarily toward weed control in vineyards. This product has been complimented by a single nozzle product introduced in 1995 having a spray pattern width which is programmed before leaving the factory. Individual modules can be mounted as close as 3 inches (75 mm), or as much as 12 inches (300 mm) apart, which allows them to be customized for specific applications. This device addresses the use of chemical herbicide in orchards and groves where wider strips are common and where trunk-to-trunk weed control has become popular in recent years. It is especially useful along freeways and railroad rights-of-way, in addition to row crops and small grain farming. Figure 2 shows the underside of an individual single nozzle unit mounted in a row-crop spray hood. Near the top of the photo, the unit is seen to have a circular detector lens, measuring approximately one inch (25 mm) in diameter. Immediately below is a cylindrical lens which shapes the modulated light beam. Below that are the electrical cables which connect each unit to the controller. Finally, in the lower portion of the photo is the solenoid valve cartridge and associated plumbing parts. This equipment has demonstrated that it is able to conserve herbicide material and application costs that return the capital investment in less than one year on average sized farms. In most cases the annual cost of weed control has been reduced by a minimum of 50% and often as much as 70%.

APPLICATIONS

It would be tempting to estimate a certain percentage of weed cover in any crop setting and relate that percentage directly to the amount of spray which could be saved using certain "selective spraying" technologies. It becomes apparent however that the relationship cannot be quantified without considering several related parameters.

The FOV of a particular detector should closely approximate the size of the spray pattern (s). It would not be prudent for the detector to "see" a particular area on the ground and for the spray pattern to be either smaller or larger than the area being examined by the optical system. In one case, weeds could be detected but the spray pattern would not be able to hit them, resulting in inadequate weed control. In the other case, an inappropriately large spray pattern would waste material by spraying outside of the FOV. Beyond this first observation, other considerations are less obvious.

A computer model has been developed which goes beyond the scope of this paper for the purpose of exploring the relationship between several important parameters including FOV, detection threshold, nozzle type and the size and shape of weeds. It represents a section of a field with variable weed content. All dimensional parameters can be varied to simulate any given weed situation. The user is able to sketch a particular weed pattern on the computer screen using a mouse and observe the effect on spray material saving with various spray patterns. Using the model it is possible to alter critical parameters such as nozzle type and detection threshold, then interactively compare various selective spraying approaches.

The current state of this technology makes possible the detection of 0.125 inches (3 mm) diameter weeds using a field of view of 2 by 0.188 inches (50 mm x 5 mm). It should be noted that spraying the minimum possible weed size may not be appropriate for every application. It is often advisable to spray only weeds of a certain size and allow the crop canopy to crowd-out the smaller ones. A wide variation of weed distributions and crop characteristics suggest many different FOV and spray pattern variations. In addition, the device is equipped with a sensitivity control which allows the operator to program the system to ignore weeds under a certain size.

Figure 3 shows a typical vineyard configuration. Vineyard weed control tends to be very intensive, focusing on the smallest of weeds. This is true because the canopy usually does not totally obscure the ground under the vine row from the sunlight and because even a relatively low weed cover can have significant effect on crop yield and quality. Conversely orchards often use strip widths which measure several feet on either side of the tree row. Being cost effective with these wider strips requires a lower cost solution, represented by Figure 4 where three single nozzle modules are able to cover a 3 foot (1 meter) strip. These boom mounted configurations are also appropriate for roadsides, railroad rights-of-way and other non-agricultural applications, simply by adding more sprayer modules to cover wider strips.

In row crop applications, these modules are mounted under hoods which protect the crop from over-spray. Some row crops tend to develop a dense canopy early enough in the growing season such that only larger weed patches are of concern. When multiples of these crop-rows are sprayed simultaneously, the equipment investment required suggests a FOV and spray pattern of 12 inches (300 mm) or more, such as that shown in Figure 5.

Because of these varying requirements, a wide range of products with different spray patterns are made available.

FUTURE PRODUCTS USING OPTOELECTRONIC TECHNOLOGY

The potential for the technology described herein goes far beyond the selective application of herbicide. The following are a few examples of future applications of derivative technologies.

Generically specific sprayers. There is reason to believe that future products using spectral reflectance will differentiate between plant species based upon their unique spectral reflectance characteristics. Figure 1 shows substantial differences between the reflectance of common chlorophyll bearing plant tissue and a particular parasitic weed. Less pronounced but substantial differences exist between various other plant species. In the future, these differences will make it possible for "selective sprayers" to identify certain crops and non-crop plants and treat them individually with applications of herbicides and other pesticides or nutrients.

Vehicle/implement guidance. Row-crop farming puts significant demands on operators of farm equipment. Whether accomplishing cultivating, spraying or other row specific farm operations, guiding the vehicle and/or implement accurately, as close to the rows as possible, at speeds as high as possible, without damaging the crop poses a constant series of tradeoffs. The technology described here holds interesting potential for this application.

Selective orchard sprayers. In modern orchard management, various types of chemicals are applied to trees using fan or air blast sprayers. In recent years, orchard sprayers have been developed which employ sonar as a means of detecting the proximity of trees. When a tree is sensed to be in close proximity of the sprayer, the sprayer is energized. These sprayers have not been widely accepted because they are expensive and demonstrate the practical limitations of the sonar technology for this application. An orchard sprayer equipped with optoelectronic technology similar to that described herein eliminates the problems experienced with the current sonar controlled equipment.

Chemical-free weed control. Equipment for chemical-free weed control and thinning in row crops is possible which will employ an optical sensing technique to determine the exact location of the foliage. When weeds or improperly spaced crop plants are detected the computer instructs a mechanical hoe to remove them leaving the desired crop plants undisturbed. This equipment eliminates costly hand labor and uses no chemical herbicide. Similar chemical-free field-crop weed removal equipment will likely be developed which relies upon the spectral reflectance differences of the foliage, along with other dimensional parameters and discriminates certain weed species from crop plants. In addition to the mechanical removal of weeds, considerable interest exists in integrating this sensing technology with currently available flame cultivation equipment as well as with high power lasers.

SUMMARY

A new technology has been described which addresses a need which has existed since the advent of agricultural chemicals. It brings elements of modern optoelectronic technology to bear on one of the most important problems facing agriculture today - maintaining profitability in the face of ever increasing costs and government regulation of the use of agrochemicals.

Equipment is now available which provides discrimination between chlorophyll bearing plant tissue and most other objects, equally well in bright sunlight, in shadows or in total darkness. It generates its own light from solid state light emitters which are modulated to isolate them from the sunlight. Problems associated with earlier attempts to accurately detect the presence of small amounts of plant tissue using spectral reflectance in sunlight have thus been eliminated.

We should expect to see significant advances in this area of technology development over the next several years. These advances will lead to dramatic reductions in the amount of agricultural chemicals used in the United States and around the world.

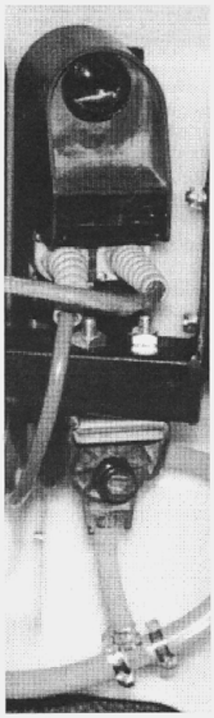

Figure 2.

Figure 3.

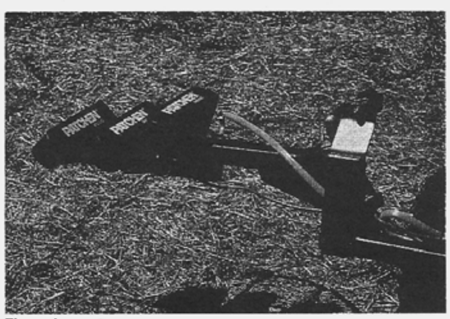

Figure 4.

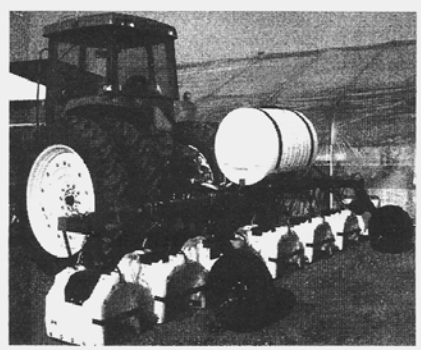

Figure 5.

MAPPING WEED POPULATIONS: ACCURACY, UTILITY AND ECONOMICS. Corey T. Colliver and Bruce D. Maxwell, Technical Support, Ashtech Agricultural Division, Belgrade, MT 59714 and Associate Professor, Montana State University, Bozeman, MT 59717.

Abstract. The ability to manage weed infestations in a spatially precise manner will rely on three components: efficient weed mapping techniques, the ability to predict the change in patch location over time and the appropriate technology to implement this approach in the field. The technology to create weed maps and to apply management practices based on these weed maps is available, but methods to create those maps efficiently and determine their value have not been developed. In 1995, we initiated a study in two small grain production fields in Montana to compare three GPS based weed surveying methods in their ability to characterize wild oat infestations. The first method included geo-referencing wild oat seedling densities for creation of interpolated maps of seedling densities. The second method included geo-referencing mature wild oat patch perimeters with a backpack GPS unit immediately prior to harvest, when the wild oat patches are most visible in the crop. The third method obtained weed patch location information from the combine during harvest. These data were used to calculate the economics of each sampling strategy in terms of sampling time, estimated area of infestation and estimated post emergence treatment area. Of the three survey techniques tested, the perimeter method provided the most detailed description of weed patch boundaries while the combine method had the least definition. The loss of boundary definition increased the estimated management area, thus the cost of the management practice also was raised. The combine survey method was the most efficient with seedling density surveying the least efficient, where the cost of a seedling survey was more than the cost of a broadcast application of herbicide. The perimeter survey resulted in the largest reduction in cost of weed management by significantly reducing the area requiring management below that of the combine survey method, and by not having the large scouting expense associated with the seedling survey. The area receiving patch management was calculated for herbicide application with a single 24.4 m boom over the weed patch map. The economics presented here are field specific, since the total area of a weed infestation is field dependent, and provide only a demonstration of the feasibility of managing weeds on the patch level.

WEED POPULATION DYNAMICS: AGRO-ECOLOGICAL ASPECTS INFLUENCING PATCH PERSISTENCE. J. Anita Dieleman and David A. Mortensen, Graduate Research Assistant and Associate Professor, Department of Agronomy, University of Nebraska, Lincoln, NE 68583-0915.

Abstract. Weed populations seldom are randomly distributed in growers fields but rather are spatially aggregated and patchy. Even with such patchiness, growers are able to return to a field year after year and identify areas of weed infestation. Such persistence of weed patches allows for the development of site-specific weed management. However, there is little information on the mechanisms generating such patchiness. This presentation will review agro-ecological aspects influencing the persistence of such weed patches. Once a weed population occurs in a growers field, five processes are thought to allow weed patches to persist: 1) limited propagule dispersal in space and time, 2) competitive interactions among weed species present in the field, 3) spatial heterogeneity of the field environment, 4) variable efficacy of applied weed management strategies, and 5) interactions between the environment and management. Some of these processes, and resultant population dynamics, are being studied in on-station and on-farm experiments in Central and Eastern Nebraska. Whole-field spatial distributions of weeds and soil properties, as well as individual weed patches, have been assessed in growers fields between 1992 and 1996. Correlation results indicate that unique groups of weeds occur with certain soil properties, however, no causation has been determined. Further mechanistic research is determining the influence of weed density, dispersal, field environment, and weed management on common sunflower and velvetleaf patch dynamics. Field observations have indicated that within-patch weed density and individual plant sizes are important ecological aspects influencing the potential for weed patch persistence.

USING KNOWLEDGE OF WEED SPATIAL VARIABILITY IN INTEGRATED WEED MANAGEMENT SYSTEMS. Alex G. Ogg, Jr. and Frank Forcella, Plant Physiologist, USDA-ARS, Pullman, WA 99164-6416 and Research Agronomist, USDA-ARS, Morris, MN 56267.

Abstract. Knowledge of the spatial variability of weeds and their propagules within a field has been touted as an important component of an integrated weed management system. To date, knowledge of weed spatial variability has been used almost entirely for the precision application of herbicides. Although precision application of herbicides is an important factor in controlling production costs and in environmental stewardship, weed scientists and others need to consider how else weed spatial variability information might be used in the management of weeds and crops.

Tillage practice. Knowing that certain large areas in a field are infested with weeds, for example, Canada thistle, field bindweed, jointed goatgrass, downy brome, that are particularly troublesome in no-till or conservation tillage systems would be important information to a grower considering adopting a particular tillage practice. Depending on the weed species present and their distribution, the grower may decide not to adopt no-till or conservation tillage at all, or he might decide not to adopt these tillage practices in only the portion of a large field infested with the troublesome weeds. Moreover, even if the entire field is- tilled, the depth of tillage can be adjusted easily while working the field. Deep tillage may be more appropriate for areas with Canada thistle, whereas shallow tillage may suffice for the remainder of the field.

Tillage implement. Growers could use a moldboard plow to deeply bury seeds of weeds such as wild oat, jointed goatgrass and downy brome in portions of a field, if they knew the spatial variability of weed seed in a field. On the other hand, growers may consider using shallow, tine-tillage in areas infested with deeply buried seeds of lambsquarters, pigweeds, nightshades and mustards. Seeds of these weeds are long-lived in the soil and deep plowing returns them to the surface where they are exposed to light and can germinate. Large-seeded broadleaf weeds, such as velvetleaf, suffer from poor establishment if not buried by about 1 to 2 inches of soil. No-tillage may be appropriate where patches of these types of weeds occur.

Crop rotation. From a weed management point-of-view, it may be okay to use a short interval between a given crop if there are no highly troublesome weed species present in the field or a portion of a large field. However, if particularly troublesome weeds are present, for example, perennial weeds, wild oat or jointed goatgrass, then long crop rotations that include spring and winter crops, warm-season and cool-season crops, and broadleaf and grass crops should be used. Dividing a field into differing crop-rotation management units according to the presence or absence of troublesome weeds represents a historical and common-sense application of knowledge of weed spatial variability.

Crop species and variety. Knowing the spatial variability of weeds in a field will provide growers with information to select the crop species and variety most competitive with a particularly troublesome weed or common group of weeds. For example, if nightshades are present, a large seeded legume would not be a good choice, or if wild oat is present spring barley rather than spring wheat should be grown, because barley is more competitive with wild oat. If downy brome is present, a tall winter wheat with rapid early growth would be preferred in those fields or portions of a field infested with this weed. If perennial weeds such as Canada thistle are present, a deep-rooted crop such as alfalfa would be more appropriate than a shallow-rooted crop such as field beans. If foxtails and barnyardgrass are present in large numbers, small-seeded vegetable crops such as carrots should be avoided until the weed seed populations can be reduced.

Seeding rate and row spacing. Generally speaking, planting crops at higher than normal seeding rates will enhance crop competition against weeds. Changing the seeding rate is relatively easy and could be used in portions of a field where weed seed populations are high. Narrow row spacings also enhance crop competitiveness, but would be difficult to change within a field. On the other hand, increasing row spacing for some crops to accommodate precision cultivation in certain areas could be accomplished by blocking every other drill opener. Some growers cross-seed areas with known high populations of weeds, thus increasing crop competitiveness.

Seedbed preparation date. Most growers need to prepare seedbeds and plant their crops as soon as possible to ensure not only high yields, but the timeliness of a myriad of other farming and family obligations. Nevertheless, purposefully delayed Seedbed preparation in weedy blocks of a field may have considerable beneficial effects on control. These effects are especially apparent in spring-sown crops for early-emerging broadleaf weeds such as ragweed and lambsquarters.

Timing of in-crop cultivation. Knowing the spatial variability of weeds within a field will help farm managers locate in-crop field cultivations for maximum weed control effectiveness. Because weed species appear at different times in a field, knowledge of weed periodicity would have to be known also to maximize the use of weed spatial variability for weed control with this strategy. The real estate adage "location, location, location" has to be appended for precision farming with "timing, timing, timing."

Precision application of certain insecticides. Certain insects are associated with specific weeds. For example, stalk borer is strongly associated with giant ragweed infestations in corn fields, and cutworms that attack asparagus are strongly associated in early spring with patches of Canada thistle and field bindweed. Knowing the spatial variability of these weeds would allow growers to place insecticide more precisely, thus reducing production costs and insecticide use.

Determining the "true" weed pressure. Given equivalent total weed populations, crop yield losses are usually less in fields where weeds are aggregated rather than distributed uniformly or randomly. Consequently, knowing the spatial variability of weeds will allow a more accurate prediction of potential yield loss, and thus give farm managers the opportunity to change production and weed management practices to minimize these losses.

Plant residues. Knowing the location within a field of certain weeds will give farm managers the opportunity to spot-burn weed and crop residues to kill most of the weed seed on the soil surface. Also, this information will allow livestock grazing to be managed selectively so that especially noxious weeds will not be spread to the rest of the field, or so that plants poisonous to livestock can be avoided.

Postharvest quality management of crop products. If the spatial variability of weeds within a field is known, farm managers can segregate crop products to minimize the impact of weeds on crop quality and price received. Some applicable examples include: 1) not harvesting areas in mint fields infested with horseweed, a weed that produces a high quantity of oil that taints mint oil; 2) not harvesting areas in green pea fields infested with nightshade because there is a zero tolerance for nightshade berries in canned or frozen peas; 3) not harvesting areas in wheat fields grown for seed that are infested with jointed goatgrass; and 4) avoiding areas in alfalfa fields infested with mustards that can impart off-favors in the milk from dairy animals fed weed-contaminated hay.

Increasing the awareness of specific weed problems. Knowledge of the spatial variability of weeds seems to be increasing the awareness among crop advisors and producers that the biology and ecology of weeds are important and that this information can be used for weed management and economic gain.

We hope these examples will stimulate more thought and research on how we can use weed spatial variability information to enhance weed management, reduce farmers dependence on herbicides, and improve farm profitability.

RESEARCH PROJECT MEETINGS

PROJECT 1: WEEDS OF RANGE AND FOREST

Chairperson: Bruce Kelpsas

Subject 1: Managing Riparian Areas; What Opportunities Exist to Increase Productivity?

Increasing emphasis is being placed on riparian areas to provide habitat for fish, wildlife and other natural resource values. While these areas are being targeted for fish production, the use of streamsides for other uses such as timber production and grazing have been restricted or eliminated. Currently, regulatory agencies have taken a hands off attitude towards active riparian management, both for wildlife values as well as for timber and grazing. Little information exists on how to manage riparian vegetation to achieve diverse objectives and the impacts this has on stream systems.

Studies on stream dynamics and vegetation management in forests of Oregon were presented by Dr. Michael Newton of Oregon State University. His work indicated that forest streams are dynamic and that vegetation removal for timber production produced a variety of results. Temperature of streams was studied intensively, and findings suggest that temperature of water fluctuated both up and down as it moved from cut to uncut areas. It was noted that streams have considerable buffering effect on temperature due to migration of water from subsurface aquifers and bedrock. Questions arose about whether this buffering would also take place in low gradient rangeland streams, but no information was offered by the group. It was noted that increases in temperature and sunlight can have a beneficial effect on fish production within limited ranges.

Planting desirable vegetation within riparian areas was discussed as a way to create habitat. It was noted that removal of competing vegetation was needed during the year of establishment to ensure adequate survival and growth. Little rangeland riparian management has been occurring based on group response. Limited planting of riparian woody species such as cottonwood and willow have been observed, but no follow up weed control is being done. It was noted that Oregon forest rules allow applications of herbicides to within ten feet of water which should be sufficient to create desirable conifer dominated habitat. The group agreed that riparian areas could be managed for multiple goals if active programs of vegetation control and habitat creation were implemented.

Subject 2: Monitoring Weed and Brush Problems; Techniques and Methods

Obtaining accurate data on weed and brush infestations is needed to make management and budgetary decisions. A number of survey methods are available to record weed problems. Norm Harris of the Department of Rangeland Resources at Oregon State University presented information on low altitude photography from tethered blimps. Photographs from low altitude have the advantage of being able to distinguish down to individual plant/species resolution, especially if used in conjunction with color filters. Low altitude photography can be used to validate high altitude aerial photos in weed surveys and research programs. These methods have been used successfully to document white top infestations in eastern Oregon and survey changes in gorse spread along the Oregon coast.

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PROJECT 2: WEEDS OF HORTICULTURAL CROPS

Chairperson: Elaine A. Hale

Subject: Glyphosate-resistant Vegetable Crops--Will This be a Boon, or a Bust? Is it a Must?

The discussion session was attended by approximately 14 people who listened to the prepared presentations of Bill Dyer, Katherine Kolacz, and Matt Elhardt who represented university and industry, respectively. Bill's thought reflected his experience and exposure to the level of interest expressed at the University vs. Industry. He has concluded that there is a lack of interest for the commercial aspect. Kolacz presented a large volume of technical data concerning gene transfer and the why's of "why there is no commercial interest" from the industry perspective. Her conclusion allowed that there are specific crops that are currently economic to produce as HRC's. This presentation prompted many questions concerning the validity of economic justification given the direction chemical enforcement is moving. Elhardt's contribution gave some in depth explanations concerning the need for individual al's per crop which equates to a large volume of very expensive research. Bottom line is that, currently, there is not enough market out there for HRC's.

1998 Officers for Project 2:

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PROJECT 3: WEEDS OF AGRONOMIC CROPS

Chairperson: Robert Downard

Subject: Weed Thresholds

What we need to learn. Phil Westra discussed actual yield reduction, value of the lost yield and long term impact of control measures. He suggested these be considered in assessing weed thresholds. Different crop varieties, differences in time of weed emergence, and other factors change competitive relationships and may alter weed thresholds. Variation in weed biotypes and density can vary year to year making thresholds hard to evaluate. He also raised the question that establishing thresholds for perennial weeds may be difficult.

Weed thresholds. Marie Jasieniuk defined differences among thresholds. The weed density that will be tolerated by the grower, based on intuition is a "perceived weed threshold." Whereas the density that impacts yield is the "biological threshold."

The "economic injury threshold" is when the cost of controlling weeds equals the loss due to weeds. It does not take into account leaving weeds in the field and their future impact. It only considers the weed density in the current year. Presently, this is a more common approach to weed thresholds.

Managing weed densities to maximize profits for several years is the "economic optimum threshold." The difficulty with this threshold is seed life, current population, current seed production, seed rain, seed bank, and emergence must be know. This threshold must also consider dockage. This approach is becoming more accepted as the area where thresholds need to be developed.

Discussion. The possibility was raised that perhaps reduced rates of herbicides that are now being used in some areas will lead to increased dockage.

Often there is no yield response in wheat from the control of broadleaf weeds. Even at very reduced rates there is a dramatic decrease in seed production. There could be a problem with reduced rates depending on the weed density and species. Weed species is critical. One velvet leaf is too many and lambsquarters will produce so many seeds that year to year the grower will know there will be a problem. Wild oat number thresholds may work, but first we need to reduce the population to a low level and then maintain. This may require going with the highest level of weed control possible for a time and then maintain. However, the approach of the highest level of weed control possible is the traditional approach and weeds are still present, so is this possible? It may work with some weeds but not hard seeded ones. Reduced rates could lead to an explosion in the weed population over time. Growers are being asked to take the risk.

Growers must weigh the economics of multiple applications versus tank mixtures. They may be sacrificing maximum weed control when they must choose between perfect timing versus increased cost of repeated applications.

Many factors which affect weed populations are out of growers control such as wind, irrigation water and lease agreements. It was the consensus that most growers still want 100% weed control and are not willing to accept risk for reduced herbicides.

The Germans were the first to come up with number thresholds to govern herbicide applications. However, it was mostly winter wheat with spring weeds so the crop was out competing the weeds. A similar situation is present in the Midwest but was not defined as a threshold. A question arose about biomass suggesting it is a better indicator of a weeds impact on the crop than actual numbers.

Period thresholds were discussed. It is possible to let weeds grow uncontrolled for some time with no impact on the crop but at the critical point they must be controlled. The fewer the weeds, the longer they can remain before they have an impact.

Thresholds are affected by environmental changes year to year. Developing a growing degree day model may work better to predict when the greatest weed emergence will occur. Others argued that moisture is more important than temperature. A better model would include an understanding of the relative time of emergence as effected by temperature, moisture, tillage, and seed dormancy.

Thresholds are extremely complex variables. How do we get the level of weed control we need and an acceptable risk factor for the grower? We need to develop models that look at trends over time.

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PROJECT 4: TEACHING AND TECHNOLOGY TRANSFER

Chairman: Tim Miller

Subject: State Noxious Weed Lists: What Should be Included?

Approximately 25 people were present for the discussion section. These participants were divided among university extension systems, county weed control personnel, federal agency personnel, and various state departments of agriculture. The chairman opened the discussion by outlining Idaho's requirements which must be met before a weed species may be designated as noxious. These four requirements are:

1. The species must be present in, but not native to, the state.
2. The species must potentially more harmful than beneficial.
3. A plan for the economic, physical, and biological control of the species must be on file with the state department of agriculture.
4. The potential adverse impact from the species must exceed the potential cost of control of the species.

The initial discussion focused on individual state lists. Two general lines of thought seemed to be present: 1) use of a short list of species (less than 10) to focus weed control interest and energy, and 2) use of a long species list to allow for quick county response to new weed species. A major concern with long species lists was the potential loss of focus of a noxious weed program, given the fact that counties have limited human resources and budgets to expend on weed control projects. It was felt that it was better to be thorough with a few weeds than to spend limited resources on several species. Conversely, longer species lists are useful to alert weed managers about potential species of concern. These lists were generally split into three categories: 1) new invaders of limited distribution but known to be weedy, 2) more or less well-known weed species whose distributions are small enough that noxious designation may limit spread, and 3) widely-distributed weed species greatly impacting agriculture or horticulture. These types of lists give counties flexibility in developing personalized programs for their individual populations of weedy species. They also allow weed control personnel to rapidly respond to newly invading species and expend public funds toward their control without first having to go through the formal process of adding the species to the state list.

Participants from the various states commented that, in most states, counties had authority to designate species from the lists to receive particular attention and/or to tailor the state noxious weed list to better fit the problems in individual counties. Because equal control efforts are not usually required for different species within a given county, this flexibility was considered to be essential to the development of effective weed control programs.

There was also some discussion about species which should be included on the lists. If a species is very widespread in the state (such as Canada thistle), should it be included on the list? Opinions were varied. Some participants maintained that there are always fields which farmers are keeping clean through great effort and expense. These individuals need to be protected from thistle spreading from neighboring fields belonging to a less-enthusiastic farmer. Others believed that particular argument was a little fuzzy, given that dandelions effectively spread from yard to yard yet are not declared noxious in any state. Given the wide distribution of Canada thistle, it was argued that there was in fact little protection being offered from the weed even with its noxious designation. The question as to what that weed's distribution would be without that designation, however, was not answered.

The discussion then turned toward funding systems. Most operated on local property taxes, although there was a wide variability in the number of mils levied. Some counties were able to tie their funding to a crop value per acre, while supplemental state funding was generated from automobile licenses or the general tax fund.

There was a general consensus among participants that neighboring counties (even across state lines) do talk to each other, although usually informally. In most cases, these counties liked their autonomy, in that they didn't feel obligated to control the same weed species being targeted in the next county. There was also a strong consensus that the nursery industry must do a better job of screening plant materials for weediness. Most participants didn't want to unduly regulate that industry, but nearly all felt that more self-policing by nurseries is warranted to slow the introduction of weedy ornamental species.

Finally, there was discussion about the role federal agencies should be playing in state noxious weed management. While most participants could point to a specific failure by an agency to adequately control weeds on federal lands, many were also encouraged by recent interest by high level federal administrators to improve their noxious weed programs.

1998 Officers for Project 4:

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PROJECT 5: WEEDS OF AQUATIC, INDUSTRIAL, & NON-CROP AREAS

Chairperson: Nelroy E. Jackson

Subject: Implementation of the National Weed Strategy for Invasive Plant Management

Deborah Hayes of the US Forest Service and Co-Chair of FICMNEW (The Federal Interagency Committee for the Management of Noxious and Exotic Weeds), stated that we need to recognize that 85% of federal land is not infested with weeds. However, the weed problem is huge. Over 7 million A of Dept. of Interior land and 5 million A of Dept. of Agriculture land are infested with weeds. Total federal land holding is 191 million A. The BLM alone, estimates that 300 weed species infest an additional 5000 of their 2.5 million A each day, like a wildfire.

The aim of FICMNEW is to raise the "Weed Awareness IQ" of the country, since the 1993 Office of Technology Assessment report stated that there was no policy on weeds at the national level. Weed control has not kept pace. Only 500,000 trackable federal dollars were spent on weed control annually. Two scoping meetings in 1995 heard the need for more survey, money, cooperation, and education. FICMNEW developed a National Weed Control Strategy with three pillars - Prevention, Control and Restoration. One hundred organizations have signed support for the Strategy which is posted on the Internet.

The "Pulling Together Initiative" - competitive grants totaling $500,000 provided by the BLM and FS - was initiated. Weed Control Proposals requesting matching funds were submitted to the U.S. Fish & Wildlife Foundation. Partnerships, to the benefit of federal land, are required where resources are pooled and include some of the following elements: Local plus Federal support, IPM, Education, County, Federal and Private land owners. Some research of exotic weeds allowed. The average make-up of cooperative projects is two federal, two state, two private, one industrial and one environmental group, with a 2:1 match, and $27,000 average request. Total requests were $2.5 million.

1998 Officers of Project 5:

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PROJECT 6: BASIC SCIENCES
Chairperson: Mary Guttieri

Subject: Emerging Data Management and Analysis Issues

The Project 6 discussion centered around emerging data management and analysis issues. Anita Dieleman, University of Nebraska, Bill Price, University of Idaho, and Tony Kern, Montana State University, introduced the key topics for the discussion section for Basic Sciences.

The first topic was geostatistical analysis for characterizing the spatial distribution of weeds. Anita Dieleman described two software packages that have been useful in the Nebraska program, GS-Lib and GS-Plus. The integrity of the large datasets generated in spatial studies can be maintained with "read-only" archived files. Accuracy of field data collection is improved by working in pairs, the same person consistently performing the same task. Prompt data entry coupled with statistical analysis can improve the dataset. Sampling grid size is an important consideration both when planning experiments and in farm-scale implementation. Anita Dieleman reported that a 7 m grid appeared useful in row crops. In a 160 acre field, a 80 foot offset grid, similar to soil sampling, was useful. The practicality of farm-scale mapping is a significant concern. Real-time optical sprayers may be more useful. It was suggested that integrating mapped yields with ground-truthed weed populations may be a useful tool to illustrate the effects of weeds on crop yields. Definition of weed patches is somewhat subjective due to the noise inherent in weed population density data. Moving averages applied to a time series, or other data smoothing techniques may assist interpretation.

The second topic of discussion was modeling weed/crop interactions. Bill Price supplied a handout on plant competition modeling. Bill suggested that in designing experiments to model competition, it is particularly important to have data points at densities where the interactions are rapidly changing. Although extremes may not be of practical importance to a grower, they are important parameters in models and need to be included in experiments. In designing experiments, there is a clear trade-off between increased replication and increased numbers of densities. Year-to-year and site-to-site variation in competitive interactions may limit the broad applicability of parameters derived from competition experiments. Moreover, economic thresholds tend to be placed at densities at which variation in competitive impact is greatest. Perhaps thresholds based on competition experiments may not be reliable; however, useful biological information on the nature of interactions can be obtained from competition experiments. An interesting point raised was that weeds may have positive effects. For example, Bob Stougard pointed out that in Montana lower sawfly densities have been noted in areas with higher wild oat infestations.

The third topic of discussion was the use of molecular markers. Tony Kern presented some of the core methodology in molecular marker studies. Molecular markers are traits that are easily followed. PCR-based markers can be very economical and very sensitive. Some uses of molecular markers in weed science include estimating general genetic variance, outcrossing/selfing ratios, and genetic linkage in populations. Molecular markers also can be used to determine the genetic background of seeds. In inheritance studies, molecular markers may be useful to determine the success of crosses. Some genetic maps of crop species may be a useful starting point in mapping weeds, for example the tomato map may be useful for nightshade species. Molecular markers are particularly useful in systematics studies.

Finally, attendees shared some favorite web sites. For molecular biology data, www.ncbi.nlm.nih.gov. For molecular biology training materials, www.cgiar.org/ipgri/training, and for PCR primer design, genome.wi.mit.edu/cgi/primer.

1998 Officers of Project 6:

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PROJECT 7: ALTERNATIVE METHODS OF WEED CONTROL

Chairperson: Ed Peachey, Chairperson-elect: Steve Eskelsen

Subject 1: The 1996 Farm Bill and its Impact on Conventional and Alternative Farming Practices.

Discussion Leader: Penny Diebel, economics instructor at Eastern Oregon State College, LaGrande, OR.

Approximately 28 people attended these discussions. Penny Diebel introduced the topic with a summary of how the 1996 farm bill differs from the previous legislation. She pointed out that the 1996 farm bill is really an amendment to the 1949 farm bill. Important points include:

1. The farm bill is budget driven, and no assurance can be made that after 7 years (or within administrations) the current strategy will be in place (ie. withdrawal of support prices).
2. Program reflects income subsidy. Not tied to output or crop.
3. Conservation reserve program will continue.
4. No set asides; complete flexibility.

The discussion then turned to the implication of this budget on weed management practices. The most important change may be that the changes will allow more flexibility in rotations. Growers may begin experimenting with new crops as they will have to diversify to manage risk as the subsidies are slowly removed. Herbicide use patterns must be scrutinized to prevent affects on succeeding crops. There will probably be a concentration of feed grains in the Midwest and an increase in wheat and corn acreage. Impacts in irrigated areas will be minimal. Land rates will probably increase with a diversification of cropping patterns.

CRP will continue but with changes that reflect a shift toward resource conservation as the objective. Though this was the theme of the original CRP of 1985, in reality the program was an attempt to regulate production. Items such as soil erosion, wind erosion, and wildlife habitat will be used to determine the potential of land for the program. Areas that may benefit most could include populated riparian areas such as the Chesapeake bay watered.

Many acres of the original CRP program will be up for reevaluation and may be brought back into production within the next 2 to 3 years. Discussion focused on how growers will deal with the immense weed seed banks that have built up in some cases, and difficulty in removing grasses from the systems. Fire will be ineffective in reducing weed seed banks but will be useful in stimulating growth of grasses if converting to pasture.

Subject 2: Alternative Weed Management Strategies in Trees and Vines.

Discussion Leader: Clyde Elmore, University of California, Davis, CA.

Clyde Elmore introduced the topic by listing a range of strategies that have developed over the years for weed management in tree and vine crops. These ranged from tree-to-tree residual herbicide approaches, to strip management, to the use of living and dead cover crop mulches.

The discussion focused primarily on interactions between system components and the changes that occur because of sometimes even small changes in weed management practices. Competition with the crop for water and nutrients is always a major concern with the use of cover crops. Winter cereals coupled with mowing (mow and blow approaches) have been successful in some cases. The use of cover crop mulches seems to delay harvest although experiments have been variable. Ground cover can increase the chance of frost. Vegetation changes also can affect insect populations; some mulches encourage ant damage, and mite populations were increased because of morning glory that was not controlled. In one case, a particular mulch increased the population of a soil insect that used micro emitters as habitat, thus causing irrigation difficulties. Steam is one method that can be used but is essentially a good contact herbicide. Large amounts of energy are needed and soil compaction can result from the heavy equipment needed for steam production. Flaming can be used but will not control grasses. A shift to grass species may be induced by flaming.

The image presented by particular practices can be used in marketing. Growers will maintain vegetation of the land even if it may mean a slight yield loss, particularly if the field is accessible for tours. A group of growers in Oregon has organized to present an image of a region that uses 'best management practices'.

1998 Officers of Project 7:

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Chairperson-elect: Clyde Elmore
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1997 WESTERN SOCIETY OF WEED SCIENCE PRESIDENTIAL MERIT AWARD RECIPIENT
Jill Schroeder

MINUTES OF THE 50th ANNUAL BUSINESS MEETING
WESTERN SOCIETY OF WEED SCIENCE
RED LION HOTEL - COLUMBIA RIVER
PORTLAND, OREGON
MARCH 13, 1997

The meeting was called to order by President Charlotte Eberlein at 7:00 a.m. Minutes of the 1996 General Business Meeting were approved as printed in the 1996 WSWS Proceedings.

COMMITTEE REPORTS

Program Committee - Barbra Mullin

a. Special thanks were given to the Program Committee members, Rod Lym and Jack Schlesselman and to the WSWS General Session speakers, Larry Burrill and Dan Hess. Appreciation was extended to the Special Discussion "WSWS Survey Results and Future Direction" Chair, Jill Schroeder, and to Jeff Tichota for moderating the What's New in Industry session.
b. Sponsored Activities
    1. Member Welcome and Retirees Reception - Monsanto
    2. Graduate Student Breakfast - Bayer and Novartis
    3. Companion's Breakfast - Zeneca
    4. Continental Breakfasts - BASF
    5. Refreshment Breaks - American Cyanamid and BASF
    6. WSWS Business Breakfast - DowElanco
c. Breakdown of Papers
    1. General Session - Barbra Mullin, Chair
       Four presentations: Presidential Address - Charlotte Eberlein, 'The History of WSWS' - Larry Burrill, 'The Next Fifty Years: Industry Must Be More Like Academia and Academia Must be More Like Industry' - Dan Hess, and a panel discussion 'In the Field with Herbicide-Resistant Crops' - moderated by Phil Westra.
    2. Education & Regulatory Section - Jack Schlesselman, Chair
       Presentation & Discussion Session - 'How to Improve our Presentation Skills'
    3. Research Section - Rod Lym, Chair
       65 papers (14 student). Areas with low paper participation included Weeds of Aquatic, Industrial, and Non-Crop Areas - 2 papers; and Alternative Methods of Weed Control - 0 papers. Ed Peachy chaired a discussion session on Alternative Methods and input has been solicited on how to increase paper presentations.

Local Arrangement Committee - Ron Crockett
Thanks were expressed to Charlotte Eberlein, Barb Mullin and Wanda Graves for their support throughout the planning of the 1997 WSWS meeting in Portland. A special thank you was given to Gus Foster for his help in obtaining support for sponsored activities and to Bob Parker for his help with the posters. Appreciation was also expressed to Kelly Lawson and the hotel staff.

Financial Report - Wanda Graves, Business Manager

a. 360 registered, the highest total in recent years. There were 350 registered last year. There were 32 graduate students and 10 spouses.
b. Wanda asked that we please register as soon as possible for next year and to get any address changes to her as soon as possible.
c. The Society is in good financial standing with $196,662 in accounts. Of this, $68,348 is in revolving accounts (Bio Control of Weeds Book, Noxious Weed Management Short Course, Weeds of the West, and Herbicide Resistance Video) for a balance of $128,313. Our By-Laws require $75,000 to be kept in reserve, leaving a balance of approximately $40,000 for operating expenses. Income less expenses (without revolving accounts) has averaged $3,000 to $5,000 for the past several years.

Finance Committee - Wayne Belles

The committee met with Wanda Graves and reviewed the financial books and investment portfolios. Wanda has kept the committee up to date with financial statements. The financial books are in order and the investment portfolio is performing well. Wanda is to be commended on a job well done.

Immediate Past President's Report - Gus Foster

a. The WSWS Member Welcome and Retirees Reception was held Monday, March 10. Retirees, Alex Ogg, Bob Callihan and George Hittle were honored.
b. Recognition and thanks were extended to the sponsors of meeting activities including the Retirees Reception, coffee breaks and various breakfasts.

Member at Large - Jill Schroeder (reported by Gus Foster)

a. A membership survey was designed and distributed during 1996. Many aspects of the WSWS were reported as positive by members. Overall the Society is doing well in providing for the needs of its members.
b. Results of the survey showed that the 2nd week of March is the preferred time for the annual meeting.

WSSA Representative - Paul Ogg

a. The WSSA held it's 37th annual meeting in Orlando, FL February 4 to 6, 1997 with approximately 775 registered.
b. The WSSA Board of Directors has retained a new management firm, Allen Marketing & Management.
c. Allen Press has become the new publisher of the two journals, *Weed Science*, and *Weed Technology*. There will be six editions of the *Weed Science Journal* in 1997.
d. AESOP was effective this past year. Weed Science had two members testify before Congress on national research priorities and weed management research.
e. The Congressional Science Fellow program is continuing. There are two new individuals who will be starting this summer. Applications can be made through the WSSA.
f. The Strategic Planning Committee is continuing to look at the feasibility of an Executive Vice-President to reside in Washington, DC and provide political support, continuity, and a voice for Weed Science.
g. Donn Thill will be the new WSSA representative.

CAST Representative - Jack Evans

a. CAST is doing well and they have gained respect in Washington DC for their ability to interpret and present information.
b. Jill Schroeder will be attending the Phase II CAST meeting.
c. Three new societies have affiliated with CAST for a total membership of 33. New members are the American Association of Veterinary Medical Colleges, the American Bar Association Agricultural Management Task Force, and the American Colleges of Poultry Veterinarians.
d. CAST has contracted with outside agencies for fund raising opportunities.
e. Several new reports have been published during 1996 and several are planned for the near future including 'Mycotoxins (update existing report), BSE (mad cow disease), Prescription Pesticides, Crop Production and Air Quality, Animal Production and Air Quality, Proprietary Rights/Production Information, Phenoxy Herbicides, and Water Quality/Hypoxia.'
f. CAST will be celebrating its 25th anniversary at this years' conference. It will be held November 2 to 4, 1997 at the Hyatt Regency, Chicago.
g. It was recommended that we continue as a member of CAST and that funding to support CAST be continued.

Site Selection Committee - Frank Young

a. An expression of thanks was given to Site Selection Committee members Keith Duncan and Bob Zimdahl for help in negotiating a good contract for the Colorado Springs meeting. Appreciation was also expressed to Charlotte Eberlein and members of the Executive Board for providing funds for travel to visit the prospective hotels. On site visitation is invaluable for hotel selection and contract negotiations.
b. The committee recommends that the 2000 meeting be held in Arizona. Tucson is the 1st choice, followed by Phoenix.

Affiliations Committee - Tom Whitson

a. A letter of invitation was extended to 35 associated organizations, including 1996 attendees as well as potential new coalition partners. A follow-up invitation with registration information and the 1997 program was also mailed to each coalition partner.
b. Tom is willing to continue as Chair of this important committee. He would appreciate any ideas on encouraging affiliation members to participate in the WSWS.

Publications Committee - Dave Cudney

a. 'Weeds of the West' was reprinted for the seventh time for a total of 80,000 copies printed.
b. The 'Biological Control of Weeds of the West' publication came out in April. Barbra Mullin reported that sales have been good and a second printing will be needed soon.
c. The WSWS membership survey was reviewed. Good ideas were expressed regarding publications.
d. The WSWS brochure is a high priority for the coming year.

Fellow and Honorary Members Committee - Gus Foster

The committee unanimously selected and recommended:

a. Michael Newton and Steve Dewey as Fellows for 1997.
b. Dan Hess is the 1997 Honorary Member.
c. The next chair of this committee is Steve Miller.

Awards Committee - Sheldon Blank

a. Arnold Appleby will be the chair of this committee for the coming year.
b. The 1997 recipients of the WSWS Outstanding Weed Scientist Award are:
   Harry S. Agamalian - Public Sector
   Jeff M. Tichota - Private Sector
c. Only one new nomination was received this past year. Members are encouraged to make the effort to nominate outstanding weed scientists for this award.

Nominations Committee - Donn Thill

a. The nominations committee extended its appreciation to members who nominated individuals for elected positions. Members were encouraged to get suggestions for next year's candidates to Tracy Sterling before the Summer Executive Board meeting.
b. Results of 130 ballots casts during the election are as follows:
   President-Elect: Rod Lym
   Secretary: Neal Hageman
   Research Section Chair: Carol Mallory-Smith
   Education and Regulatory Section Chair: Dan Ball
c. Members were asked to please vote. Of 400 members, 130 voted this past year.

Student Paper/Poster Judging Committee - Doug West

a. There were 7 student papers in the basic and 7 student papers in the applied section of the oral paper competition. Winners were:
   Basic Section:
      First Place - Anthony Kern, Montana State University
      Second Place - Ramon Cinco-Castro, University of Arizona
      Third Place - Harwood Cranston, Colorado State University
   Applied Section:
      First Place - Patrick Miller, Colorado State University
      Second Place - Sandra Shinn, University of Idaho
      Third Place - Jeff Nelson, North Dakota State University
b. There were 7 participants in the poster contest, an increase compared to 1996. Winners were;
      First Place - Andrea Sultana, New Mexico State University
      Second Place - Marie Campanella, New Mexico State University
      Third Place - Martina Murray, New Mexico State University

c. The following awards are given as per WSWS Guidelines:
   First place for each category $100; second place $75; third place $50.
   In addition, each cash award recipient will receive a plaque and the first place award recipients will receive a gift certificate for a WSSA monograph.

Student Educational Enhancement Committee - Phil Stahlman (reported by Claude Ross)

a. This program continues to be a worthwhile endeavor
b. Plans are to have two students go together to visit with a company representative. They will then travel on to visit with one or more subsequent company representatives.
c. Brief reports of their experiences were given by Steve Enlow who traveled with Jack Schlesselman of Rohm and Haas and by Roland Maynard who was with Claude Ross of FMC.
d. It was moved by Claude Ross to change the Student Educational Enhancement Committee from an Ad Hoc to a standing committee and to make the required changes in the Constitution and By-Laws. The motion was seconded and passed unanimously. (See addendum for Changes to the WSWS Constitution and By-Laws as enacted by this motion).

Legislative Committee - Vanelle Carrithers

a. Carol Mallory-Smith has been acting as a liaison with the WSSA Legislative Regulatory Committee and as a member of the WSSA Washington, D.C. Liaison Committee.
b. Vanelle Carrithers moved to change the Legislative Committee from an Ad Hoc Committee to a Standing Committee and to make the required changes in the Constitution and By-Laws. The motion was seconded and passed unanimously. (See addendum for changes to the WSWS Constitution and By-Laws as enacted by this motion).

Herbicide Resistant Plants Committee - Steve Seefeldt

a. The Herbicide Resistant Weeds video has been completed. Over 200 copies have been sold to date.
b. It was moved by Steve Seefeldt to change the Herbicide Resistant Weeds Committee from an Ad Hoc Committee to a Standing Committee and to make the required changes in the Constitution and By-Laws. The motion was seconded and passed unanimously. (See addendum for changes to the WSWS Constitution and By-Laws as enacted by this motion.

Sustaining Membership Committee - Rick Arnold

a. Sustaining membership increased from 18 companies in 1996 to 22 companies in 1997.
b. New companies included ISK Biosciences Corporation, Oregon-California Chemical Company, Inc., Patchem, Inc., R & D Sprayers, Terra Industries, and Valent USA. Last year's members not continuing this year were Pioneer of Jackson Hole and Wintersteiger, Seedmech Division.

Internet-WWW Committee - Joan Campbell

a. New WSWS Web Site on line space has been provided by the University of Idaho on their web server at no charge. The url is www.uidaho.edu/ag/wsws/.
b. The WSWS Web Site has the WSWS objectives, officers, available publications, information on WSWS annual meetings, an events calendar with workshops and tours in the western USA, committee members, and sustaining members,
c. It was requested that information/updates be forwarded to the Committee when available to keep the website current.

Operating Guide Committee Report - Joan Campbell

All revisions received to date have been incorporated into the Operating Guide. Committee members will edit the revised Operating Guide after this annual meeting. The By-Laws will be revised to reflect changes approved at the 1997 Business Meeting. Both documents will be placed on the WSWS Website.

Weed Management Short Course Committee - Celestine Duncan

a. There will be two Noxious Weed Management Short Courses this year. One is scheduled for the week of April 21 through April 24, 1997 and the second for the week of September 22, 1997. Both will be held in Bozeman, MT.
b. Dr. Arnold Appleby will be critiquing the course this year to determine areas for improvement and possible expansion.

Necrology - Jay Gehrett

The death of Dr. Robert Lamoreaux was reported. Dr. Lamoreaux was the Research Manager of the Sandoz Gilroy Facility in Gilroy, California. Bob will be remembered for his dedication to research and his colorful personality.

Public Relations Committee - Jack Schlesselman

a. Members were reminded to fill in the appropriate forms for PCA/Consultant continuing education credit.
b. Student poster and paper presentation award recipients were reminded that photographs will be taken immediately following the meeting.

Poster Committee - Tim Prather

a. There were 25 posters presented at the session (1 withdrawn). Thanks was extended to all who helped set up the poster session.
b. The poster committee is looking to replace the current poster boards with foam core boards. These should be purchased in Hawaii.

Placement Committee - Dennis Scott (reported by Charlotte Eberlein)

Plans are being made to get the Placement Service on the WSWS Website.

Resolutions - Phil Westra

a. Resolution 1.

Whereas; The 1997 program presented a thought provoking and relevant message, and
Whereas; The meetings were run smoothly and efficiently, and
Whereas; The facilities were excellent and the staff helpful and courteous,

Be it resolved that the Western Society of Weed Science expresses its appreciation to Barbra Mullin, Ron Crockett and the Local Arrangements Committee, and to the management and staff of the Red Lion Hotel - Columbia River, Portland, Oregon.

Phil Westra moved to accept the resolution. The motion was seconded. The motion passed unanimously without discussion.

b. Resolution 2.

Whereas; Herbicide resistant weeds are of major concern and economic impact, and
Whereas; One of the most common recommendations to prevent, delay, or manage herbicide resistant weeds is to rotate herbicides having different sites of action, and
Whereas; Herbicide users do not always know the biochemical site of action of a herbicide, making it difficult to choose a herbicide with a different site of action for herbicide resistance management, and
Whereas; The Herbicide Resistant Weeds Committee of the Weed Science Society of America has approved a herbicide classification based on herbicide site of action,

Be it therefore resolved that the Western Society of Weed Science does here by support the use of the classification system for educational purposes.

c. It was moved by Donn Thill that the last paragraph be amended to add following educational purposes, "which includes use in University extension, information news releases by the agricultural popular press, and on herbicide labels". The motion to amend was seconded.

d. Discussion followed mainly on the pros and cons of adding the classification to labels. Those in agreement felt it would be useful for fieldmen and growers as a tool for herbicide resistance management. Those opposed were concerned about opposition from industry and possible incorrect interpretation of the classification as a resistance management tool if added to the label.
e The question was called for and the amendment as stated above was voted on. The motion failed by a show of hands with 44 in favor and 75 against.
f. The original resolution was then voted on. The motion carried with two no votes.

New Business
a. Bill Furtick, Past President and Fellow of the WSWS, gave a brief update of his post retirement activities.
b. There was no further New Business

Announcements
1. The IPM WRRC Coordinating Committee will meet in Portland March 24-25, 1997. See Charlotte Eberlein or Bob Stougaard for details.
2. Jill Schroeder was the recipient of the 1997 President's Award.
3. Shafeek Ali is the new Member-at-Large.
4. A special thanks was given to DowElanco for a great Business Meeting Breakfast.

Charlotte Eberlein expressed appreciation for the support she received from the WSWS membership this past year with her Presidential duties.

President Charlotte Eberlein passed the gavel to incoming President Barbra Mullin. Charlotte was presented a plaque and thanked for her work with the Society.

Thanks were extended to those who have volunteered to serve on committees and as officers. The New Board Luncheon meeting will be at noon today. The official dress for the 1998 Hawaii meeting will be bright colors and no ties.

The meeting adjourned at 8:20 a.m.

Respectfully submitted,

Wayne Belles, Secretary

ADDENDUM TO THE WSWS GENERAL BUSINESS MEETING
MARCH 11 - 13, 1997
RED LION HOTEL - COLUMBIA RIVER
PORTLAND, OREGON

CHANGES TO THE WSWS CONSTITUTION AND BY-LAWS

Elevating the Legislative committee, Herbicide Resistant Weeds Committee, and the Student Educational Enhancement Committee from Ad Hoc to Standing Committees will bring about the following changes to the Constitution:

Article VII. Section 1. There shall be ~~fifteen~~ eighteen Standing Committees: Program, Finance, Resolutions, Local Arrangements, Nominations, Public Relations, Placement, Nominations of Fellows and Honorary Members, Site Selection, Awards, Poster, Student Paper Judging, Necrology, Publications, Sustaining Membership, Legislative, Herbicide Resistant Weeds, and Student Educational Enhancement appointed by the President with the advice and consent of the Executive Committee.

ARTICLE VII.
Add: Section 16. The Legislative Committee shall consist of a Chairperson and two additional members. Terms of office of this committee shall be: Chair appointed to a two-year term and an additional year as past-chair, and 2 other members appointed to two-year terms. Terms of the committee members shall rotate in alternate years.

Section 17: The Herbicide Resistant Weeds Committee shall consist of a chairperson and five additional members. Terms of office of this committee shall be: Chair appointed to a three-year term, and 5 other members appointed to three-year terms, established to expire alternately so that at least 4 members continue over each year

Section 18: The Student Educational Enhancement Committee shall consist of three members from private industry and two members from academic institutions and/or government agencies who will serve for three years. Members from industry should reside in different geographic regions at the time of their appointment. Relocation to another region already represented on the committee shall not prevent the relocated member from completing his/her term. A member serving his/her second year shall serve as a Chairperson. Terms of the committee members shall rotate in alternate years.

Proposed Changes to the By-Laws:

Article VII.

Add: Section 16: The Legislative Committee shall be responsible for keeping the Executive Committee informed about the activities of the WSSA liaison in Washington, D.C., and with organizing the society membership on legislative issues.

Section 17: The Herbicide Resistant Weeds Committee shall be responsible for keeping the Executive Committee informed about issues concerning herbicide resistant plants and organizing educational materials and workshops to address critical aspects of herbicide resistance.

Section 18: The Student Educational Enhancement Committee shall be responsible for soliciting applicants and matching applicants with industry hosts based on the applicant's geographic preference and goals.

1997-98 WESTERN SOCIETY OF WEED SCIENCE OFFICERS AND EXECUTIVE COMMITTEE
Seated (L to R): Rick Arnold, Education and Regulatory Section Chairman; Charlotte Eberlein, Immediate Past President; Barbra Mullin, President; Rod Lym, President-Elect; Paul Ogg, WSSA Representative. Standing (L to R): Neal Hageman, Secretary; Don Morishita, Research Section Chairman; Shaffeek Ali, Member-At-Large; Wanda Graves, Treasurer/Business Manager; John Evans, CAST Representative.

WESTERN SOCIETY OF WEED SCIENCE
FINANCIAL STATEMENT
APRIL 1, 1996 THROUGH MARCH 31, 1997

CAPITAL		
1995-1996 Brought Forward	$175,788.03	
Current Loss	-9,860.55	
	$165,927.48	

DISTRIBUTION OF CAPITAL		
Mutual Funds	$117,875.00	
Certificate of Deposit	18,811.77	
Money Market Savings	18,815.03	
Checking Account	10,425.68	
	$165,927.48	

INCOME	**1996**	**1997**
Registration & Membership Dues	$ 960.00	$21,290.00
Proceedings	1,377.08	3,272.99
Research Progress Reports	958.59	2,640.50
Noxious Weed Short Course	22,550.00	
Bio Weed Control Handbook	46,932.57	
Weeds of the West Book	99,474.47	
Bank Interest	6,532.62	
WSU Audio Visual Expense Reimbursement	158.39	
Sustaining Members		7,200.00
Herbicide Resistance Video	2,490.00	
Preconference Tour		495.00
History Book		210.00
	$216,542.21	

EXPENSES		
Office Supplies	$ 900.34	$
Postage & Shipping	2,142.53	
Telephone		383.97
Tax Accountant	180.00	
Franchise Tax Bd & Sec of State Annual Filing Fee	20.00	
Noxious Weed Short Course	16,139.28	
Weeds of the West Book	140,000.00	
Bio Weed Control Handbook	25,948.59	
WSSA Fellow & AESOP Liaison	4,000.00	2,000.00
CAST Membership Dues & Representative Expenses	700.00	245.91
Printing - Proceedings	2,521.76	
Research Progress Report	2,441.18	2,203.51
Newsletters, Envelopes, etc.	810.53	
Programs		1,509.81
Conference Guest Rooms	205.91	1,170.66
Speaker Expense	162.00	812.19
Student Room Subsidy & Award Plaques	449.04	975.00
Business Manager	5,200.00	
Site Selection & Proceedings Editor Expenses	943.00	
Executive Board Planning Meetings	525.94	468.75
Herbicide Resistance Video	760.19	
Registration & copyright of WSWS Logo	510.00	
Refund - Registration Fees		385.00
Preconference Tour		137.61
Awards Luncheon		5,079.70
Audio Visual (inc WSU & OSU)		4,999.66
50th Conference Anniversary Lapel Pins		1,470.70
	$226,402.76	

1997 FELLOW AWARD
WESTERN SOCIETY OF WEED SCIENCE

Steven A. Dewey

Dr. Steven A. Dewey is presently the Extension Weed Specialist at Utah State University in Logan, Utah. Steve received his B.S. degree from Utah State University, his M.S. in agronomy from Montana State University and his Ph.D. in crop science from Oregon State University. In 1981, after completing his Ph.D., Steve assumed the position of Extension Weed Specialist and Associate Professor of Weed Science at the University of Idaho, Twin Falls. In 1985, Steve accepted his current position as Extension Weed Specialist at Utah State University.

At Utah State University, including his state weed extension responsibilities, Dr. Dewey teaches introductory plant science courses and guest lectures in other university courses. He has advised 7 graduate students and served on 21 graduate student committees.

Steve participates actively in the WSWS. He has presented 22 papers at society meetings and contributed 37 Research Progress Reports. Steve willingly involves himself with the requests of the society having served and chaired numerous committees for the WSWS to include Student Paper Judging Committee, Publications Committee, Poster Session Committee, Resolutions Committee, and Necrology Committee. Steve served the WSWS as Local Arrangements Chair for the 1993 meeting and represented the membership on the Executive Committee as Secretary from 1990 to 1991 and Member-at-Large from 1993 to 1994.

Steve's contributions are not just confined to the WSWS. Steve has contributed seven professional presentations at the WSSA and served the WSSA on five key committees. Steve is an active member with the Utah Weed Control Association and was active with the Idaho Weed Control Association. Dr. Dewey has authored 14 refereed journal manuscripts, 30 plus extension handbooks-extension bulletins, and numerous articles for associated trade journals and popular press.

Steve was very influential in raising the awareness of noxious, invasive weeds on public lands to a national level. Steve conceived, developed, and promoted the concept of combating noxious weeds in the same manner as fighting wildfires. Dr. Dewey was requested by the Department of Interior to testify at the US Senate and House committee meetings in Washington, DC about the noxious weed problems on public lands.

One of the supporting letters for Steve says a lot about him. "With his knowledge, abilities and background, he could have left the university on many occasions for more money, but he sincerely wants to make Utah, and the intermountain area, an even greater place to live by improving agriculture and its aesthetic beauty."

1997 FELLOW AWARD
WESTERN SOCIETY OF WEED SCIENCE

Michael (Mike) Newton

Dr. Michael Newton is currently Professor of Forest Ecology in the College of Forestry at Oregon State University, Corvallis, Oregon. Mike received a B.S. in Animal and Dairy Husbandry in 1954 at the University of Vermont. After 2 years of military service in the US Army, Mike completed a B.S. and M.S. in Forest Management, College of Forestry at Oregon State University and his Ph.D. in Plant Ecology in the Department of Botany also at Oregon State University.

Dr. Newton has developed a research and teaching career at Oregon State University with sabbaticals to the University of Tennessee and the University of Maine during his tenure at Oregon State University. Mike, during his 35 year career, has been involved in forest herbicide and weed research in every aspect. Mike has sponsored over

50 graduate students. Mike has been a positive influence on forest weed research not only in the Pacific Northwest but nationally in Maine, Vermont, Alaska, Virginia and internationally in Vietnam and New Zealand. Mike was on the research team that studied the effects of phenoxy herbicides in Vietnam.

Mike has had a long, positive and active relationship with the WSWS attending and participating at annual meetings and serving as Research Section Chairs. Mike's earliest publication is found in the 1962 ResearchProgress Reports from the then Western Weed Conference. He has presently contributed over 60 papers and research reports to the WSWS as well as numerous articles in refereed journals. Mike is a Fellow in the Weed Science Society of America.

Reflective of Mike are comments from his support letters to include: "It would be difficult to find an individual that has provided as much service to weed and herbicide research." "He is the consummate professional who is committed to his work." "Mike has had a career that has touched and influenced many people."

1997 HONORARY MEMBER AWARD
WESTERN SOCIETY OF WEED SCIENCE

F. Dan Hess

Dr. Dan Hess, located at the Palo Alto, California research facility, has been Vice President of Research for Sandoz Agro. Dan is presently assisting in the transition of Sandoz Agro research into Novartis Crop Protection, a merger of Sandoz Agro and Ciba Crop Protection. Dan received a B.S. in Horticulture in 1969 from Michigan State University and completed his M.S. in 1973 and Ph.D. in 1975 both in Plant Physiology at University of California, Davis.

In 1976, Dr. Hess held a faculty appointment at Colorado State University, and in 1977 joined the faculty at Purdue University where he conducted research on herbicide mode of action and taught advanced weed science in the Department of Botany and Plant Pathology. Dan joined the Research Division of Sandoz Agro, Inc. in 1986 where he was Director of all biology and biochemistry research for chemical and biological weed control. However, Dan's commitment to teaching continued as a lecturer at the Purdue University Herbicide Mode of Action course offered every year since its inception 15 years ago. He was named group Vice-President of Research for Sandoz North America in 1995.

During his career Dan has published more than 40 refereed papers and 15 book chapters and was awarded the Outstanding Publication in Weed Science in 1987. In his 20 years as a member of WSSA, he has served as a Reviewer and Associate Editor for Weed Science and Abstract Editor for the WSSA annual meeting. He has served on several WSSA committees, including Chair of the Research Committee, and is currently Member-at-Large on the WSSA Board of Directors. In 1985, he received the Outstanding Weed Scientist Award from WSSA. He is referenced in American Men and Women in Science, Who's Who in Science and Engineering and Who's Who in Finance and Industry.

Dan has devoted substantial professional time and energy to provide weed science education outreach to many people in the western United States. From invited papers, to guest lectures at universities, to provision of weed science training of professionals, Dan has consistently exhibited a dedication to many people in the western US. Strong evidence of this major contributions to the WSWS can be found in the large number of people from the west who have benefited from Dan's lectures at the annual Purdue University Herbicide short course.

Dan's strong commitment to people, and his high standard of conduct as a weed scientist reflect the values of the WSWS. The Western Society of Weed Science is well served by the association with F. Dan Hess.

1997 WESTERN SOCIETY OF WEED SCIENCE AWARD RECIPIENTS
(L to R): Michael Newton (Fellow), Dan Hess (Honorary Member), and Steve Dewey (Fellow)

1997 OUTSTANDING WEED SCIENTIST AWARD
PRIVATE SECTOR

Jeff M. Tichota

Jeff Tichota received his B.S. degree in Plant Science and his M.S. degree in Weed Science from South Dakota State University. He has been a member of the WSSA, North Central Weed Science Society and CAST for 20 years and has been an active member of our WSWS since 1981. Jeff has served on both the Finance and Nominations Committees of the WSWS, moderated the "What's New in Industry" sessions the past two years, and presented numerous papers at our society's annual meeting. He has also been very instrumental in endorsing and supporting the WSWS student educational enhancement program. Jeff began his career with Uniroyal Chemical and in 1977 he began an association with Velsicol Chemical and then Sandoz Agro. Since 1986, Jeff has served as Western Regional Product Development Manager for Sandoz until recently joining Monsanto Company.

Jeff continues to be instrumental in seeking, developing and understanding new and innovative solutions to production problems associated with western agriculture. As regional research manager for Sandoz, Jeff was actively involved in the development of Marksman herbicide on corn and Frontier herbicide for corn, drybeans, and sorghum. He also was instrumental in developing a dicamba/glyphosate combination for annual weed control in fallow, and in developing Banvel SGF for the small grain markets. Through his leadership, a program was developed to more accurately define proper crop growth staging for dicamba applications in wheat and sorghum. He has also been instrumental in coordinating a regional program among academic and industry personnel to improve understanding of dicamba activity on diverse kochia populations.

Jeff represents agriculture and the agricultural industry in a very positive professional manner, and takes great pride in his profession. He is described by his peers as a strong team member and leader. His willingness to serve on committees, coupled with his strong people skills have made him an effective, strong asset to the discipline of weed science. He is recognized for his focus on developing practical information and techniques for agriculture that will enable farmers to grow more food economically and in a manner that protects the environment.

1997 OUTSTANDING WEED SCIENTIST AWARD
PUBLIC SECTOR

Harry S. Agamalian

Harry Agamalian earned his B.S. in Agronomy at the University of California, Davis and his M.S. in Weed Science at the University of Arizona. He excelled as a farm advisor and weed scientist for Monterey County in the University of California Cooperative Extension Service for 34 years prior to his retirement in 1991. He was granted Emeritus status with a quarter-time appointment in 1991 and has continued to serve the South Central Region of the San Joaquin Valley.

Harry has been an active member of the WSSA, California Weed Society and WSWS for over 30 years. He has served on and chaired numerous committees in these organizations and was the California Weed Society President in 1978. He is also a member of the American Society of Agronomy and the California chapter of the Agronomy Society. Harry has presented numerous papers and chaired many committees within the WSWS and was selected as a Fellow in our organization in 1990.

Harry has been honored by his extension colleagues with the Distinguished Service Award in Teaching and with the Award of Excellence in Education by the California Weed Society. He is also a recipient of the USDA/IR-4 Meritorious Service Award.

During his career, Harry has developed new weed control technology in dry beans, winter cereals and numerous vegetable crops which populate the Salinas Valley. He has authored University of California publications and bulletins in weed management and established weed control guidelines for agronomic, vegetable, vineyard, and tree fruit crops. He has been a part of four international consulting assignment projects to develop new weed technology for vegetables and tree fruits and participated in several international weed society meetings. He is well recognized by his colleagues and peers for his years of applied research and stands alone in development of weed management practices for the intensive vegetable cropping systems of the Salinas Valley. He has served as mentor for many current university and private sector weed scientists. His many leadership roles reflect his personality by always willing to give of his time to maintain the importance of weed science through his endless hours of agricultural research and extension outreach. Commodity boards, private industry, and the University of California all have recognized his valued input for over three decades.

Excerpts from Letters:

"Harry is truly in institution. He was a pioneer and leader in the development of Weed Science as a science and discipline. His work has been recognized internationally, particularly in the area of vegetables. His work on minor crops has been vital to the development of the vegetable industry in Santa Cruz and Monterey Counties"

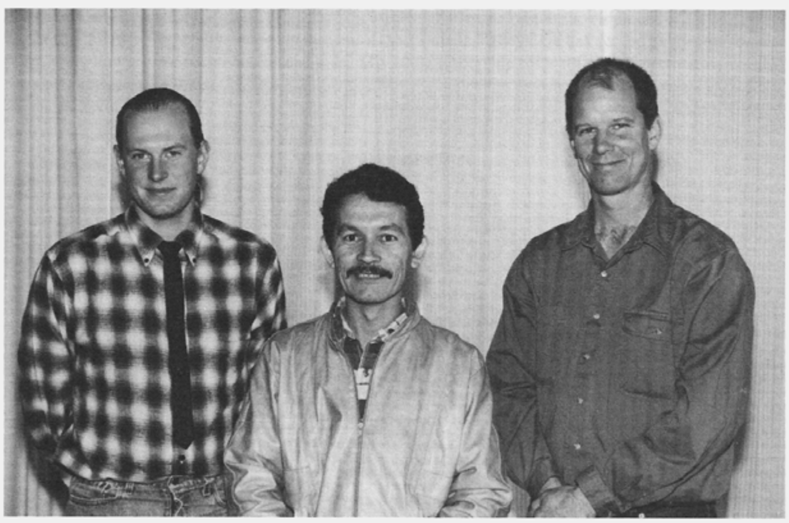
"I truly believe that there is not a grower or representative of agri-business concerned with weed control in Monterey County, CA who would not concur with me that Harry Agamalian is outstanding"

"Harry is probably the best known weed scientist in the area of vegetable production worldwide. There are few weed control practices accepted by growers in California that are not recommended by Harry. I do not know of anyone that has made a greater contribution to vegetation management in vegetable production than Harry Agamalian"

1997 WESTERN SOCIETY OF WEED SCIENCE OUTSTANDING WEED SCIENTISTS
(L to R): Harry Agamalian (Public Sector) and Jeff Tichota (Private Sector)

1997 WSWS STUDENT POSTER WINNERS
(L to R): Andrea N. Sultana (1st), Marie C. Campanella (2nd), and Martina W. Murray (3rd)

1997 WSWS STUDENT PAPER WINNERS IN APPLIED RESEARCH
(L to R): Patrick A Miller (1st) , Sandra L. Shinn (2nd), and Jeff A. Nelson (3rd)



1997 WSWS STUDENT PAPER WINNERS IN BASIC RESEARCH
(L to R): Anthony J. Kern (1st), Ramon Cinco-Castro (2nd) , and Harwood J. Cranston (3rd)

1997 REGISTRATION LIST

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Harry Agamalian
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