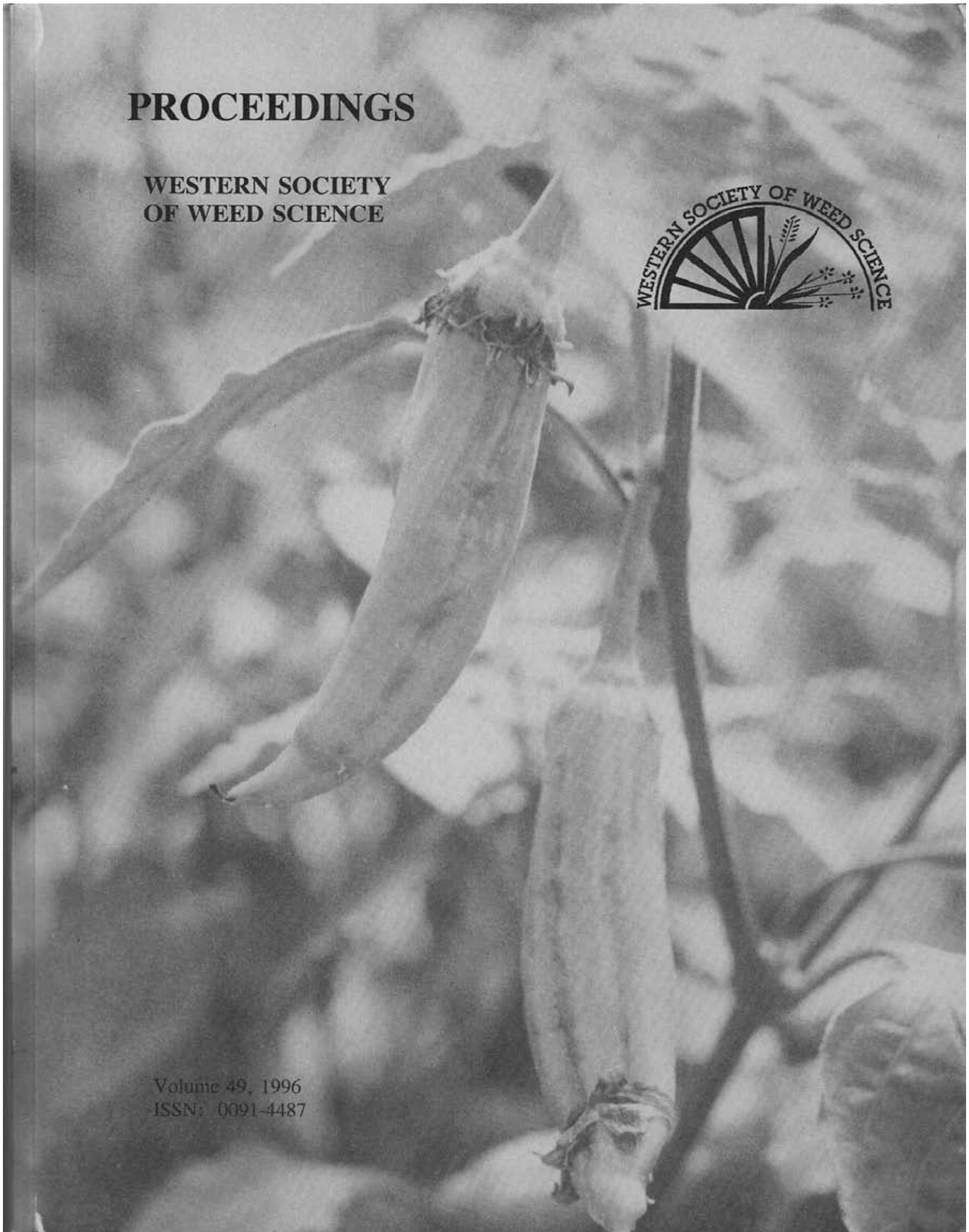
PROCEEDINGS

WESTERN SOCIETY OF WEED SCIENCE



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1996

PROCEEDINGS

OF

THE WESTERN SOCIETY OF WEED SCIENCE

VOLUME 49

PAPERS PRESENTED AT THE ANNUAL MEETING

MARCH 11 TO 14, 1996

ALBUQUERQUE HILTON

ALBUQUERQUE, NEW MEXICO

PREFACE

The Proceedings contain the written summary of the papers presented at the 1996 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: Chile pepper (*Capsicum annuum* L.). Cover photograph by Paul Bosland, New Mexico State University. All other photographs are courtesy of Jack Schlesselman.

Proceedings Editor: Rodney G. Lym

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GENERAL SESSION

PRESIDENTIAL ADDRESS

WEEDS BE WITH YOU

Gus Foster
Sandoz Agro, Inc.
Fort Collins, Colorado

Good Morning!

I am nervous--but--Charlotte did ask me to give the Presidential address. I was a little surprised but please pay attention since I will only do this one time. Here it is: WHITE HOUSE, 1600 Pennsylvania Ave, Washington DC.

I don't know much about this presidency stuff, but in bringing my presentation together, I looked for direction and thought of remarks made by John Wayne:

"Speak Slow. Speak Low. Speak in as Few Words as Possible" and
"Remember--be quick on the draw".

Shortly after last year's WSWS meeting, a very scholarly professorial gentleman had some very focused recommendations for me. Gus - Please, do not begin your address with:

"It has been an honor to serve you..."
"Can you hear me in the back of the room..."
"I am pleased to be here today......"

Additionally, I did receive an anonymous written protocol providing more mechanical instructions rather than content suggestions. While stated in an elaborate, elegant boutique of words, the message clearly stated: - "Stand Up. Speak Up. Shut Up". This was more than insightful in that I did not realize that Robert Zimdahl and John Wayne had so much in common.

The best direction came from a gentleman for whom I have a great deal of respect--Bart Brinkman--, he always seems to be working. He said "Gus - No Fluff". With these as my paradigm, this may not be too disgusting.

First, some thoughts about my year as your president recognizing two issues concerning the WSWS and then challenges for people like us who spend our careers trying to outwit weeds.

Despite criticism that I am not always serious enough, I do feel strongly about the WSWS. As I prepared for today, I revisited previous WSWS presidential addresses. In 1986, ten years ago, Harvey Tripple in his Presidential Address stated that change is part of getting better. He offered that anyone who is still doing his/her job the same today as five years ago, is not prepared for the future but functioning in the past. He encouraged us to consider new ideas and to be receptive to the kind of changes that would make our work or our organization better. He strongly suggested continued re-evaluation of how we do business. His closing remark was not to allow "that's the way we have always done it" to block change.

In Sacramento, your executive committee and officers tried to find ways that we might do some things better. We considered changing the WSWS structure because we believed that a structural change may be important to assure the strength of WSWS. Maybe it was a bad idea. Maybe not. Either way, I am concerned, not necessarily about this issue but future issues that may not get the kind of dialogue and discussions we need. I would caution that on issues of importance to the WSWS we do not have the luxury to become polarized and have the traditional "we-they" argument. It is absolutely critical that we provide dialogue on both sides of an issue-objectively and openly. Remember Harvey Tripple's charge: "that's the way we have always done it" is not an appropriate rebuttal or argument.

Second issue is that Jeff Tichota, Chair and his Nomination Committee redesigned the candidate voting ballot to a detachable pre-stamped postcard to encourage a higher participation on selection of 1996-97 officers. How much easier can it be? Review the candidates bio-sketches, detach postcard, vote, drop in mail. One hundred and forty-two people voted, there are 2½ times that many WSWS members sitting in this general session this morning. We may not give Steve Miller a megaphone but we certainly will provide him the power of the podium: **VOTE** for your 1997-1998 officers.

I want the candidates to know right now that they have my support in their efforts towards change--and my full participation in the dialogue. Please--I am asking that you give them yours.

Lets change gears from the internal WSWS and look more broadly at weed science. I choose today not to sermonize on the value that weed science brings to agriculture. I do not want to get grumpy and frustrated over food safety concerns, regulations, the Agency, or any of the other speed bumps in our profession. I refuse to whine about the fact that society doesn't appreciate the importance of what we do.

Gentle people of the WSWS, let's quit all this moaning and groaning. Instead of wishing for the rest of the world to realize how lucky they are to have us and the discipline of weed science, I want us to spend a few minutes this morning thinking about how lucky we are. Think how fortunate we are to have weeds to outwit: how our job is not a battle to be won tomorrow, but a war that has lasted since humans first put a seed in the ground and found it crowded out by unwanted plants. I will ask you collectively to think with me what that means to each of us, to the farmers we serve, and the society that we feed. Then after we have all agreed that it is our great good fortune to be in this truly honorable profession, I will urge that we all take three deep breaths and two steps backwards and reevaluate our current challenges with a smile.

First, where would I be without weeds? Certainly, not your president.

Where would you be without weeds?

For me, I know that if I hadn't had the opportunity to work with Dr. Zimdahl in weeds:--I might have become a hippie--but that would have meant having long hair--even with Rogaine that may not be possible.

I did considered farming, briefly, but I really don't like the thought of getting up early or getting dressed before noon. More importantly, I may not be adapted to some key farming skills, shovel, hoe.

All things being equal, we are very lucky. Consider the challenge of Tom Whitson trying to outwit Russian knapweed. Think how blessed we are to have pigweed, kochia, Russian thistle, leafy spurge, nutsedge and quackgrass--tough adversaries that demand our long term attention, energy and intellect.

I think sometimes we become so focused on being unappreciated for what we have given society that we forget just how fortunate we are that society needs us. Actually, society may *never* appreciate the value of weed science. It's like lecturing my thirteen year old daughter Kate on how good she has it as she innocently prepares for school about how I had to wake well before dawn on the coldest of mornings to do chores before bundling up and walking a long way to school, only to return home from school to do more chores. Kate just gives me those looks. She has no appreciation for that life, so nothing I say makes any difference. I believe our public is like that about weed science.

No matter, though. We do make a difference. We know that without the work of weed scientists, people in this country wouldn't eat nearly as well as they do, or be as healthy as they are. It is important--without the successes that we have had in weed science, a lot more people would be harnessed to agriculture--sweating to produce food and fiber for this ever-growing and always demanding population.

We are a core part of a huge academic-industrial complex: a $7 billion pesticide industry and $9 billion farm implement industry. An academic network that includes 72 land-grant colleges and universities in 50 states, a federal Agricultural Research Service that carries out research activities at 114 locations in partnership with state universities, experiment stations, and 57 cooperative extension services, among other things.

In summary, it's a huge, enormous, mind-boggling spiderweb of brains, brawn, technology, and many, many billions of dollars. The dollars aren't nearly as important as the ability of the weed scientists. Please, stop to think with me, recognize what incredible assemblage of scientists that are here this week, the possibility of these kinds of minds collectively together at one place in time in an attempt to outwit pigweed. Step back during the week and take the opportunity to realize what you are participating in.

We have many very worthy opponents in weeds, and we face constant new challenges as we work to keep our farmers successful and our people well fed.

We are blessed with resources to do our work, equipment, scientific know-how, the stored learning of other generations who worked in behalf of agriculture. But well-equipped and well-educated as we are, and successful as we have been, challenges remain. I would like for you to consider three:

- First, we must avoid smugness in the face of our scientific advances, and turn our energies instead to preventing any further strains of resistant weeds. We must continue to look at novel ways to combine old technology with new science--taking advantage of knowledge built up over ages and adding to it, to provide a more efficacious and cost-effective approach to weed control. Paul Ogg in his 1992 Presidential Address warned us not to rely on herbicides alone for our answers but to go back and look at how things used to be done. He is a wise man, and we must continue to take his advice: find innovative advantages in crop rotation, tillage, and other techniques developed over the ages, and use them as a starting and ending point for biotechnology, and our chemical crop protection products. This is not a message to return to the Good Old Days, this should not be a Field of Dreams to remember, anyway, but rather it is an urging not to lose the applied skills from the past as we move into the future.

- Second, what I believe may be a dangerous intersection, we must relearn to understand the immediacy of growers' needs, and find ways to bring new weed control technology to the market place more quickly. I know of situations where growers have struggled against weed infestations, recognizing an experimental product that could help them was in a dealer's test plot just down the road, felt their anger when they found they had to wait two or more years before the product would be commercially available.

My caution: maybe we are not as close to the weeds as we once were. It is important that we continue to appreciate that our business of managing weeds is for the user and that there is a difference between academic solutions and solving the problems of the grower. We must be part of the solution and not part of the problem.

If we want to keep our standing as a resource to the people in production agriculture, we have got to find a way to be on the lead side of their problems, not the back side. The view of the farmer must be returned to our discussions. "To find the right answers, we've got to go where the questions are."

- The third challenge is difficult to get a handle on. However, just like wild oats, it won't go away, so we must address it if we want to keep on working in weeds. There is a changing scene. The agricultural community is a diminishing part of the American population. As we develop new tools for weed control, we must continue to be concerned with public acceptance of these tools.

Dr. C. R. Curtis, Professor at Ohio State University, conducted a study of the public and pesticides. He looked at what people think about pesticides, which isn't much, and what we should do about it, which is to get out there and explain, especially to the media, what we do and why we are doing it. "While farmers think of pesticides as a crop protection and management tools, most urban people view pesticides as dangerous poisons."

It is like we are at a pedestrian crossing: wanting to walk out in the cross walk but knowing we will get hit--truly a double bind. If science is all that great, why can't we solve the problem and find a cure for weeds once and for all?--and--if it isn't, why are we messing around? The public has a history of watching scientists invent airplanes and telephones, cars and computers, hair transplants and hearing aids. They grew up with the slogan "better things for better living through chemistry". Scientists put a man on the moon. The consumer public has trouble believing that we can't just give farmers a tool that will simply, safely, cleanly and permanently control weeds in their crops. They want a silver bullet. We believe we have learned to manage most weeds effectively; the public sees our results as ineffective: they wanted a cure here, too.

They don't understand that over the time that humans has been on the earth, weeds have remained a challenge and an adversary to farmers, and a limitation on how many people the crops would feed. They don't truly understand the scope of the problem or the successes we have had. They certainly don't understand that as long as crops are grown on the earth, there will be a need for weed scientists. Gentle people, this is not Pete Fay's Sidney, Montana but an urban explosion. "We have a whole generation of Americans who take their food supply for granted and who are woefully ignorant of the basics of production agriculture." People will interpret what they hear in terms of what they know. Lecturing about food safety and clean drinking water based on our knowledge and expertise will not convince the public. We need to personalize the message in terms of benefits to the public. So my weed science friends, we must find ways to go out there and tell them. Osmosis will not work.

Even with our best efforts, the challenges of weed management haven't gone away. Every time we devise a perfect solution to our problem, we look around only to find another one meaner and tougher than the first. I believe, the challenge of outwitting weeds is what we are all about.

We can be proud of the work we have done at our universities, in our companies, and in the government. We know that we made agriculture safer, easier, and more abundant. But our growers and producers know that weed science has not yet worked itself out of a discipline. There are still plenty of weeds out there for us to outwit.

Please, let's take a minute and reflect on our good fortune to be in weed science. We certainly should acknowledge our successes, but, remember we have miles to go before we sleep, we need to keep going-keep going-keep going. And as Ricksaw (Arnold) says in the true Nike spirit "let's just do it".

Before I step away from the podium, I would like to recognize Barbra Mullin, Montana Department of Agriculture for her persistence with a special project. I am pleased to announce the release of a new WSWS sponsored reference: Biological Control of Weeds in the West. Very much like Tom Whitson nurtured the Weeds of the West, Barbra has accepted the challenge of overseeing the success of this reference. Our sincere appreciation to Barbra for her vision and dedication.

I must recognize Charlotte Eberlein-Chair, Program Committee for doing more than dotting the i's and crossing the t's. This meeting, as we move through it, will provide an opportunity to understand what a terrific job Charlotte has done. Not to be missing in the success of the 1996 meeting are Jill Schroeder-Chair, Research Section and Kai Umeda-Chair, Education and Regulatory Section. Jill and Kai were excellent in assisting Charlotte in framing the program and providing the excellent support necessary for Charlotte to keep her arms around all the planning. Please, "atta's" for the 1996 Program Committee. We do have one other person to recognize for stepping forward and making things happen. Keith-Local Arrangements Chair-Duncan has absolutely over achieved in pulling the facility and all the activities together. Keith was asked last February to help us--all I can say is what a job he has done!

Old Business: A story has been left untold, and I truly believe that is unfair to the membership. After the proceedings from last year's meeting were released, an incomplete sketch was introduced showing what appeared to be a scrawny sheep being pushed to the ground by then an unidentified cowboy. I did receive a challenge from an animals rights group concerning the rights of animals. They contended that we showed a higher respect for weeds than for animals. I must clarify this. Clearly, the Samaritan cowboy was attempting to lead this poor starving ram to a pasture for grazing. Unknown to the cowboy, the pasture was leafy spurge. The Ram upon introduction to the leafy spurge not only showed a appetite for the management of spurge but developed into a well toned muscular specimen. The cowboy recognizing what he had discovered, was much too eager to remove the RAM from the spurge patch and found himself sailing through the air without hat, boots, and pants courtesy of a very strong RAM kick--falling back to earth in a patch of uneaten spurge. I can now leave you with the rest of the story: Our good humanitarian Cowboy is none other than our own North Dakota State Weed Scientist--Rodney *Save-a-Ram* Lym. What a perfect ending to a wonderful story.

New Business: There have been some candid comments that highlighting the Colorado-Wyoming border war controversy from the podium last year was frivolous. I agree and apologize to the membership for the frivolity. I do want to nip this activity in the bud at this time well before it becomes perennial. I know that I would have Harold Alley's blessing, NO MORE WYOMING. All reference to Colorado-Wyoming will cost $100 payable to WSWS through Wanda.

Just remember, a fresh weed is better than a wilted rose. [Ed. note: And any old cowpie smells better than a Ram].

Weeds be with you.

Thank you Western Society of Weed Science.

NOXIOUS AND INVASIVE WEEDS: SHOULD WE HAVE A NATIONAL POLICY FOR A NATIONAL PROBLEM? Mike Dombeck, Acting Director, Bureau of Land Management, Washington, D.C.

Good morning. I'm Mike Dombeck, Acting Director of the Bureau of Land Management, and obviously not B.J. Thornberry, the Department of Interior point person on weeds, who was originally supposed to speak to you today. For those of you who may not have heard, B.J. has accepted the position of Executive Director of the Democratic National Committee. This is a great opportunity for B.J. She has the talent to do a great job at the DNC, and this is clearly their gain.

B.J. put a lot of energy and devotion into the weeds effort. I want to tell you that we do not plan to miss a step behind B.J's departure. You may hear weeds mentioned in the President's or Vice-President's speeches. Mark Schaefer, the Deputy Assistant Secretary for Water and Science and I will be delivering the weeds initiative for the Department. We will be partners in this effort, Mark delivering the science aspect and I leading the land management side. Together, we will be pushing this issue very hard.

Mark has an impressive list of qualifications:

Assistant Director for Environment in the Office of Science and Technology Policy, in the Executive Office of the President [1993-1995]
Three years as Senior Staff Associate and Director of the Washington Office of the Carnegie Commission on Science, Technology and Government
Guest Scholar at the Brookings Institute
Staff at the Congressional Office of Technology and Assessment

He taught an environmental policy seminar at Stanford University's Stanford in Washington program
Worked in EPA's Research and Development Office
He is a biologist by training, received a BA from the University of Washington and a PHD from Stanford.
And, being from the west, spending a lot of time in California and Washington, and an avid hiker, I'm sure that Mark has first hand experience on how [Star Thistle], [Russian Thistle] can ruin a good outing on the public lands.

You as weed scientists, know better than most Americans, just how devastating invasive plants can be to the health of the land. But, what the American public may not know is how harmful noxious weeds are on our country's public lands and those who pursue recreation on or earn their living from the land-- public or private. Here's just a sampling of the reasons why we take this problem so seriously:

In 1985, we estimated that 2.5 million A of Bureau of Land Management lands were infested. Just ten years later, that figure has risen to about 9 million acres infested, almost quadruple the amount in 1985. By the year 2000, without dramatic action, we expect that figure to double, to about 19 million A nationally. And that is only on the public lands managed by BLM. As you know, weeds respect no administrative boundaries.

We estimate that on average, about 2300 new BLM acres are being infested every day. That figure jumps to an average of about 4600 A of new infestations per day when lands managed by other Federal agencies are included. That's about 1.7 million A, an area larger than the state of Delaware, of new infestations each year just on Federal lands. Unfortunately, infestations are also underway on huge tracts of state and private lands throughout the country.

While the numbers are alarming, the real alarm is what these weeds do to our lands and to the people who use these lands. This is the message we must continue to send the American public.

•Weeds reduce and destroy wildlife habitat, including important winter ranges and birthing areas.

•Weeds reduce forage for livestock and cost that industry millions of dollars, and in some instances, render public lands and family ranches virtually useless for grazing.

•Weeds reduce recreational opportunities, including hunting, boating, camping, hiking and family outings.

•Weeds increase soil erosion and degrade streams and watering ponds.

•Weeds can poison children, pets, and livestock.

Weeds have been called a biological wildfire--and like wildfire, we must look to similar strategies to fight them--through prevention, early detection, and quick control--wherever possible. As weed scientists, you also know, better than most, that science alone can do only so much to alleviate this problem, especially given the tight budgetary climate in which we work today.

One of the keys to fighting this problem, we believe, is to raise public awareness. Right now, one of the biggest hurdles we face is to effectively and efficiently educate the public about the damage weeds cause, their own unintentional role in the spread of weeds, and what they can do to help.

The messages we need to send the hunters, the anglers, the hikers and the picnickers are simple, but fundamental to our efforts. These basic messages are:

•Weeds, even those that look like pretty flowers, harm the land and those who rely on the land;

•Everyone who works and plays on the public lands can help stop the damage caused by weeds; and

•Doing your part will help keep our lands healthy.

Sounds simple enough, doesn't it? Don't let the simplicity of these messages fool you into thinking that our task is an easy one. We often compared fighting weeds with fighting wildfire--and we all know the public is well aware of the costs of unchallenged wildfires. That's why, even in this era of declining budgets, the fire suppression budgets of land managing agencies are not declining. The wildfire comparison is a sound one--with one exception. I believe that noxious weeds are more insidious than wildfire. There are no clouds of smoke and no spectacular flames to attract National media and political scrutiny. There are no national campaigns like Smokey Bear to tell the public about the dangers of weeds. And yet, the degradation caused by noxious weeds is overwhelming compared to fire. Today, we are losing ground in some of the most valued and prized areas across the country. For example:

Saltcedar, here in the Southwest, is the scourge of more than 1.5 million A of riparian and wetland ecosystems.

Leafy spurge is now estimated to infest about 5 million A in 23 states. Economic impacts of spurge nationally are estimated to be about $110 million annually.

Knapweed is now found in eight states, with Montana having the largest infestation with about 500,000 A.

Yellow starthistle is in eight states. California alone has around 12 million A infested. So many acres are infested that California has removed starthistle from its list of noxious weeds because, by law, all plants listed must be treatable. An impossibility in California.

You know many more examples, but this illustrates the point that weeds are increasingly limiting the ability of the land to sustain healthy and natural functions. Weeds are steadily reducing the value and productivity of land in our local communities. The bottom line is that weeds are both an environmental and economic threat.

In its 1993 report on the broader issue of all non-indigenous species the Office of Technology Assessment came to the following conclusions:

There is no real policy for the management of harmful introductions;

The current system is inadequate, piecemeal, lacking rigor and comprehensiveness;

State and federal statues, regulations and programs are not keeping pace with new species introductions;

Better environmental education and greater accountability for action that causes harm could prevent some problems; and

Faster response, and adequate funding would help limit new introductions.

Some of these concerns can be met by doing a number of things:

•We need to do a better job of documenting status and trend of invasive weeds;

•We can upgrade data bases to provide a complete picture of the problem;

•We can develop a better understanding of the physiology, genetics, transportation and migration methods of weeds; and

•We need to continue to develop cost-efficient methods to control invasive plants.

Despite the rather gloomy picture I've painted so far, we do have a number of things working in our favor and a number of successes. Part of my job is to ensure that people who make decisions on budgets and resources understand that expenditures for the prevention of weeds is minor compared to the staggering costs of rehabilitation. My job is made easier by the fact that there is a high level of interest and understanding right now in the Departments of Interior and Agriculture.

John Garamendi, the Deputy Secretary at Interior, who spoke at a national weeds conference in Denver in the late fall, is a rancher. His counterpart at the Department of Agriculture, Richard Rominger is a farmer, who spoke at a national meeting in Ft. Lauderdale. These top departmental officials have a full understanding of the environmental and economic problems associated with weeds, both on cultivated and wild lands. They also have a keen interest in seeing progress made on this issue.

As a result, we are seeing unprecedented cooperation between the two Departments on the weeds issue. And, we are seeing a high-level of interest from state and local governments and academia and constituency groups in working with us to gain the upper hand in this battle. I recognize that many states and local groups are ahead of the Federal government on the issue of noxious weeds. And ultimately, efforts at the national level will fail without leadership at the local level.

Our role at the national level, and our commitment to the local level, is to support and facilitate efforts where public land managers and private landowners can join forces to implement weed control plans. Just as weeds cross administrative boundaries, so must we.

At the national level, several initiatives are underway that I hope will translate to on-the-ground successes:

A Secretarial Order has been issued that clarifies the responsibility of the Department of Interior agencies to ensure a coordinated effort to identify, prevent the spread of, and treat invasive plants wherever they occur on lands within our jurisdiction.

The Departmental Manual for the weed control program has been updated. Now the Assistant Secretary for Policy, Management and Budget is responsible for establishing and developing funding initiatives for an undesirable plant management program in coordination with the Department of the Interior agencies. The National Biological Service is responsible for development and coordination of a science based program to support management activities for control of invasive plants.

The DOI Weed Control Committee, which operates under the direction of the Assistant Secretary for Fish and Wildlife and Parks, has been involved with the development of agency action plans, guidance for Departmental policies, and coordinated with a variety of weed committees.

We are developing partnerships through cooperative demonstration weed management areas. Money has been set aside this year to fund four areas.

One of those areas, the Blackfoot Ecosystem Weed Management area, is in Montana. One of the reasons it was chosen for funding is because of the tremendous efforts already underway among Federal, state and private partners.

This area is about 1.4 million A, of which 80,000 are BLM-managed lands. It is infested with four very aggressive noxious weed species. The goal of establishing these demonstration areas is to highlight what can be accomplished through partnerships.

In particular, we hope to 1) obtain a comprehensive inventory, 2) stop the spread of the weeds, 3) reduce current infestations, and 4) rehabilitate heavily infested areas after treatment. The keys to these demonstration areas are to treat them through a cooperative and integrated approach.

We will document our successes and failures in weed management in these areas so that the knowledge gained can be used to effectively manage weeds in other areas. The other three demonstration areas are in Idaho, Oregon and Utah.

But on-the-ground success stories don't have to wait for funding or policy from Washington. For example:

In 1983, a BLM botanist in Vernal, Utah, District, found the first know infestation of dyer's woad on public land in the Diamond Mountain area. She eradicated the weeds by hand. Because of her action, dyer's woad has not been seen in that district since.

In 1986, Forest Service employees on the Ashley National Forest in Utah noticed a new patch leafy spurge about 75 feet by 100 feet. It was most likely introduced by wood cutters. Six years of spot treatment with herbicide eradicated this infestation. Currently, no other known leafy spurge infestations exist on the Ashley National Forest.

In 1992, the Owyhee County Idaho Weed Supervisor noticed and eradicated three plants of dalmation toadflax. Frequent monitoring of that site over the last couple of years show no other toadflax in that part of the county.

High school students in Montana, as part of a vocational agriculture project, became the first group in the state, and perhaps the country, to have successfully reproduced on a large scale, horned beetles imported from Europe to destroy leafy spurge.

These stories show that employees' and the public's vigilance, alertness and creativity can play vital roles in the early, efficient eradication of noxious weeds.

Today, we stand at an important brink in the fight against invasive plants. While the number of infested acres is alarming and growing, we need to remember that nearly 95 percent of federal lands is not yet overcome.

We can, by working together, prevent the spread of noxious weeds, and do our job of protecting the health of land for generations to come.

LINKING RANGELAND SCIENCE TO WESTERN RANGELAND ISSUES. Kris Havstad, USDA-ARS, Jornada Experimental Range, Box 30003, NMSU, Dept. 3JER, Las Cruces, NM 88003

It would be an understatement to say that management of our nation's rangelands has become an extremely difficult, highly divisive, emotionally charged set of processes. For three decades we have been in a transition from a single use based management to an "affected interest" involvement for multiple uses. This transition has been driven by a series of federal laws, is contentious and is far from over. The current situation is a management environment driven by court decree where the biological rationale is lost within a myriad of legal arguments and competing agendas.

Rangelands are primarily a publicly owned resource in the 11 western states and the inability of the government to dispose of these lands over a 200 year period has not meant that they were not important to a wide spectrum of the public. Actually, for a resource defined as having limitations (climatic, edaphic or physical), relatively low agricultural production (we annually harvest $20 g/m^2$ from our desert grasslands) and generally regarded as wasteland (by the poorly informed) our rangelands invoke strong passions beyond a seemingly logical reason. It can seem difficult for those of us involved in rangeland science to find a link of relevance of our research to some of the social issues debated today that encompass range management. However, at a time when our research is being increasingly scrutinized for relevance it is extremely important that we make these links.

There are four general categories of issues that encompass the management of our rangelands today. In no particular order, these categories are 1) rights, 2) equity, 3) expectations and 4) values. Many of these issues have a long history of debate and a pertinent history of federal policies that shape the current debate. This is particularly true for the issues of rights and equity. None of these general issues are strictly biological. Range management encompasses not only considerations of the biological features of the resources, but also the cultural, political, social and economical features. Thus, debates about rangeland biology are embedded in each of these four general issues.

Rights. Throughout this century the language within federal legislation regarding use of the public domain for grazing has clearly described it as a privilege. Even in the Grazing Act of 1934 it is clearly stated that "the issuance of a permit pursuant to the provisions of this act shall not create any right, title, interest or estate in or to the lands."

It is important, however, to recognize that the implementation of the provisions of the Grazing Act was intentionally oriented to the needs of the ranching community in the west. The Grazing Act was established to address the needs of the lower elevation rangelands that remained in the unappropriated public domain until their final disposal. The responsible agency (initially just a few federal employees drawn from other agencies including the Treasury Department) did not even have an organizational (organic) act even after it was reorganized as the Bureau of Land Management in 1947. The original grazing districts were established under direction of an advisory committee comprised of cattle and sheep ranchers in each region. The adjudication of land and water rights serving millions of acres of rangelands was accomplished primarily by these users. These actions by the federal government of empowering the permittee in land use decisions has contributed to a perception of permittee "rights" regarding public land grazing. Even more recently, in section 8 of the Rangeland Improvement Act of 1978, the standing of the users has been reaffirmed. Section 8 of this act states that the action of the federal government must give "careful and considered consultation, cooperation and coordination with the lessees, permittees and land owners involved . . ."

Our public land management continues to operate in a transitional state from the grazing emphasis of the 1934 Grazing Act to the environmental impact statement based bureaucracy fostered by the Federal Land Policy and Management Act of 1976 (FLPMA). However, FLPMA was the result of 15 years of development and revision within the political arena. Today, proposed legislation such as the Public Rangelands Management Act is another step in this transition. One factor that will accelerate this transition will be the reduced staffing of federal agencies such as the BLM. It is likely that state and local governments will play a much larger role in mediating the balance of rights and privileges among resource users.

Equity. Grazing fees were first established for Forest Service lands in the early 1900's. Initial challenges to the governments authority to charge fees were denied. By the 1930's it was understood that grazing fees would be charged for use of the public rangelands, but that these fees would be set to cover the cost of administration, and would recognize the value of the industry to rural communities. Fee rates have been routinely studied over the past 50 years, and government policies to raise fees have always met with resistance from the range livestock industry. Today, the federal government sells about 20 million animal unit months (AUM) of forage from the public domain at a price (in 1996) of $1.35 per AUM. The estimates of the administrative cost of this program range from $50 to $200 million per year. Obviously, the approximately $27 million in fees projected for 1996 will be far short of administrative costs, even on the conservative side ($50 million) of the estimate. However, one issue in this debate about subsidized public land ranching and the disparity of fair market values between public and private land is the fact that grazing permits and their associated low cost are a capital asset. These permits have a value to public land based ranches, and changes in the fee structure will impact the value of those capital assets. The ranching industry argues that government policies have created these values, and they can not simply be arbitrarily changed. Fair market value calculations need to consider opportunity costs associated with public land permits. When these type of considerations are included in calculation of the actual costs of grazing on public land the differences between fees on public and private land are greatly diminished.

Expectations. It is commonly assumed that overgrazing is the principal cause of retrogression on rangelands, and removal of livestock will lead to regeneration of climax conditions. Actually, we have probably underappreciated and underestimated the extent of damage to our western rangelands caused by widespread overgrazing in the late 1800's following the passage of the Original Homestead Act in 1862 and the conclusion of the Civil War. Though livestock have been in North America for nearly 500 years, and in the area of the United States for 400 years, their numbers and distribution were limited until widespread availability of transportation and water pumping technologies. In a 20 to 40 year period following the Civil War many areas were over utilized extensively in the west. In many regions, especially the more arid areas, recovery has been slow or even non existent. In spite of fairly intensive use of improvement technologies (triggered by availability of phenoxy herbicides and germplasm), many of these landscapes still show effects of early abuses. In many instances these areas were further negatively impacted by droughts during the 1920's, 1930's and 1950's. A widespread amount of the western US has been classified as desertified, a result of the lingering effects of these disturbances. Continued study of these landscapes however, has lead us to revise our theories about succession and climax. We now think that many of these lands have multiple steady-states of self-perpetuating equilibrium. Simple removal of an agent of retrogression will not regenerate prior vegetative conditions of the 1850's or earlier. The basic assumptions of Clementsian ecology (closed system, balance of habitat factors, single state equilibrium, predictable successional patterns and rare occurrence of disturbance) have been modified with an increasing understanding of the complexity and dynamics of open systems where habitat factors are not viewed as static (especially the biotic component). Expectations for western rangelands vary greatly depending upon ecological perspectives. The earlier Clementsian based expectation has been widely accepted, and many people envision waving seas of tall grass returning to western landscapes. Yet, for many areas the landscape was never (at least the last 10,000 years) a highly productive grassland. Much of the west has always been a low and sporadically productive environment with a prominent shrub component.

Values. Certainly, range management has had at its roots an anthropocentric value system. The cardinal principles of range management found in most basic textbooks are utilitarian. The developing concepts of sustainability of rangelands, including as grazing lands for domestic livestock, are based on a management scale of the pasture, ranch unit or allotment. Evaluations of proper management are centered around concepts of utilization levels of available forage that will allow replenishment of the key forage species. Yet, a biocentric based value system is now emerging. These concepts are rooted in the principle of biodiversity. Under this value system, management principles are based on maximum life processes rather than harvest rates that ensure species renewal. A biocentric value system also changes the management scale from the pasture, or ranch level, to a landscape level. The concepts of ecosystems and biospheres become more relevant to the biocentric-based set of values. From this perspective many of the utilitarian based management practices traditional to western rangelands have been judged to be ineffective, if not out-right failures. The inability of an anthropocentric value system to address effects of management beyond ranch-level scales has been one point of disagreement between these value systems. In addition, the methods of evaluating resource conditions are almost incompatible. The anthropocentric system typically assesses utilization levels of key forage species as a primary feedback mechanism for adjusting management. A biocentric system would assess a wide array of resource conditions, including biological processes in describing biodiversity of landscapes. Grazing by domestic livestock would have to be judged based on its impacts upon biodiversity at these larger scales. We do not presently have extensive information on grazing effects at this array of scales for effective judgements.

Scientific issues. Unfortunately, rangeland science will probably not contribute greatly to resolving issues of rights and equity. Though some scientists are conducting credible research on aspects of these issues, these are primarily political, cultural and economic issues with minimal biological components. However, rangeland research can be extremely relevant to questions pertaining to issues of expectations and values. Both of these issues have prominent biological factors that need to be investigated.

Expectations. Research should be identifying technologies for assessing, monitoring and remediating rangelands. These technologies need to be ecologically-based with recognition of the open-system nature of these landscapes. In particular, we need to identify reasonable ecological goals that are not simply based on prior vegetative conditions of the last century. The technologies must be affordable, which will probably dictate that they are extensive rather than intensive, narrowly focused rather than broadly applied, and evaluated for effectiveness on a decadal time scale rather than growing seasons. This will also require an interdisciplinary approach to research. Though this is a commonly stated goal, it can be rare in practice. However, relevant technologies will require a broad biological evaluation. It will also be extremely important that we make the effort to effectively articulate the complexity of these landscapes and their management. False expectations have been partly built on oversimplification of rangeland ecology.

Values. These are numerous differences between a biocentric and an anthropocentric value system. However, there are research questions that should be addressed which would contribute to a greater understanding regardless of value. Of particular importance are questions of scale, both spatial and temporal. Our research should be conducted at multi spatial scales. We have expended considerable scientific energies at small plot, patch and community scales. We should be integrating this research at landscape scales, at least. It is not unreasonable to expect that we understand grazing impacts and management influences beyond the borders of the management unit. Current ecological understanding has reinforced an appreciation for the cascading effects of disturbance at a local scale.

It is also imperative that we plan our research for long-term studies. Much of the present rethinking of rangeland management principles is a result of the long-term research established in the west by agricultural experiment station and USDA scientists in the early part of the century. We should be designing studies that can be continued by the scientists that follow us.

There is an increasing demand by the public that research is relevant to important issues. We are in a situation today where rangeland research, even at its most basic, can be extremely relevant to the public. We have a tremendous opportunity for our science to lead in the development of new technologies for rangeland management and to understand the importance of the resource to society, even on a global scale.

POSTER SESSION

IMAGE ANALYSIS OF LEAFY SPURGE COVER. Jennifer L. Birdsall[1&3], P. Chuck Quimby, Jr.[1], Anthony J. Svejcar[2], Norman E. Rees[1], and Bok Sowell[3], Botanist, Plant Physiologist, Range Scientist, Entomologist, and Assistant Professor, [1]USDA-ARS Rangeland Weeds Laboratory, Bozeman, MT 59717, [2]USDA-ARS Eastern Oregon Agricultural Research Center, Burns, OR 97720, and [3]Department of Animal and Range Natural Resources, Montana State University, Bozeman, MT 59717.

INTRODUCTION

Ocular plant canopy cover is useful to describe trends following certain treatments (2). However, ocular estimates of cover can be highly biased and influenced by the subjectivity of the observer (1). Image analysis offers technology which could be useful to determine vegetative cover with less bias. In image analysis, a video image is digitized into pixels which are assigned numeric values. The pixels can then be quantified. Comprehensive software packages for image analysis that are personal computer based have recently been developed. The objective of this study was to determine if an image analysis program could separate leafy spurge from other component species in a quadrat and measure leafy spurge cover, and to compare the image analysis method of estimating leafy spurge cover to the ocular cover method.

MATERIALS AND METHODS

Image generation. In 1993 and 1994, leafy spurge canopy cover was measured ocularly in the field at forty 0.1 m^2 sampling loci in each of eighteen plots. Plots were located near Glasgow, MT, Grassrange, MT and Mackay, ID. Color photos one meter above ground level were taken at the sampling loci using a 35 mm camera. Two observers determined ocular cover for each photo. A cover value was also determined for each photo using Jandel video analysis software.

Image processing. To obtain cover values using Jandel video analysis software, each photo was converted to a digital image composed of pixels with grey values that could range from 0 to 255. Leafy spurge cover was estimated by selecting the grey value range that corresponded to leafy spurge in the image, producing a binary image where all pixels in the selected range were white and all pixels outside the range were black, and determining the percentage of white pixels.

Data analysis. To compare the precision of the ocular and image analysis cover estimates, 10 photos were selected which ranged in cover from low to high. Four observers ocularly estimated leafy spurge cover 10 times for each photo on different days. Similarly, leafy spurge cover was estimated 10 times for each photo using image analysis. Precision was defined as the relative measure of the reliability and repeatability of the estimates. The variable used to measure reliability was the mean cover value for each photo. The variable used to compare repeatability was the variance of the repeated measures for each photo. Analysis of variance procedures were used to compare the means and variances. The reliability of the image analysis method was also tested by comparing the image analysis cover estimates to the ocular cover estimates made in the field and by the two observers from the photos using Kruskal-Wallis tests and measures of correlation for all the sampling loci together. The number of quadrats per plot required to estimate leafy spurge cover with a 10% error level at a 95% confidence level was calculated for the image analysis and ocular methods according to Molloy and Moran (4).

RESULTS AND DISCUSSION

Image analysis could separate leafy spurge from other component species in a quadrat. This is attributed to leafy spurge's significantly higher reflectance measurements which result in different digital values from those of associated vegetation and soil (3). Image analysis could estimate leafy spurge cover with the same level of precision as the ocular cover method. The means and variances of the repeated measures made on the ten photos by image analysis and ocularly by four observers were not statistically different (P>0.05). Nutter et al. (5) found image analysis estimates of percent disease severity of bentgrass more precise than ocular estimates of disease severity.

Comparison of the means for the image analysis versus ocular cover methods for all the sampling loci together revealed that the ocular estimates of leafy spurge cover made in the field and from the photos by the two observers did not differ from the image analysis estimates as evidenced by the nonparametric groupings. The mean of the ocular estimates of the second observer differed from that of the field observer (P = 0.01). However, all means were within 4%. The correlations between image analysis and ocular estimates of cover produced correlation coefficients of 0.73, 0.82, and 0.86. Other researchers have found coefficients of determination ranging from 0.82 to 0.97 when image analysis was compared to other assessment methods (5,6).

Image analysis required an average sample size of 10 quadrats to estimate leafy spurge cover with a 10% error. This was fewer (P = 0.01) than the 17 quadrats required by Observer 1 and the 15 quadrats required by the field observer, but not different from Observer 2's average of 13 quadrats. Image analysis never needed more than 19 quadrats per plot while Observers 1 and 2 and the field observer required a high of 35, 32, and 38 quadrats, respectively.

CONCLUSIONS

Image analysis can separate leafy spurge from surrounding vegetation and soil and quantify leafy spurge cover. The image analysis method of determining leafy spurge cover is as precise as the ocular method and estimated leafy spurge cover similarly to the ocular method. Image analysis required half as many samples as the ocular method to estimate leafy spurge cover with a 10% error. Image analysis is recommended as a management tool because quantification is rapid, the equipment is inexpensive, and the color prints would provide a permanent photo record.

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COMPUTER MAPPING OF WEED INFESTATIONS AND OTHER FEATURES IN DOS OR WINDOWS. Lawrence W. Lass, Hubert W. Carson, and Robert H. Callihan, Plant Science Division, University of Idaho, Moscow, ID 83844-2339.

Abstract. COUNTYCAD 3.0 and REGIONCAD 3.0 for DOS, Windows and Windows 95 are simple, but useful systems for the computer mapping of geographically-distributed data. Each enables non-cartographers to draw, edit and display data in map form without the expense of a full Geographic Information System (GIS) and highly-trained support personnel.

COUNTYCAD and REGIONCAD are data sets which are used with the EasyCAD software program. Data is added or edited as layers, much as transparencies are overlaid on an overhead projector. Positions or boundaries of weed populations and other features are easily entered with a mouse or from global positioning system data. COUNTYCAD and REGIONCAD display roads, streams, water bodies, towns, political boundaries and a latitude and longitude grid. Map features of COUNTYCAD includes both primary and secondary names.

COUNTYCAD and REGIONCAD are fully compatible with EasyCAD for Windows and EasyCAD for DOS. The EasyCAD for Windows programs utilizes the Windows Clipboard feature and has full printer support including color and FAX capabilities. The program offers many different feature styles, lines of variable width, an increased selection of text fonts, and a new button-bar menu. It also allows for easy alignment of a background grid for mapping features with a mouse. Data entered in COUNTYCAD and REGIONCAD can be exchanged with other GIS packages. Both the COUNTYCAD and REGIONCAD data set for DOS and Windows is supported by an expanded and improved manual and helpful tutorials. It runs on any IBM or compatible computer that operates Windows or DOS and has a hard disk, mouse and printer. This low-cost mapping system allows for simple record-keeping of pest locations and management planning.

PLANT-ID: COMPUTER-ASSISTED POISONOUS PLANT IDENTIFICATION SOFTWARE. Robert H. Callihan, Sherri L. Carson, Robert Dobbins, Nancy Haefer, and Art Moore, Extension Weed Specialist, Laboratory Aide, Programmer/Analyst, and Lab Aides, Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83844-2339.

Abstract. Reliable diagnosis, treatment, documentation and reporting of plant poisonings depend on correct plant identification. Printed identification guides are limited in scope, yet over 900 vascular plant species in North America alone can cause toxicity in humans and animals. Paging through illustrations is tedious, time-consuming, and imprecise when diagnosis is urgent. Plant-ID computer software, unlike dichotomous keys, uses random access to quickly identify the majority of toxic vascular plants, and refers the user to the exact page in standard reference texts. The untrained user can observe attributes seen on an unknown specimen, choose menus, and select attributes to describe the plant. After identification, a keystroke lists the exact page in all of the most significant reference books that describe the plant and its toxicology. Minimum hardware requirements: IBM compatibility, 400K RAM, and 2.5 Mb hard disk space. Based on University of Idaho computer-assisted expert systems for weed identification, which have been widely accepted in U.S. and other countries by diagnostic, regulatory and educational personnel. With the user's guide, a computer novice can learn to use the software in 30 minutes. University of Idaho extension classes are available as well.

WEED SCIENCE SOCIETY OF AMERICA ON WORLD WIDE WEB. Lawrence W. Lass and David R. Pike, University of Idaho, Moscow, ID 84844-2339 and University of Illinois, Urbana, IL 61821.

Abstract. The WSSA has an operational World Wide Web site. The site will contain sections for information on the Society, calendar/news, plant and chemical terminology, herbicide and labels, government regulations, new publications, committee work, jobs available and positions desired, just to name a few. More sections can be added if there is an interest. Members can upload and download items of interest. Each section has an administrator who will receive, review suitability, and post uploaded items. The web site address is http://www.uiuc.edu/ph/www/wssa/. The site is under construction. Many site sections need items of interest uploaded to allow the completion of the site structure. E-mail concerning the site may be sent to David Pike at WSSA@uiuc.edu or Larry Lass at LWLASS@uidaho.edu.

SITE-SPECIFIC HERBIGATION WITH AN AUTOMATED IRRIGATION CONTROL SYSTEM.

Charlotte V. Eberlein, Bradley A. King, Mary J. Guttieri, and Troy N. Price, Professor, Assistant Professor, Support Scientist, and Research Technician, University of Idaho Research and Extension Center, Aberdeen, ID 83210.

Abstract. Improvements in irrigation technology that address the spatial variability inherent within fields could reduce the potential for agrichemical contamination of surface and ground water by allowing chemical application rates to be tailored to soil type and/or weed populations. Recently, an automated irrigation control system that permits variable rate irrigation and chemigation at each nozzle on center-pivot or linear-move irrigation systems has been developed at the University of Idaho. The objective of our research was to evaluate site-specific herbigation with metolachlor and metribuzin using a prototype automated irrigation control system installed on a three-span (95 m) linear move system at Aberdeen, ID. A 2-ha field was arbitrarily divided in management zones requiring low, medium, high, or no herbicide application. Each zone was 30 m wide by 21 m long and was replicated six times in the metolachlor study and four times in the metribuzin study; each study was repeated. Target rates for metolachlor were 0, 1.8, 2.7, and 3.6 kg ha^{-1}, and target rates for metribuzin were 0, 0.28, 0.43 and 0.56 kg ha^{-1}. Ten catch cans were placed near the center of each management zone; the volume collected in each catch can was recorded and the herbicide concentration in four cans per zone per rep was quantified by HPLC. The prototype system accurately applied the desired rate of the EC formulation of metolachlor and the DF formulation of metribuzin to each management zone. Metolachlor rates applied were 0, 1.8 ± 0.12 kg ha^{-1}, 2.8 ± 0.19 kg ha^{-1}, and 3.7 ± 0.18 kg ha^{-1}, and metribuzin rates applied were 0, 0.28 ± 0.04 kg ha^{-1}, 0.45 ± 0.06 kg ha^{-1}, and 0.55 ± 0.09 kg ha^{-1}. Thus, accurate control of herbicide application rates both in the direction of movement of the irrigation system and along the length of the lateral is possible, which will permit site-specific herbigation.

NATIONAL BIOLOGIC AND ECONOMIC ASSESSMENT OF HERBICIDES USED IN ASPARAGUS.

Steven R. Eskelsen, A. Alan Schreiber, Scott E. Crawford, and Raymond J. Folwell, Research Associate and Assistant Professor, Food and Environmental Quality Lab, Washington State University-TriCities, Richland, WA 99352; Former Graduate Research Assistant and Professor, Department of Agriculture Economics, Washington State University, Pullman, WA 99164-6210.

Abstract. Growers of minor use crops, such as asparagus, have access to a decreasing number of pesticides, and few pesticides are being registered on minor use crops due to the cost of meeting registration requirements. The regulation of pesticides under the Federal Insecticide, Fungicide, Rodenticide Act is carried out using benefit/risk assessments where the economic benefits of pesticide use are balanced against the risks incurred by use. Regulatory decisions concerning pesticides are best made when judgements are based on complete data sets for both the benefits and the risks. This economic and biologic benefits assessment of chemical and nonchemical control of asparagus pests will provide the necessary information to address any future state or federal action on pesticides registered for use on asparagus. Also, since resources to test and register pesticides are limited, data from this assessment can be used to set priorities on pests and pest control methods.

Approximately 25% of the asparagus growers in California, Washington, and Michigan were sent surveys requesting information on pesticide use. General information requested was:

1. The number of acres of bearing asparagus
2. The number of acres of non-bearing asparagus
3. Yield
4. The percentage of harvested asparagus that was processed

Pesticide use information requested included:

1. Pesticide
2. Formulation
3. Target
4. Rates
5. Application timing
6. Application method

Survey results were used to estimate the total number acres treated with each pesticide and total number of base acres (some acres received multiple applications of a particular pesticide). Next, a biological assessment was conducted using efficacy trials and expert opinion (industry and university cooperators in all three states). For each of the pesticides used (as estimated by the grower survey), a scenario was set up by asking the following questions: if pesticide X were lost because of a regulatory decision, what pest control method(s) take its place, by what percentage would yield decrease, would asparagus quality decrease, would the risk of resistance increase, would the risk to humans and the environment increase, and are there any other impacts? With the information from the biological assessment, the economic assessment was performed which included the cost associated with the alternative pest practice, the cost associated with the yield decrease, and total impact.

Nationally, linuron (Table) was applied to 21,207 A (19,428 base A) immediately before and during harvest to control annual weeds. If linuron was not available, 2,4-D, diuron, metribuzin, and handweeding (nonbearing). Asparagus yield could decrease by 0 to 10% because 2,4-D (an alternative) does not control grasses. The overall cost (cost of replacement chemicals plus yield loss) in changing from linuron to 2,4-D, diuron, metribuzin, and handweeding would be $6.1 million, potentially devastating the industry. The supply of crowns for new plantings would be severely reduced. The loss of linuron would increase the risk of resistance and weed shifts.

In California (Table), linuron was applied to 7,741 bearing A (6.161 base A) and 5016 nonbearing A for controlling annual weeds. If linuron were not available, 2,4-D, diuron, and metribuzin would be applied. Asparagus yield in bearing fields would decrease by 15%. The overall cost (replacement chemicals plus yield loss) of replacing linuron with 2,4-D, diuron, metribuzin, and handweeding would be $4.5 million.

In Michigan (Table), linuron was applied to 3,518 bearing A (3,276 base A) and 1,900 nonbearing A. If linuron were not available, 2,4-D, metribuzin, diuron, fluazifop-P (nonbearing), and handweeding would be used. Asparagus yield would decrease by 1 to 3% because grasses (postemergence control of grasses during cutting season) will become a problem and decease yields in the future. The overall cost (replacement chemicals plus yield loss) of replacing linuron with 2,4-D, metribuzin, diuron, and handweeding would be $890,337.

In Washington (Table), linuron was applied to 1,440 bearing A (1,440 base) and 1,823 nonbearing A for controlling annual weeds. If linuron were lost, 2,4-D, diuron, metribuzin, fluazifop, and handweeding would be used. Asparagus yield will not change in bearing acres. The overall cost of replacing linuron with 2,4-D, diuron, metribuzin, fluazifop and handweeding would be $715,764.

A similar scenario was completed for the rest of the herbicides used in asparagus (Table).

Table. Costs of replacing herbicides currently used in asparagus with the next best alternatives.

Herbicide	Target pest	Treated acres	Base acres	Alternative control methods	Market share	Δ[a] Control costs[b]	Δ[a] Yield	Δ[a] Yield[b]	Total Δ[a] cost[b]
		X 1000 A	X 1000 A		%	X $1000	%	X $1000	X $1000
2,4-D	annual bl[c] perennial bl[c]	12.7	11.8	dicamba glyphosate linuron	33 2 65	275	0-12	41.9	316.9
Dicamba	annual bl[c] perennial bl[c]	3.6	2.6	2,4-D	100	-5.1	0-12	812.5	807.6
Diuron	annuals	49.8	43.5	linuron metribuzin napropamide norflurazon	50 18 12 20	2154.1	0-15	4133	6287.4
Glyphosate	annuals and perennials	37.9	36.9	paraquat 2,4-D + dicamba	92 8	104.2	0-20	6563	6666.8
Linuron	annuals	21.2	19.4	2,4-D diuron metribuzin sethoxydim handweeding	30 7 7 28 28	3476.6	0-15	2668	6144.5
Metribuzin	annuals	32.2	28.7	diuron norflurazon	45 55	397.8	0	0	397.8
Napropamide	annuals	1.5	1.5	trifluralin norflurazon	25 75	76.1	0	0	76.1
Norflurazon	annuals	2.8	2.7	diuron glyphosate	50 50	6.3	0-10	387.5	393.8
Paraquat	annuals	11.7	10	glyphosate	100	78.3	0	0	78.3
Trifluralin	annuals	26.8	26.2	napropamide norflurazon 2,4-D dicamba	84 4 6 6	1281	0	0	1,281.0

[a]The symbol Δ is the mathematical symbol indicating the value of a change after an action has been taken.
[b]A postive number indicates the increased cost to the industry. A negative number would be a savings to the industry.
[c]bl=broadleaf.

AN OVERVIEW OF THE CHEMISTRY AND FIELD PERFORMANCE OF CARFENTRAZONE-ETHYL (F8426), A NEW POSTEMERGENCE HERBICIDE FOR CONTROL OF BROADLEAVED WEEDS IN CEREALS. W. Dennis Scott, Research Biologist, FMC Corporation, College Place, WA 99324.

Abstract. F8426 is a new broadleaf herbicide for use in cereals being developed by FMC Corporation with the ISO proposed common name of carfentrazone-ethyl. The anticipated release date for F8426 entering the market is 1998. Applied postemergence, F8426 results in rapid desiccation of sensitive weed species with activity

observed within 24 hours. This product is an inhibitor of protoporphyrinogen oxygense, with limited translocation from treated tissues. F8426 is rapidly absorbed by the foliage of treated plants, with rainfastness achieved in 1 hour of application. Based on laboratory studies, carfentrazone-ethyl has a field half-life of less than 1 day and has demonstrated no measurable soil activity at the use rates tested for postemergence broadleaved weed control. Carfentrazone-ethyl has been found to control a broad spectrum of broadleaf weeds at application rates between 9 and 35 g/ha. Carfentrazone-ethyl is particularly effective on velvetleaf, nightshade(s), bedstraw, lambsquarters, morningglories, Russian thistle, kochia, pigweeds and on a wide range of winter annuals and mustards. Field testing has included applications of carfentrazone-ethyl alone and in combination with most commercially available grass and broadleaf herbicides with no antagonism evident. Adjuvants increase the coverage of carfentrazone-ethyl, thereby increasing activity. The use of 28% UAN gives the same level of control compared to NIS, with less crop injury. Silicone and crop-oil seed adjuvants resulted in unacceptable levels of crop injury, but regardless of the level of injury observed the wheat outgrew the necrosis and yields were not affected. Carfentrazone-ethyl is expected to offer a useful, non-cross resistant, alternative to current chemical weed control practices.

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 1995 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 at applied at 0.12 and 0.094 lb/A caused significantly more injury (stunting only) than any other treatment. Black nightshade, redroot and prostrate pigweed control were excellent (>98%) with all treatments except the check. The check plot yielded significantly more T/A than any other treatment. All treatments had a significantly higher protein content than the check.

IMAZETHAPYR FOR WEED CONTROL IN ALFALFA ESTABLISHMENT. Richard K. Zollinger and Dwain W. Meyer, Assistant and Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105.

Abstract. Weed control is most critical during establishment of alfalfa without a companion crop. Bromoxynil has been used for broadleaf weed control in alfalfa but leaf burn may occur if applied during hot temperatures. Therefore, additional herbicides with greater crop safety and spectrum of weeds controlled would be useful. Imazethapyr, labeled in 1995 at 0.75 to 1.5 oz/A, can control many common annual grass and broadleaf weeds. However, adequate weed control has been obtained at 0.5 oz/A. Therefore, adequate annual weed control in alfalfa may be possible with reduced imazethapyr rates when applied with superior adjuvants.

An experiment was conducted to evaluate weed control and effect of imazethapyr on alfalfa establishment. 'Vernal' alfalfa was seeded at 10 lb/A on April 29, 1992 and at 12 lb/A on April 23, 1993. Early postemergence herbicides were applied on May 27, 1992 and May 20, 1993 to 0.5- to 2-inch alfalfa , 1.5-inch green foxtail, 4-inch diameter waterpod, 1- to 8-inch field pennycress, 1- to 8-inch sheperd's-purse, 1.5- to 2-inch redroot pigweed, 1-inch prostrate pigweed, 0.5- to 1.5-inch common lambsquarters, 1- to 2-inch common purslane,

1- to 2.5-inch kochia, 0.5- to 1-inch diameter prickly lettuce, pre-bolt curly dock, 0.5- to 1.5-inch common mallow, 2- to 6-inch Canada thistle, 4-inch diameter perennial sowthistle, 2- to 7-inch common milkweed with 66 to 69 F, 58 to 60% relative humidity, partly cloudy sky and 3 to 8 mph wind. Postemergence herbicides were applied on June 1, 1992 to 1- to 4-inch alfalfa , 2- to 4-inch green foxtail, 4- to 8-inch diameter waterpod, 6- to 14-inch field pennycress, 6- to 14-inch sheperd's-purse, 2- to 4-inch redroot pigweed, 1- to 3-inch prostrate pigweed, 2- to 4-inch common lambsquarters, 1- to 3-inch common purslane, 2- to 8-inch kochia, 0.5- to 1.5-inch diameter prickly lettuce, 14- to 20-inch curly dock, 1- to 2.5-inch common mallow, 1-inch sunflower, 0.5- to 1-inch common ragweed, 4- to 8-inch Canada thistle, 6- to 14-inch diameter perennial sowthistle, 5- to 12-inch common milkweed on June 1, with 74 F, 61% relative humidity, partly cloudy sky and 2 mph wind. Treatments were applied to an 16 foot wide area the size of 20 by 30 foot plots with a bicycle-wheel-type plot sprayer delivering 8.5 gpa at 40 psi through 8001 flat fan nozzles. The experiment had four replicates per treatment.

Table 1. Weed control from imazethapyr in alfalfa.

Treatment[a]	Rate	July 20 Prpw	Colq	Copu	Prle	Cath
	oz/A	% control				
Early postemergence						
Imazethapyr + Sun-It II + UAN 28%	0.5+2%+2%	98	93	93	97	31
Imazethapyr + Sun-It II + UAN 28%	0.75+2%+2%	97	96	96	99	40
Imazethapyr + Sun-It II + UAN 28%	1+2%+2% 99	99	99	99	98	49
Imep + brox + Sun-It II + UAN 28%	0.5+3+2%+2%	99	99	99	99	57
Imep + seth + Sun-It II + UAN 28%	0.5+3+2%+2%	99	99	99	97	25
Untreated		0	0	0	0	0
LSD (0.05)		3	2	3	3	2
Postemergence						
Imazethapyr + Sun-It II + UAN 28%	0.5+2%+2%	93	90	90	95	23
Imazethapyr + Sun-It II + UAN 28%	0.75+2%+2%	94	94	95	99	33
Imazethapyr + Sun-It II + UAN 28%	1+2%+2% 99	99	99	99	98	40
Imep + brox + Sun-It II + UAN 28%	0.5+3+2%+2%	99	99	99	99	50
Imep + seth + Sun-It II + UAN 28%	0.5+3+2%+2%	99	99	99	97	33
Untreated		0	0	0	0	0
LSD (0.05)		4	3	3	5	3

[a]Sun-It II = methylated seed oil adjuvant, Seth = sethoxydim, Brox = bromoxynil.

Table 2. Forage yield of 'Vernal' alfalfa and weeds treated with imazethapyr, Fargo, 1992 and 1993.

Treatment[a]	Rate	Forage yield - 1992 24 July	4 Sept	Total	Forage yield - 1993 27 July	27 Aug	Total	Weeds July 92
	oz/A	tons DM/A						%
Imazethapyr	0.5	1.51	1.41	2.92	1.57	0.98	2.55	3
Imazethapyr	0.75	1.50	1.46	2.96	1.62	0.93	2.55	0
Imazethapyr	1	1.38	1.42	2.80	1.58	0.95	2.53	1
Imep+brox	0.5+3	1.27	1.33	2.60	1.64	1.02	2.66	3
Imep+seth	0.5+1.28	1.50	1.53	3.03	1.64	1.06	2.70	3
Untreated	1.78	1.28	3.06	2.21	0.83	3.04		28
LSD (0.05)		0.25	0.16	0.31	0.15	0.09	0.17	7

[a]All herbicide treatments contained Sun-It II and 28% UAN applied at 1.5 pt/A and 1 qt/A, respectively. Sun-It II = methylated seed oil, Seth = sethoxydim, Brox = bromoxynil.

In 1992 and 1993, both early postemergence and postemergence treatments gave greater than 97% control of green foxtail, yellow foxtail, waterpod, field pennycress, shepherd's-purse, redroot pigweed, kochia, curly dock, common mallow, common sunflower, common ragweed, and wild mustard (Table 1). All treatments gave greater than 90% control of prostrate pigweed, common lambsquarters, common purslane, and prickly lettuce at both application stages, but slightly greater control at the early date (Tables 1 and 2). All treatments gave poor control of Canada thistle, perennial sowthistle and had no activity on common milkweed. No crop injury was observed in 1992. In 1993, no crop injury was observed at evaluation, but some short-term stunting had occurred which reduced biomass yield of all herbicide treated plots compared with the untreated plot.

Imazethapyr applied alone had little effect on establishing alfalfa (Table 2). No alfalfa injury was observed at evaluation either year. No alfalfa density reduction was observed at harvest either year. Imazethapyr plus Bromoxynil had lower harvest measurements in 1992 but not in 1993, probably due to the cooler weather in 1993. Plots that received treatments of imazethapyr plus sethoxydim usually had greater forage yield. More biomass was harvested in the untreated plots than treated plots at the first harvest but treated plots had greater biomass than untreated plots at the second harvest. This was due to heavy weed infestations in the untreated area and the limited weed regrowth after the first cutting. Biomass in the untreated plots was composed of 28% weeds in 1992 and nearly 10% in 1993. Alfalfa stand was similar with all treatments. Plant density ranged from 333 to 376 plants/m^2 in 1992 and 420 to 463/m^2 in 1993.

In summary, imazethapyr at 0.5 oz/A with Sun-It II and 28% UAN at 2% v/v gave excellent annual grass and broadleaf weed control. Imazethapyr gave poor or no perennial weed control. Annual weed control generally was slightly better at the unifolioliate to first-trifolioliate growth stage; therefore, imazethapyr can be applied to alfalfa emerging at different growth dates. Tankmixes of imazethapyr with sethoxydim or Bromoxynil slightly increased weed control, but is probably not worth the additional cost. Stunting of alfalfa occurred in 1993, which reduced seeding-year forage yields slightly. No phytotoxic effects were observed on stunted plants.

BROADLEAF WEED CONTROL IN PINTO BEANS WITH PREEMERGENCE, PREEMERGENCE/POSTEMERGENCE AND POSTEMERGENCE HERBICIDES. 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 1995 at Farmington, NM to evaluate the response of pinto beans (var. Bill Z) and annual broadleaf weeds to preemergence, preemergence/postemergence and postemergence herbicides. Dimethenamid applied preemergence at 1 lb/A followed by imazethapyr applied postemergence at 0.047 lb/A and a preemergence/postemergence treatment of dimethenamid/imazethapyr applied at 1/0.047 caused the highest crop injury rating of 5, respectively. All treatments gave good to excellent control of broadleaf weeds except the postemergence treatment of dimethenamid applied at 1 lb/A with or without X-77 and one qt of 32% nitrogen solution and the check. Dimethenamid applied postemergence at 1 lb/A with or without X-77 and 32% nitrogen solution and the check had significantly lower yields than any other treatments. Yields were 102 to 2715 lb/A higher in the herbicide treated plots as compared to the check.

DRY EDIBLE BEAN RESPONSE TO DIMETHENAMID HERBICIDE. Casey McDaniel and Gus Foster, AgSales, Sandoz Crop Protection, and Product Development, Sandoz Agro, Fort Collins, CO 80524.

Abstract. Dimethenamid, a chloroacetamide, is pending federal registration for use in dry edible beans as a preplant to early postemergence herbicide for control of summer annual grasses and small seeded annual broadleaf weeds. This field trial was established to evaluate relative tolerance of dimethenamid to three dry edible bean classes based on seed size. Dimethenamid was applied preemergence-shallow incorporated, preemergence-surface applied, and postemergence (third trifoliate).

The field experiment was conducted in weed free dry edible beans in a randomized complete block with three replications. Factor studied included three bean classes (kidney, pinto, and navy) and one herbicide, dimethenamid, at three concentrations equivalent to 0, 0.75 X, 1.0 X, and 2.0 X application rates. Observed data included dry bean visual phytotoxicity and crop yields. Statistical analysis compared dimethenamid rates, timings, bean classes and interactions between each.

TOLERANCE OF SWEET CORN CULTIVARS TO DIMETHENAMID AND METOLACHLOR. Carol Mallory-Smith, Bill D. Brewster, and Dennis M. Gamroth, Assistant Professor, Senior Instructor, and Faculty Research Assistant, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331-3002.

Abstract. Trials were conducted at the Hyslop Research Farm at Corvallis, OR, during 1993, 1994, and 1995 to evaluate the tolerance of sweet corn cultivars to dimethenamid and metolachlor. Five cultivars were evaluated in response to preemergence-surface applications in 1993, and five preplant incorporated applications in 1994. In 1995, preplant incorporated and preemergence treatments were evaluated on 'Jubilee' and 'Supersweet Jubilee' cultivars. Experimental design was a randomized complete block with three or four replications and 10 by 23 or 10 by 35 foot plots. The herbicide treatments were applied with a single-wheel, compressed-air plot sprayer that delivered 20 gpa at 15 psi. A Roterra set at a depth of 4 inches was used to incorporate the herbicides. The soil was a Woodburn silt loam with a cation exchange capacity of 20 meq/100g. The trial area was cultivated to reduce weed competition. A total of 24 feet of row was harvested from the center two rows in each plot.

The higher rates of metolachlor and dimethenamid reduced yield in 'Supersweet Jubilee' and 'Jubilee' in 1993 (Table 1). Yields of 'GSS 3492' and 'GH 2839' were also reduced, but 'GH 2690' appeared more tolerant. Injury ratings were considerably higher on the 'Supersweet Jubilee' than on 'Jubilee' in 1993. The cold, wet spring may have exacerbated the crop injury. Injury ratings were lower in 1994, but yields from treatments containing the higher rate of dimethenamid or metolachlor were lower than the untreated check in the 'Supersweet Jubilee' and 'Jubilee' trials (Table 2), as well as in the 'Vantage' trial. 'GH 2684' and 'Crisp and Sweet 710' seemed to be less susceptible to the herbicides. The metolachlor-benoxacor treatments were less injurious on most cultivars. No crop injury or yield reductions occurred in the 995 trials (Table 3).

Table 1. Visual evaluations and yield of two sweet corn varieties following preemergence surface chloroacetamide applications in 1993, Corvallis, OR.

		Crop injury and yield[b]			
		'Supersweet Jubilee'		'Jubilee'	
Treatment[a]	Rate	Injury	Yield	Injury	Yield
	lb/A	%	T/A	%	T/A
Dimethenamid	1.25	20	9.4	5	10.3
Dimethenamid	2.5	43	7.2	25	9.3
Metolachlor	2	20	9.5	10	11.2
Metolachlor	4	47	7.8	20	10.2
Check	0	0	10.5	0	12.3
LSD (0.05)			1.9		1.8
CV (%)			11.4		8.8

[a]Applied May 19, 1993.
[b]Visual evaluations July 29, 1993; Harvested 'Supersweet Jubilee' August 30, 1993, and 'Jubilee' September 3, 1993.

Table 2. Visual evaluations and yield of two sweet corn varieties following preplant incorporated chloroacetamide applications in 1994, Corvallis, OR.

		Crop injury and yield[b]			
		'Supersweet Jubilee'		'Jubilee'	
Treatment[a]	Rate	Injury	Yield	Injury	Yield
	lb/A	%	T/A	%	T/A
Dimethenamid	1.25	13	7.3	8	10.6
Dimethenamid	2.5	21	6.2	11	10.0
Metolachlor-benoxacor	2	3	9.5	0	11.4
Metolachlor-benoxacor	4	4	8.8	4	11.9
Metolachlor	2	4	8.5	5	11.0
Metolachlor	4	8	7.7	10	10.7
Check	0	0	9.7	0	12.6
LSD (0.05)			1.0		1.4
CV (%)			8.2		8.6

[a]Applied May 2, 1994, incorporated 4 inches with roterra.
[b]Visual evaluations June 20, 1994; Harvested 'Supersweet Jubilee' August 23, 1994, and 'Jubilee' August 22, 1994.

Table 3. Visual evaluations and yield of two sweet corn varieties following preplant incorporated and preemergence surface applications of chloroacetamides in 1995, Corvallis, OR.

		Crop injury and yield[b]			
		'Supersweet Jubilee'		'Jubilee'	
Treatment[a]	Rate	Injury	Yield	Injury	Yield
	lb/A	%	T/A	%	T/A
Preplant incorporated					
Dimethenamid	1.17	0	12.1	0	11.4
Dimethenamid	2.34	0	9.8	0	10.9
Metolachlor-benoxacor	1.95	0	9.9	0	10.7
Metolachlor-benoxacor	3.9	0	10.4	0	11.0
Metolachlor	2	0	10.7	0	10.6
Metolachlor	4	0	9.8	0	10.5
Preemergence surface					
Dimethenamid	1.17	0	10.8	0	11.4
Dimethenamid	2.34	0	9.4	0	10.7
Metolachlor-benoxacor	1.95	0	9.6	0	11.0
Metolachlor-benoxacor	3.9	0	9.9	0	9.9
Metolachlor	2	0	9.6	0	11.4
Metolachlor	4	0	11.5	0	11.0
Check	0	0	10.9	0	10.9
LSD (0.05)			NS		NS
CV (%)			14.5		8.5

[a]Applied May 15, 1995; incorporated 4 inches with roterra.
[b]Visual evaluations June 15, 1995; Harvested 'Supersweet Jubilee' August 30, 1995, and 'Jubilee' August 29, 1995.

VARIETAL TOLERANCE OF GREEN PEA (*PISUM SATIVUM*) TO METRIBUZIN. Kassim Al-Khatib, Carl Libbey, and Sorkel Kadir, Extension Weed Specialist, Agricultural Research Technician, and Research Associate, Washington State University, Mount Vernon, WA 98273.

INTRODUCTION

Metribuzin herbicide is widely used in the Pacific Northwest for broadleaf weed control in green peas. Metribuzin is labeled for PRE and POST applications to control prostrate knotweed, Pennsylvania smartweed, shepherd's-purse, pineappleweed and other troublesome weeds, but application to some green pea cultivars results in foliar injury. Metribuzin also may injure green peas grown on sandy soil or when heavy rain follows application.

Differential genotypic tolerance to metribuzin has been reported for soybean, tomato, potato, barley, and winter wheat. The basis of differential tolerance has been attributed to differential rates of metribuzin metabolism before the herbicide reaches the binding site. We have observed differential pea tolerance to metribuzin in preliminary field and greenhouse studies. Metribuzin has injured 'Sundance' more than other peas. Such injury is of particular concern when green peas are grown in conditions that accentuate herbicide injury. Howard et. al.

showed that green pea plants generally recovered from metribuzin injury and that yield increased despite the injury, due to improved weed control compared with weedy crop (1). Unfortunately, weed competition was a confounding factor in this study, preventing any conclusion about pea tolerance to metribuzin.

Because of the potential differential response of green pea cultivars to metribuzin, and since temperature and excessive soil moisture can magnify metribuzin injury, this research has been conducted to evaluate pea cultivars' response to metribuzin and to study the influence of temperature and soil moisture on metribuzin injury.

MATERIALS AND METHODS

Green pea varietal response to metribuzin. Greenhouse studies were conducted to evaluate the tolerance of green pea cultivars to metribuzin. 'Bolero', 'Bonito', 'Charo', 'CMG 287', 'CMG 298', 'Leah', 'Nun 1889', 'Perfected Freezer 70A', 'Pureline 62', 'Pureline 123', 'Pureline 519', 'Puget', 'Scout', 'Sundance', and 'Tahoe' green pea were planted in 10-cm-diam. plastic pots containing a Skagit silt loam soil. Technical grade metribuzin (97%) was mixed with air-dried soil at 0.25, 0.5, 1, and 2 μg/g soil prior to filling pots. Plants were grown in the greenhouse at 23/21 C (day/night) with a 16-h photoperiod. Treatments were replicated six times and the experiment was repeated twice.

Three weeks after planting, chlorophyll fluorescence was measured on the abaxial surface of the middle trifoliolate of the first and second leaf of the two plants in each pot. Initial (F_0) and maximum (F_{max}) fluorescence were measured with a Plant Efficiency Analyzer (Hansatech, Norfolk, England). The treated leaf spot was held in the dark for 30 minutes with leaf clips. Variable fluorescence (F_v) was calculated as $F_v = F_{max} - F_0$. Plants were harvested, dried at 75°C for 48 h and weighed.

The response of green pea cultivars to metribuzin grown under weed free conditions was also evaluated in the field. The experiment was conducted in 1993, 1994, and 1995 at the Mount Vernon Research and Extension Unit in Mount Vernon, WA. The soil was a Skagit silt loam. 'Bolero', 'Sundance', 'Charo', and 'CMG 298' green pea were planted on May 21, May 20, and May 4 in 1993, 1994, and 1995, respectively. The seeding rate was 111 kg/ha. Plots contained 16 rows, spaced 18 cm apart and 3 m long. The experiment was a split-plot design with four replications. The main plots were pea cultivars, and subplots were metribuzin rates. Metribuzin was applied preemergence at 0, 0.28, 0.56, 1.12 kg/ha. Plots were maintained weed free by hand hoeing. Crop injury was visually evaluated on a percent scale 30 and 45 days after planting (DAP), where 0 = no control or crop injury and 100 = complete mortality. Green pea population and total yield were determined from 2.25 m^2 in the middle of each plot.

Effect of temperature on pea response to metribuzin. 'Sundance' and 'Charo' green peas were planted in the greenhouse and metribuzin applied as described earlier. Ten-day-old seedlings were treated in an environmental chamber at 30/25, 25/20, and 20/15 C (day/night) with 16-h photoperiod. Light intensity was 400 $\mu E/m^2/s$ photosynthetic photon flux. Fluorescence parameters and shoot dry weight were measured after 2 wk of differential temperature treatments as described earlier.

Effect of soil moisture on pea response to metribuzin. 'Sundance' and 'Charo' green peas were planted in the greenhouse and metribuzin applied to the soil as described earlier. Soil moisture was maintained at 100%, 70% and 40% of field capacity by weighing pots twice a day and adding the required water to raise the pot weight to the desired field capacity. Chlorophyll fluorescence and dry weight were measured 4 weeks after planting as described earlier.

Data analysis. The data were analyzed using analysis of variance and regression analyses as appropriate. Means were compared using LSD at P = 0.05. To evaluate the susceptibility of green pea cultivars to metribuzin, percent visible injury and pea yields were plotted against the metribuzin rate, and the rate that caused 25% injury symptoms (I_{25}) and 25% yield reduction (YR_{25}) was determined (2).

RESULTS AND DISCUSSION

Pea response to metribuzin. In the greenhouse test, pea cultivars responded differently to metribuzin. Variable chlorophyll fluorescence (F_v, a measure of photosystem II activity) of 15 pea cultivars decreased as the concentration of metribuzin increased in the soil. The highest reduction in F_v was in 'Sundance', 'Pureline 62', 'Pureline 123', and 'Bolero', whereas the least reduction was in 'Charo', 'Scout', 'CMG 298', and 'Puget' (Table 1). The decrease in F_v was mainly due to a decrease in F_{max} and a slight increase in F_0 (data not shown).

Metribuzin reduced the efficiency of the photosystem II of pea cultivars, as indicated by reduction in F_v/F_{max}. Again the greatest reduction was in 'Sundance', 'Pureline 62', 'Pureline 123', and 'Bolero', whereas the least reduction was in 'Charo', 'Scout', 'CMG 298', and 'Puget' (Table 2).

The differential decline in chlorophyll fluorescence and efficiency of photosystem II caused by metribuzin in pea was also associated with differential reduction in shoot biomass (Table 3). The highest reduction in shoot biomass was in 'Sundance' and the lowest reduction was in 'Charo'. The reduction in shoot dry weight was highly correlated with the reduction in F_v and the efficacy of photosystem II in pea seedlings.

Field study. All metribuzin rates caused injury symptoms in pea 30 days after planting. Symptoms of leaf chlorosis, leaf marginal necrosis, and stunting were severe in 'Sundance' and 'Bolero' and slight in 'Charo' and 'CMG 298'. At 45 DAP, plants recovered from metribuzin injury except at the highest rate of application. Recovery from injury symptoms was more rapid in 'Charo' and 'CMG 298' than 'Sundance' and 'Bolero' (Figure 1). At 45 days after planting, metribuzin rates that caused 25% injury were 0.44, 0.59, 1.6, and 1.74 kg/ha in 'Sundance', 'Bolero', 'Charo', and 'CMG 298', respectively (Figure 2).

Metribuzin reduced pea populations only at the highest rate. Again, this reduction was more severe in 'Sundance' and 'Bolero' than 'Charo' and 'CMG 298' (data not shown). The highest rate of metribuzin tended to reduce 'Sundance' and 'Bolero' yields more than 'Charo' and 'CMG 298'. Metribuzin rates that caused 25% yield reduction were 0.67, 0.94, 1.74, and 1.8 kg/ha in 'Sundance', 'Bolero', 'CMG 298', and 'Charo', respectively, (Figure 2). Metribuzin rates causing 25% yield reduction were higher than the rates causing 25% injury symptoms. This indicates the ability of pea plants to recover from metribuzin injury.

Effect of temperature and soil moisture on metribuzin injury in pea. Metribuzin injury increased as the growing temperature increased (Figure 3). At 20/15 C the injury caused by metribuzin at 1 μg/g soil was equivalent to the injury caused at 0.25 μg/g in peas grown at 30/25 C. Shoot dry weight of both 'Sundance' and 'Charo' reduced in similar pattern as the rate of metribuzin and temperature increased. The reduction in shoot biomass coincided with the reduction in F_v (data not shown). The increased injury at higher temperature may be attributed to higher metribuzin absorption.

Metribuzin injury increased as soil moisture increased (Figure 4). Shoot dry weight of 'Sundance' and 'Charo' was reduced more when soil moisture was at field capacity compared to 40% and 70% of field capacity. The difference in response to metribuzin between 'Sundance' and 'Charo' was more pronounced in soil wetted to field capacity, compared to 40% of field capacity. Again the reduction in shoot biomass at higher soil moisture was highly correlated with the reduction in F_v (data not shown). The lower metribuzin injury at low soil moisture may be attributed to lower metribuzin absorption by the roots.

CONCLUSIONS

1. Pea cultivars showed different tolerance to metribuzin, with 'Sundance' and 'Bolero' the most sensitive and 'Charo', 'Scout', and 'CMG 298' the least sensitive.

2. Metribuzin injury increased as temperature and soil moisture increased. Injury was higher to peas grown at 30/25 C compared to 25/20 and 20/15 C. Metribuzin injury was also higher to peas grown in soil saturated to field capacity, compared to 40% and 70% of field capacity.

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Table 1. Variable fluorescence (F_v) of fifteen green pea cultivars, grown in the greenhouse, as affected by metribuzin.

	Metribuzin concentration (μg/g soil)			
Cultivar	0.25	0.50	1	2
	% of nontreated control			
Bolero	60	49	27	24
Bonito	77	72	62	47
Charo	96	80	64	64
CMG 287	83	49	38	21
CMG 298	92	80	72	54
Leah	106	97	78	51
Nun 1889	89	71	67	33
Perfected Freezer 70A	101	87	59	24
Pureline 62	80	48	20	12
Pureline 123	81	55	36	19
Pureline 519	81	65	43	25
Puget	105	98	93	55
Scout	102	87	82	57
Sundance	67	44	15	13
Tahoe	104	69	73	44
LSD (0.05) between cultivars within the same rate	20			
LSD (0.05) between rates within the same cultivar	15			

Table 2. Efficiency of electron transport activity (F_v/F_{max}) of fifteen green pea cultivars, grown in the greenhouse, as affected by metribuzin.

	Metribuzin concentration (μg/g soil)			
Cultivar	0.25	0.50	1	2
	% of nontreated control			
Bolero	69	44	32	27
Bonito	76	66	62	53
Charo	92	76	66	59
CMG 287	84	54	36	26
CMG 298	88	78	73	53
Leah	87	83	76	57
Nun 1889	82	67	69	44
Perfected Freezer 70A	92	78	59	36
Pureline 62	88	52	28	26
Pureline 123	78	62	47	31
Pureline 519	74	57	51	35
Puget	92	84	80	54
Scout	84	75	74	56
Sundance	61	42	21	13
Tahoe	89	63	67	52
LSD (0.05) between cultivars within the same rate	14			
LSD (0.05) between rates within the same cultivar	12			

Table 3. Shoot dry weight of fifteen green pea cultivars, grown in the greenhouse, as affected by metribuzin.

Cultivar	Metribuzin concentration (μg/g soil) 0.25	0.50	1	2
	% of nontreated control			
Bolero	78	35	30	23
Bonito	73	69	51	38
Charo	93	70	58	39
CMG 287	70	43	39	36
CMG 298	85	62	58	35
Leah	77	55	37	28
Nun 1889	63	45	38	35
Perfected Freezer 70A	80	51	39	29
Pureline 62	80	30	24	21
Pureline 123	72	35	21	20
Pureline 519	59	35	24	19
Puget	70	62	36	35
Scout	82	57	41	33
Sundance	60	29	19	15
Tahoe	80	61	36	30
LSD (0.05) between cultivars within the same rate	4			
LSD (0.05) between rates within the same cultivar	5			

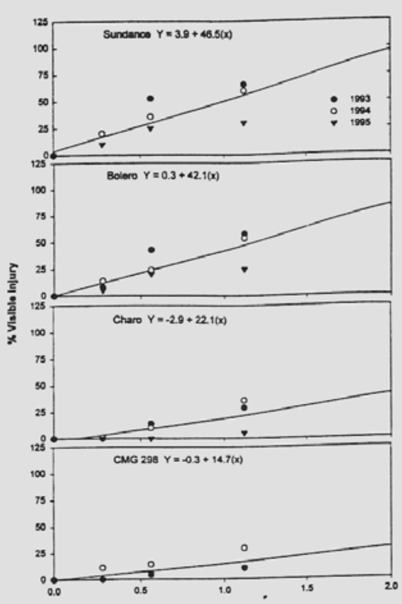

Figure 1. Visible metribuzin injury to four pea cultivars 45 days after planting.

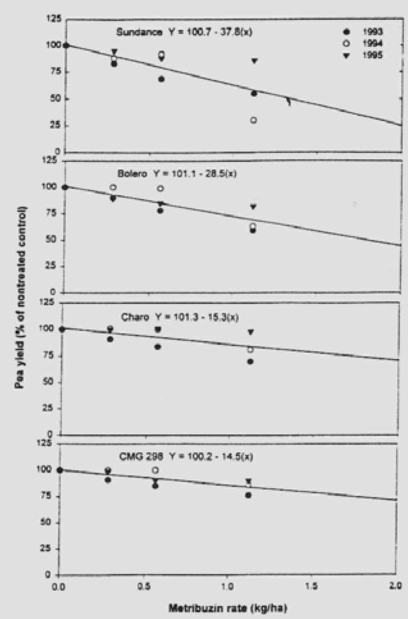

Figure 2. Yields of four pea cultivars as affected by metribuzin.

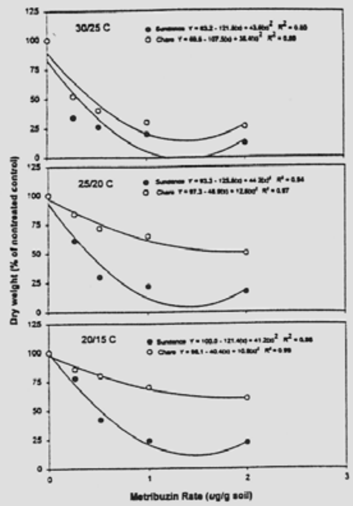

Figure 3. Total biomass of 'Sundance' and 'Charo' peas as affected by metribuzin and temperature.

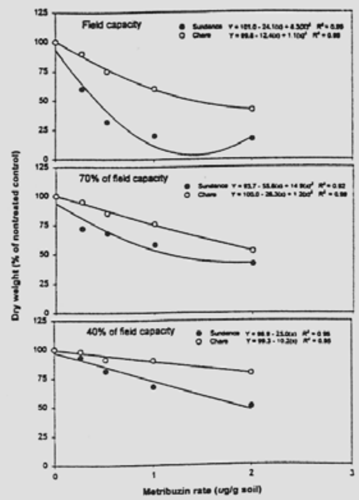

Figure 4. Total biomass of 'Sundance' and 'Charo' peas as affected by metribuzin and soil moisture.

RESPONSE OF CHILE PEPPER TO RESIDUAL NORFLURAZON AND APPLIED CLOMAZONE.
R. Cox, J. Schroeder, and G. Hoxworth, Student Apprentice, Associate Professor, and Research Assistant, Department of Entomology, Plant Pathology, and Weed Science, New Mexico State University, Las Cruces, NM 88003.

Abstract. Norflurazon is a herbicide registered in cotton, soybeans, and peanuts. Clomazone is a herbicide registered in soybeans, cotton, chile peppers, pumpkins, succulent peas, and fallow land. In summer 1995, chile showed visual signs of rotational norflurazon injury from a cotton experiment conducted two years previously. The chile was damaged the most in plots treated in 1995 with clomazone, and in 1993 with norflurazon. Norflurazon injury symptoms were less pronounced in plots not treated with clomazone in 1995. Therefore, the objective of the research was to determine if residual soil concentrations of norflurazon enhances chile response to clomazone. A greenhouse bioassay was conducted with a factorial treatment arrangement in a randomized complete block design, and five replications. The treatment factors were norflurazon at 0, 0.0158, 0.0315, 0.0625, 0.125, 0.25 ppm, and two concentrations of clomazone at 0 and 0.5 ppm. All combinations of norflurazon plus clomazone were uniformly mixed into a Belen clay loam soil (1.47% O.M., 7.6 pH). Fifteen chile seeds were planted into treated soil in 6 oz styrofoam cups, and watered twice a day as needed. Approximately 14 days after establishment, chile was visually rated for injury (0 = no damage, 100 = complete chlorosis), and plant counts were taken for each cup. Twenty-eight days after establishment, chile was again visually rated, plants were counted and harvested to determine shoot fresh weight and dry weight.

Norflurazon rates of 0.125 ppm reduced plant counts by 67%, and dry weight declined by 52% compared to the control. Results of the experiment proved to be statistically insignificant to claim an interaction between norflurazon and clomazone; however, visual ratings indicated that there may be a possible interaction between the two herbicides. The rates of norflurazon evaluated were possibly not appropriate to show interaction. Norflurazon at concentrations less than 0.0625 ppm had no effect on peppers in these experiments. However, dry weights were greatly reduced at 0.125 ppm norflurazon, which was the next concentration in the series. Future research should involve more dilutions in the range of 0.0625 ppm to 0.125 ppm norflurazon.

NIGHTSHADE AND DODDER CONTROL IN PROCESSING TOMATOES. Jack P. Orr, Weed Science Advisor, University of California Cooperative Extension Sacramento County, 4145 Branch Center Road, Sacramento, CA 95827.

INTRODUCTION

Hairy nightshade, black nightshade and dodder are widespread major weed problems in California processing tomatoes causing severe economic loss to growers. This loss amounts to greater than $80 million due to hand hoeing cost and yield reductions. The present experiments show rimsulfuron applied preemergence and postemergence, gives good to excellent control of hairy and black nightshade. Effective control of dodder was only possible with postemergence treatments. Experiments were conducted on the Amastead Ranch in Walnut Grove and the UC Davis Vegetable crops farm.

METHOD AND MATERIALS

Rimsulfuron was applied preemergence and postemergence in a randomized complete block design with four replications. Treatments were made in the field to direct seeded and transplant tomatoes with rates ranging from 0.008 to 0.062 lb/A. Applications were made with a CO_2 backpack sprayer at a rate of 30 gal/A. Preemergence treatments were made after Hally variety processing tomatoes were direct seeded into a loam soil, and to transplanted tomatoes. Sprinkler irrigation followed within 1 day of treatment. Postemergence applications plus 0.25% surfactant were made to direct seeded tomatoes after they reached the cotyledon to two-leaf stage and to transplants in the five-leaf stage. Black and hairy nightshade were in the cotyledon to two-leaf stage. Tomatoes at the UC Davis location were hand harvested and weighted in September.

In the dodder experiments, the first treatments were made when the Cambell 152 tomatoes were in the cotyledon stage and a single strand of dodder attached to the tomatoes. Rates of application ranged from 0.021 to 0.062 lb/A. One application was a split with a first rate at 0.021 lb/A followed 3 days later with a second application of rimsulfuron at 0.031 lb/A.

RESULTS AND DISCUSSION

Postemergence treatments of rimsulfuron plus 0.25% X-77 at rates from 0.0078 to 0.0434 lb/A gave 90 to 100% control of hairy nightshade applied at the cotyledon to two-leaf growth stage. There was slight early vigor reduction to the tomatoes which they soon outgrew. Control of black nightshade in the 80 to 90% range could be obtained when application was made at the cotyledon growth stage. When the growth stage of the nightshade was at the two-leaf or larger stage, rates of 0.025 to 0.062 lb/A were required for 80 to 90% control. In one experiment where surfactants X-77, COC and Scoil were compared; control of black nightshade in the two to four-leaf stage was very poor even at the 0.062 lb/A rate. Tomato yields ranged from 50.4 to 24.5 T/A. (Table 1)

Preemergence treatments at the UC Davis farm consisted of rimsulfuron alone and in combination with napropamide and pebulate. Napropamide and pebulate and the combination of the two were used as standards. Pebulate and napropamide were the only treatments which gave poor black nightshade control. Yields ranged from 52.8 T/A with rimsulfuron at 0.062 lb/A to 41.0 T/A for the hoed control (Table 2).

The tomato tolerance was excellent with all preemergence treatments. The standard treatment napropamide plus pebulate caused slight stand reduction and moderate vigor reduction. The three way combination of rimsulfuron plus napropamide plus pebulate also caused slight stand reduction and moderate vigor reduction. There was not any significant yield reduction from the treatments.

Dodder control was 95 to 100% when application of rimsulfuron was made to tomatoes in the cotyledon stage and dodder attached as a single strand. The rimsulfuron as a multiple application, 0.019 and 0.031 lb/A gave 100% control. Fairly severe yellowing occurred to the tomatoes. After 3 weeks they grew out of this condition. Dodder control was excellent all season (Table 3).

CONCLUSIONS

Rimsulfuron applied preemergence at rates of 0.008 to 0.062 lb/A can give excellent control of black and hairy nightshade in a sandy loam soil, with excellent tolerance for transplants and direct seed tomatoes. Hairy nightshade can be controlled very effectively with rimsulfuron postemergence. However, higher rates, multiple applications starting when black nightshade is in the cotyledon stage and dodder with a single strand attached will be necessary for good to excellent control. Tomato tolerance with postemergence applications is not as good as with preemergence treatments. Early tomato vigor reduction and chlorosis will occur. However, the tomatoes grow out of this condition within 30 to 45 days.

Table 1. Postemergence control of hairy and black nightshade.

Treatment	Rate	Tomatoes	Hairy nightshade	Black nightshade
	- lb/A -	T/A	%	
Rimsulfuron + Scoil	0.06	50.4	10	4
Rimsulfuron + COC	0.03	44.4	9	3
Rimsulfuron + COC	0.06	42	7	3
Rimsulfuron + X-770.02	41.4	10	3	
Rimsulfuron + Scoil	0.02	41.4	9	1
Rimsulfuron + X-77	0.06	39.2	10	3
Rimsulfuron + Scoil	0.03	39	10	4
Rimsulfuron + COC	0.02	36.3	8	0
Rimsulfuron + X-77	0.01	35.6	8	0
Rimsulfuron + COC	0.01	34.8	10	0
Rimsulfuron +X-77	0.03	34.2	10	2
Rimsulfuron + Scoil	0.01	33.3	5	0
Control	------	28.8	2	0
Metribuzin	0.15	24.5	10	0
LSD		11.52		

Table 2. Preemergence black nightshade control and yield results.

Treatment	Rate	Tomatoes	Black nightshade
	lb/A	T/A	
Rimsulfuron	0.06	52.6	9
Napropamide + rimsulfuron	2 + 0.031	49.6	9
Rimsulfuron	0.01	46.3	10
Rimsulfuron	0.008	46.1	8
Rimsulfuron	0.016	46.0	10
Pebulate	6	46.0	5
Napropamide + rimsulfuron	2 + 0.062	46.0	10
Rimsulfuron	0.031	45.4	10
Pebulate + napropamide + rimsulfuron	6 + 2 + 0.031	44.9	9
Pebulate + rimsulfuron	6 lb + 0.062	43.7	10
Napropamidel	2	43.5	4
Rimsulfuron	0.023	43.2	10
Pebulate + napropamide	6 + 2	41.2	9
Control (hoed)	----------	41.0	0
LSD		11.52	

Table 3. Dodder control - postemergence - 1995.

Treatments	Rate	Dodder	Tomato	Tomato[a] yellowing	Tomato vigor
	lb/A	No./20 ft			
Rimsulfuron	0.031	1	58	3	7
Rimsulfuron	0.025	1	64	3	8
Rimsulfuron	0.019 + 0.031	0	59	2	8
Control	----------	8	44	0	10
Rimsulfuron	0.062	2	48	3	7
Rimsulfuron	0.045	1	47	3	6

[a]Tomato yellowing 1=slight 3=severe.

PREEMERGENCE AND POSTEMERGENCE APPLICATION OF HERBICIDES ON SUGAR BEETS. Marvin D. Butler, Extension Crop Scientist, Oregon State University, Central Oregon Agricultural Research Center, Madras, OR 97741.

Abstract. 1995 was the first season sugar beets have been grown commercially in central Oregon. To evaluate herbicides for control of the weed spectrum under central Oregon conditions, preemergence and postemergence herbicides were applied to sugar beets at three locations near Prineville and Madras, Oregon. Preemergence treatments included ethofumesate alone and in combination with pyrazon. Postemergence applications included phenmedipham and desmedipham, phenmedipham and desmedipham and ethofumesate, clopyralid, ethofumesate, and triflusulfuron, alone and in combination. Postemergence treatments were applied at the cotyledon stage, followed by a second application a week later at the 2-leaf stage. A third application was made to the non-preemergence treatments when the sugar beets were at about the 6-leaf stage. Plots which received ethofumesate or ethofumesate plus pyrazon applied preemergence had significantly fewer weeds than those receiving only postemergence applications. Only two postemergence applications were necessary following the preemergence treatments. Ethofumesate applied preemergence followed by phenmedipham and desmedipham plus triflusulfuron provided the best weed control. Ethofumesate applied preemergence produced slight stunting of the sugar beets only on sandy soil. When pyrazon was added to the ethofumesate preemergence application, moderate stunting resulted. Some leaf distortion was found following clopyralid applications. Yield was not reduced following slight stunting from ethofumesate preemergence applications, or moderate stunting following the ethofumesate plus pyrazon preemergence application. The application of triflusulfuron alone did not provide adequate weed control and significantly reduced yield from the 32 to 35 T/A range for other treatments to 21 T/A, while the untreated plots yielded 7 T/A. Evaluation of percent sugar and nitrate content revealed no significant differences between treatments. Sugar ranged from 18.3 to 19.1% and nitrate ranged from 71 to 133 ppm.

CULTURAL AND CHEMICAL MANAGEMENT OF YELLOW TOADFLAX. K. Neil Harker, John T. O'Donovan, and Robert E. Blackshaw, Weed Scientists, Agriculture and Agri-Food Canada, Lacombe, Alberta, Canada T4L 1W1, Alberta Environmental Centre, Vegreville, Alberta, Canada T0B 4L0, and Agriculture and Agri-Food Canada, Lethbridge, Alberta, Canada T1J 4B1.

Abstract. Yellow toadflax is not susceptible to most broadleaved herbicides, is favored by reduced tillage practices, and is increasing in frequency in central Alberta field crops. Yellow toadflax is susceptible to glyphosate, especially as a preharvest application. A 4-year zero tillage study was initiated in 1993 on a site heavily infested with yellow toadflax near Red Deer, Alberta, Canada. Preharvest glyphosate (0, 450, or 900 g/ha) was applied in a barley-canola rotation seeded in 20 or 30 cm rows at 1 X (conventional), 1.5 X, or 2 X seeding rates. The presence or absence of preharvest glyphosate was the key factor for the control of yellow toadflax. After one application of glyphosate, yellow toadflax cover, counts, and dry weights were all reduced

by glyphosate at 450 g/ha. Further reductions often occurred as the glyphosate rate was increased to 900 g/ha. After two applications of preharvest glyphosate, all yellow toadflax parameters were reduced equally by glyphosate at 450 or 900 g/ha. Crop yields (averaged over seeding rates and row spacings) were increased as a result of the glyphosate treatment. Different crop seeding rates had only small effects on yellow toadflax compared to the glyphosate effects. Nevertheless, in the absence of glyphosate, the 2 X seeding rate treatment usually reduced yellow toadflax cover and counts by approximately 50% in comparison to the 1 X seeding rate. Crop row spacing had no significant effects on yellow toadflax. Combining higher crop seeding rates with treatments of preharvest glyphosate appears to be an effective, integrated method of managing yellow toadflax.

WEED CONTROL AND STAND LONGEVITY IN NON-BURNED GRASS SEED PRODUCTION.
George W. Mueller-Warrant[1], S. Caprice Rosato[2], and D. Scott Culver[1], Research Agronomist, Research Assistant, and Biological Technician, [1]National Forage Seed Production Research Center, 3450 SW Campus Way, Corvallis, OR 97331 and [2]Crop and Soil Science Department, Oregon State University, Corvallis, OR 97330.

Abstract. Grass seed producers in the Pacific Northwest have greatly reduced field burning in response to public concern over the impact of smoke on quality of life. Growers have adopted a variety of mechanical techniques to remove straw after seed harvest and promote the regrowth of perennial grasses. New weed control practices have been developed for the non-burned environment, especially the use of pendimethalin, metolachlor, and oxyfluorfen as preemergence treatments to control the early fall flush of volunteer crop seedlings and common annual weeds. Because establishment of new, weed-free stands is a lengthy and expensive process, stand longevity is an important concern for grass seed growers. Declining crop yields, increasing weed contamination, seed certification rules, and contract limits are the major factors determining the useful life of any stand.

Tests were initiated in 1992 to explore the ability of mechanical residue management options and various herbicide treatments to control weeds while maintaining normal seed yields in perennial ryegrass, tall fescue, Kentucky bluegrass, orchardgrass, and chewings fescue for an indefinite duration. Residue management treatments were imposed as mainplot factors, and included bale/flail chop/rake (BFR) and "vacuum sweep" (VS) in all crops, field burn (FB) in Kentucky bluegrass and chewing fescue, and full straw load chop *in situ* (FSLC) in perennial ryegrass, tall fescue, and orchardgrass. Herbicide treatments included currently registered materials, experimental treatments for which efforts to obtain registrations are underway, a biological control agent, and mechanical methods for shallow incorporation of chemicals in the soil or placement under the straw. Treatments were reapplied to the same plots each year, except the untreated checks which rotated location with duplicate applications of the most successful treatments from previous years.

With suitable herbicide treatments and BFR or VS residue management, perennial ryegrass, tall fescue, and orchardgrass have maintained normal seed yields in nearly weed-free stands throughout four harvests. FSLC management has been less successful: perennial ryegrass stands have been destroyed by herbicide treatments needed to control volunteer crop seedlings, and tall fescue yields have declined over time, possibly due to invasion of weeds such as roughstalk bluegrass. In BFR and VS residue management, pendimethalin was superior to metolachlor and oxyfluorfen as a preemergence herbicide. Shallow incorporation of pendimethalin with a rake-tedder improved control but reduced crop tolerance slightly. Postemergence applications of oxyfluorfen plus diuron or metribuzin following preemergence pendimethalin were generally necessary for adequate weed control, although shallowly incorporated pendimethalin by itself was sometimes satisfactory with VS residue management. Establishment of large numbers of volunteer crop seedlings usually reduced yield in perennial ryegrass and sometimes in tall fescue. Older volunteer plants had more impact on tall fescue yield than first-year seedlings. A granular formulation of pendimethalin was moved below the surface of the straw by stirring the straw with a rake-tedder in the first 2 years, while a modified knife flail has been used to lift the straw off the soil surface while spraying pendimethalin in the last two years. Either incorporation technique

improved the performance of pendimethalin compared to surface application. Treatments without pendimethalin (i.e., metolachlor, oxyfluorfen, and diuron tank-mixes and sequential applications) generally caused greater crop injury when achieving similar weed control or poorer weed control when causing similar crop injury compared with treatment sequences beginning with preemergence pendimethalin. The most successful treatment for VS and BFR management was preemergence pendimethalin shallowly incorporated with a rake-tedder followed by a tank-mix of oxyfluorfen plus diuron applied when the surviving volunteer seedlings were in the 3-leaf stage. The best herbicide treatments for FSLC management were preemergence pendimethalin "under the straw" followed by oxyfluorfen plus metolachlor, terbacil, or diuron at the 1- to 2-leaf stage. In some years these treatments failed to adequately control volunteer perennial ryegrass, and a late postemergence application of oxyfluorfen plus diuron was necessary. In other years, this late application caused unacceptably severe stand loss. Residue management and herbicide treatments had little effect on chewings fescue through 2 years of testing. Unfortunately, an accidental fire after harvest in 1994 forced abandonment of the chewings fescue test.

Downy brome posed severe threats to Kentucky bluegrass seed production. Downy brome densities increased greatly from one year to the next in treatments providing only partial or no control, and crop yields were reduced compared to treatments that controlled this weed. The best registered treatment, terbacil, caused moderate to severe Kentucky bluegrass leaf chlorosis at rates required to control downy brome, and sometimes reduced yield compared to primisulfuron treatments. Late-fall application of dicamba provided only partial control of downy brome. Tank-mixes of terbacil plus primisulfuron reduced Kentucky bluegrass phytotoxicity compared to terbacil by itself. Split-application of half-rates of primisulfuron in early and late-fall provided slightly better control than a single application at the full rate. The best treatment was split-application of half-rates of tank-mixes of terbacil plus primisulfuron. Effects of 2 years of post-harvest residue management were relatively minor, although FB plots outyielded VS. Yields with BFR management were intermediate, despite having the highest density of downy brome. Applications of *Pseudomonas fluorescens* strain D7 had no effect on the downy brome except for an early February timing which immediately preceeded a snow storm and freezing weather. In this case, downy brome was stunted and 30 to 48% of the plants were killed.

ALTERNATIVE HERBICIDES TO CONTROL TRIALLATE-RESISTANT WILD OAT. Robert E. Blackshaw[1], K. Neil Harker[2], and John T. O'Donovan[3], Weed Scientists, [1]Agriculture and Agri-Food Canada, Lethbridge, Alberta, Canada T1J 4B1 and [2]Lacombe, AB and [3]Alberta Environmental Center, Vegreville, Alberta, Canada T4L 1W1.

Abstract. Wild oat populations were identified in 1990 in Alberta to be resistant to triallate after 15 to 20 years of triallate use in cereal production. Dose response experiments were conducted in the greenhouse to determine the response of these wild oat populations to other selective wild oat herbicides. Triallate-resistant wild oat populations were effectively controlled by atrazine, ethalfluralin, fenoxaprop-P, flamprop, imazamethabenz, and tralkoxydim. EPTC and cycloate, which are chemically related to triallate, differed in their efficacy on triallate-resistant wild oats. EPTC at the 0.25 X field rate was more efficacious on triallate-resistant than triallate-susceptible wild oats. In contrast, cycloate at the 0.25 to 0.5 X field rate was less efficacious on triallate-resistant than susceptible wild oats. At higher rates, both EPTC and cycloate killed triallate-resistant wild oat populations. Growers have several herbicide options to selectively control triallate-resistant wild oats in cereal, oilseed and pulse crops.

CONTROL OF SALTCEDAR WITH VARIOUS HERBICIDE APPLICATIONS. William G. Noffke[1], Keith W. Duncan[2], and Kirk C. McDaniel[1], Graduate Assistant, Brush and Weed Specialist, and Professor, [1]Department of Animal and Range Science, New Mexico State University, Las Cruces, NM 88003, [2]Cooperative Extension Service, New Mexico State University, Artesia, NM 88210.

Abstract. Saltcedar is an exotic tree introduced to North America from Eurasia in the early 1800's. Saltcedar is an aggressive competitor and has spread across hundreds of thousands of acres, primarily in the southwestern

United States, and often forms a near mono-culture in the flood plain of major watersheds. Saltcedar is a facultative phreatophyte (well-plant) and has been shown to significantly alter the water table in areas that it has been introduced. Other problems attributed to saltcedar include degradation of wildlife habitat, displacing native vegetation, altering soil salinity by exuding salts, and increasing the severity and occurrence of floods.

New Mexico State University began testing various herbicides for saltcedar control in 1987. Since this time 28 different trials have been installed throughout New Mexico. Herbicides compared include imazapyr, glyphosate, tebuthiuron, hexazinone, and triclopyr applied in various combinations and rates. Application methods tested include aerial spraying with fixed wing aircraft and helicopter, backpack sprayer, truck mounted sprayer and carpet roller. Saltcedar mortality was determined by plant counts 2 to 3 years after initial treatment to determine herbicide effects and to compare application methods.

Early trials comparing the control of individual plants using soil applied applications of tebuthiuron and hexazinone resulted in low mortality and, because of this, were not tested after 1988. Foliar sprays using imazapyr were shown to provide high mortality but treatment costs were expensive. Therefore trials involving a combination of imazapyr and glyphosate were begun in 1990. These trials demonstrated that control can be comparable to imazapyr alone, and at a lower cost. The mixture of imazapyr and glyphosate, applied at rates of 0.5% + 0.5% v/v or higher provided mortality 95% and greater. Imazapyr alone can give good control if applied at concentrations of 0.75% or greater. Tests of glyphosate sprayed alone gave unacceptable control when formulated herbicide was mixed as a 2% solution in water. Triclopyr applied as 2.5% and 5% solutions also gave poor control.

In 1992 a helicopter application of imazapyr applied alone and in combination with glyphosate was made to 5 and 25 A plots. This trial showed that saltcedar could be controlled by the herbicides but this method of application was considered unsatisfactory because of streaking that occurred. The effective swath width of the helicopter was only 30 feet and could only cover a small area before it was necessary to refill the tank. Aerial applications using fixed wing aircraft were started in 1993 and showed an improvement in mortality compared to the helicopter plots. The fixed wing applications provided 99% control when a 0.5 + 0.5 lb/A mixture of imazapyr plus glyphosate was applied.

BEHAVIOR OF THREE ALS INHIBITORS IN TWO SOILS AT DIFFERENT MOISTURE LEVELS. A. Ríos-Torres, J. Schroeder, and T. M. Sterling, Graduate Student, Associate Professor, and Associate Professor, Department of Entomology, Plant Pathology and Weed Science, New Mexico State University, Las Cruces, NM 88003.

Abstract. Imazethapyr, imazaquin and chlorimuron have very high biological activity levels in soil and can be difficult to detect by analytical methods. However, bioassay methods are sensitive and detect very low herbicide concentrations in soil (ng g^{-1}). Previous research indicated that the bioactivity and detection of these herbicides were poorly described using a bioassay method; therefore, research to determine factors influencing the accuracy of bioassay systems using these herbicides was conducted. A bioassay method was used to determine the effect of imazethapyr at concentrations of 0, 30, 60, 90 and 120 ng g^{-1}; imazaquin at 0, 20, 40, 60 and 80 ng g^{-1} and chlorimuron at 0, 3, 6, 9 and 12 ng g^{-1} on corn root growth (*Zea mays* L. cv. Pioneer 3369A). Three soil moisture levels were used (-0.01, -0.02 and -0.2 MPa), based on water retention curves previously determined, on two soil types with pH 5.8 (Hapludult sandy loam) and 7.7 (Belen clay loam), in a randomized complete-block design with five replications in a factorial treatment arrangement. Stock solutions of herbicide were prepared and applied to soil using a pipet. The soil and herbicide were hand-mixed by shaking in a plastic bag. One hundred g of treated soil were placed in a 14-cm-long cone tube. One pre-germinated seed was planted 2 cm deep in each cone tube. The different soil moisture levels were established and maintained by weighing and watering twice a day. Fresh and dry root and shoot weights and root and shoot length were measured 8 days after planting. The results were expressed as percentage of the control. Dose response curves were calculated by

the linear regression equation [y = a + b(ln)x] to evaluate corn root response to increasing herbicide concentration in each treatment.

There was an interaction between moisture levels and soil type ($p = 0.004$) only for chlorimuron. The concentration of chlorimuron that inhibited root length by 50% (I_{50}) was lower in the high pH soil with low moisture level (3.9 ppb) than in low pH soil with low moisture level (6.8 ppb). The I_{50} of imazaquin was lower in low pH soil (37.4 ppb) than in high pH soil (40.7 ppb) regardless of moisture levels. The I_{50} of imazethapyr was lower in high moisture levels (67.1 ppb) than low moisture level (77.5 ppb) regardless of soil pH. Future research is needed to clarify the soil pH and moisture level effects.

DETECTION OF RESIDUAL CONCENTRATIONS OF IMAZAPYR IN SOIL BY BIOASSAY TECHNIQUES. Richard J. Barnes and Jill Schroeder, Research Technician, and Associate Professor, Department of Entomology, Plant Pathology, and Weed Science, New Mexico State University, Las Cruces, NM 88003.

Abstract. The Pecos River Native Riparian Restoration Organization is currently employing the herbicides imazapyr and glyphosate as part of an integrated saltcedar management program. While preliminary studies have demonstrated prior success of these herbicides in controlling saltcedar, little is known about the biological availability of trace concentrations of imazapyr remaining in the soil and water. The purpose of this study is to identify any potentially detrimental effects caused by residual concentrations of imazapyr. These effects include responses of sensitive agricultural crops as well as responses of native riparian species. The development of bioassay techniques on sensitive species is a useful tool in detecting trace concentrations of biologically active compounds. Imidazolinone herbicides have been shown to exhibit toxic effects on corn in concentrations too low to be detected by current analytical techniques. A bioassay procedure was, therefore, designed to identify and quantify phytotoxic concentrations of imazapyr in the soil for corn, chile, and cotton. Seedlings of each species were grown in styrofoam cups containing one of six treatments which ranged in concentration from 0 to 80 ppb imazapyr. The seedlings were grown in a greenhouse for up to 1 month and then examined for morphological responses. Measurements included: 1) above ground: fresh weight and dry weight, 2) below ground: root length, fresh weight and dry weight. Each response variable was regressed against concentration level to establish a Standard Dose Response Curve. The data fit a quadriatic model. The curves were then analyzed to determine which variables responded consistently with increasing concentrations of imazapyr. A response variable from each plant species was then selected as an index for detecting and quantifying residual concentrations of imazapyr in soil.

The optimal response variable for corn was root length. Imazapyr at 5 ppb decreased corn root length by 16%. This trend was also apparent for root length in chile seedlings. Imazapyr inhibited chile root length by 37% at 5 ppb. The development of true leaves in chile was also delayed by increasing herbicide concentration. Cotton seedlings responded similarly to the chile assay. Here, root length and true leaf development were both significantly reduced by increasing imazapyr concentrations. At 5 ppb cotton root length was decreased by 10%. Based on a relative comparison of root length responses, chile appears to be the most susceptible of the three species. Future research on this project will incorporate *Sporobolus airoides* (Torr.) Torr. (Gram.) (a grass species native to the Pecos River riparian area) as well as the previously mentioned crop species.

INFLUENCE OF WINTER WHEAT HEIGHT ON COMPETITIVENESS WITH JOINTED GOATGRASS. Steven S. Seefeldt, Alex G. Ogg, and Robert E. Allen, Agronomist, Plant Physiologist, and Research Geneticist, USDA-ARS Washington State University, Pullman, WA 99164.

Abstract. Jointed goatgrass is a troublesome weed in winter wheat in the Pacific Northwest as there are no selective herbicides for its control. Jointed goatgrass is highly competitive in a wheat crop, reducing yields in the field, and jointed goatgrass spikelets are difficult to separate from wheat seed, increasing dockage at the market. Experiments are underway to identify plant characteristics that make winter wheat more competitive against jointed goatgrass. One characteristic that may be important in the competition equation is winter wheat height.

A field experiment was conducted at the Palouse Conservation Farm using near-isolines of 'Nugaines' winter wheat. These near-isolines, which had either *Rht1* (reduced height gene 1), *Rht2*, *Rht1+2*, or *no Rht* genes, were grown with and without jointed goatgrass. The experimental design was a randomized strip plot with 4 replications. Main blocks were jointed goatgrass treatments subplots were isolines and were 2.4 m by 15 m with 18 cm row spacing. Heights of the wheat isolines at physiological maturity were 51, 79, 77, and 101 cm for *Rht1+2*, *Rht1*, *Rht2*, and *no Rht*, respectively. When growing with the *Rht1*, *Rht2* or *no Rht* lines, jointed goatgrass grew 80 cm tall. When growing with the short *Rht1+2* line, jointed goatgrass height grew 69 cm tall. Under weed free conditions, the *Rht1* and *Rht1+2* lines yielded significantly more grain than the *no Rht* line. Grain yield form the *Rht2* line was intermediate and not statistically different from the other three lines. When the wheat lines were grown with jointed goatgrass, wheat yields were reduced 39% in the *Rht1+2* line, 37% in the *Rht1* line, 30% in the *Rht2* line, and 20% in the *no Rht* line. There were significant differences in jointed goatgrass spikelet yields in the different isoline plots. Jointed goatgrass yielded the most spikelets when growing in competition with the *Rht1+2* line and least with the *no Rht* line. Jointed goatgrass spikelet weights were the same in the *Rht2* and *Rht1* plots.

Increasing wheat height was an important factor in increasing competition against jointed goatgrass. However, there were some small differences in competitiveness between the *Rht1* and *Rht2* lines, which have equivalent heights. The *Rht1* line yielded slightly higher in the weed free plots and reduced jointed goatgrass yields slightly more than the *Rht2* line. In these near-isolines, there may be another characteristic in the *Rht1* line that is enhancing its yield potential and its competitiveness against jointed goatgrass compared to the *Rht2* line.

SEED LONGEVITY OF TEN WEED SPECIES FOUR YEARS AFTER BURIAL AT TWO SOIL DEPTHS. Stephen D. Miller and Stephen VanVleet, Professor and Research Associate, Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. The potential for weed problems exist as long as weed seeds remain viable in the soil. Plots were established at four dryland sites in Wyoming during the fall of 1990 to evaluate seed longevity of 10 weed species when buried at two soil depths. Weed seed was placed in packets made from 100 micron mesh nylon screen. Holes 4 inch in diameter were dug 12 inches apart in rows that were 12 inches apart at all four sites. One seed packet was buried at 1 and 6 inches in each of four replicate holes per sampling date. The holes were refilled with soil that was tamped firmly after each packet was placed at the desired soil depth. A grass cover was allowed to develop over the study site at each location. The study was arranged as a split plot with sampling date as the main plot and species and burial depth as the subplot. Groups of seed packets sufficient for five sampling dates were buried the last week of October in 1990 at all four sites. Seed packets were carefully removed without disturbing adjacent sites in October of 1991, 1992 and 1994 at all four locations. The holes were refilled with soil after the seed packets were removed. The seed packets were transferred to the laboratory, opened and seed tested for viability using the tetrazolium chloride test (Wyoming Department of Ag Seed Testing Lab). In addition, a sample of seed of each species stored in the lab was also analyzed for viability at each date.

Average seed viability declined over 2 and 4% between the 12 and 24 month sampling period and 6 and 7% between the 24 and 48 month sampling period at 1 and 6 inches, respectively. Seed viability in the laboratory declined less than 2% during this same period. Forty-eight months after burial, seed viability was 5 to 9% greater at the 6 than 1 inch burial depth when averaged over species. Average seed viability at the four locations ranged from 4 to 10% at the 1 inch and 9 to 19% at the 6 inch burial depth. Seed viability of kochia and downy brome was essentially lost at all locations after 48 months regardless of burial depth. Further viability of wild oat and leafy spurge had declined to 1% at the 1 inch depth when averaged over location. Cutleaf nightshade seed viability was still over 40% at both depths 48 months after burial when averaged over location. Seed viability is being lost more rapidly at Torrington and Sheridan than at Archer or Laramie. (Published with the approval of the Wyoming Agricultural Experiment Station.)

PICLORAM RESPONSE BY PICLORAM-RESISTANT AND -SUSCEPTIBLE YELLOW STARTHISTLE IN A REPLACEMENT SERIES AND F1 SEEDLINGS. L. A. Gibbs, T. M. Sterling, and N. K. Lownds, Research Assistant, Associate Professor, Department of Entomology, Plant Pathology, and Weed Science, and Associate Professor, Department of Agronomy and Horticulture, New Mexico State University, Las Cruces, NM 88003.

Abstract. Yellow starthistle can decrease the carrying capacity of grazing land and seriously damage non-grazed ecosystems. Picloram, an auxin-like herbicide, is the primary herbicide used to control this weed. Resistance to picloram was detected in 1989 in a field near Dayton, WA. To determine if there is a competitive advantage between picloram-resistant (R) and -susceptible (S) plants in the presence or absence of picloram, the two accessions were grown in replacement series over time. Greenhouse studies were conducted in 1994 and 1995 to evaluate dry weight accumulation and seed production when grown in five S to R ratios; 8:0, 6:2, 4:4, 2:6, and 0:8. Picloram (0.28 kg/ha) was applied at the rosette stage with a CO_2 backpack sprayer. Following treatment, plants were harvested at rosette, bolting, and after seed set. Plants that flowered were cross-pollinated with all other flowering plants within each pot. Pollination was conducted by hand using dried bees mounted on Q-Tips®. At each harvest date, plant fresh and dry weights were taken and at the final harvest, seeds were collected, counted and weighed. In the absence of picloram, both S and R plants contributed equally to pot biomass. In the presence of picloram, R contributed more dry weight to the total pot dry weight than S. These results suggest that R has a competitive advantage over S only in the presence of picloram. Both S and R parent plants produced seeds in untreated pots although S parent plants produced more seed per pollinated flower than R parent plants regardless of pot ratio. In addition, only R parent plants produced seeds when treated with picloram. Results from the two experiments were similar except that plants in the 1995 study were more sensitive to picloram than plants in the 1994 study.

Seedlings (F1) grown from seed collected from each untreated parent plant of all five ratios were screened for picloram resistance by spraying with picloram at 0.14 kg/ha ca. one month after germination. Ten seedlings representing each R or S parent plant from each of the five ratios were treated and compared to untreated controls. Visual ratings of epinasty on a scale of 1 to 10 were recorded twice a week for 4 weeks. Four weeks after treatment fresh and dry weights of roots and shoots were taken. Survivorship was similar among untreated F1 seedlings from all ratios. For treated seedlings, survivorship was two to three times greater for F1 seedlings from pot ratios (S:R) 0:8 than of F1 seedlings from pot ratios 8:0. For pot ratios 6:2, 4:4 and 2:6, survivorship was intermediate.

THE ROLE OF ETHYLENE IN YELLOW STARTHISTLE RESISTANCE TO THE AUXINIC HERBICIDE PICLORAM. Robert P. Sabba, Tracy M. Sterling, and Norm K. Lownds, Research Specialist and Associate Professor, Department of Entomology, Plant Pathology and Weed Science, and Associate Professor, Department of Agronomy and Horticulture, New Mexico State University, NM 88003.

Abstract. Yellow starthistle is a poisonous weed endemic to western rangelands, and is commonly controlled by the auxinic herbicide picloram. Though picloram is believed to operate in plant systems in a manner similar to auxin, the details are poorly understood. Yellow starthistle resistant to this herbicide was found in 1989 in a Washington pasture with a history of picloram application.

Since picloram is known to induce ethylene evolution in susceptible plants (a common auxin response), the effect of ethylene inhibitors and an ethylene precursor on picloram efficacy was tested. Starthistle plants were grown in the greenhouse to full vegetative stage, and were then treated with 0.28 kg/ha picloram, applied to the foliage with a CO_2 backpack sprayer. The ethylene synthesis inhibitor aminoethoxyvinylglycine (AVG), was applied to test plants 24 h before picloram application at a concentration of 0.1 mM. The ethylene action inhibitor silver thiosulfate (STS) was applied to test plants 1 hour before picloram application at 2 mM, and the ethylene-releasing compound ethephon was applied to plants at 2000 ppm immediately after picloram application.

Picloram induced a 2 to 3.5 fold increase in ethylene evolution within 24 hours in susceptible (wildtype) plants, while only inducing a small increase in resistant plants. AVG was able to either completely or partially prevent this induction. Picloram also induced epinastic bending within 5 hours and chlorosis within a week. These symptoms were much more prominent in susceptible compared to resistant plants. Picloram also consistently reduced shoot dry weight in susceptible plants by 25 to 55% after 1 month. Shoot dry weight of resistant plants was either unaffected by picloram or only reduced slightly.

AVG and STS were either ineffective, or only partially effective in reversing the epinasty and chlorosis induced by picloram. Furthermore, neither treatment was able to prevent the reduction in shoot dry weight induced by picloram. Application of ethephon increased ethylene evolution in both susceptible and resistant plants by 7 to 40 fold. Despite this, ethephon was unable to induce the chlorosis and shoot dry weight reduction associated with picloram effects, and was only partially able to mimic the epinasty induced by picloram. These results imply that the ethylene evolution induced by picloram is not responsible for picloram efficacy in yellow starthistle, and that the reduced ethylene production in resistant plants is not the primary mechanism of resistance.

WEED SUPPRESSION WITH RAPESEED AND WHITE MUSTARD MANURE IN PEAS. Carl Libbey and Kassim Al-Khatib, Agriculture Research Technician and Extension Weed Specialist, Washington State University, Mount Vernon, WA 98273; Rick Boydston, USDA-ARS, Prosser, WA 99350.

INTRODUCTION

Brassica species have been planted as crops in many countries, for edible and industrial oil, forage or fodder, greens, root crops, condiments, smother crops, and green manure. Reduced growth of crops and weeds is often reported following addition of *Brassica* residues to the soil or following *Brassica* species in rotations (1, 2). More recently, attempts have been made to exploit the apparent allelopathic potential of *Brassica* residues for control of weeds (3).

Planted in mid-late August as green manure, *Brassica* species often fit well into crop rotations following a winter annual crop such as wheat or a short season summer annual crop such as sweet corn. They can produce enough biomass to reduce soil erosion, add organic matter to the soil, and suppress weeds. *Brassica* species can replace winter cover crops planted to reduce soil erosion at no additional cost to growers. Fall-planted green manure crops reclaim leachable nutrients and make them available to the succeeding crop the following spring. *Brassica* species could also be utilized as a spring-planted green manure crop preceding late planted crops.

Recently, benefits of fall-planted *Brassica* manure crops have been reported, including suppression of weeds, nematodes, insects, and diseases (4). This pest suppression has been attributed to the decomposition products, mainly isothiocyanates, from glucosinolate compounds present in the tissues.

OBJECTIVES

1. Evaluate weed suppression in pea following fall-planted rapeseed, white mustard, rye, and winter wheat.

2. Evaluate the efficacy of white mustard and rapeseed as green manures in combination with herbicide and cultivation.

3. Study the effect of several exogenous isothiocyanates that exist in *Brassica* foliage on germination and growth of barnyardgrass, redroot pigweed, and pea.

MATERIALS AND METHODS

Field study. This experiment was conducted in 1993 and 1994 on a Skagit silt loam soil, where organic matter was 4.6 and 5.9 and pH was 5.7 and 6.0, respectively. The design was a split plot with four replications, in which the main plots were cover crops and the subplots were weed control practices. 'Martigena' white mustard, 'Jupiter' rapeseed, 'Wheeler' rye, and 'Cashup' wheat were planted on August 27, 1993 and September 26, 1994. White mustard and rapeseed were planted at 6.7 kg/ha, winter wheat and rye were planted at 134 kg/ha; plots contained 18 rows spaced 8 cm apart and 36 m long.

Plots were subsoil plowed on March 29, 1994 and April 14, 1995, then plants were incorporated into the soil with a rototiller, and the soil immediately compacted with a roller drum. Total dry weight of white mustard, rapeseed, rye, and winter wheat were 4.2, 8.2, 4.9, 4.0 T/ha in 1994 and 4.5, 6.3, 5.8 and 4.6 T/ha in 1995. White mustard was winter killed in 1993. However, plant residues were incorporated into the soil in 1994.

Thirteen and 20 days after incorporation in 1994 and 1995, respectively, plots were rototilled again and 'Bolero' green pea was planted on April 11, 1994 and May 4, 1995 (Figure 1). Each plot received three subtreatments: 1) weedy check, 2) cultivation with pea weeder when weeds were less than 1 cm tall, and 3) metribuzin at 140 g ha applied premergence.

Crop injury and total broadleaf weed control were visually evaluated on a percent scale, where 0 = no control or crop injury and 100 = complete mortality. Green pea and weed populations were measured in 1 m^2 of each plot at 30 days after planting (DAP). Immediately before harvest, dry weight of weed plants and green pea population were measured in the middle 2 m^2 of each plot. In addition, yield component and yield were determined in the same area.

Greenhouse study. 'Martigena' white mustard and 'Jupiter' rapeseed were grown in 21-cm-diam containers filled with 6 kg soil, a mixture of sand:Skagit silt loam (1:1 by volume). Each container held four plants. Shoots and leaves of white mustard and rapeseed were harvested when plants were at bud stage. Plant tissue was cut into 0.5 cm^2 pieces and 20 g fresh plant material was uniformly mixed into 400 g dry Skagit silt loam soil in 500-ml plastic pots. Non-amended soil was included for comparison. Pots were watered immediately and 25 seeds of green foxtail, kochia or shepherd's-purse placed on the soil surface, covered by an additional 2 mm of soil. Pots were watered as needed, the number of plants counted 3 wk after planting, then plant foliage was harvested and dried.

A separate study evaluated the effect of rapeseed biomass on common chickweed emergence. Rapeseed plants were grown, harvested, and cut as described above, and 20, 40, or 60 g of plant tissue mixed into the soil. Fifty seeds of common chickweed were placed on the surface and covered with thin layer of soil. Plant populations were measured 7, 14, 21, and 28 days after planting. Treatments were replicated ten times and the experiment was repeated twice.

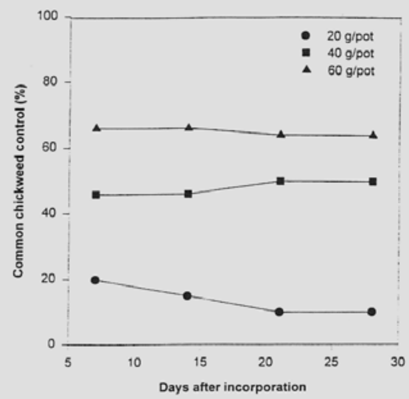

Figure 1. Common chickweed control as affected by the amount of rapeseed foliage incorporated into the soil.

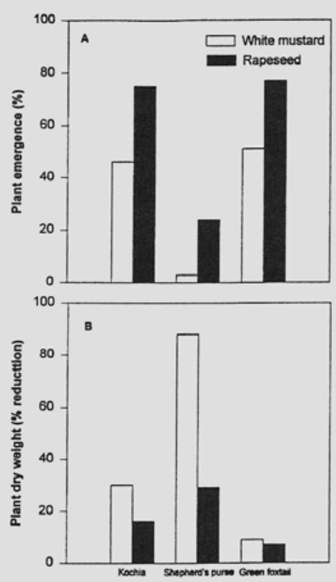

Figure 2. Kochia, shepherd's-purse and greeen foxtail emergence (A) and dry weight (B) reduction as affected by rapeseed and white mustard foliage incorporated into the soil.

Seed germination study. The effect of methyl, ethyl, allyl, propyl, butyl, benzyl, phenyl, and β-phenylethyl isothiocyanate on redroot pigweed, barnyardgrass and pea in closed containers was evaluated. Container volume was 1100 cm^3. Fifty seeds of 'Bolero' pea, redroot pigweed and barnyardgrass were laid in germination paper moistened with 0.01 ml NaCl. The papers were rolled and placed in containers, then different isothiocyanates were applied on 4 cm^2 filter paper placed on glass-watch in the middle of the container. Amounts of isothiocyanates were calculated to provide 1, 5, and 20 ppm (v by v) when vaporized in the sealed containers. After inserting the isothiocyanates, containers were immediately sealed with plastic covers, then kept in closed plastic bags. Seeds were germinated at 25 C, and germination and shoot length measured 7 days after treatment. Treatments were replicated four times and the experiment was repeated twice.

RESULTS AND DISCUSSION

Weed populations varied between pea plots following different green manure or cover crops. The highest weed population was in peas planted after winter wheat, whereas the lowest weed population was in peas after rapeseed. Weed populations 1 month after pea planting were 810, 689, 680, and 540 plants/m^2 in pea following winter wheat, rye, white mustard, and rapeseed, respectively (Table 1). At 2 months after planting, rapeseed continued to show weed suppression. However, by harvest time weed pressure was similar in all pea plots.

Cultivation with a pea weeder gave 60 to 65% weed control 30 DAP, but 2 months after planting, controlled only 25 to 46% of weeds. Weed control with cultivation was less effective than metribuzin (Table 1). Metribuzin applied on pea planted after wheat controlled fewer weeds than metribuzin applied following mustard, rapeseed, and rye. This response may be largely attributed to high weed pressure in pea following wheat.

Pea populations were not affected by cover crop or green manure crops, except rapeseed which reduced pea populations by 25% (Table 2). Rapeseed was incorporated into the soil 13 and 19 days before planting pea in 1994 and 1995, respectively. Rapeseed green manure reduced pea populations more in 1994 than 1995 although the amount of rapeseed biomass incorporated into the soil was larger in 1995. The reduction in pea populations after rapeseed may be attributed to isothiocyanate or other toxic materials it released. The short time period between rapeseed incorporation and planting peas may not be enough to allow for the complete decomposition of rapeseed foliage and the release of toxic materials.

Cultivation slightly reduced pea populations (Table 2). This reduction may be higher with multiple cultivations, as pea fields may require 2 to 3 cultivations to obtain sufficient weed control without herbicides. However, cultivation may have less effect on pea populations if peas are planted deeper. In this study peas were shallow planted because of high soil moisture due to excessive rain, which may cause seed rot if seeds are planted too deep. Although cultivation caused injury to peas, yields were higher in plots cultivated with a pea weeder compared to the nontreated control. This increase in yields was mainly due to lower weed pressure.

Pea yields were higher in white mustard plots compared to other crops. (Table 2) This may not be attributed solely to the effect of white mustard on weeds (Table 1). Weed control was similar in white mustard and rye, but yield was higher in peas following white mustard than rye. It is likely that white mustard increased yield due to the reduction in nematodes, diseases, and weeds. Pea yield was significantly reduced when peas were planted after rapeseed, mainly due to reduction in pea population.

Greenhouse and seed germination study. Weed suppression with *Brassica* green manure crops is correlated with the amount of foliage incorporated into the soil. Common chickweed control increased as the amount of rapeseed foliage incorporated into the soil increased (Figure 2). The increase in weed control at higher rapeseed biomass may be attributed largely to the greater amount of isothiocyanate released from glucosinolate in rapeseed foliage. Bell and Muller have shown that inhibition of weed germination increased as the concentration of isothiocyanate increased (1).

The degree of weed suppression by *Brassica* species is dependent on the species. The emergence and growth of kochia, shepherds-purse, and green foxtail were inhibited more by white mustard than by rapeseed when equal amounts of foliage were incorporated into the soil (Figure 2). Different *Brassica* species often exhibited different allelopathic effects due to higher level and/or more potent glucosinolates present (4).

Seed germination and shoot growth of barnyardgrass, redroot pigweed, and pea responded differently to isothiocyanates. Methyl, phenyl, ethyl, and allyl isothiocyanates inhibit germination and growth of barnyardgrass, redroot pigweed and pea more than benzyl, butyl, propyl, and β-phenylethyl isothiocyanates (Tables 3 and 4). In addition, methyl, ethyl, allyl, propyl, butyl, benzyl, phenyl, and β-phenylethyl inhibited germination of redroot pigweed and barnyardgrass more than they affected pea. Inhibition of seed germination by isothiocyanates was correlated to seed size, with redroot pigweed being the most sensitive and pea the most tolerant species. The susceptibility of small-seeded plant species to isothiocyanates compared to large-seeded species may be attributed to the larger surface area relative to weight of reserves in small-seeded species. Waddington (60) reported that the effect of rapeseed on seed germination may be influenced by seed structure as well as size. In seeds where water initially enters near the embryo, the concentrated toxins will damage the seed more severely than if the same amount of toxins was spread throughout the seed.

CONCLUSIONS

Growing a green manure crop of rapeseed or white mustard before planting pea may suppress certain small-seeded weeds, but timely use of chemical or cultural practices must be combined with it to prevent losses from competition by surviving weeds. However, as a component in integrated cropping systems, *Brassica* green manures may suppress weeds, insects, diseases, and nematodes, reduce soil erosion, and reclaim leachable nutrients.

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Table 1. Visible weed control, weed population 30 DAP and total weed dry weight at pea harvest as affected by fall planted cover and green manure crops and weed control practices.

Crop	Weed control practices	Visible weed control (DAP) 30	60	80	Population 30 DAP	Weed dry weight at harvest
		% control			plant/m²	g/m²
White mustard						
	Metribuzin	80	70	50	148	236
	Cultivation	60	40	10	359	356
	Nontreated control	30	25	0	680	469
Rapeseed						
	Metribuzin	75	60	45	144	270
	Cultivation	65	40	15	85	387
	Nontreated control	30	30	0	540	451
Rye						
	Metribuzin	70	60	50	239	264
	Cultivation	65	35	15	266	299
	Nontreated control	25	20	0	689	436
Winter wheat						
	Metribuzin	60	50	40	283	309
	Cultivation	60	25	10	168	369
	Nontreated control	0	0	0	810	495
LSD (0.05) for weed control practices within the same crop		10	8	7	80	140
LSD (0.05) for crops within the same weed control practice.		7	4	3	40	70

Table 2. Population and yields of pea as affected by fall planted cover and green manure crops and weed control practices.

Crop	Weed control practices	Population	Yield
		Plant/m^2	kg/ha
White mustard			
	Metribuzin	109	3858
	Cultivation	86	2743
	Nontreated control	101	2062
Rapeseed			
	Metribuzin	75	2232
	Cultivation	71	1612
	Nontreated control	70	861
Rye			
	Metribuzin	90	3279
	Cultivation	78	2886
	Nontreated control	94	1740
Winter wheat			
	Metribuzin	94	2342
	Cultivation	71	1976
	Nontreated control	94	1546
LSD (0.05) for weed control practices within the same crop		7	695
LSD (0.05) for crops within the same weed control practice.		5	340

Table 3. Inhibition of germination of barnyardgrass, redroot pigweed, and pea by exposure to isothiocyanate vapors in sealed plastic containers.

Isothiocyanate R-group	Air concentration	Germination		
		Barnyardgrass	Redroot pigweed	Pea
	ppm	%		
Allyl	1	55 ± 19	15 ± 10	97 ± 8
	5	1 ± 2	1 ± 1	85 ± 11
	20	0	0	0
Benzyl	1	90 ± 8	19 ± 6	100 ± 15
	5	82 ± 10	8 ± 5	101 ± 7
	20	82 ± 11	4 ± 3	102 ± 5
Butyl	1	89 ± 7	85 ± 11	89 ± 8
	5	76 ± 12	7 ± 6	96 ± 19
	20	12 ± 9	7 ± 4	40 ± 30
β-phenylethyl	1	92 ± 4	67 ± 14	100 ± 4
	5	89 ± 4	18 ± 6	95 ± 8
	20	89 ± 7	26 ± 15	97 ± 7
Ethyl	1	80 ± 16	20 ± 10	98 ± 6
	5	0	1 ± 1	0
	20	0	0	0
Methyl	1	0	2 ± 4	104 ± 10
	5	0	2 ± 2	0
	20	0	0	0
Phenyl	1	82 ± 7	19 ± 20	98 ± 9
	5	43 ± 29	6 ± 8	95 ± 7
	20	0	4 ± 3	94 ± 8
Propyl	1	85 ± 7	93 ± 6	95 ± 19
	5	49 ± 17	4 ± 47	3 ± 25
	20	0	2 ± 2	0

Table 4. Shoot growth inhibition of barnyardgrass, redroot pigweed, and pea by exposure to isothiocyanate vapors in sealed plastic containers.

Isothiocyanate R-group	Air concentration	Shoot growth		
		Barnyardgrass	Redroot pigweed	Pea
	ppm	% of nontreated control		
Allyl	1	31 ± 11	6 ± 7	82 ± 26
	5	2 ± 5	1 ± 1	32 ± 29
	20	0	0	0
Benzyl	1	40 ± 3	6 ± 4	92 ± 15
	5	19 ± 8	3 ± 2	105 ± 8
	20	2 ± 1	2 ± 1	90 ± 10
Butyl	1	26 ± 7	15 ± 4	67 ± 15
	5	18 ± 5	3 ± 2	73 ± 19
	20	1 ± 1	2 ± 1	42 ± 29
β-phenylethyl	1	27 ± 9	10 ± 4	103 ± 18
	5	16 ± 5	6 ± 4	100 ± 18
	20	9 ± 5	4 ± 2	94 ± 12
Ethyl	1	41 ± 6	11 ± 7	89 ± 18
	5	0	1 ± 1	0
	20	0	0	0
Methyl	1	0	1 ± 1	116 ± 21
	5	0	1 ± 2	0
	20	0	0	0
Phenyl	1	5 ± 5	3 ± 2	108 ± 14
	5	1 ± 1	3 ± 3	83 ± 8
	20	0	2 ± 1	36 ± 6
Propyl	1	39 ± 6	45 ± 16	94 ± 26
	5	23 ± 3	3 ± 4	66 ± 20
	20	0	1 ± 1	0

SOIL SOLARIZATION FOR WEED CONTROL IN THE LOWER COLORADO RIVER DESERT. Carl E. Bell, Weed Science Farm Advisor, University of California Cooperative Extension, Holtville, CA 92250.

Abstract. Soil solarization is a method of soil disinfestation by heat which uses clear polyethylene tarps placed over moist soil during periods of intense sunlight and heat. This process has the potential to substitute for herbicide use in areas with warm summers and fall sown vegetable crops. The Lower Colorado River Desert encompasses agricultural valleys in southeastern California and southwestern Arizona which have the appropriate climate and cropping seasons for soil solarization.

Research on soil solarization has been conducted in the Imperial Valley of southeastern California from 1980 through 1995. This paper is a brief review of that research along with consideration of future research needs, the potential for grower adoption of solarization, and the possibilities for adoption of solarization in other areas of the southwestern U.S.

Soil solarization in the Imperial Valley has focused on adapting the process to vegetable production on raised beds. Solarizing bed tops as strips in the fields rather than flat tarping has positive and negative aspects. Positive attributes are cost saving, since less plastic is required; limiting treatment to a smaller overall proportion of the field; avoid mixing untreated and treated soil after the process is completed, the plastic tarp is removed, and the beds are made. Negative attributes of strip tarping are that weeds are not killed in the irrigation furrows and that less heat is accumulated under the tarp because there is more heat loss from the edge of the strip. When the solarization process is started in early summer and the tarp is left in place for at least 4 weeks, annual weed control can approach 100%, except for certain tolerant species.

In the Imperial Valley, about 1000 A were solarized during the summers of 1994 and 1995. All of this was for production of organic carrots. Carrots are an example of a crop that is ideally suited for solarization for two reasons. One is that they are fall planted in the desert. Another is that carrots are sown with 6 to 8 seedlines on the top of a bed 22 inches wide, leaving no room for mechanical cultivation or hand weeding. Growing carrots without a herbicide requires a soil disinfestation process, such as fumigation or soil solarization. Another fall planted crop that could benefit from solarization is onions, also grown in several seedlines on a bed top. The benefit of solarization to vegetable weed control is less obvious in crops such as lettuce and broccoli that are easy to cultivate and hand weed. In the immediate future, solarization will most likely be adopted in warm areas by organic growers or those trying to avoid herbicide use. It would also have a place on small scale farms with a diversity of crops, since there are no concerns about herbicide registrations or rotations.

Research efforts for solarization should focus on technical issues regarding plastics and improving control of perennial and problem weed species. A parallel effort is required to determine barriers to grower adoption and to incorporate methods to ameliorate these barriers. Economic studies would also be useful to compare the benefits of soil solarization, which also control soil diseases and nematodes in addition to weeds, to alternative control methods. The overall cost of solarization, currently about $300/A, may actually be less in some crops than the conventional methods.

SEED WEEVIL (*ANTHONOMUS TENUIS*) PREFERENCES FOR BROOM AND THREADLEAF SNAKEWEEDS. Joyce B. Payne, Mona Ahmed Hussein, David B. Richman, Graduate Student and Science Specialist, Department of Entomology, Plant Pathology and Weed Science, New Mexico State University, Las Cruces, NM, 88003, and Research Assistant, National Research Center, Department of Plant Protection, Biological Control Section, Cairo, Egypt.

Abstract. Broom and threadleaf snakeweeds are woody perennials found throughout southwestern rangelands. Given the opportunity, snakeweed will overcome an area and become the dominant plant species. Snakeweeds reproduce by seed production with each plant producing an average of 10,000 seeds/year. The seed weevil is part of the host-specific insect complex that attacks snakeweed plants. The adult weevils are plant tissue feeders. The immature or larval stage feeds on developing seed heads in the flower capitula of snakeweed plants. Although the feeding of the adult weevil does little to diminish the capacity of the parent plant, the ability of the weevil larvae to control future snakeweed outbreaks by destruction of the seeds has great potential. Bioassays to investigate feeding and ovipositional preferences were conducted in 1994 using weevils from Torrance and Lincoln Counties, NM and in 1995 using weevils from a common garden of snakeweed maintained at the Leyendecker Research Farm in Dona Ana County, NM, which contains both broom and threadleaf snakeweeds in a randomized complete block arrangement, and from rangeland plots in Socorro, NM, which are a monoculture of broom snakeweed.

Broom and threadleaf snakeweed stems, flowering (1994 and 1995) and non-flowering (1995), were used in the double-choice feeding bioassays. Snakeweed plant stems were collected from labeled plants in the Leyendecker plots. Stems of broom and threadleaf snakeweed were placed on opposite sides of a five inch petri dish lined with filter paper. Ten weevils were placed in a petri dish for each replication. In 1994, the weevils were kept in the petri dishes for 12 days. The number of weevils on each snakeweed stem was counted daily and stems were changed as needed. In 1995, the weevils were kept in the petri dishes for 1 hour and the number of weevils on each stem was counted and recorded. A total of 200 weevils were tested on flowering stems in 1994 and in 1995, 100 weevils were tested on non-flowering stems and 400 weevils on flowering stems. For the ovipositional experiment, 800 (1994) and 300 (1995) capitula of both snakeweeds were dissected to determine larval presence.

The data from the double-choice feeding bioassays suggests that the adult weevils will feed on either snakeweed. However, after 2 to 3 days they tended to favor the broom snakeweed. It is not clear if the adult

weevils have a feeding preference or if the onset of an egg laying period motivated female weevils to migrate to the broom snakeweed. The weevils displayed an ovipositional preference for the broom snakeweed capitula. In 1994, 190/800 and in 1995, 6/300 broom snakeweed seeds were infested with weevil larvae. The larvae were not found in any of the threadleaf capitula either year. These findings convince us that further investigations into the biology of the seed weevil are needed to understand the role this insect plays in the control of snakeweed on rangeland.

EFFECTS OF CONTROLLING RANGELAND INSECT PESTS ON NATURAL ENEMIES OF A PERENNIAL RANGELAND WEED. Justin L. Knight and David C. Thompson, Graduate Assistant and Assistant Professor, Department of Entomology, Plant Pathology and Weed Science, New Mexico State University, Las Cruces, NM 88003.

Abstract. Weeds and insect pests are problems on rangeland throughout the western United States. In many instances native insects are very important in suppressing weed populations. Many ranchers are questioning whether a weed may become more of a problem after controlling pest insects because the natural predators of the weed are also eliminated. To test this theory, we used a model system in northeastern New Mexico where broom snakeweed, *Gutierrezia sarothrae*, was the primary weed, range caterpillar, *Hemileuca oliviae*, was the primary insect pest and native snakeweed biological control agents were common. Two separate experiments were established to determine the effect of treating range caterpillars on the biological control agents of broom snakeweed.

In the first experiment 20 pastures (>100 ha each) that had been treated to control range caterpillars at least once in the last 10 years, and a corresponding untreated site for each, were sampled to determine if the biological control agents of broom snakeweed were influenced. Root feeding insects were sampled by digging up 40 plants along a transect in each pasture, recording crown size, evidence of root boring activity, and number of live root borers. Above ground insects were sampled by taking one hundred sweeps in each pasture. In the second experiment, samples were taken from 20 small (0.4 ha) plots that had been treated for 3 consecutive years at two different locations in N.M. At each location five replicates of four treatments -- permethrin (for range caterpillars), carbaryl (for range grasshoppers), carbofuran (insecticidal check), and a control (no insecticide) were established. Above ground insects were sampled by taking one hundred sweeps per plot each month during the summer and root feeding insects were sampled once at the end of the study using the same methods as in the first experiment.

Densities of root-boring snakeweed biological control agents were not different between treatments in either of the experiments. In fact, the percentage of live root borers found in snakeweed was positively correlated with the number of years that a pasture had been treated. However, densities of aboveground snakeweed feeding insects were less in the treated plots as compared to the untreated plots.

THE BEHAVIOR OF *APHTHONA NIGRISCUTIS* AND THE RESPONSE OF LEAFY SPURGE OVER A FOUR YEAR PERIOD IN FREMONT COUNTY WYOMING. John L. Baker, Nancy A. P. Webber, Kim K. Johnson, and Robert L. Lavigne, Supervisor, Research Associate, Research Associate, Fremont County Weed and Pest, Lander, WY 82520, and Professor, University of Wyoming, Plant, Soil, and Insect Sci., Laramie, WY 82071.

Abstract. *Aphthona nigriscutis* was released in Fremont County in 1990 at a location west of Lander, WY. These sites have been monitored for establishment and development of the insect and its impact on leafy spurge each summer. Data has been collected on emergence date, a degree day model, rate of spread, interference from

harvesting of insects for redistribution, and adaptation of the insect to differing habitats at the site. Impact on the leafy spurge over time was measured using photo points and point frame analysis of the changing plant community along 100 foot transects radiating from the point of release. Maps of insect distribution were developed using a global positioning system (GPS) and geographical information system (GIS) software. Data reflects *A. nigriscutis* emergence can be predicted using a degree day model, spread from the point of release is random, spread into irrigated pastures is rapid, acceptance of the insect toward leafy spurge which has been sprayed with 2,4-D amine is good and integrated herbicide:biological:grazing control systems are possible. Over 1 million insects were removed from these sites in 1994 and 1995 for redistribution. Locations that were heavily exploited show increased leafy spurge density within the area of infestation and reduced rate of spread as compared to other sites. As the leafy spurge plant density decreases under insect pressure, bare ground decreases, while other forbs and grasses increase.

THE ECONOMICS OF CONTROLLING RUSSIAN KNAPWEED. Bridger M. Feuz, James J. Jacobs, Larry J. Held, and Thomas D. Whitson, Graduate Student, Professor, Professor, Department of Agriculture Economics, University of Wyoming, Laramie, WY 82071, and Professor, Department of Plant, Soil and Insect Science, University of Wyoming, Laramie, WY 82071.

Abstract. It is expected that economic impacts caused by an infestation of Russian knapweed, or other similar invaders, can be severe. Intuitively it is realized that a loss of usable production must occur. Therefore an integrated method of control, using herbicides and perennial grasses, was established near Riverton, WY to determine if controlling Russian knapweed has the potential of generating economic benefits.

Two test sites were established in 1991, and consist of five perennial grasses associated with five different treatments. The following grasses were used: 'Hycrest' crested wheatgrass, 'Sodar' streambank wheatgrass, 'Crytana' thickspike wheatgrass, 'Rosana' western wheatgrass, and 'Bozoisky' russian wildrye. Each of the grasses was combined with the herbicides clopyralid plus 2,4-D, metsulfuron, picloram, mowing, and burning.

Production data was collected in 1994 and 1995, and analyzed using capital budgeting. Dollar values were assigned to the production based on grass hay prices. For the areas treated with clopyralid and 2,4-D, production on site one averaged over 2 yr ranged from 869 lb/A of 'Rosana' western wheatgrass to 1274 lb/A of 'Hycrest' crested wheatgrass, and site two ranged from 2666 lb/A of 'Rosana' western wheatgrass to 4611 lb/A of 'Hycrest' crested wheatgrass. At $70.00/T and an average yield of 3535 lb/A site two would break-even in 5 years. At $70.00/T sites would require an average yield of 1355 lb/A to break-even in 15 years.

DOES CHAFF COLLECTION PAY? A SIMULATION MODEL OF COMBINE WEED SEED DISPERSAL. Steven J. Shirtliffe, Martin J. Entz, and Bruce D. Maxwell, Graduate Student, Associate Professor, Department of Plant Science, University of Manitoba, Winnipeg, MB, Canada, R3T 2N2, and Assistant Professor, Plant, Soil and Environmental Sciences Department, Montana State University, Bozeman, MT 59717.

Combine harvesters have the potential to disperse weed seeds. Seed dispersal results from combine movement down the field while the weed seeds are being processed prior to a portion of them being returned to the field with chaff and straw. Chaff collection systems have been developed that collect the chaff as it is expelled from a combine and transfer it to a wagon where it is dumped in a pile in the field where it is latter picked up and can be fed to cattle. The aim of this study was to quantify the spread of wild oat seeds from a combine passing through a patch and to determine if the collection of the chaff fraction of residue will reduce the spread and the amount of wild oat seeds returned to the field. The dispersal data is also integrated into a computer simulation model along with parameters collected from field studies in Montana in order to determine the long term economic benefit related to weed control of a chaff collection system.

Wild oat seed dispersal was determined by placing seed traps every 5 m for the first 40 m and every 10 m up to at a distance of 120 m in the path of a combine passing through a 7.5 m wide wild oat patch. The field was combined with a harvester either equipped or not equipped with a chaff collection system. The wild oat seeds were later separated from the residue. This data was incorporated into a spatial simulation model that was conducted on a scale of 1 m^2 with a size of 80 m^2 and was run for 10 years.

When chaff was returned to the ground five times as many wild oat seeds were deposited on the ground when compared to chaff collection. The spread of wild oat seeds was also reduced. Chaff collection resulted in an eight fold reduction in the amount of wild oats spread beyond the patch when compared with chaff return. In a 10 year simulation of chaff collection with no herbicide application there was little movement of the initial weed patch. When chaff was returned to the field the resulting increase in seed dispersal resulted in the simulation area being completely infested with wild oats. Economic analysis revealed that chaff collection resulted in higher annualized net returns when herbicides were used infrequently or not used within a cropping system. Chaff collection is a tool that can provide producers with weed control benefits of reduced wild oat patch expansion under reduced herbicide applications.

WEEDS OF RANGE AND FOREST

HERBICIDAL CONTROL OF SOME ALIEN PLANTS INVADING HAWAII FORESTS.

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INTRODUCTION

Since the discovery of Hawaii by the west, many plants have been introduced for food, as ornamentals, and, ironically, for soil and water conservation in denuded forests. Many of these species are now naturalized and threaten the integrity of native forests. State and federal agencies are conducting a number of projects aimed at managing alien species invading native forests. Herbicide-based management strategies offer more efficiency, economy and safety than mechanical-based methods. In rain forests, herbicidal methods precludes resprouting of shoot and root fragments left on the forest floor, is more labor efficient, reduces the use of sharp implements and power tools, and does not disturb the soil surface. However, for remote forest areas, application methods would be ideal if they did not require heavy and bulky material.

In cooperation with the Hawaii Department of Land and Natural Resources and the Hawaii Department of Agriculture, the University of Hawaii undertook trials to develop herbicide-based control methods for five alien plant species naturalized in forests of Hawaii.

MATERIALS AND METHODS

Karakanut. Karakanut is a tree from New Zealand with dark green, leathery leaves. The pulp of the fruit is edible and although the kernel is poisonous raw, the Maoris have learned to cook it to detoxify it. Karakanut was introduced into Hawaii prior to 1891 and was naturalized by 1912. In 1929, the territorial government had Karakanut spread by air over Kauai forests. As a result, it is most common on that island but is also found on Oahu, Molokai, and Hawaii (4).

At the Kokee State Park on Kauai, karakanut trees, 12 to 20 cm basal diameter, were treated by applying an undiluted herbicide into notches cut around the circumference of the base of the trunk, at 20 cm between cuts. One ml of herbicide was applied to each cut. Treatments were blocked according to trunk diameter and replicated 10 times. The herbicides evaluated were 2,4-D, dicamba, glyphosate, and triclopyr. The results were evaluated at 6 months after treatment. Plant injury for all trials reported herein were scored visually on a 0 to 100 scale, 0 being no effect, 100 indicating plant death. Statistical analyses were made on arcsin transformed data (2).

Highbush blackberry. Highbush blackberry is native to central and southern United States and was introduced into Hawaii in the late 19th century. The first recorded collection was in 1904 (4). It is found on Kauai, Oahu, Maui, and Hawaii in both forests and pastures. By 1979, it infested 80,000 ha (3). Foliar application of dicamba at 2 kg/ha, picloram at 0.5 kg/ha, and triclopyr at 1 kg/ha were evaluated on blackberry shrubs 1.5 m in diameter in a pasture in the Kona district. Applications were made with a CO_2-powered sprayer, at 1.44 kP, with four 8003 LP flat fan stainless steel nozzles on a boom. The treatments were replicated 10 times, completely randomized. The response was evaluated at 3 months after treatment.

Miconia. Miconia is one of 14 melastomes naturalized in Hawaii. A large shrub, it has large leaves (70 cm long) with pronounced venation typical of the *Melastomaceae* and purplish undersides. This makes for an attractive ornamental for which it was imported ca. 1955. A native of tropical America, it is also a problem in Sri Lanka and Tahiti (4). In Hawaii, miconia infests forests on the windward, high rainfall sides of Hawaii and Maui. Because several of the melastomes are problems in Hawaii, conservationists have proposed declaring the entire *Melastomaceae* noxious. A basal application trial was installed in windward Hawaii on plants with basal diameters of 7 cm to 14 cm. The plants were treated cut-surface with 2,4-D, dicamba, glyphosate and triclopyr; basal bark with 2,4-D, 2% product in diesel oil; imazapyr, ready-to-use formulation; triclopyr, 2% product in diesel; and tebuthiuron soil-applied in one meter radius around the target plant at 2 kg/ha. Treatments were replicated 10 times, completely randomized. Plant injury was evaluated at 4 months after treatment.

Australian tree fern. The Australian tree fern, native to Queensland, was a recent ornamental introduction to Hawaii. It is naturalized on Kauai, Oahu, and Maui, having escaped from domestic and botanical gardens. It is a fast growing plant (1) and its height and canopy breadth precludes foliar applications of herbicides. The standard control measure was to fell the tree and chop the apical meristem into pieces (1). If the terminal meristem area were not so destroyed, the tree fern would resume its upward growth. To develop a safer more effective control measure, a trial was conducted at the Kokee State Park, where Australian tree fern had become naturalized after escaping from vacation homes within the park that are leased to individuals by the state. Undiluted 2,4-D, dicamba and triclopyr were applied to the terminal shoots of plants 1 m to 2.5 m tall and evaluated 10 months after treatment. The use of herbicide concentrates and household plastic spray bottles were intended to reduce the size and weight of material for working in remote forest areas. Ten replicates were installed, completely randomized.

Mulesfoot fern. Mulesfoot fern, a native of Southeast Asia, has a short trunk but large fronds that make a wide canopy. It is a recently introduced ornamental now spreading into the Waiakea Forest near Hilo. Ear-like stipules at the base of the fronds contain meristematic tissue and are capable of regenerating new plants. Thus chopping the terminal as is done with the Australian tree fern would not be effective on the mulesfoot fern. Undiluted dicamba and triclopyr applied to the terminal shoots was evaluated in the Waiakea Forest. Seven replicates were installed, completely randomized and evaluated at 3 months after treatment.

RESULTS AND DISCUSSION

Karakanut. Cut-surface applications of glyphosate and triclopyr caused more severe injury to karakanut trees than 2,4-D or dicamba (Table 1). Although there was no significant difference in injury ratings between glyphosate and triclopyr, glyphosate treatment killed 80% of the treated trees whereas triclopyr killed 40%. This method is suitable for remote areas of forests as the volume herbicide and the equipment needed are very portable.

The Hawaii Department of Agriculture and the United States National Park Service are cooperating on a trial on Maui in which tall miconia were treated individually with triclopyr through a single nozzle suspended from a helicopter. Initial observations indicate that miconia is susceptible to triclopyr (E. Tamura, Hawaii Department of Agriculture, pers. comm.).

Highbush blackberry. Foliar applications of picloram and triclopyr were both effective in controlling highbush blackberry at one month after treatment, dicamba was not (Table 2). Although the trial was scheduled to go on longer, the rancher had the entire paddock sprayed with 2,4-D. Nevertheless, based on the severity of the injury at one month, it was felt that both triclopyr and picloram should be recommended for highbush blackberry control. Although a more convenient method for remote parts of the forest would be desirable, there appears to be no alternative to foliar applications to control brambles of blackberry.

Miconia. Cut-surface applications of 2,4-D, and dicamba, soil-applied tebuthiuron and basal bark application of 2,4-D were inadequate for controlling miconia. Triclopyr and glyphosate applied cut-surface and triclopyr and imazapyr applied basal bark were effective (Table 3). Cut-surface treatment with glyphosate or triclopyr would probably be preferred over basal bark treatments as diesel oil is noxious to use and must be transported on foot in remote areas of forests.

Table 1. Karakanut control by cut-surface applications of undiluted herbicides at 6 months after treatment.

Treatment	Injury rating[a]	Kill
		%
Check	5	0
2,4-D	68^{b}	10
Dicamba	78^{b}	10
Glyphosate	99^{a}	80
Triclopyr	94^{a}	40

[a]Means followed by different letters are significantly different by LSD test, $p=0.05$.

Table 2. Control of highbush blackberry by foliar applications of herbicides at 1 month after treatment.

Treatment	Rate	Injury rating[a]
	kg/ha	
Check		0
Dicamba	2	43^{c}
Picloram	0.5	88^{b}
Triclopyr	1	95^{a}

[a]Means followed by different letters are significantly different by t-test, $p=0.01$.

Table 3. Control of miconia by basal applications of herbicides at 3 months after treatment.

Herbicide	Method of application	Injury rating[a]	Kill
			%
Check	---	0	0
2,4-D	cut-surface	64^{b}	20
Dicamba	cut-surface	63^{b}	10
Glyphosate	cut-surface	90^{a}	40
Triclopyr	cut-surface	92^{a}	40
Tebuthiuron, 20kg/ha	soil applied	9^{c}	0
2,4-D, 2% in diesel	basal bark	57^{b}	10
Imazapyr, RTU	basal bark	98^{a}	60
Triclopyr, 2% in diesel	basal bark	99^{a}	80

[a]Means followed by different letters are significantly different by LSD test, $p=0.05$.

Table 4. Control of Australian tree fern by application of herbicide concentrates to the apical shoots at 10 months after treatment.

Treatment	Injury rating[a]
Check	3
2,4-D	75^{ab}
Dicamba	94^{a}
Triclopyr	62^{b}

[a]Means followed by different letters are significantly different by t-test, $p=0.05$.

Australian tree fern. Dicamba caused more severe injury than triclopyr and 2,4-D results were not significantly different from that of dicamba or triclopyr (Table 4). Although target-plant injury was severe by the most effective treatment, a higher rate of kill was desirable. Better coverage of the terminal shoot area or enhancement of uptake may be needed to provide more effective control. Some dilution of the herbicide and the addition of a surfactant for better uptake and an increase in spray volume for better coverage may improve efficiency of dicamba and 2,4-D.

Mulesfoot fern. In contrast to the results achieved by herbicide application to the terminal shoots of Australian tree fern, the method was ineffective on mulesfoot fern with both dicamba and triclopyr (data not presented). More effective penetration of meristematic tissues by herbicides is probably needed, perhaps by applying ester formulations in diesel or esterified vegetable oils.

CONCLUSION

Effective basal application methods, suitable for working remote areas of forests were developed to control karakanut and miconia. Highbush blackberry was susceptible to foliar applications of triclopyr and picloram, but no effective method was conveniently portable for transport on foot throughout the forest. Terminal applications of dicamba or 2,4-D were promising for controlling Australian tree fern, but the method needs refining. Further research is needed to devise control measures for mulesfoot fern.

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GREENLEAF MANZANITA CONTROL WITH 2,4-D, 2,4-DP AND IMAZAPYR. Bruce R. Kelpsas and Byron D. Carrier, Northwest Chemical Corporation, Salem, OR 97303 and Weyerhaeuser Company, Springfield, OR 97477.

Abstract. Greenleaf manzanita is a common woody associate found in many commercial ponderosa pine stands on drier sites in Oregon and many western states. Manzanita competes effectively for soil moisture on these sites and is often targeted for control with mechanical or chemical methods. Several field trials were installed in 1994 and 1995 to determine effective herbicides and rates for manzanita control and to a lesser degree, pine tolerance.

Individual manzanita shrubs were tagged and groups of seven to ten plants were randomly selected for each treatment on each site. All plants were sprayed with a gas operated backpack sprayer and handheld six-nozzle boom calibrated to deliver 10 gpa with 8002 spray tips. Two sites were treated in May of 1994 for manzanita; a smaller subset of treatments was repeated in May of 1995 on a third site for shrubs and pines. Two rates of 2,4-D (1.9 and 3.8 lbs/A), 2,4-DP (2 and 4 lbs/A) or imazapyr (0.19 and 0.38 lbs/A) were applied to manzanita plants. The two rates of imazapyr were also tank mixed with the 2,4-D or 2,4-DP treatments to determine if tank mixes offer broader control. A partial set of herbicide treatments contained a crop oil

concentrate (2.5% v/v) to assess its contribution for manzanita control. Shrubs were visually evaluated for percent crown kill at four and 16 months after treatment (MAT). Pine seedlings were evaluated for vigor at 4 MAT.

Manzanita was controlled effectively with either 2,4-D or 2,4-DP. Both the low and high rate of either compound resulted in 90 to 100% crown kill 4 MAT. At 16 MAT most crowns still had a net crown kill of more than 90% except for the low rate of 2,4-DP at 74%. Imazapyr treatments were inferior to either 2,4-D or 2,4-DP and resulted in crown kill ratings of 2 to 10% 16 MAT. The addition of imazapyr to 2,4-D or 2,4-DP contributed little if any improvement in control over those compounds alone. Crop oil additions to any compound made small and variable differences in control. Ponderosa pine seedlings were least affected by the low rate of 2,4-DP and showed vigor ratings close to the untreated controls. Treatments containing 2,4-D reduced pine vigor the most with many trees near mortality. Imazapyr treatments were intermediate in vigor reduction.

SURVIVAL AND GROWTH OF YOUNG PACIFIC NORTHWEST CONIFERS IN VARIOUS SIZED VEGETATION-FREE AREAS. Robin Rose and J. Scott Ketchum, Professor and Research Assistant, Department of Forest Science, Oregon State University, Corvallis, OR 97331-7501.

Abstract. Responses of Douglas-fir seedlings were studied for 3 years following eight vegetation control treatments in three western Oregon clearcuts. The objectives were to determine seedling growth response to different sizes of spot vegetation control (centered on seedling), and to determine the relative influence of woody and herbaceous competition on seedling growth. Spot herbicide treatments, maintained vegetation free for 2 years, varied from no control to a 5 foot radius of control at 1 foot radius increments. Additionally, a treatment consisting of complete control of woody vegetation only and another treatment consisting of complete control of herbaceous vegetation only were examined. This experiment was replicated on three sites of differing climatic and soil conditions. Seedling volume increased with increased radius of control up until a 3 foot radius on all sites. Response of seedlings to greater than 3 foot radius of vegetation control varied among study sites, this variability resulted from differing effectiveness of the treatments on invasive competitors specific to each site. On all study sites, control of herbaceous only vegetation resulted in significantly ($p < 0.05$) greater third year stem volume than control of woody only vegetation. In the first and third growing seasons, little difference was observed in relative growth rate among treatments. However, second year relative growth rates varied significantly ($p < 0.05$) with the maximum relative growth rates occurring in treatments of three foot radii or better. These differences in second year relative growth rate are responsible for differences observed in seedling size in year three and have the potential to influence these seedlings through the entire rotation.

BROOM SNAKEWEED SEEDLINGS IN THE CHIHUAHUAN DESERT. 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 from November 1994 through February 1995 produced abundant broom snakeweed seedlings on the Chihuahuan Desert Rangeland Research Center (CDRRC) near Las Cruces, NM. This provided the opportunity to study seedling establishment and survival through the 1995 growing season. Vegetation of the CDRRC is typical of the Chihuahuan desert with black grama considered to be an indicator of a high seral stage and mesquite/mesa dropseed indicative of low seral vegetation. Precipitation on the CDRRC averages 235 mm per year but during the usually moist summer months rainfall was less than 70% of the average in 1995.

Study sites were established in both grazed and non-grazed (exclosure) areas within four vegetation types: black grama grassland (BGG), mesquite-black grama mix (BGM), mesa dropseed grassland (MDG), and mesquite-mesa dropseed mix (MDM). Within each site, forty parent plants were permanently marked along four parallel 100 m line transects. In June 1995, parent plants were measured to determine volume and given a vigor rating. The number and distribution of seedlings, around each parent were mapped within a 2 m diameter frame centered over each plant. Plant cover and species composition data was also recorded within each frame. Measurements were retaken in September to determine snakeweed seedling survival.

Herbaceous plant cover was less than 15% on all sites, whereas bareground comprised 80% and litter 5% of the total ground cover. Parent plant volume was highest in the ungrazed BGM, averaging 1.3 m^2/plant, and lowest was on the grazed BGG, averaging 0.6 m^2/plant. About 50% of all parent plants died during the study while 20% remained healthy and the remaining 30% were in some state of decadence. In June, the grazed sites averaged 2.7 seedlings/m^2 and the non-grazed sites averaged 1.3 seedlings/m^2 irrespective of vegetation type. The highest number of seedlings were recorded in the grazed BGM (4.8 seedlings/m^2) and the lowest number were counted in the non-grazed BGG (0.2 seedlings/m^2). Most seedlings were found between 0.5 m and 1 m from the center of the parent plant, and the majority were distributed on the leeward side(east). Snakeweed seedling mortality ranged between 57% (MDM) and 97%(BGG) for the grazed sites. Mortality on the non-grazed sites was between 74%(BGG) and 88%(BGM).

SUCCESS AND TREATMENT LIFE OF CHEMICAL BROOM SNAKEWEED CONTROL ON NEW MEXICO RANCHES. C. L. Townsend[1], L. A. Torell[1], and, K. C. McDaniel[2], Research Assistant, Professor and Professor, [1]Department of Agricultural Economics and [2]gricultural Business, Department of Animal and Range Sciences, Las Cruces, NM 88003.

Abstract. Broom snakeweed is a common weed on New Mexico rangelands and during the 1980s many livestock operators invested in herbicide treatments in an attempt to control the plant. In 1989 a survey of these ranchers was conducted to determine treatment success and producer's perceptions of the value of controlling broom snakeweed. A second survey of these same ranchers was conducted in 1994 to gather more information about treatment life and to determine how perceptions of treatment success had changed.

Data collected from surveyed areas was used to estimate an average treatment life of about 4 years; however, results were highly variable. In general the perceptions by ranchers about the treatment success corresponded positively with the length of treatment life. In 1994, approximately half of the ranchers surveyed indicated they would use chemical treatments again. Half believed the physical success of the treatment to be effective and 40% believed the economic success of spraying broom snakeweed to be good. Treatment life, forage response, and the short-lived cyclic nature of broom snakeweed are important considerations when choosing whether to control the weed. These uncertainties make management decisions difficult.

RESPONSE OF BROOM SNAKEWEED AND SHRUBBY BUCKWHEAT TO A SUMMER PRESCRIBED BURN IN CENTRAL ARIZONA. John H. Brock and Susan Pierce, Professor and Research Student, Environmental Resources Program, School of Planning and Landscape Architecture, Arizona State University, Tempe, AZ 85287-2005.

Abstract. Six hundred ha of desert grassland in central Arizona on the Prescott National Forest was treated with a prescribed burn on June 28, 1994. This burn period proceeds the summer thunderstorm season characteristic of the basin and range region of the western United States. The objectives of the fire were to stimulate rangeland recovery by suppressing the growth of invading woody plants and undesirable herbaceous plants while

promoting positive responses of non-target species such as tobosa grass and associated plants. The study area was sampled pre-fire for vegetation density and cover in early June 1994 from approximately 100 randomly located sample points. At each point a 100 m^2 (2 by 50 m) belt transect was established from which data such as woody plant density and cover, and the number of half-shrub species such as broom snakeweed and shrubby buckwheat were recorded. These same points were sampled again at 3 and 15 months post-fire. Average pre-fire broom snakeweed density was 52.1 plants/100 m^2 while shrubby buckwheat density was 26 plants/100 m^2. Broom snakeweed is of interest because it competes for environmental resources at the expense of more desirable plants, and its poisonous potential to grazing animals. Shrubby buckwheat is considered a desirable browse species with a growth form comparable to broom snakeweed. At 3 and 15 months after fire, broom snakeweed density was reduced by 87 and 81% respectively, while shrubby buckwheat density was initially reduced by 45%, but increased to 191% of the pre-fire density 15 months after the fire. Fire has been an historic weed control agent in western rangelands, and the sustainability of most grassland ecosystems, including this desert grassland, is enhanced by periodic fire events.

ECOLOGICAL IMPLICATIONS OF RUSSIAN KNAPWEED (*CENTAUREA REPENS* L.) INFESTATION: SMALL MAMMAL AND HABITAT ASSOCIATIONS. Gregg L. Kurz, Richard A. Olson, and Thomas D. Whitson, Graduate Research Assistant and Professor, Department of Rangeland Ecology and Watershed Management, and Professor, Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Adjacent Russian knapweed infested and native (non-infested) plots established in 1993 at Boysen Reservoir, Fremont County, WY and near Craig, Moffat County, CO were sampled in 1994 and 1995. Randomly located permanent vegetation transacts were established in each plot in 1993. Point-frame sampling was executed at intervals along each transect to determine vegetative cover by species. Biomass and frequency measurements were attained via double sampling procedures. Curtis-McIntosh importance values for each plant species were used to identify plant community dominants and to develop estimates of alpha and gamma scale diversity. Mark-and-recapture data were used to generate Schnabel estimates of small mammal abundance as well as alpha and gamma scale diversity estimates. Vegetation measurements indicated major differences in structure and composition between plant communities in knapweed infested and noninfested plots. Assessments of diversity at the alpha scale did not show strong differences between the plant or small mammal communities in the infested and non-infested plots. However, diversity comparisons at the gamma scale show a large shift in species composition for both the small mammal and plant communities, indicating a displacement of native species. This displacement of native species constitutes a loss of rangeland biodiversity at the gamma and epsilon scales.

CHEMICAL AND BIOLOGICAL CONTROL TECHNIQUES FOR RUSSIAN KNAPWEED. Rick M. Bottoms[1], Tom D. Whitson[2], and David W. Koch[2], Extension Agronomist, Extension Weed Specialist and Extension Agronomist, [1]University of Missouri, Columbia, MO 65201 and [2]University of Wyoming, Laramie, WY 82071.

INTRODUCTION

Russian knapweed is difficult to control perennially found throughout the western United States, and the most persistent of the knapweeds (7). It competes with desirable forage and is of no value to cattle producers. However, control can be maintained for only 3 to 5 years. After this time a retreatment program must be implemented to maintain adequate control.

Although herbicides play an important part in the control of Russian knapweed, alternative methods are available and may be used where persistent herbicides cannot be tolerated. This type of approach of integrated weed management is a multidisciplinary, ecological approach to managing weed populations. There is no example of an extensive noxious weed infestation being eradicated by a single method (8).

One such complementary method is plant competition. Grass competition has long been recognized as a method of weed control. Crested wheatgrass has been used successfully in Saskatchewan, Canada to decrease the rate of vegetative spread, limit density, reduce seed production and suppress the growth of other perennial weeds.

Russian knapweed is highly competitive on disturbed sites and severely reduces land values. Russian knapweed is also allelopathic (6). Therefore, areas must be tilled before newly established grass seedlings can survive. Without tillage, grass seedlings can survive only after Russian knapweed residues have been exposed to moisture for two growing seasons.

Biological control of weeds is the planned use of living organisms to reduce the vigor, reproductive capacity, density, or effect weeds. This broad definition also encompasses competitive grass species (9). Many grass species are known to be well adapted for reseeding western rangelands. Wheatgrasses, fescues and wildryes are among the most commonly used. Selection of rhizomatous species are good choices where noxious weeds are a consideration (4). Grasses selected for these studies were Russian wildrye cv. Bozoisky, thickspike wheatgrass cv. Critana (*Agropyron dasystachyum*), streambank wheatgrass cv. Sodar (*Agropyron dasystachyum riparium*), crested wheatgrass cv. Hycrest (*Agropyron cristatum*), and western wheatgrass cv. Rosana (*Agropyron smithii*).

The purpose of this research was to determine the potential of perennial grass competition as an alternative to repetitive herbicide treatment and other cultural practices for control of Russian knapweed.

MATERIAL AND METHODS

Studies were established on the Wind River Indian Reservation near Arapaho and Ft. Washakie in Wyoming. Study sites were located on Lander Complex sandy loam soils and were treated with herbicides on 10 and 11 October, 1991. Plots were tilled with a rototiller May, 1991. Metsulfuron (8.5 g/ha), clopyralid (0.32 kg/ha) plus 2,4-D (1.65 kg/ha), and picloram (0.28 kg/ha) were applied in August 1992. All herbicides, except picloram, were reapplied in August 1994. Russian knapweed had started into winter dormancy during the 1991 application and in late bloom in 1992 and early bloom in 1994. Plots were seeded with streambank wheatgrass cv. Sodar, thickspike wheatgrass cv. Critana, crested wheatgrass cv. Hycrest, western wheatgrass cv. Rosana and Russian wildrye cv. Bozoisky at 11.2 kg pure live seed/ha, except Russian wildrye which was seeded at 6.6 kg/ha on 11 and 12 April 1992.

RESULTS AND DISCUSSION

Russian knapweed live canopy cover was reduced from an average of 58% (0% control) in the untreated unseeded checks to 99% in tilled and 97% in non-tilled, as well as 96% in tilled and 91% in non-tilled treatments of picloram and clopyralid plus 2,4-D respectively (Tables 1 and 2). There was no significant difference between grass varieties when compared to percent Russian knapweed cover. Reductions to 0% live canopy cover of Russian knapweed were obtained with a single application of picloram.

A vegetative inventory using Levy and Madden's point method of pasture analysis (5) was used to determine live species canopy cover. A point-frame containing 10 equidistant points spaced at 5 cm was located at ten 0.92-m intervals on a permanent 10.22-m transect line within each treatment replication. Three-hundred pinoint species identifications were taken to determine the species inventories per treatment. Counts for each species were converted to a percentage of the live canopy cover. Point transect readings were taken 12 and 13 June 1995, and 13 and 14 June 1995 at Arapaho and Fort Washakie respectively.

Stands of the five perennial grasses averaged 56% live grass cover in tilled and 52% live grass cover in non-tilled picloram treatments and 54% live grass cover in tilled and 47% live grass cover in non-tilled treatments of clopyralid plus 2,4-D compared to 21% and 19% for the untreated seeded tilled and non-tilled plots respectively (Tables 3 and 4). The two grasses having the highest overall establishment in tilled plots were streambank wheatgrass cv. Sodar with 45% live grass cover and thickspike wheatgrass cv. Critana with an average overall treatments of 42% live grass cover. The two grasses having the highest overall establishment in non-tilled plots were streambank wheatgrass cv. Sodar with 34% live grass cover and crested wheatgrass cv. Hycrest with 31% live grass cover. The lowest amount of Russian knapweed (0%) and the highest percent live cover of grass (79%) in non-tilled and 71% in tilled were found in plots treated with picloram and seeded to crested wheatgrass and western wheatgrass and thickspike wheatgrass, respectively.

Critana thickspike wheatgrass and Sodar streambank wheatgrass are very similar grasses. They are native perennial grasses which can be used to vegetate and reduce erosion disturbed sites such as mined lands, roadsides, recreation areas, and construction sites. Both are excellent for reseeding range sites that are severely eroded or that have low fertility. Both are also strongly rhizomatous and grow to 25 to 30 cm in height on good sites. They produce abundant, fine, light green leaves and form a tight sod under dryland conditions. Both have excellent seedling vigor and are adapted to medium- to coarse-textured soils. They grow in the 25- to 51-cm precipitation zone in the northern Rocky Mountains and adjacent Great Plains regions. Both adapt to elevations ranging from 610 to 2287 m (2). These grasses averaged the highest live grass cover in the tilled study.

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Table 1. Russian knapweed percent control in untilled land, Arapaho (AR) and Fort Washakie (FW), Wyoming.

	Metsulfuron		Clopyralid		Picloram		Mow		Burn		Untreated/seed		
Grass	AR	FW	AR	FW	AR	FW	AR	FW	AR	FW	AR	FW	Mean
Russian wildrye	39	55	100	86	100	98	56	50	27	58	41	54	67
Crested wheatgrass	74	30	99	94	100	97	60	44	40	30	50	37	63
Thickspike wheatgrass	63	61	93	98	99	100	45	59	51	51	48	55	69
Western wheatgrass	63	31	100	94	99	97	28	53	36	38	32	45	60
Streambank wheatgrass	53	42	99	100	100	100	51	53	46	46	48	49	66
LSD (0.05)													22
Mean	51		96		99		50		42		45		

Table 2. Russian knapweed percent control in no-till, Arapaho (AR) and Fort Washakie (FW), Wyoming.

	Metsulfuron		Clopyralid		Picloram		Mow		Burn		Untreated/seed		
Grass	AR	FW	AR	FW	AR	FW	AR	FW	AR	FW	AR	FW	Mean
Russian wildrye	56	60	98	90	100	98	42	51	55	49	48	51	67
Crested wheatgrass	51	38	99	90	100	100	46	59	42	38	44	43	63
Thickspike wheatgrass	39	45	99	81	100	86	44	64	38	56	41	39	61
Western wheatgrass	51	52	99	86	100	94	44	45	45	65	44	44	64
Streambank wheatgrass	36	49	98	76	100	99	49	69	60	66	54	57	71
LSD (0.05)													22
Mean	48		92		97		51		52		47		

Table 3. Percent grass cover on tilled land, Arapaho (AR) and Fort Washakie (FW), Wyoming.

	Metsulfuron		Clopyralid		Picloram		Mow		Burn		Untreated/seed		
Grass	AR	FW	AR	FW	AR	FW	AR	FW	AR	FW	AR	FW	Mean
Russian wildrye	24	26	63	56	68	57	17	13	11	12	14	12	31
Crested wheatgrass	55	8	66	22	69	31	36	6	29	13	32	9	31
Thickspike wheatgrass	42	45	59	61	71	57	28	35	24	27	26	30	42
Western wheatgrass	45	20	50	33	41	31	10	12	7	13	8	12	24
Streambank wheatgrass	45	31	56	69	70	69	33	40	30	28	31	34	45
LSD (0.05)													22
Mean	34		54		56		23		19		21		

Hycrest crested wheatgrass is a winter hardy, drought resistant bunchgrass. Although the new cultivar is well adapted to sagebrush and juniper vegetation sites (30 cm of annual precipitation), good to excellent stands have been established on shadscale, greasewood, and Indian ricegrass sites where annual precipitation is less than 20 cm. In southern areas, it is best adapted to elevations of 1500 m or more. The upper elevation limits are from 2590 to 2740 m. It performs well on a wide variety of soil types; however, it is particularly well adapted to sandy or sandy loam soils. In general, crested wheatgrass will not tolerate prolonged flooding and is only moderately tolerant of saline soils when compared to tall wheatgrass, quackgrass, or western wheatgrass (3). This grass had the greatest live grass cover in non-tilled plots along with Rosanna western wheatgrass.

Rosana western wheatgrass, a native perennial grass, was developed for reseeding depleted rangelands and abandoned cropland in Montana and Wyoming. Seedling vigor also makes Rosana a valuable grass for mine reclamation. The plants are blue-green, leafy, moderately fine stemmed, and easy to establish. Rosana is adapted to the moderately rolling topography of the northern Rocky Mountain region and the adjacent Great Plains. It does best on medium to fine textured soils and tolerates soils that are neutral to strongly alkaline. Rosana is adapted to areas with 30 or more cm of precipitation. Production is enhanced by extra moisture from irrigation or on overflow sites. Rosana forms a tight sod under dryland conditions. Rosana will produce excellent seed crops under irrigation (1).

Table 4. Percent grass cover on no-till, Arapaho (AR) and Fort Washakie (FW), Wyoming.

	Metsulfuron		Clopyralid		Picloram		Mow		Burn		Untreated/seed		
Grass	AR	FW	AR	FW	AR	FW	AR	FW	AR	FW	AR	FW	Mean
Russian wildrye	45	27	52	49	64	40	17	9	19	16	18	12	31
Crested wheatgrass	40	12	67	39	79	27	20	11	28	13	24	12	31
Thickspike wheatgrass	32	25	46	26	74	42	21	18	16	10	18	14	29
Western wheatgrass	36	18	53	38	79	22	19	13	24	22	21	17	30
Streambank wheatgrass	29	33	59	44	42	47	19	25	31	27	25	26	34
LSD (0.05)													22
Mean	30		47		52		17		21		19		

Because of their performance in these studies, Bozoisky Russian wildrye, Critana thickspike wheatgrass, Hycrest crested wheatgrass, Rosana western wheatgrass and Sodar streambank wheatgrass appear to provide effective competition with Russian knapweed when either clopyralid plus 2,4-D or picloram and specific tillage practices are applied. There is a need for continued long-term research to confirm that these grasses or others will effectively compete with this weed and reduce the amount of herbicides needed for control of Russian knapweed and other perennial weeds.

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THE ECONOMIC FEASIBILITY OF DEVELOPING A MANAGEMENT SYSTEM TO RECLAIM RUSSIAN KNAPWEED INFESTED RANGELAND FOR MULTIPLE USE. Lani J. Benz, K. George Beck, Tom D. Whitson, and D. W. Koch, Graduate Research Assistant and Associate Professor, Department of Plant Pathology and Weed Science, Colorado State University, Fort Collins, CO 80523 and Associate Professor and Professor, Plant Science Division, University Station 3354, University of Wyoming, Laramie, WY 82071.

Abstract. Russian knapweed is considered a serious habitat invader due to its aggressive nature and allelopathic properties. Annual production losses in rangeland and cropland are problematic in the arid western United States. Although herbicide treatments are temporarily effective, they are short term solutions that must be repeated each season. Two field experiments were initiated in 1993: Mead, CO and Riverton, WY. The split-

block design was replicated four times at each site. Whole plots were 9 by 30 m and were the five suppression treatments: mowing (initially at bud stage and again when regrowth reached bud stage); clopyralid plus 2,4-D (0.3 plus 1.7 kg/ha applied at late bloom stage); metsulfuron (42 g/ha applied at late-bloom stage); glyphosate (1 kg/ha applied first at bolting and again at full bloom); and the no suppression control. Split-blocks were 6 by 9 m and were over-seeded in November, 1993 with one of the perennial grass species: crested wheatgrass, Bozoisky wildrye, thickspike wheatgrass, streambank wheatgrass and no grass control at 8, 8, 10, 22, and 0 kg/ha of pure live seed. Species cover was measured each year in May, biomass and percent control were determined each year in August. Analysis of variance compared suppression treatments, seeded perennial grasses, and interactions between each. In 1995, Russian knapweed cover and biomass was greater in mowed and control plots compared to herbicide treated plots. A suppression treatment by seeded grass interaction was present.

THE USE OF FIRE TO CONTROL YELLOW STARTHISTLE AND ENHANCE PLANT DIVERSITY.

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Abstract. Around 1984, yellow starthistle began to spread rapidly through the Sugarloaf Ridge State Park in the northern Coast Range of Sonoma County, California. Within 5 years, nearly all open grassland areas were severely infested. In these infested areas, no existing control options were practical or acceptable. Consequently, in July 1993 and again in 1994, a 30 A plot was experimentally burned to evaluate the effect of surface fire on yellow starthistle control. At burn time, yellow starthistle was in the early flowering stage (<2% flower). In spring and summer 1995, vegetative cover and plant diversity were evaluated using point line transects. Biodiversity (species richness) was further accessed by counting the total number of species in quadrats of varying sizes. In July 1995, the same 30 A region and an additional 155 A were burned. Yellow starthistle soil seed banks were subsequently estimated in all three regions (no burn, 1995 burn, and 1993/1994/1995 burn).

Results demonstrate a dramatic reduction in total (85%) yellow starthistle vegetative cover (rosette stage in May) following two consecutive annual burns. Even at maturity (July), yellow starthistle cover was reduced by 62%. The effectiveness of burning for yellow starthistle control was reflected by a significant reduction in seeds/m^2 in the soil. After a single burn, the yellow starthistle soil seed bank was reduced by 74%, and after 3 years of burning the reduction was over 99%.

In addition to controlling yellow starthistle, burning had a beneficial effect on total plant diversity (species richness) and species evenness using the Shannon index. This increase in diversity was due to a higher number of forb (non-grass) species. Using both line transect and quadrat data, we determined the most common species showing greater prevalence in both burned and unburned sites. Six species, all non-natives, increased in both frequency and vegetative cover in the unburned sites. In contrast, 15 species were more prevalent in the burned sites. Of these, eight were California-native broadleaf species. Overall, the total native vegetative cover doubled after two consecutive annual burns. These results indicate that controlled burning can be an effective and natural tool for the management of yellow starthistle. This method also has the added benefit of stabilizing the ecosystem by increasing native plant diversity.

THE EFFECTS OF VARIOUS HERBICIDE APPLICATIONS ON GRASS SEED PRODUCTION AND DOWNY BROME. Tom D. Whitson[1], M. E. Majerus[2], R. D. Hall [1] and J.D. Jenkins [1], Extension Weed Specialist and Professor, Department of Plant, Soil and Insect Sciences, [2]Assistant Plant Materials Center Manager, Bridger, MT 59014; Coordinator Seed Certification, University Extension Educator, [1]University of Wyoming, Laramie, WY 82071.

Abstract. Control of downy brome in cool season grasses grown for seed production must be done before seed is harvested because seed cleaners cannot separate it from cool-season grass seed. Two field experiments were conducted at Powell, WY and Bridger, MT the past 3 years to evaluate various herbicides for cool-season grass crop tolerance and for their control of downy brome. Trials were conducted on these perennial grasses: western wheatgrass (*Agropyron smithii* Rydb. var. Rosana), slender wheatgrass [*Agropryon trachycalum* (Link) Matte] var. Pryor, beardless Wildrye (*Elymus triticoides* Buckl.) var. Shoshone, thickspike wheatgrass [*Agropyron dasystachyum* (Hook.) Scribn.] var. Critana, meadow brome (*Bromus biebersteinii* R. and S.) var. Regar. Trials were established on 22 inch irrigated rows. All treatments were applied in water with a six-nozzle knapsack sprayer delivering 30 gpa at 40 psi. All applications were made to dormant established perennial grasses in October and November except glyphosate and paraquat treatments that were applied in April after grasses had broken dormancy and downy brome was actively growing in the 4 to 6 leaf stage.

Downy brome emergence was excellent at Bridger and poor at Powell, therefore, perennial grass tolerance and yields were the only data taken at Powell while downy brome control data was taken at Bridger along with grass tolerance and yields. Grasses were only selected for harvest when they had good downy brome control from the dormant treatments. Glyphosate was selected as a salvage, non-dormant treatment.

Those dormant treatments providing excellent downy brome control and not resulting in perennial grass damage included oxyfluorfen plus metribuzin at 1 + 0.25 lb/A and metribuzin at 0.38 lb/A. Perennial grass damage was 13% with metribuzin applied at 0.5 lb/A. Early spring applications of paraquat at 0.75 lb/A provided excellent downy brome control but perennial grasses had 75% suppression. When glyphosate was applied in early spring at 0.25 lb/A, downy brome control was inadequate (37%) while perennial grass suppression was 16%.

WEED CONTROL WITH TRIASULFURON IN RANGELAND. Robert N. Klein and Donald J. Thrailkill, Professor and Extension Research Technologist, University of Nebraska West Central Research and Extension Center, North Platte, NE 69101.

Abstract. In the West Central District of Nebraska over 12.7 million A of the District's 17.6 million A of farmland are in range and pasture. That represents nearly 55% of the total pasture and rangeland in Nebraska. Weeds compete with desirable range grasses for nutrients, moisture, light, and space. They also reduce the quality of the forage.

Range land experiments were conducted in 1994 and 1995 on Randy Kramer's farm approximately 20 miles northeast of North Platte, NE. The same herbicide treatments, with the exception of 2,4-D with triasulfuron rate in 1994 at 0.5 lb and in 1995 at 0.25 lb, were applied May 25, 1994 and May 24, 1995 on plots laid out in a randomized complete block design with four replications. The plots were in different areas each year. The treatments were applied with a CO^2 backpack sprayer using a 10 foot boom (6-11002XR nozzles on 20 inch spacing). Carrier volume was 15 gpa and nozzle pressure was 26 psi. All treatments except the 2,4-D plus dicamba treatment contained non-ionic surfactant at 0.25% v/v.

In 1994 the pasture grasses were 5 inches tall at time of application. Weeds in the plot area included common lambsquarters to 8 inches tall, common sunflower to 6 inches, common ragweed to 4 inches, and blue vervain to 6 inches. Three treatments gave 98 to 100% control of the three annual weeds when visually rates at 4 and 7 weeks after treatment. The three treatments include 0.0267 lb/A trisulfuron, 0.0134 lb/A triasulfuron

plus 0.5 lb/A 2,4-D, and 1 lb/A 2,4-D plus 0.25 lb/A dicamba. Triasulfuron alone at 0.0134 lb/A gave 100% common sunflower control and 60 to 80% common lambsquarters and common ragweed control. With blue vervain the triasulfuron plus 2,4-D LVE and 2,4-D plus dicamba gave 99 to 100% control. Other treatments gave 12 to 60% control.

In 1995 at the time of application the weeds present included blue vervain most less than 2 inches tall some to 3 inches and annual ragweed up to 2 inches tall. All treatments with visual ratings 4 and 7 weeks after application gave 99% annual ragweed control. The 2,4-D LVE plus dicamba treatment was the most effective in controlling blue vervain with ratings of 98 to 99%. Triasulfuron alone at 0.0134 lb/A resulted in control of 50 to 58% and the triasulfuron at 0.0267 lb/A alone or at 0.0134 lb/A plus dicamba or 2,4-D at 0.25 lb/A gave blue vervain control of 77 to 80%.

LONG-TERM CONTROL OF DUNCECAP LARKSPUR WITH VARIOUS HERBICIDES APPLIED AT TWO PLANT GROWTH STAGES. Larry E. Bennett, Thomas D. Whitson, Gerald E. Fink and James R. Gill, Research Associate, Professor, University Extension Agent (Ret.) and University Extension Agent, University of Wyoming, Laramie, WY 82071.

Abstract. Duncecap larkspur is commonly found on high elevation rangeland (above 2400 m) in the United States and Canada. It is both palatable and acutely toxic to cattle. In addition to direct economic losses due to mortality, Its presence precludes efficient management on many productive mountain range ranges.

The responses of duncecap larkspur to various herbicides applied at two plant growth stages were investigated in several replicated field experiments in the Big Horn Mountains of Wyoming. Two initial screening studies, established in 1987, demonstrated picloram and metsulfuron provided effective control for 2 years following treatment. In 1989, two additional studies were established to refine the preliminary results of the 1987 study. Sixteen herbicides and herbicide combinations were applied at the 4- to 6-leaf and the bud to early bloom stage of duncecap larkspur. Evaluations were made 6 years postreatment (26 July 1995).

Picloram at 1.7 and 2.2 kg/ha applied at the 4- to 6-leaf stage and at the early bloom stage provided 91, 94, 76 and 80% control, respectively. Metsulfuron at 0.004 kg/ha provided 91% control when applied at the 4- to 6-leaf stage but decreased to 62% when applied at the early bloom stage. When metsulfuron and picloram was combined at 0.009 + 1.12 kg/ha, 97 and 96% of the duncecap larkspur was controlled in the 4- to 6-leaf and bud to early bloom stage, respectively. Several herbicides and herbicide combinations were identified that are capable of providing a long-term and cost-effective chemical control strategy for duncecap larkspur.

Table 1. Control of duncecap larkspur with herbicides applied at two plant growth stages.

Treatment	Rate	Control	
		Vegetative stage	Bloom stage
	lb/A	%	
Picloram	0.75	63	57
Picloram	1	73	72
Picloram	1.5	76	91
Picloram	2	80	94
2,4-D LVE	1	55	66
2,4-D LVE + picloram	1 + 1	66	78
Triclopyror ester + 2,4-D ester	0.5 + 1	66	58
Triclopyror ester + 2,4-D ester + picloram	0.5 + 1 + 0.25	71	58
Picloram + X-77	0.75 + 0.25% v/v	80	71
Triclopyror ester + 2,4-D ester + X-77	0.5 + 1 + 0.25% v/v	71	58
Metsulfuron + X-77	0.063 + 0.25% v/v	91	62
Metsulfuron + picloram + X-77	0.063 + 0.75 + 0.25% v/v	90	88
Metsulfuron + picloram + X-77	0.063 + 1.0 + 0.25% v/v	87	83
Metsulfuron + picloram + X-77	0.125 + 1.0 + 0.25% v/v	97	96
Metsulfuron + dicamba + X-77	0.063 + 0.5 + 0.25% v/v	84	65
Metsulfuron + dicamba + X-77	0.125 + 0.5 + 0.25% v/v	91	69
Untreated check		0	0

INTEGRATION OF HERBICIDES WITH *APHTHONA* SPP. FLEA BEETLES FOR LEAFY SPURGE CONTROL. Rodney G. Lym[1], Robert B. Carlson[2], Katheryn M. Christianson[3], Don A. Mundal[2], and Calvin G. Messersmith[1]. [1]Professors and [3]Research Specialist, Plant Sciences Department and [2]Professor and Research Specialist, Department of Entomology, North Dakota State University, Fargo, ND 58105.

Leafy spurge is one of the most difficult perennial weeds to control in North America and currently infests nearly 1 million ha. Herbicides alone have not controlled the weed. Biocontrol insects have been introduced but have been slow to establish and spread. The effect of herbicide treatments on the flea beetle *Aphthona nigriscutis* survival and establishment on leafy spurge was evaluated. *A. nigriscutis* were established in 1989 and herbicide treatments were initiated in June 1992. The treatments included picloram plus 2,4-D at 0.28 plus 1.1 kg/ha spring applied, picloram plus 2,4-D at 0.56 plus 1.1 kg/ha fall applied, and *A. nigriscutis* alone. Stem density was annually evaluated in the spring, and adult sweep counts were conducted throughout each summer. Stem density in the insect-only treatment declined by 95% from May 1992 to May 1995. However, control was reduced to only 30% by September 1995 once the larvae quit feeding and pupated to adults in early summer. The greatest leafy spurge stem density reduction was 99% by the insect plus fall-applied herbicide treatment which occurred after the first application in 1992. The spring-applied herbicide plus insect treatment reduced leafy spurge less than the insects alone. The *A. nigriscutis* population in the non-herbicide treatments increased from 7 beetles/m^2 in 1992 to 130 beetles/m^2 in 1994. The *A. nigriscutis* population declined to less than 1 beetle/m^2 when herbicides were spring applied, but increased to 30 beetles/m^2 when herbicides were fall applied. Beetle populations declined in 1995 compared to 1994 regardless of treatment as leafy spurge stem density decreased. Fall-applied herbicide treatments combined with *Aphthona* flea beetles provided better long-term leafy spurge control than either control method used alone.

ABSORPTION AND FATE OF IMAZAMETH IN LEAFY SPURGE. W. Mack Thompson, Scott J. Nissen, and Robert A. Masters, Graduate Research Assistant, Assistant Professor, Department of Plant Pathology and Weed Science, Colorado State University, Fort Collins, CO 80523; and Range Scientist, USDA-ARS, University of Nebraska, Lincoln, NE 68583.

Abstract. Absorption, translocation, and metabolism of imazameth by leafy spurge was studied over an 8 day time period. Vegetatively propagated leafy spurge plants were grown in the greenhouse for 6 months. Top growth was removed and root systems were chilled at 4 C for 1 month before being transferred to cone-tainers. The rooting medium was a fine, washed silica sand. Plants were fertilized with 0.6 g of controlled release, complete fertilizer and watered daily. Plants were maintained in a growth chamber with 16 h photoperiod, 50% relative humidity, and a PPFD of 500 $\mu E/m^2$ sec. Imazameth was applied at a rate of 0.07 kg/ha with 1.25% v/v methylated seed oil and 1.25% v/v urea ammonium nitrate (UAN) in a spray volume of 187 L/ha. Two alternate leaves, approximately 10 cm below the shoot apex, were protected from the spray application with aluminum foil. ^{14}C-imazameth was mixed with spray solution and applied to these leaves as 20, 0.5 μl droplets (10 droplets/leaf, 5 either side of the mid-rib). A total of 17,000 Bq of ^{14}C-imazameth was applied to each plant. Plants were harvested 2 and 8 DAT and divided into 7 parts: (1) treated leaves, (2) shoot above and (3) below treated leaves, (4) crown, (5) root, (6) elongated root buds, and (7) dormant root buds. Treated leaves were vortexed for 30 s in 10% aqueous methanol containing 0.25% v/v non-ionic surfactant. Radioactivity of leaf wash solutions was determined by liquid scintillation spectroscopy (LSS) and was used to estimate herbicide absorption. Plant parts were oven dried for 72 h at 60 C to obtain dry weights. Treated leaves, crowns, roots, and root buds were homogenized in 90% methanol and extracted for 2 h at 22 C. Aliquots were taken before extracts were filtered and evaporated to aqueous phase under vacuum. The amount of radioactivity present as parent compound was resolved by C_{18} HPLC and flow-through LSS. Shoots above and below treated leaves and solids from filtered extracts were oxidized and radioactivity determined by LSS. Translocation of imazameth was calculated from the radioactivity in the oxidized material and extract aliquots.

Based on the amount of herbicide applied and recovered from the leaf surfaces, 49% of imazameth was absorbed by leafy spurge 2 DAT with no further absorption observed 8 DAT. Eight days after treatment, 22% of applied ^{14}C-imazameth had translocated to below ground plant parts and 6% of applied ^{14}C-imazameth was exuded into the sand. Imazameth remained primarily intact 2 DAT in the crown, root, and root buds, but only 52% of radioactivity was parent compound in the treated leaves. Intact imazameth was reduced to 61 and 80% in the root and root buds 8 DAT, while treated leaves contained only 10% of the parent compound. No attempts were made to identify imazameth metabolites.

CONTROL OF SILKY CRAZYWEED WITH VARIOUS HERBICIDES APPLIED AT TWO GROWTH STAGES. William C. Akey and Tom D. Whitson, Assistant Professor and Professor, Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Silky crazyweed is a poisonous plant common on Western U.S. rangelands where it causes nervous disorders, abortions, and death in cattle, sheep, and horses. Studies were established in 1990 near Buford, Wyoming to determine the long-term effectiveness of various herbicides for control of silky crazyweed. All herbicides were applied at either the vegetative stage (silky crazyweed plants 3 to 4 inches tall) or at early bloom. With the exception of 2,4-D at 2 lb/A, all herbicides tested provided 98% or greater control of silky crazyweed during the first 2 yr after treatment and there was no significant difference between stages of application. Control with 2,4-D at 2 lb/A was more variable than with other herbicides and appeared to be somewhat better when applied at the later treatment date. Only picloram at 0.5 lb/A continued to provide 90% control of silky crazyweed up to 5 yr after treatment. Retreatment at the vegetative stage, 4 yr after the initial herbicide application, resulted in 90% or greater control of silky crazyweed in the following year with all herbicides except clopyralid at 0.13 lb/A or clopyralid plus 2,4-D at 0.13+0.61 lb/A. The study involving

treatment of silky crazyweed at the bloom stage was repeated in 1993 with essentially identical results as those obtained from the initial study.

Yield of perennial grasses was determined 2 years after treatment on those plots treated with the least costly rate of herbicides giving acceptable control of silky crazyweed. In all instances, perennial grass yields of treated plots were significantly greater than those of the untreated checks with dicamba plus 2,4-D at 0.5+1 lb/A increasing grass production more than three fold. In addition to controlling silky crazyweed, percent live canopy cover of associated forb species such as threetip sagebrush and fringed sagebrush was also altered to varying degrees by the tested herbicides as determined from point-frame quadrat measurements. Two years after treatment, 2,4-D at 2 lb/A and dicamba plus 2,4-D at 0.5+1 lb/A had significantly increased the grass/forb ratio relative to the untreated check. However, by 5 yr after treatment, only picloram at 0.5 lb/A showed a significant effect on the ratio of grasses to forbs.

WEEDS OF HORTICULTURAL CROPS

HALOSULFURON FOR CONTROL OF YELLOW (*CYPERUS ESCULENTUS* L.) AND PURPLE NUTSEDGE (*CYPERUS ROTUNDUS* L.) IN TURFGRASS. Nelroy E. Jackson, Jeff N. Travers, and Kay D. Jolly, Local Technical Manager and Research Specialist, Monsanto Company, St. Louis, MO 63167.

Abstract. Field studies were conducted in 1992 and 1993 to compare the efficacy of halosulfuron to bentazon, imazaquin, and MSMA for postemergence control of CYPES and CYPRO. Thirty-five experiments were conducted across the continental United States on turfgrass sites with natural infestations of sedges. Halosulfuron was applied at rates of 35, 53, and 70 g ha^{-1}, and sequential treatments were applied at rates of 35 + 35, 53 + 53, 70 + 53, and 70 + 70 g ha^{-1}. Single and sequential applications of the following herbicides were compared: bentazon, 0.56 and 0.84 kg ha^{-1}; imazaquin, 0.21 and 0.28 kg ha^{-1}; MSMA, 1.12 and 2.24 kg ai ha^{-1}. Single applications of halosulfuron at rates of 35, 53, and 70 g ha^{-1}, provided commercial levels of control of CYPES (86%, 92%, and 95%, respectively). CYPES control peaked 5 to 6 weeks after treatment for the two lower rates of halosulfuron, but good suppression control was maintained at 70 g ha^{-1} for 6 to 8 weeks. Sequential treatments were very effective, if properly timed, providing season-long CYPES control. Single applications of bentazon provided fair suppression of CYPES (71%), and activity peaked within 3 weeks after application. Sequential applications of bentazon sequentials provided good suppression of CYPES (78%). Single applications of halosulfuron provided an average of 85%, 97%, and 93% control of CYPRO at 35, 53, and 70 g ha^{-1}, respectively. But vigorous regrowth after 6 weeks necessitated sequential treatments, which then provided excellent control through 12 to 14 weeks. Single applications of imazaquin provided good to fair suppression of CYPRO (73%) and control peaked 3 to 4 weeks after treatment. A sequential treatment of imazaquin was required to achieve commercial CYPRO control. Halosulfuron demonstrated selective control of both CYPES and CYPRO growing in major turfgrasses adapted to North America.

EVALUATION OF POSTEMERGNECE HERBICIDES AND A GROWTH REGULATOR FOR CHEMICAL EDGING OF HYBRID BERMUDAGRASS. David W. Cudney, Clyde L. Elmore, and Victor A. Gibeault, Extension Specialists, Botany and Plant Sciences Department, University of California, Riverside, CA 92521.

Abstract. Aggressive, stoloniferous grasses such as bermudagrass, kikuyugrass, zoysiagrass and St. Augustinegrass often extend their growth into ornamental beds, tree wells, and sidewalks within landscaped areas. This requires repeated mechanical edging or hand removal during the growing season. These procedures are time-consuming and often costly. Chemical edging has been an alternative to the drudgery of mechanical and hand-removal. Cacodylic acid, diquat, and weed oil were used in the past for short-term chemical edging. When glyphosate was introduced, it replaced much of these usages; however, because of its systemic nature in these stoloniferous grasses, the effects of the glyphosate often extend beyond the edges into the desirable turf areas. Two newer chemicals have been introduced which may be useful as chemical edgers, glufosinate and cimectacarb. Glufosinate is a rapid acting "contact" foliar herbicide while cimectacarb is a turf growth regulator.

A trial was established at the University of California, Riverside Experimental Turf Farm on an 8-year-old, vigorous stand of "Santa Anna" hybrid bermudagrass, on September 28, 1995, 1 day after the turf had been uniformly mowed to a height of 0.75 inches. Treatment bands 10 inches wide and 15 feet long were applied to the turf. Treatments consisted of the commonly used rates of diquat, cacodylic acid, glyphosate, glufosinate, and cimectacarb. Phytotoxicity ratings were made regularly over a 50 day period. In addition light reflectance from the turf surface was measured with a line quantum sensor. Reflectance correlated closely with the phytotoxicity ratings as the desiccated tissue from the most severely affected treatments reflected more light than the green, healthy tissue in the untreated and cimectacarb plots.

Diquat desiccated the turf within 2 days, cacodylic acid required 5 days to reach maximum effect. Regrowth of the turf then occurred and diquat and cacodylic acid had lost their effect by 19 and 26 days respectively. Glyphosate required 14 days to reach its maximum effect, however the turf remained desiccated throughout the 50 day evaluation period, although regrowth from the edges of the band was in evidence at the end of the evaluation period. Glufosinate reached its maximum effect in 5 days with the effects persisting for 45 days. Cimectacarb stopped growth of the turf and caused only a slight yellowing of the turf, its growth reducing effects were evident throughout the 50 day period.

Glufosinate was quicker acting than glyphosate and longer lasting than diquat or cacodylic acid. Cimectacarb stopped turf growth with little discoloration. It appears that both of these products may have a place in chemical edging. Glufosinate for a quick burn back and cimectacarb after mechanical edging to slow regrowth an the need for a second mechanical edging.

VOLUNTEER POTATO CONTROL IN FIELD CORN. Rick A. Boydston, Plant Physiologist, USDA-Agricultural Research Service, Irrigated Agriculture Research and Extension Center, Prosser, WA 99350.

Abstract. Volunteer potatoes are difficult to control in rotational crops and can harbor harmful diseases, nematodes, and insects, thereby lessening the positive effects of crop rotation. Five herbicide treatments were compared for potato control in field corn grown under no-till and conventional tillage. Whole seed potato tubers were planted on March 21, 1994, and March 15, 1995, to simulate volunteer potatoes. No-till plots were chisel plowed, planted to corn on April 25, 1994, and April 27, 1995, and treated with glyphosate at 1.12 kg/ha and metolachlor at 1.7 kg/ha 4 days after planting. Cultural practices for conventionally-tilled corn were identical to no-till corn except that plots were disced and packed after chisel plowing, which removed any potatoes that had emerged. Conventionally-tilled corn was also reservoir tilled (dammer diked) at 4.5 to 5 weeks after planting.

Glyphosate killed emerged potato shoots in the no-till corn, but new plants emerged within 2 weeks. In mid June of 1994 and 1995, potato control was greater in conventionally-tilled corn than in no-till corn primarily due to the reservoir tillage operation (Table). Potato control with herbicide treatments ranged from 66 to 91% in 1994. Atrazine applied preemergence at 1.1 kg/ha followed by 2,4-D plus dicamba applied postemergence at 1.1 plus 0.28 kg/ha, respectively, in conventionally-tilled corn suppressed potatoes the most. In 1995, all herbicides controlled potatoes similarly in conventionally-tilled corn and potato control ranged from 94 to 96%. In no-till corn, potato control ranged from 87 to 96% and was greatest with dicamba plus primisulfuron applied postemergence at 0.28 plus 0.04 kg/ha, respectively, atrazine applied preemergence at 1.1 kg/ha followed by 2,4-D plus dicamba applied postemergence at 1.1 plus 0.28 kg/ha, respectively, or fluroxypyr applied postemergence at 0.22 kg/ha.

Potato final tuber weight was not significantly different among tillage levels in 1994 or 1995, but in both years final tuber weights tended to be greater in no-till corn than in conventionally-tilled corn. All herbicide treatments reduced potato tuber weight compared to nontreated checks in both years (Table). In 1994, reduction in potato tuber weight with herbicides ranged from 64 to 96% in no-till corn and 89 to 99% in conventionally-tilled corn. In 1995, reduction in potato tuber weight with herbicides ranged from 76 to 95% in no-till corn and 85 to 98% in conventionally-tilled corn compared to nontreated checks. In both years, potato tuber weight averaged the lowest in conventionally-tilled corn that received atrazine preemergence followed by 2,4-D plus dicamba applied postemergence. Corn yield was not affected by tillage level or herbicide treatments in 1994 or 1995, and averaged 10.5 MT/ha in 1994 and 15.1 MT/ha in 1995.

Table.

Treatment	Timing	Rate	1994: 15 Jun 94 Potato control	1994: Potato tuber wt.	1994: Corn yield	1995: 12 Jun 95 Potato control	1995: Potato tuber wt.	1995: Corn yield
No till		kg ai or ae/ha	%	g/m[2]	MT/ha	%	g/m[2]	MT/ha
Cyanazine	pre	0.84	66	555	8.8	87	220	12.6
2,4-D + dicamba	post	1.1 + 0.28						
Atrazine	pre	1.1	75	67	10.0	94	49	15.1
2,4-D + dicamba	post	1.1 + 0.28						
Fluroxypyr	post	0.22	76	386	9.4	94	168	14.3
Dicamba + nicosulfuron	post	0.28 + 0.05	73	296	9.2	91	217	14.7
Dicamba + primisulfuron	post	0.25 + 0.04	78	479	9.4	96	185	13.5
Nontreated check			0	1524	7.8	0	906	16.0
		Mean	61	552	9.1	77	291	14.3
Conventional								
Cyanazine	pre	0.84	83	69	11.0	94	81	15.3
2,4-D + dicamba	post	1.1 + 0.28						
Atrazine	pre	1.1	91	12	12.2	96	13	15.7
2,4-D + dicamba	post	1.1 + 0.28						
Fluroxypyr	post	0.22	86	52	13.3	96	55	16.3
Dicamba + nicosulfuron	post	0.28 + 0.05	84	201	11.7	95	118	16.3
Dicamba + primisulfuron	post	0.25 + 0.04	86	107	11.2	96	96	16.3
Nontreated check			26	1910	11.9	19	780	15.5
		Mean	76	392	11.9	82	190	15.9
LSD 0.05 for main plot means			5.7	NS[a]	NS	2.3	NS	NS
LSD 0.05 for subplots within each main plot			4.7	404	NS	3.7	235	NS

[a]NS = F test for factor not significant at the 0.05 level of probability.

EFFECT OF IRRIGATION ON IMAZAMETHABENZ PERSISTENCE. Jin-Ho Joo[1], Charlotte V. Eberlein[2], and Mary J. Guttieri[2], Graduate Student, Professor, and Research Support Scientist, [1]Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83843, and [2]University of Idaho, Aberdeen Res. & Ext. Ctr., Aberdeen, ID 83210.

Abstract. Imazamethabenz is a postemergence imidazolinone herbicide that selectively controls weeds in cereal crops. Potatoes are typically grown in rotation with cereal crops such as wheat or barley, and, under some conditions, may be injured by soil residues of imazamethabenz. Experiments were conducted at the University of Idaho Research and Extension Center at Aberdeen, ID over a 3 year period to evaluate the effect of irrigation of the cereal crop on carryover of imazamethabenz to the following potato crop. The experimental design was a randomized arrangement of a split plot design in which main plots were irrigation amounts (20, 30, 40, or 50 cm) applied to the wheat crop, and subplots were imazamethabenz rates (0, 0.26, 0.53, or 1.05 kg ha^{-1}) applied to the wheat crop. Imazamethabenz soil residue analyses were conducted to determine the persistence of imazamethabenz under field conditions. Herbicide degradation over time followed a log-linear relationship at all irrigation amounts, and herbicide degradation increased with irrigation rate. Foliar injury of potatoes grown the year following imazamethabenz application increased with increasing herbicide rate and was mild to moderate (0 to 14%). U.S. #1 and total tuber yield of potatoes were not affected by irrigation amount or herbicide rate.

FIELD BIOASSAY OF RESIDUAL NORFLURAZON FOLLOWING ASPARAGUS APPLICATIONS.
Harry S. Agamalian and Brooks Bauer, Weed Advisor - Emeritus, University of California Cooperative Extension, 1432 Abbott Street, Salinas, CA 93901, and Research Specialist, Sandoz Agro, Escalon, CA 95320.

Abstract. In California, upon the completion of perennial asparagus production, fields are planted to annual vegetables in the rotation system. The utilization of norflurazon for yellow nutsedge control in weed management has required the need for information on vegetables tolerant to soil residual norflurazon.

Field trials were established on 4 ha after a 12 month application of norflurazon at 3.3 kg/ha. The asparagus field was disced and chiseled. The soil was subsequently prepared for seeding. Soil analysis prior to seeding indicated 0.22 mg/kg (0 to 15 cm) and 0.13 mg/kg (15 to 30 cm) depth.

Eight vegetables and three forage crops were seeded during a spring summer and fall period in 1994. The field studies consisted of 4 m wide by 1200 m long. The crops were broccoli, cabbage, carrots, cucumber, onion, snap beans, squash, spinach, tomato, oats, rye, and sudan grass. Crop assessments were made on stand establishment, symptoms and crop maturity evaluations. Data collection was made at 14, 30, 60, and 90 days after plantings (DAP).

The 10 month experiment indicated that one could group several crops into three categories. Highly tolerant crops at this level of norflurazon were: spinach, snap bean, carrot, tomato, onion, cereal rye, and oats. Crops in a moderate level of tolerance were broccoli, red and green cabbage. The most sensitive crops were lettuce, Chinese cabbage, and sudan grass.

WEED CONTROL, GROWTH AND MOISTURE EFFECTS OF GEOTEXTILE FABRICS PLUS MULCH ON MOCK ORANGE IN THE LANDSCAPE.
Clyde L. Elmore and J. Roncoroni, Extension Weed Specialist and Staff Research Associate, Weed Science Program, University of California, Davis,CA 95616.

Abstract. A field study was established in 1988 to evaluate weed control, moisture status, growth of mock orange, and longevity of geotextile mulches. Plots 15 by 15 feet were seeded with barnyard grass and redroot pigweed then covered with black polyethylene, four non-woven polypropylene mulches (Typar Landscape fabric, 2 or 3 oz., Duon Weed Control Mat, and Soil-Check), a non-woven polyester mulch (Warren's Weed Arrest) or a woven polypropylene mulch (DeWitt Pro5 Weed Barrier). Each of the geotextile mulches was covered with 3 inches of redwood bark chips. Sixteen 2 liter containers of mock orange were planted per plot. Other treatments were, bark covered soil, oryzalin at 4.4 kg/ha and a hand-weeded control. A neutron probe access tube was put in the center of each plot moisture evaluation. The plots were replicated four times. Sprinkler irrigation was used for the first year to establish the plants, after which rainfall was the only available moisture.

There was excellent control of barnyard grass and redroot pigweed with Typar Landscape Fabric (3 oz.) (Typar 3), black polyethylene, oryzalin and in the hand weeded plots. The poorest weed control was from a bark mulch (35%), Duon Weed Control Mat (50%), Warren's Weed Arrest (67%), and Soil-Check (67%).
Mock orange growth was increased with any of the geotextile plus bark mulches, compared to the bark mulch or hand weeded control.

There was no difference in weed control between the Typar Landscape fabric, Soil-Check, Warren's Weed Arrest, Duon Weed Control Mat, DeWitt Pro5 Weed Barrier, black plastic or with oryzalin treated plants. There was greater plant growth in Typar Landscape Fabric 3 oz. plots than the thinner 2 oz. material. These growth measurements also corresponded to dry weight of prunings taken from the plants. Pruning weights were greater with black plastic, Typar 3, Weed Arrest, and Soil-Check than the hand-weeded or bark mulch. Soil moisture profile analysis indicated that water was permeable into the soil from winter rainfall, and that there was adequate moisture in geotextile plus bark mulch plots to maintain established mock orange in California without added irrigation.

WEEDS OF AGRONOMIC CROPS

INTERACTION OF WINTER ANNUAL GRASSES AND THE RUSSIAN WHEAT APHID IN WINTER WHEAT. K. A. Howatt and P. Westra, Graduate Research Assistant and Associate Professor, Colorado State University, Fort Collins, CO 80523-1174.

Abstract. Yield loss and grain price deductions due to Russian wheat aphid (RWA) damage and winter annual grass competition are major concerns for winter wheat producers throughout the United States. This experiment examines the effects of the RWA as well as three winter annual grasses on the growth and yield of winter wheat. Experimental design was split-plot replicated six times. Whole plots were RWA levels (presence or absence). These were split into winter annual grass treatments (none, volunteer rye, downy brome, or jointed goatgrass). Treatment plots were 3 m wide and 3.5 m long. RWA's were released and weeds were broadcast seeded to achieve desired treatments. Wheat height and fresh weight, tiller damage, and RWA population were determined at select growth stages. Also wheat height, plant population, tiller number, biomass, and grain yield and weed species biomass and plant population were measured at harvest.

Yield results from both the 1994 and 1995 growing seasons indicate that the presence of RWA greatly reduces final wheat yield. Grain yields were reduced an average of 69% across all weed species treatments over 2 years by RWA. Yield reduction was larger for all treatments where a weed was present than in weed free plots. Yield reduction from aphids was greatest in plots with downy brome followed by jointed goatgrass and then volunteer rye. However, averaging across insect treatments, volunteer rye was the greatest competitor reducing yield up to 95% in 1995 (81% over 2 years). Volunteer rye was followed by jointed goatgrass and downy brome in competitive ability, respectively, averaging 50% and 37% yield loss.

Data show an interaction between RWA and downy brome which synergistically reduced grain yield over 2 years. Data also show antagonistic interactions between RWA and jointed goatgrass stresses for wheat height and between RWA and jointed goatgrass or volunteer rye for wheat biomass production. The warm, dry weather of the 1994 season enhanced the stress from RWA, while in the 1995 season, the cool, wet spring enhanced weed species competition. In both years of this study a single stress from RWA or a weed species greatly reduced wheat growth parameters, reducing the capability of detecting interactions.

VOLUNTEER RYE AND JOINTED GOATGRASS COMPETITION IN WINTER WHEAT. Brady F. Kappler[1], Gail A. Wicks[1], Gordon E. Hanson[1], Drew J. Lyon[2], Robert K. Higgins[2], Kent M. Eskridge[3], Phillip W. Stahlman[4], Francis E. Northam[4], Stephen E. Miller[5], Randall L. Anderson[6], Graduate Research Assistant, Professor, Research Technician, Professor, Research Technician, Professor, Professor, Research Technician, Professor, Research Agronomist, [1]Department of Agronomy, University of Nebraska, North Platte, NE 69101, [2]Department of Agronomy, University of Nebraska, Sidney, NE 69162, [3]Department of Biometry, University of Nebraska, Lincoln, NE 68583-0712, [4]Agricultural Research Center, Kansas State University, Hays, KS 67601, and [5]Department of Plant, Soil, and Insect Science, University of Wyoming, Laramie, WY 82071, [6]USDA-ARS, Akron, CO 80720.

Abstract. Volunteer rye (VR) and jointed goatgrass (JGG) are two weeds that have become troublesome for wheat producers in the Great Plains area. Both weeds compete with winter wheat for the vital resource of water. There are currently no selective herbicides that control VR and JGG in winter wheat. In 1993 a study was initiated in four states to examine the effects of five different densities of volunteer rye (VR) and jointed goatgrass (JGG) on winter wheat. This study involved sites in Akron, CO, Hays, KS, Archer, WY, North Platte, NE, and Sidney, NE. The Kansas, Wyoming and North Platte, NE sites all collected 3 yr of data. Two yr of data were collected at Akron, CO and only 1 yr of data was collected at Sidney, NE. This gave a total of 12 site by year environments. The five densities for each weed were 0, 5, 10, 25, and 50 plants/m^2.

Linear regression analysis was performed for yieldloss and dockage data for the two weeds. For JGG percent yieldloss it was found that the equation percent yieldloss = 8.64 + 0.29 · density/m^2 was statistically sufficient for all sites. It was found that JGG percent dockage could be statistically separated into three equations. The equation percent dockage = 1.46 + 0.56 · density/m^2 was sufficient for the Colorado and Kansas sites while the equation percent dockage = 2.17 + 0.3 · density/m^2 was sufficient for the North Platte and Sidney sites. The equation for Wyoming was found to be percent dockage = 0.23 + 0.05 · density/m^2. For rye percent yieldloss was able to be divide into two equations. For Colorado and Sidney sites the equation is percent yieldloss = 20 + 0.69 ·density/m^2. The equation for Kansas, North Platte, and Wyoming is percent yieldloss = 12.89 + 0.41 · density/m^2 The rye dockage equation for all sites is percent dockage = 5.39 + 0.83 · density/m^2. High C.V. for some of the equations probably masked statistical differences that we may have seen otherwise. The single regression for JGG yieldloss would probably be two or three lines instead of one line as indicated by trends shown on a site by site basis. Dockage is also a very random event considering how difficult it can be to collect a representative sample.

JOINTED GOATGRASS ECONOMIC THRESHOLDS AND TIME OF PLANTING EFFECTS ON COMPETITION IN WINTER WHEAT. Philip Westra[1], Kirk Howatt[1], Tim D'Amato[1], Stephen D. Miller[2], Bruce Maxwell[3], Jack Evans[4], and Don Morishita[5], [1]Associate Professor, Research Associate, and Research Graduate Assistant, Department of Plant Pathology and Weed Science, Colorado State University, Ft. Collins, CO 80523; [2]Professor, Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY 82071; [3]Associate Professor, Department of Plant and Soil Science, Montana State University, Bozeman, MT 59717-0312; [4]Professor, Department of Plant, Soils and Biometerology, Utah State University, Logan, UT 84322-4820; and [5]Associate Professor, Twin Falls Research and Extension Center, University of Idaho, Twin Falls, ID 83303-1827.

Abstract. Jointed goatgrass is a winter annual grass that causes more than $145,000,000 annual loss of income to wheat producers in the western United States. Coordinated regional economic threshold studies involving jointed goatgrass and winter wheat were initiated in the fall of 1994 in Colorado, Wyoming, Montana, Utah, and Idaho. Five targeted levels of jointed goatgrass (0, 5, 10, 25, and 50 plants/m^2) were established in a major winter wheat variety for each location. Actual jointed goatgrass densities were recorded in the fall of 1994 and plant density and tiller numbers were recorded in the spring of 1995 and at harvest. One meter square quadrats were harvested from each plot, threshed, and goatgrass spikelets hand separated from each sample to establish the amount of dockage. Actual wheat yield data per plot was converted to percent yield reduction using comparison to the yield from the zero jointed goatgrass density within each replication. Non-linear regression was used to regress percent wheat yield reduction against jointed goatgrass plant density using a hyperbolic yield reduction equation ($y=b \cdot x/(1+b \cdot x/a)$). This analysis yielded a b-parameter value which approximated the additional yield reduction caused by each jointed goatgrass plant added to the system at low densities, and an a-parameter value which describes the asymtote or maximum yield reduction observed in each study. In addition, an r^2 value generated for each equation gives some approximation of the amount of wheat yield variation that was due to the jointed goatgrass density. These parameter values for each study are shown in Table 1. Work by Maxwell at Montana suggests that addition of a wheat density factor in the equation may improve the r^2 values for some data sets.

Table 1. Parameter values for five jointed goatgrass economic threshold competition studies in winter wheat.

State	b-parameter	a-parameter	r^2
Idaho	3.7	45	0.64
Montana	3.1	38	0.48
Colorado	1.5	38	0.18
Utah	7.7	25	0.07
Wyoming	4.6	22	0.39

From these data it can be seen that maximum yield reduction ranged from 22% to 45% within the range of 0 to 80 jointed goatgrass plants/meter^2 (Figure 1). Graphing the data revealed that even low jointed goatgrass densities of 5 to 10 plants/m^2 (common densities in a field situation) caused 10 to 20% yield loss which translates into $20 to $40/A revenue loss calculated for $5/bushel wheat for a 40 bu/A yield (Figure 1). The steepness of the response surface at low plant densities shows the strong competitive ability of jointed goatgrass growing in winter wheat. This implies that wheat growers with low densities of jointed goatgrass cannot be complacent because of the serious financial loss caused by low numbers of jointed goatgrass, and the explosive population dynamics of this weed especially in wet years. This first set of regional economic threshold studies suggest that jointed goatgrass causes more serious economic impacts than perhaps first believed by researchers and farmers. The results of these studies will be incorporated into a jointed goatgrass bioeconomic management model currently under development at Montana State University.

Wheat time of planting effects on jointed goatgrass were evaluated in Colorado. Winter wheat was planted on September 6, September 16, and September 23, 1994. Jointed goatgrass was planted either with the wheat, 2 weeks later, or the following spring. Wheat yields were depressed at the earliest planting date due to dry fall growing conditions. Delaying jointed goatgrass planting (and emergence) until 2 or more weeks after wheat planting greatly reduced jointed goatgrass seed production by 83% or more. Jointed goatgrass emerging with winter wheat caused greater yield reductions (up to 44% reduction) than jointed goatgrass emerging two or more weeks after the wheat. Yields from the latest fall planting were less impacted by the presence of jointed goatgrass than yields from the middle planting. It appears that timing of wheat planting, relative to jointed goatgrass management strategies, can impact jointed goatgrass population dynamics and the amount of damage caused by jointed goatgrass in winter wheat.

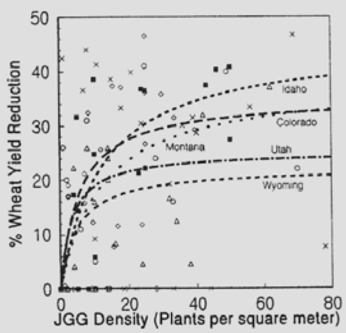


Figure 1. Percent wheat yield reduction in winter wheat caused by varying levels of jointed goatgrass density.

WINTER WHEAT OR SPRING CROPS? ONLY YOUR JOINTED GOATGRASS POPULATION KNOWS FOR SURE! Frank L. Young, Alex G. Ogg, Jr., and John Burns, Research Agronomist and Plant Physiologist, USDA-ARS, Washington State University, Pullman, WA 99164 and Extension Agent, Washington State University, Colfax, WA 99111.

Abstract. Information on jointed goatgrass population dynamics in dryland winter wheat is limited. In the past, research has focused on weed control and winter wheat yield reductions by various jointed goatgrass populations. Subsequently this information was used to determine goatgrass/wheat economic thresholds. However, these short-term thresholds are of little value because jointed goatgrass cannot be controlled

selectively in winter wheat. A long-term, holistic approach, in lieu of an economic threshold must be implemented for jointed goatgrass in winter wheat. A 3-yr study was initiated in 1992 to collect data such as weed seedling establishment, weed seed production, crop yield reduction, crop quality and price dockage.

Initially, jointed goatgrass spikelets were planted at densities of 2, 4, 8, 16, 32, 64 and 128 spikelets/m^2 in winter wheat planted after spring dry pea. Weed seed production, crop yield, and plant biomass were measured. In an adjacent area, shattering of jointed goatgrass spikelets before harvest was determined to be 40%. To evaluate jointed goatgrass population increases, 40% of the total spikelets produced from a specific initial goatgrass population was placed on the soil surface of the respective quadrat and the experimental site was planted to winter wheat for a second year. Weed seed production, crop yield and plant biomass were again measured. The first cycle of the study (wheat after pea followed by wheat after wheat) was conducted during the 1992-93 and 1993-94 growing seasons. The cropping cycle was repeated during the 1993-94 and 1994-95 growing seasons. Precipitation during the 1993-94 season was approximately 50% less than the precipitation during the other 2 yrs. Jointed goatgrass was more competitive and reduced wheat yield severely during the dry year compared to the other 2 yrs. Jointed goatgrass plant population and spikelet production increased greatly over the 2 yr cycle but varied with environmental conditions. As an example, when wheat was planted in spring pea stubble, 18 plants/m^2 produced 2,170 spikelets/m^2. In the following wheat crop (wheat after wheat) 140 plants/m^2 were established and produced 7,975 spikelets/m^2

WHEAT VARIETY RESPONSES TO DICAMBA APPLICATIONS. Tim D'Amato, Kirk Howatt, and Phil Westra, Research Associate, Graduate Student, and Professor, Department of Plant Pathology and Weed Science, Colorado State University, Ft. Collins, CO 80523.

Abstract. Dicamba is a critical component of herbicidal tank mixes applied for control of kochia in winter wheat. The importance of dicamba as a chemical alternative in a weed management system for wheat stems from the fact that kochia has quickly developed resistance to sulfonylurea chemistry. However, there is concern that dicamba may cause intolerable injury to wheat if applied at certain wheat growth stages. This study was designed to assess the effect of broadleaf herbicide treatments, applied at three timings, on five varieties of winter wheat.

The study was established in a split-plot design with three replications at two separate locations, Akron, Colorado and the CSU research facilities. The wheat varieties used were Lamar, Scout-66, TAM 107, TAM 200, and Yuma. Herbicide was applied at wheat dormancy break, fully tillered wheat, and first joint. Herbicide treatments included an untreated check, dicamba (0.125 lb/A), 2,4-D (0.375 lb/A), metsulfuron (0.004 lb/A), dicamba and 2,4-D (0.125 and 0.375 lb/A), dicamba and metsulfuron (0.125 and 0.004 lb/A), metsulfuron and 2,4-D (0.004 and 0.375 lb/A), and dicamba with 2,4-D and metsulfuron (0.125, 0.375, and 0.004 lb/A). Plots were visually evaluated for injury symptoms and plots were harvested for grain yield.

There was little variation in test weights or grain moisture percentage. Wheat yields were not statistically different across timings or treatments at either location. At the Akron site, plots treated with dicamba showed matted injury and slight reduction in height, although this did not result in final yield loss. Wheat at the CSU research facilities showed no visual injury symptoms.

WEED MANAGEMENT DEMONSTRATION AND MAPPING. Terry L. Neider, Donald C. Thill, Geoffrey Shropshire, Miaobin Gao, and William J. Price; Research Support Scientist and Professor, Department of Plant, Soil and Entomological Science; Assistant Professor and Graduate Assistant, Department of Biological and Agricultural Engineering; and Research Associate, Statistics Programs; University of Idaho, Moscow, ID 83844-2339.

Abstract. Studies were established in fields at two locations to evaluate different weed management strategies and mapping techniques. Crops in both fields are grown using a three year rotation (winter wheat-spring cereal-food legume). Studies were initiated during the spring cereal part of the rotation in 1994. Each site is split into two management units with one half managed by the grower (cooperator's half) and one half managed by University of Idaho weed scientists (researcher's half). Each management unit (5.25 to 6 A) is divided into 0.25 A sections, and weeds are counted each spring within each section. Weed counts have been used to help determine the best weed management practices on the researcher's half and to measure the effectiveness of previous weed management treatments. Crop yields also are used as a measure of weed management effectiveness. A global positioning system (GPS) mounted on harvest equipment is used to map weed distribution at harvest.

After two cropping seasons, distinct weed patterns and densities are apparent in each management unit. The primary sampling scheme, in combination with GPS, was used to determine the effectiveness of the different management strategies. Frequency distribution of four weed density categories (very low, low, moderate, and high) for the weed counts were compared between management strategies. Initially, 18% of the total frequency distribution of mayweed chamomile densities fell into the very low density category for both management units before any herbicide treatment (baseline). Weeds in both halves were then treated with MCPA plus bromoxynil in 1994. In the second year, 56% of the total frequency distributions of mayweed chamomile fell into the very low density category after two different preemergence herbicide treatments (imazethapyr on the researcher's half or metribuzin on the cooperator's half). However, by the end of the growing season, using a visual mapping technique, over 70% of the total frequency distribution of mayweed chamomile was in the very low and low density categories on the researcher' half, while there was over 60% in the moderate and high density categories on the cooperator's half. Mapping weed densities is a useful way to evaluate these large scale research studies. We also will use these data to calibrate remote sensing techniques used to map weed densities.

WILD OAT DENSITY AND IMAZAMETHABENZ DOSE AFFECTS WILD OAT SEED PRODUCTION.
Michael J. Wille and Donald C. Thill, Graduate Research Assistant and Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83344-2339.

Abstract. One method of lowering production costs and achieving an overall reduction in pesticide use is by using reduced herbicide rates. However, the long-term effectiveness of this strategy requires consideration, not only of the effects that reduced rates can have on the current weed population, but on the fecundity of survivors, as well. Reduced current-year costs may not be justifiable if large numbers of weed seed are added to the soil seed bank. A study was initiated during the spring of 1995 to determine the effect of wild oat density and imazamethabenz rate on wild oat seed production in spring barley. The experiment was a five by five split-plot with four replications, with wild oat stand densities of 8, 30, 56, 72, and 110 plants/m^2 as main plots, and imazamethabenz doses of 0.131, 0.263, 0.395, 0.526 kg/A, plus an untreated control as subplots. Imazamethabenz rates represent 100, 75, 50, or 25% of the recommended maximum dose. Wild oat was seeded in main plots to achieve specific plant densities. Spring barley was seeded at 95 kg/ha with a commercial grain drill in rows spaced 10 cm apart. Established plant populations of both barley and wild oat were counted prior to herbicide treatment. At maturity, defined as the point when the uppermost florets of wild oat began to shed their seeds, wild oat plants were harvested from within a 0.5 m^2 quadrat in each plot. The number of panicles were counted, and the seeds were collected and counted.

Actual wild oat stands ranged from 7.6 to 109.8 plants/m^2. Weed control at all wild oat densities was greater than 90% with imazamethabenz, except at the lowest dose at which control was reduced to 40%. The number of wild oat panicles/m^2 ranged from 17.6/m^2 for the control to 2.3/m^2 for the highest imazamethabenz dose. The number of wild oat seeds produced were over 2000/m^2 for the control and 803, 114, 35, and 25 for the 25, 50, 75, and 100% imazamethabenz doses, respectively, when averaged over wild oat density. There was, however a significant wild oat density by herbicide dose response for wild oat seed population. Grain yields from all herbicide treated plots were greater that the control, but did not differ from each other.

EFFECT OF APPLICATION TIMING AND HERBICIDE RATE ON WEED CONTROL IN IRRIGATED SPRING BARLEY. Mark J. Pavek, Donald W. Morishita, and Robert W. Downard, Graduate Research Assistant, Associate Professor, and Support Scientist, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Twin Falls, ID 83301.

Abstract. Profitable barley production normally requires some method of weed control and growers typically rely on herbicides. Influenced by economics, food safety, and environmental concerns, researchers are evaluating existing weed control strategies. In two 1994 studies we investigated the effects of applying commonly used herbicides at rates reduced from the recommended label rate to weeds in barley at different weed growth stages. Both studies included six rates 1X, 0.83X, 0.67X, 0.5X, 0.33X, 0.167X (where 1X = labeled rate) and an untreated control. Imazamethabenz (1X = 0.46 kg/ha) was used in one study for wild oat control and was applied to wild oat at the spike to 1-leaf, 1- to 3-leaf, and 3- to 5-leaf stages. In a second study, bromoxynil/MCPA plus thifensulfuron/tribenuron (1X = 0.42 + 0.016 kg/ha, respectively) was used to control common lambsquarters at the cotyledon to 2-leaf, 2- to 4-leaf, and 4- to 8-leaf stages. Imazamethabenz rates between 0.5X and 1X controlled wild oat > 87%. The 0.167X and 0.33X rates controlled wild oat 50% and 80%, respectively. Application time had no effect on wild oat control. All imazamethabenz-treated barley yielded more grain than the untreated control. The three lowest application rates (0.167X, 0.33X, and 0.5X) of the broadleaf herbicide tank-mix controlled common lambsquarters 73% or more when applied at the cotyledon to 2-leaf and 2- to 4-leaf growth stages. Common lambsquarters control was 90% or greater when the herbicides were applied at the three highest rates regardless of application time. Generally, grain yield in tank-mix treated plots was greater than the untreated control. All herbicide treatments (both studies) dramatically reduced weed-seed production compared to the untreated control. These data suggest that application of reduced herbicide rates can satisfactorily control common lambsquarters when applied at early growth stages and wild oat when applied before the five leaf stage.

CONTINUOUS REDUCED HERBICIDE RATES IN A WINTER WHEAT-SPRING PEA ROTATION. Joan M. Campbell and Donald C. Thill, Research/Instructional Associate and Professor, Plant Science Division, University of Idaho, Moscow, ID 83844-2339.

Abstract. Reduced herbicide input may sustain crop yield, crop quality and weed populations in the short term. However, long term effects of continuous reduced herbicide rates are often not investigated. Two separate experiments, one in wheat and one in pea, were established spring 1993 to determine the effects of reduced herbicide rate in winter wheat-spring pea rotations on the Palouse. Herbicides were applied at reduced rates for 3 years in two pea-wheat rotation experiments. In wheat, weed seedlings were counted in two, 1 m^2 areas per plot before herbicide application. Bromoxynil and thifensulfuron/tribenuron were applied at 0.28 + 0.021, 0.19 + 0.013, and 0.09 + 0.007 kg/ha, respectively. An untreated check was included for comparison. Weed plants were sampled, recounted, and weighed from the same areas 4 weeks later. In pea, weeds were sampled and counted 6 weeks after the pre-emergence treatment of ethalfluralin plus triallate at 0.84 + 1.7, 0.57 + 0.93, and 0.28 + 0.47 kg/ha. Bentazon at 0.28, 0.57, and 0.84 kg/ha was applied post-emergence when necessary.

Spring pea in 1993 was highly competitive with weeds due to delayed seeding, which controlled weeds initially, and a wet, cool summer. Common lambsquarters control was high with all herbicide rates (4 to 12 plants/m^2) compared to the check (37 plants/m^2). There were few other weeds. Wild oat stand was low (2.2 plants/m^2) and the 1X and 0.66X rates controlled 100% of the wild oat present. Some injury from the 1X and 0.66X rates was evident in reduced pea seed yield (2813 and 3096 kg/ha, respectively) compared to the check (3210 kg/ha). Weed control in wheat was not different between the 1X and the 0.66X rate for any weed species present. Mayweed chamomile (0.03 to 2.14 plants/m^2) and prickly lettuce (0.13 to 0.35 plants/m^2) control was not different among any treated plot, but control in all treated plots was better than the untreated check (43 mayweed chamomile plants/m^2 and 2.65 prickly lettuce plants/m^2). However, shepherd's-purse was not controlled with the 0.33X rate. Wheat yield and test weight did not differ among any rates including the untreated check.

In 1994, fewer weeds (12 to 19 plants/m^2) tended to emerge in winter wheat after only one year of reduced herbicide rates in the previous pea crop compared to the untreated check (24 plants/m^2). There were no weeds in the 1X and 0.66X treatment after herbicide application. The 0.33X treatment and the check had the same number of weeds (3 plants/m^2), but the biomass was reduced greatly with 0.33X herbicide treatment (8 g/m^2) compared to the check (33 g/m^2). Wheat test weight and grain yield did not differ among treatments. Herbicides were applied in the pea experiment before weeds emerged so the effect of carryover from reduced herbicide applications in the previous wheat crop was indeterminable. However, total weed emergence was 8, 20, 31, and 76 plants/m^2 for the 1X, 0.66X, 0.33X and check, respectively; the same trend as the wheat experiment. Nine weed species were present in the pea experiment. Weed density and biomass generally was similar among the 1X and 0.66X treatments and similar among the 0.33X and the untreated check.

In 1995, there were fewer weeds in the treated wheat plots (3 to 73 plants/m^2) after herbicide application compared to the check (369 plants/m^2). Wheat test weight was 8% lower and grain yield was 48% lower in the check compared to the treated plots. The trend for lower wheat yield and wheat test weight within reduced rate treated plots was not statistically significant. In pea, total weed emergence after the pre-emergence treatments was 2.5, 3.2, 9.5 and 77.5 plants/m^2 for the 1X, 0.66X, 0.33X and check, respectively; the same trend as the wheat experiment. Seven weed species were present in the pea experiment. Weed density tended to be greater in the 0.33X treated plots (9.5 plants/m^2) than in the 1X and 0.66X treated plots (2.5 and 3.2 plants/m^2, respectively). Pea seed yield was the same for all herbicide treated plots, but seed yield from the check was 16% lower by comparison. In both pea and wheat, the trend is for reduced weed numbers and biomass as the amount of herbicide increases, but this was not statistically different due to variation in weed populations.

CHEMICAL CONTROL OF PERSIAN DARNEL (*LOLIUM PERSICUM* Boiss & Hoen.). Jessie A. Strobbe, Peter K. Fay, and Ann Carlson, Student, Professor, and Student, Department of Plant, Soil and Environmental Sciences, Montana State University-Bozeman, Bozeman, MT 59715.

Abstract. Persian darnel is becoming an increasingly troublesome weed for small grain producers in Montana. Field experiments were conducted in barley, spring and durum wheat, and on fallow at seven locations in 1995. Diclofop-methyl (1.1 kg/ha) and tralkoxydim (0.18 kg/ha) provided an average of 90% and 95% control of Persian darnel, respectively. The addition of ammonium sulfate to the spray solution improved the performance of tralkoxydim. Fenoxyprop and imazamethabenz were ineffective. Approximately 0.9 kg/ha glyphosate was needed to provide 96% control of Persian darnel on fallow land. Persian darnel seed was collected from grain bins containing spring wheat seed of the 1994 crop on a farm near Cut Bank, MT where a carefully timed application of diclofop-methyl failed. The Persian darnel plants grown from the recovered seed were resistant to diclofop-methyl, tralkoxydim, and metsulfuron methyl, but susceptible to fluazifop, sethoxydim, glyphosate, EPTC, triallate and trifluralin.

USE OF QUINCLORAC FOR LONG TERM MANAGEMENT OF FIELD BINDWEED. Stephen Enloe, Phil Westra, and Scott Nissen, Graduate Research Assistant, Associate Professor, and Assistant Professor, Department of Plant Pathology and Weed Science, Colorado State University, Fort Collins, CO 80523.

Abstract. Field bindweed is a very serious perennial weed in most dryland agricultural areas of the United States. Its extensive root system makes it both an excellent competitor for moisture and very difficult to control. Four field studies were established in the fall of 1994 to evaluate the long term control of field bindweed. Treatments included quinclorac, picloram, dicamba, and glyphosate. Each treatment also included 1.0 lb/A of 2,4-D. Twenty by thirty foot plots were established in wheat-fallow rotations in areas with severe infestations of field bindweed. Treatments were applied with a CO_2 pressurized backpack sprayer at 15 gallons/A. Field bindweed was under moisture stress at two of the four locations at the time of application. Visual evaluations (0=no control; 100=total control) were taken at either 9 or 10 and 11 months after treatment.

Quinclorac at 0.25 lb/A gave excellent control of field bindweed at three of the four locations, as did picloram at 0.25 lb/A nine months after treatment. Control with dicamba, glyphosate, and 2,4-D alone reduced bindweed biomass significantly less when the bindweed was under moisture stress. At 11 months after treatment, field bindweed control was slightly reduced with quinclorac, but still comparable to picloram. The efficacy of quinclorac and picloram were not affected when field bindweed was under moisture stress.

MILKWEED CONTROL WITH LOW RATES OF GLYPHOSATE. R. L. Zimdahl, R. D. Zeller and M. G. Boosalis, Professor, Department of Plant Pathology and Weed Science, Colorado State University, Fort Collins, CO 80523, Director, Production and Research, Natural Fibers Corporation, Ogallala, NE 69153, and Professor Emeritus, Department of Plant Pathology, University of Nebraska, Lincoln, NE 68583.

Abstract. Milkweed is being developed as a crop in western Nebraska by the Natural Fibers Corporation. The cropping system demands weed management in the year of milkweed establishment from seed and for the subsequent five harvest years. After five harvests the stand declines and milkweed must be destroyed so it doesn't become a weed in succeeding crops. Recommended rates for control of mature milkweed are 2.5 to 3 lb/A of the isopropylamine salt of glyphosate. Field trials from 1991 to 1994 in western Nebraska have shown that nearly 100% of mature milkweed plants can be controlled with 0.021 lb/A applied in late May or late June, with two subsequent applications of the same rate about 10 days apart. Intervening tillage reduces control. The total amount of glyphosate applied in 20 days was 0.063 lb/A.

MON 37500: A NEW SELECTIVE HERBICIDE TO CONTROL ANNUAL AND PERENNIAL WEEDS IN WHEAT. Neal R. Hageman, Sheldon E. Blank, Gary L. Cramer, 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.

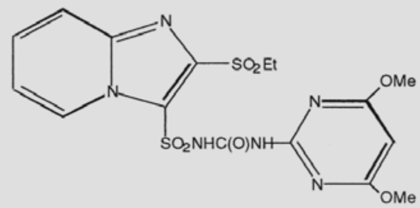
INTRODUCTION

Selective control of grass weeds in wheat has been a difficult task. North American winter wheat growers have essentially had no means of selectively controlling the brome complex (downy brome, Japanese brome, and cheat) and these species have been an increasing problem for years. Quackgrass represents another uncontrolled weed problem in wheat. Weeds like wild oat and green foxtail have herbicide solutions, but still remain key weed problems for the wheat grower.

MON 37500, a new herbicide being developed by Monsanto Company, has demonstrated good activity against the above mentioned hard to control weed species while demonstrating good crop safety in both winter and spring wheat. MON 37500 herbicide has activity on many of the grass weed species in wheat, especially the brome complex in winter wheat, and also has a very useful broadleaf spectrum. As a grass active sulfonylurea herbicide, MON 37500 will be adding another mode of action to the currently available arsenal of grass herbicides in spring wheat. This could possibly decrease the risks of developing herbicide resistance.

PHYSICAL AND CHEMICAL PROPERTIES

Structure:



Chemical name (IUPAC)	:	1-(2-ethylsulfonylimidazo[1,2-a]pyridin-3-ylsulfonyl)-3-(4,6-dimethoxypyrimidin-2-yl)urea
Common name	:	Sulfosulfuron (proposed)
Code number	:	MON 37500
Emperical formula	:	$C_{16}H_{18}N_6O_7S_2$
Molecular weight	:	470.48
Physical state	:	Solid, white, odorless
Melting point	:	201.1 to 201.7^{O}
Vapor pressure	:	$<10^{-6}$ Pa
Octanol water partition coefficient	:	pH5 buffer <10 pH7 buffer <10 pH9 buffer <10

TOXICOLOGY

Technical material.

Acute oral LD_{50} (rat)	:	>5000 mg/kg, practically non-toxic (EPA category IV)
Acute dermal LD_{50} (rat)	:	>5000 mg/kg, practically non-toxic (EPA category IV)
Acute inhalation LD_{50} (rat)	:	practically non-toxic (EPA category IV)
Skin irritation (rabbit)	:	essentially non-irritating (EPA category IV)
Eye irritation (rabbit)	:	moderate eye irritant (EPA category III)
Dermal sensitization (guinea pig)	:	negative

Environmental toxicity.

96-hr LC_{50} (rainbow trout)	:	>95 mg/L
96-hr LC_{50} (carp)	:	>91 mg/L
5-day dietary LC_{50} (mallard duck)	:	>5620 ppm
48-hr LD_{50} oral (bee)	:	>30 µg/bee
48-hr LD_{50} dermal (bee)	:	>25 µg/bee
48-hr LC_{50} (Daphnia)	:	>96 mg/L

MODE OF ACTION

MON 37500 is a sulfonylurea herbicide. The mode of action is almost certainly inhibition of acetolactate synthase. Upon application, meristematic growth stops immediately. Affected plants appear dark green and stunted. This is followed by a reddening of the stem base. The next phase of plant death is usually very slowly developing necrosis. Death can take 3 to 6 weeks to occur and the speed of death is dependent upon plant growth rate (1).

CROP TOLERANCE

Winter wheat phytotoxicity has been insignificant from both preemergence and postemergence applications of MON 37500 at rates up to 100 g/ha in the field and 560 g/ha in greenhouse studies. Some spring wheat varieties have shown less tolerance than winter wheat. However, the hard red spring wheat varieties appear to be just as tolerant as winter wheat. Durum wheat is generally much less tolerant and tolerance is variety specific. Barley and oats are sensitive to applications of MON 37500 at normal use rates, so applications to these crops are not recommended. Control of volunteer barley in winter wheat has been demonstrated with MON 37500.

WEED CONTROL

MON 37500 controls a broad spectrum of important grass (Table 1) and broadleaf (Table 2) weeds infesting North American wheat. The rate needed to control these weeds is generally between 26 and 35 g/ha, however some weeds are controlled with a much lower rate.

An important group of weeds in winter wheat that are controlled by MON 37500 is the brome complex, which includes downy brome, Japanese brome, ripgut brome, cheat, and hairy chess. The activity of MON 37500 on the brome species is unique to this compound and represents a novel solution to many wheat farmer's problems. MON 37500 has excellent activity on all the brome species in the brome complex. The best control of these winter annual grass species occurs with fall postemergence applications. However, a wide window of application exists to control brome species, with MON 37500 exhibiting good activity from preemergence through spring postemergence applications (Figure 1).

Table 1. Efficacy of MON 37500 on selected grass weeds that infest North American wheat. Susceptible = 85% or higher control is normally achieved at rates of 26 to 35 g/ha. Moderately Susceptible = 60% or better control in normally achieved at rates of 26 to 35 g/ha.

Susceptible	Susceptible	Moderately susceptible
Bluegrass, bulbous	cheat	bluegrass, annual
Brome, downy	chess, hairy	foxtail, green
Brome, Japanese	oat, wild	foxtail, yellow
Brome, ripgut	quackgrass	

Table 2. Efficacy of MON 37500 on selected broadleaf weeds that infest North American wheat. Susceptible = 85% or higher control is normally achieved at rates of 26 to 35 g/ha. Moderately Susceptible = 60% or better control in normally achieved at rates of 26 to 35 g/ha.

Susceptible	Susceptible	Moderately susceptible
Bedstraw, catchweed	mustard, black	buckwheat, wild
Chamomile, mayweed	mustard, tumble	lambsquarters, common
Chickweed, common	mustard, wild	mustard, blue
Cornflower	pennycress, field	
Fiddleneck, tarweed	shepherd's-purse	
Flixweed	sunflower, common	
Ladysthumb	tansymustard, pinnate	

Key weeds in spring wheat controlled by MON 37500 are wild oat and green foxtail. MON 37500 provides excellent wild oat control in spring wheat (Figure 2). Best control occurs when MON 37500 is applied postemergence to the wild oat. Soil applications of MON 37500 are not as active as postemergence applications on wild oat.

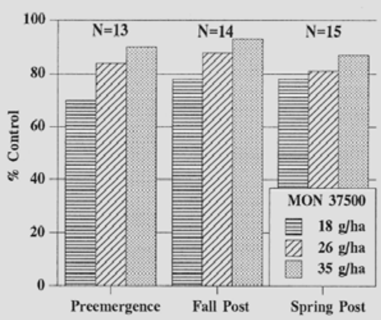


Figure 1. Activity of MON 37500 on downy brome. Data is a 3-year average (1993, 1994, and 1995) of experiments conducted in Colorado, Kansas, and Washington.

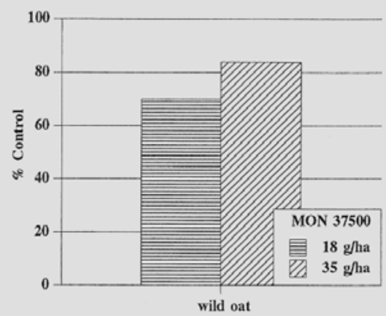


Figure 2. Wild oat control with MON 37500 applied postemergence in spring wheat. Data is an average of 6 experiments conducted in Montana and North Dakota during the 1993 season.

Broadleaf weed control with MON 37500 is an added benefit for the wheat producer. MON 37500 provides excellent control of many winter annual broadleaf weeds, such as field pennycress, shepherd's-purse, flixweed, tansymustard, tumble mustard, and wild mustard (Table 2). It also is very effective on several annual broadleaf weeds, such as mayweed chamomile, tarweed fiddleneck, catchweed bedstraw, and common sunflower. Greater than 95% control of pinnate tansymustard (DESPI), tumble mustard (SSYAL), mayweed chamomile (ANTCO), and tarweed fiddleneck (AMSLY) was obtained with MON 37500 at 26 to 35 g/ha (Figure 3).

Quackgrass is an important perennial grass weed controlled by MON 37500 (Figure 4). MON 37500 has demonstrated very good activity on quackgrass, providing nearly 90% quackgrass control with only 13 g/ha. Spring postemergence applications provide the best window for control of this tough perennial grass species.

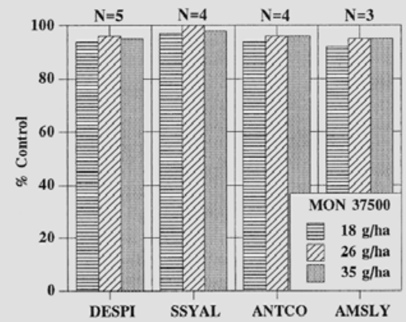


Figure 3. Broadleaf weed control with MON 37500. Data is a three year average (1993, 1994, and 1995) of experiments conducted in Colorado, Idaho, Montana, and Washington.

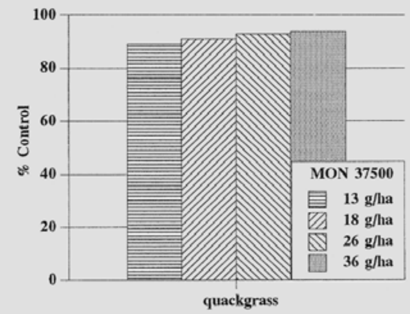


Figure 4. Quackgrass control with MON 37500. Evaluations were taken from 45 to 64 days after treatment. Data is an average of 3 experiments conducted during the 1994 and 1995 seasons.

SOIL CHARACTERISTICS

MON 37500 dissipates rapidly in the soil. The DT_{50} of MON 37500 was determined at four locations in the United States. Field studies were conducted under normal soil conditions in California and Washington during 1994 and in Texas and North Dakota during 1995. These studies show that MON 37500 has a DT_{50} between 13 and 75 days. As with all sulfonylurea herbicides the speed of breakdown is dependent upon factors such as soil moisture, soil temperature, organic matter content, soil pH, and soil texture.

Similar to other sulfonylurea herbicides, some rotational crops show extreme sensitivity to MON 37500. Some of the most sensitive crops include sugarbeets, sunflowers, and sorghum. Despite its rapid breakdown, injury to some of these crops can be expected depending upon the soil and weather conditions and the sensitivity of the rotational crop.

CONCLUSIONS

MON 37500 is a new wheat selective sulfonylurea herbicide with activity on grass and broadleaf weeds. It has the unique ability to control brome species selectively in winter wheat. MON 37500 also has valuable activity on wild oat, quackgrass, and green foxtail. The ability to control brome species fills an unmet need for the wheat producer in the western part of the United States. The wide application window will make MON 37500 a useful new tool for the wheat grower.

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

Abstract. Winter annual brome species infest more than 1.5 million A and jointed goatgrass infests more than 600,000 A of winter wheat in Kansas. Field experiments were conducted in 1994 and 1995 to evaluate

application rate, timing, and downy brome density effects on the efficacy, selectivity, and weed control spectrum of MON 37500 in winter wheat. The three densities of downy brome averaged 38, 45, and 60 plants/m^2. Flixweed and henbit densities averaged 300 and 200 plants/m^2, respectively, regardless of downy brome density. A dose-response study also was conducted in the greenhouse to determine the relative susceptibility of cheat, downy brome, Japanese brome, jointed goatgrass, and winter wheat to MON 37500.

Downy brome density did not affect herbicide efficacy or crop tolerance, so data were averaged over downy brome density. Herbicide rate by application timing interactions occurred for downy brome, flixweed, and henbit control, but no interactions occurred for winter wheat parameters. When averaged over herbicide rate, downy brome control decreased with each later application: PRE, 94% > fall POST, 79% > spring POST, 58%. When averaged over application timing, downy brome control increased with increasing herbicide rate 0.016 lb/A, 66% < 0.023 lb/A, 79% < 0.031 lb/A, 85%. PRE applications of MON 37500 at 0.016 lb/A and higher controlled henbit 99 or 100%, compared with 75 and 63% at the 0.031 lb/A rate applied fall- or spring-POST, respectively. Flixweed control ranged from 94 to 99%. Wheat heading date, head density, and grain test weight were not affected by herbicide rate, application timing, or weed density. In contrast, wheat receiving spring-POST applications was shorter, yielded less, and had higher grain moisture content than wheat receiving PRE or fall-POST applications. However, considering the dense populations of flixweed and henbit, it is not known whether these effects were caused by MON 37500 or weed competition. In the dose-response study, winter wheat dry weights were not reduced by preplant-incorporated MON 37500 at concentrations up to 60 ppbw. The relationship between winter annual grass weed susceptibility and MON 37500 dose was curvilinear. Response of the four winter annual grass to MON 3700 in increasing order of susceptibility were: jointed goatgrass << cheat = downy brome < Japanese brome.

CHEAT CONTROL IN OKLAHOMA WHEAT WITH MON 37500. Thomas F. Peeper and Jeffrey A. Koscelny, Professor and Senior Agriculturist, Agronomy Department, Oklahoma State University, Stillwater, OK 74078.

Abstract. Cheat is the major weed winter annual grass weed in winter wheat in Oklahoma. The severity of infestation is increased by farmers' desire to seed wheat early to increase forage production in the traditional wheat forage plus grain production system. Thus, we have a critical need for a selective cheat herbicide control with little or no grazing restriction.

MON 37500 was applied at three rates (0.25, 0.375, 0.5 oz/A) preemergence to wheat, and postemergence to wheat with 4-leaves to 3-tillers, with 3 to 6 tillers, and in late February. All treatments except those delayed until February controlled cheat 83% to 98% and increased yield at one site from 11.9 to 39 or more bu/A and at a second site from 12.4 to 23.7 or more bu/A. MON 37500 caused no negative effects on wheat forage production, tillering, or grain volume weight (test weight).

INTRODUCTION OF BAY FOE 5043, A NEW HERBICIDE FOR WINTER WHEAT AND SEED GRASSES IN THE PACIFIC NORTHWEST. Jack W. Warren, Bayer Corporation, Beavercreek, OR 97004.

Abstract. BAY FOE 5043, a new acetamide herbicide, with pre-emergence and post-emergence activity, has been investigated since 1992 as a potential herbicide for winter wheat and seed grass crops. The compound has been investigated alone, and in combination with metribuzin.

Downy brome, Italian ryegrass, rattail fescue and annual bluegrass control has been excellent with rates of 0.25 lb/A to 0.5 lb/A. Tank-mixing of FOE 5043 at 0.25 lb/A with metribuzin at 0.125 lb/A enhances grass activity and also enhances broadleaf activity on tarweed, tumble mustard, tansy mustard, and wild radish. Crop

tolerance has been excellent at these rates with both pre-emergence and post-emergence applications, comparable to metribuzin plus chlorsulfuron, metribuzin plus triasulfuron and diclofop standards used for comparison.

CONTROL OF ANNUAL GRASSES IN WINTER WHEAT WITH FOE 5043. Carol Mallory-Smith, Bill D. Brewster, and Dennis M. Gamroth, Assistant Professor, Senior Instructor, and Faculty Research Assistant, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331-3002.

Abstract. Annual grasses, particularly Italian ryegrass, are a major problem in wheat production in western Oregon. Trials were conducted at six locations in 1994 to 1995 and at seven locations in 1995 to 1996 to evaluate the efficacy and crop safety of a new herbicide, FOE 5043, in combination with metribuzin. Treatments were applied preemergence and at the 1-leaf stage of growth of the wheat and weeds in 1994 to 1995, and at the 1-leaf stage in 1995 to 1996. The experimental design was a randomized complete block with four or five replications and 8 by 25 foot plots. FOE 5043 plus metribuzin was more effective than triallate followed by chlorsulfuron-metsulfuron plus metribuzin on rattail fescue (100% vs 70%), California brome (75% to 97% vs 57% to 68%), and ripgut brome (85% vs 51%), but was less effective on cheat (0% to 53% vs 70% to 88%). Both treatments provided at least 90% control of annual bluegrass. Italian ryegrass control was comparable at both timings of FOE 5043 plus metribuzin at four locations in 1994-95 (Table 1). Visual ratings of crop injury were sometimes higher for the FOE 5043 treatments than for the triallate treatment, but wheat grain yield was usually about equal to or greater than the triallate treatment (Table 2).

Table 1. Visual evaluations of Italian ryegrass control with herbicide treatments in winter wheat at four locations in western Oregon, 1994 to 95.

		Application	Italian ryegrass control[2]			
Treatment[1]	Rate	timing	Lafayette	Sheridan	Perrydale	Hyslop
	lb/A		%			
Triallate/ metribuzin + chlr-met	1.25 0.14 + 0.019	PEI 2 leaf	94	99	90	100
FOE 5043 + metribuzin	0.25 + 0.125	PES	100	98	97	100
FOE 5043 + metribuzin	0.375 + 0.125	1 leaf	100	99	97	100
Check	0		0	0	0	0

[1]Non-ionic surfactant added to metribuzin + chlorsulfuron-metsulfuron (chlr-met) treatment at 0.25% v/v.
[2]Evaluated February, 1995.

Table 2. Wheat grain yields and visual evaluations of crop injury from herbicide treatments at four locations in western Oregon, 1994-95.

			Visual evaluation and wheat yield[2]							
		Application	Lafayette		Sheridan		Perrydale		Hyslop	
Treatment[1]	Rate	timing	Injury	Yield	Injury	Yield	Injury	Yield	Injury	Yield
	lb/A		%	bu/A	%	bu/A	%	bu/A	%	bu/A
Triallate/ metribuzin + chlr-met	1.25 0.14 + 0.019	PEI 2 leaf	0	90	14	90	0	40	15	107
FOE 5043 + metribuzin	0.25 + 0.125	PES	0	106	24	71	14	48	5	105
FOE 5034 + metribuzin	0.375 + 0.125	1 leaf	5	105	13	86	11	56	22	111
Check	0	---	0	26	0	26	0	14	0	50
LSD (0.05)				16.6		20.7		6.1		6.9
CV (%)				12.7		19.1		10.6		5.4

[1]Non-ionic surfactant added to metribuzin + chlorsulfuron-metsulfuron (chlr-met) treatment at 0.25% v/v.
[2]Evaluated February, 1995.

KOCHIA CONTROL IN SPRING WHEAT WITH POSTEMERGENCE HERBICIDE TREATMENTS.
Gary A. Lee and Alex G. Ogg, Jr., Professor, Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow ID 83844-2339 and Plant Physiologist, Nonirrigated Weed Science Research Unit, USDA-ARS, Pullman, WA 99164-6416.

Abstract. Spring wheat has become an important component of the cropping system in the traditionally winter wheat growing areas of the Palouse Region of northern Idaho and eastern Washington. The spring cereal crop affords producers an opportunity to more effectively combat winter annual grassy weeds such as downy brome and jointed goatgrass. However, rapidly spreading and intensifying infestations of kochia, a relatively new weed to the region, pose a serious threat to the economic production of spring wheat. Kochia populations with resistance to sulfonylurea herbicides are now common in this region and are limiting the development of effective control tactics for this aggressive annual weed. Dense infestations of kochia not only compete vigorously with wheat and reduce crop yields, but they also impede the harvest operation and reduces the crop value by contributing to excessive dockage at the elevator.

Studies were conducted in Whitman County, WA, to evaluate postemergence applied herbicide treatments for the control of kochia in spring wheat. Herbicide treatments were applied when kochia plants ranged from the 6 to 8-leaf rosette stage to 2-inch tall, 22-leaf stage of growth and the spring wheat (var. 'Centennial') plants had 5 leaves and 2 tillers (principal growth stage: 22G). Herbicides were applied May 14, 1995, with a CO_2 pressurized backpack sprayer calibrated to deliver 12 gpa at 30 psi. Treatments were arranged in a randomized complete block design with four replications and individual plots were 10 by 35 feet. Herbicide treatments were evaluated for crop injury and weed control 8 days and 30 days after application. Spring wheat was harvested at maturity with a small plot Wintersteiger combine on August 28, 1995. Crop yield and bushel test weights were calculated on samples after cleaning with a clipper cleaner.

Kochia was not controlled effectively with any sulfonlyurea herbicide alone or in combination. F-8426 at 0.031 lb/A and F-8426 plus 2,4-D amine DF at 0.031 + 0.25 lb/A killed the kochia plants rapidly (within 8 DAT), but did caused slight to moderate chlorosis to the wheat leaves. New wheat leaves produced after F-8426

applications were healthy and only slight stunting was detectable 30 DAT. All herbicide treatments which contained dicamba at 0.094 to 0.19 lb/A controlled 96% or more of the kochia population 30 DAT. Wheat plants were at the upper limits of the recommended stage for treatment and dicamba caused initial slight to moderate internode bowing and/or some prostrate growth of the wheat plants. Vigor of wheat plants in the plots treated with MCPA plus dicamba at 0.25 + 0.19 lb/A and 2,4-D amine plus dicamba at 0.5 + 0.19 lb/A was reduced 15 and 18%, respectively, 30 DAT, but crop yields and bushel test weights from the these plots were among the highest in the study. Initial kochia control was 79% or more with bromoxynil plus 2,4-D LVE at 0.25 + 0.5 lb/A, clopyralid plus MCPA at 0.095 + 0.5 lb/A, bromoxynil plus 2,4-D amine at 0.25 + 0.25 lb/A and prosulfuron at 0.027 lb/A, but the surviving kochia plants grew vigorously throughout the growing season and formed a dense canopy which prohibited the mechanical harvest of the wheat crop. Only 2,4-D LVE at 0.75 lb/A, F-8426 at 0.031 lb/A, F-8426 plus 2,4-D amine DF at 0.031 + 0.25 lb/A and dicamba at rates of 0.094 to 0.19 lb/A in combination with bromoxynil, pyridate, MCPA and 2,4-D amine controlled kochia sufficiently to allow the wheat crop to be harvested mechanically.

Wheat yields were obtained from plots treated with 9 of the 24 herbicides or herbicide combinations. All other plots contained such dense kochia growth that the crop would have been considered a total loss under commercial conditions. F-8426 plus 2,4-D amine DF at 0.031 + 0.25 lb/A, pyridate plus dicamba at 0.47 + 0.094 lb/A and MCPA plus dicamba at 0.25 + 0.19 lb/A treated plots yielded 70 to 72 bu/A with test weights of 61 lb/bu compared to yields of 24 bu/A with test weights of 51 lb/bu from the nontreated check plots. Kochia air dried biomass harvested from the weedy check plots averaged 16400 lb/A. Although herbicide treatments containing F-8426 or dicamba caused some initial phytotoxicity to the wheat crop, the suppression of kochia throughout the growing season resulted in wheat yields nearly three times greater than yields from the nontreated check plots.

USE OF A WEED-SENSING SPRAYER IN CONSERVATION FALLOW. Robert E. Blackshaw, Weed Scientist, Agriculture and Agri-Food Canada Research Center, Lethbridge, AB T1J 4B1.

Abstract. Experiments were conducted over 3 years to determine the most efficient use of the Detectspray-S50 weed-sensing sprayer to control weeds on fallow. Grass weeds were more difficult for the sprayer to detect than broadleaf weeds. Grass weeds had to have 4 to 5 leaves to be consistently detected unless present at high densities. Broadleaf weeds were often detected when they had 3 to 4 leaves. Kochia rosettes needed to be about 10 cm in diameter to be consistently detected. The sprayer's ability to detect weeds was reduced within 1 to 1.5 hours of dawn or dusk; a limitation when trying to avoid windy conditions. Over the 3 years, the amount of glyphosate/dicamba (at a rate of 330/150 g ha^{-1}) used during the fallow season was reduced 9 to 60% with the weed-sensing sprayer. The Detectspray treatments occasionally had to be sprayed more frequently than the broadcast herbicide treatments because small weeds were missed. A two boom system applying 30% of the herbicide continuously in one boom and 70% through the boom equipped with detecting nozzles saved less herbicide than Detectspray alone but did provide more consistent weed control and the time interval between sprayings more closely matched that of the blanket broadcast applications. Treatments combining two herbicide applications with Detectspray or the two boom system followed by wide blade cultivation for the remainder of the fallow season provided a good alternative to total chemical fallow. These combined herbicide and tillage treatments controlled weeds economically and maintained sufficient crop residues to minimize soil erosion.

WeedSOFT$_{SM}$: A COMPREHENSIVE COMPUTER-AIDED WEED MANAGEMENT SYSTEM. David A. Mortensen[1], Alex R. Martin[1], Fred W. Roeth[2], Thomas E. Harvill[1], Robert N. Klein[3], Gail A. Wicks[3], Robert G. Wilson[4], David L. Holshouser[5], and John W. McNamara[1], Associate Professor, Professor, Professor, Computer Specialist/Programmer, Professor, Professor, Professor, Assistant Professor, and Extension Assistant, [1]Agronomy Department, University of Nebraska, Lincoln, NE 68583, [2] University of Nebraska South Central Research and Extension Center, Clay Center, NE 68933, [3]University of Nebraska West Central Research and Extension Center, North Platte, NE 69101, [4]University of Nebraska Panhandle Research and Extension Center, Scottsbluff, NE 69361, and [5]University of Nebraska Northeast Research and Extension Center, Concord, NE 68728.

Abstract. WeedSOF$_{SM}$ is a computer program that brings the latest technical information from the University of Nebraska Weed scientists. This comprehensive tool will help with the weed management decision process: from problem identification to selection of the most cost-effective and environmentally-sound treatment including both postemergence and soil applied. WeedSOFT$_{SM}$ is a comprehensive, computer-aided weed management system that works three ways.

Advisor is a diagnostic and analytic decision support system to help you select the best management solution to your specific weed problem. The Advisor function takes the guesswork out of weed management by providing real numbers. The grower provides the data -- crop, soil moisture, climate, and number and type of weeds -- and Advisor analyzes those contributing conditions and recommends effective herbicide treatments. Advisor incorporates both soil applied and postemergence treatments, and allows pre-season weed management measures, as well as reactive measures if problems develop in season.

In addition, for each recommendation, Advisor will calculate the cost to treat the problem versus the expected dollar loss if the crop goes untreated. It provides a complete damage estimate based on the latest research, including reduced rates and resistant weeds, and helps assess treatment cost and effectiveness.

WeedVIEW is a picture database for weed identification. This option is a visual display on the computer screen of more than 35 species of weeds to confirm the specific identification of your weed problem.

EnviroFX alerts to potential environmental issues. With this application one can determine some of the potential environmental impacts of specific herbicide treatments. By selecting product names and providing information about the soil and water table depth, one can obtain output including: relative herbicide mobility, relative soil vulnerability to leaching as well as combined herbicide/soil ranking and the potential for a herbicide to reach ground water.

WeedSOFT$_{SM}$ has been designed to make the weed management decisions as easy as possible from start to finish -- including using WeedSOFT$_{SM}$ itself! If familiar with running Windows it is easy to install and operate. It requires an IBM compatible computer, Windows 3.1 (or greater) operating system, and 8 MB of available hard drive space. WeedSOFT$_{SM}$ includes a set of 3.5 inch diskettes and an easy-to understand user's guide.

For additional information contact John McNamara at (402) 472-1544 or weedsoft@mortsun.unl.edu. The date for release has yet to be determined.

EFFECT OF NORFLURAZON ON COTTON STAND ESTABLISHMENT AND YIELD. William B. McCloskey, Assistant Specialist, Department of Plant Sciences, University of Arizona, Tucson, AZ 85721.

Abstract. The effects of preemergence applications of norflurazon in combination with pendimethalin or in combination with both pendimethalin and prometryn on cotton stand establishment and yield was studied at the University of Arizona, Maricopa Agricultural Center. The coarse textured soil in the study area was Casa Grande sandy loam which contained 0.7% organic matter, 65% sand, 20% silt, and 15% clay. The study was conducted during the 1994 and 1995 cotton seasons using a randomized complete block design with six blocks.

Individual plots were either 90 (1994) or 40 (1995) feet long with each treatment being applied to the same plots both years. The effects of the herbicide combinations were examined using both a plant to moisture strategy (wet planting) and a plant dry and irrigate up strategy (dry planting). Preemergence herbicide applications (see data tables for combinations and rates) were made to flat ground on April 6, 1994 and March 24, 1995 and incorporated using a tandem finishing disk to a depth of about 2 inches. The wet plant experiments were established by listing to form a large peaked bed and pre-irrigated to fill the soil profile with moisture. The field was then mulched and planted to moisture with Delta and Pine Land (DPL) cotton variety 5415 on April 20, 1994 and April 10, 1995. The dry soil mulch placed over the seed row to conserve moisture by the planting operation was removed 4 or 5 days after planting to facilitate seedling emergence. The dry plant experiments were established by listing, mulching with a bed shaper, and planting DPL 5415 about 0.5 inches deep. The dry plant experiments were planted on the same day as the wet plant experiments and irrigated on the day of planting or the following day. In 1995 a period of cold weather following planting combined with the herbicide treatments to dramatically increase seedling mortality. Due to the extensive stand loss the experiment was destroyed by disking. The beds were then reshaped, replanted and irrigated on May 31, 1995. Early season stand counts were made in late May, June or early July depending on the experiment and year. The center two rows of the four row plots were machine harvested on October 3, 1994 and November 14, 1995.

Cotton stand counts were highest when pendimethalin was used alone or when no preplant-incorporated herbicide was applied in both the wet plant and dry plant experiments in both years of the study (Table 1). These two treatments were the standards against which other treatments were compared. Tank mixing prometryn with pendimethalin (treatment 9) did not reduce plant populations compared to the standard treatments (treatments 10 and 11) in either the wet plant or dry plant experiments in either year of the study. Tank mixing increasing amounts of norflurazon with pendimethalin (treatments 1 to 4) resulted in decreasing plant populations in both the wet and dry plant experiments in 1994. Tank mixing increasing rates of norflurazon with both pendimethalin and prometryn (treatments 5 to 8) caused a similar decline in plant populations in both the wet and dry plant experiments in 1994. These data and comparisons as well as the symptomatology of the dying cotton seedlings indicate that norflurazon was the component of the tank mixes that caused the seedling mortality in these experiments. Note that the label rate for norflurazon in coarse textured soils is 0.5 lb/A.

In 1995, tank mixing increasing rates of norflurazon with pendimethalin (treatments 1 to 4) also caused a reduction in cotton populations in both the wet and dry (Dry I) plant experiments (Table 1). While the data for the tank mixes of norflurazon with both pendimethalin and prometryn is variable, norflurazon also appeared to cause stand reductions similar to those in 1994. In 1995, a period of cold air and soil temperatures occurred in mid-April combined to cause much greater stand loss than in 1994. For example, in the dry plant experiment of 1994, the stand reduction in treatment 4 was 43% compared to treatment 10 whereas there was a 87% reduction in treatment 4 in 1995. Thus, the 1995 dry plant experiment was because it was obvious there would be significant yield reductions due to the severe stand losses. There were no significant differences in stand counts between any of the treatments in the replanted dry plant experiment (Dry II) in 1995. This was probably because replanting occurred when environmental conditions were more favorable for cotton germination and establishment and because the 68 day interval between replanting and application of the preplant-incorporated herbicides may have allowed some dissipation of the herbicides.

The effect of the herbicide treatments on seed cotton yields was much less than on stand counts but the same trends discussed above were evident (Table 2). The smaller effect of the herbicide treatments on seed cotton yields was probably due to the bush type nature of DPL 5415 and increased growth of surviving plants when plant populations were reduced. The data suggest that yield losses were not significant unless plant populations declined below about 20,000 plants/A.

Table 1. Effect of preplant incorporated herbicides on cotton stand establishment.

Treatment	Rate	1994 Wet	1994 Dry	1995 Wet	1995 Dry I	1995 Dry II[a]
	—— lb/A ——	———	———	plants/A	———	———
1. pend + norf[b]	0.62 + 0.5	25785 bc[c]	32900 ab	46718 abc	24055 a	34146 ab
2. pend + norf	0.62 + 0.75	22034 cd	27382 bc	30117 d	13371 bcd	35852 ab
3. pend + norf	0.62 + 1.0	20449 cd	23886 cd	27128 d	8059 de	30952 b
4. pend + norf	0.62 + 1.25	17351 d	19590 de	23268 d	3618 e	36453 a
5. pend + norf + prom	0.62 + 0.5 + 1.2	29173 ab	29706 abc	40256 c	15924 b	36506 a
6. pend + norf + prom	0.62 + 0.75 +1.2	21090 cd	24176 cd	27189 d	15028 bc	34981 ab
7. pend + norf + prom	0.62 + 1.0 + 1.2	22094 cd	20292 de	40837 bc	9257 cde	29693 b
8. pend + norf + prom	0.62 + 1.25 +1.2	17727 d	14835 e	-	-	-
9. pend + prom	0.62 + 1.2	34195 a	32125 ab	49078 abc	28677 a	31738 ab
10. pendimethalin	0.62	34086 a	34545 a	50179 a	28871 a	32416 ab
11. no herbicide	-	-	-	49937 ab	27237 a	31146 ab

[a]Dry I are data for the first planting whereas Dry II are data for the second planting (i.e. replanting).
[b]pend= pendimethalin, norf=norflurazon, prom=prometryn.
[c]Means within columns followed by the same letter do not significantly differ (P=0.05, Duncan's multiple range test).

Table 2. Effect of preplant incorporated herbicides on seed cotton yield.

Treatment	Rate	1994 Wet	1994 Dry	1995 Wet	1995 Dry II[a]
	—— lb/A ——	———	——— plants/A	———	———
1. pend + norf[b]	0.62 + 0.5	3750 a[c]	3663 a	3890 ab	2523 bcd
2. pend + norf	0.62 + 0.75	3200 ab	3433 a	3330 ab	2710 ab
3. pend + norf	0.62 + 1.0	3327 ab	3241 ab	3292 ab	2691 ab
4. pend + norf	0.62 + 1.25	2959 b	2727 bc	3187 ab	2766 ab
5. pend + norf + prom	0.62 + 0.5 + 1.2	3782 a	3566 a	3853 ab	2674 ab
6. pend + norf + prom	0.62 + 0.75 +1.2	3215 ab	3304 ab	3165 ab	2612 abc
7. pend + norf + prom	0.62 + 1.0 + 1.2	3636 ab	3128 ab	4085 a	2694 ab
8. pend + norf + prom	0.62 + 1.25 +1.2	3375 ab	2465 c	-	-
9. pend + prom	0.62 + 1.2	3911 a	3244 ab	3931 ab	2502 bcd
10. pendimethalin	0.62	3818 a	3592 a	3995 a	2227 de
11. no herbicide	-	-	-	4023 a	1925 e

[a]Dry II are data for the second planting (i.e., replanting).
[b]pend= pendimethalin, norf=norflurazon, prom=prometryn.
[c]Means within columns followed by the same letter do not significantly differ (P=0.05, Duncan's multiple range test).

CONTROL OF NIGHTSHADE IN COTTON WITH STAPLE (PYRITHIOBAC SODIUM) AND ITS EFFECT ON ROTATIONAL CROPS IN CALIFORNIA. Ron Vargas[1], Steve Wright[2], Tomé Martin-Duvall[1] and Manuel Jimenez[2], Interim Cotton Specialist/Farm Advisor, Farm Advisor and Staff Research Associates, University of California Cooperative Extension, [1]Madera County, Madera, CA 93637 and [2]Tulare County, Visalia, CA 93291-4584.

Abstract. The most persistent and difficult weeds to control in the San Joaquin Valley of California have evolved due to herbicide tolerance and rotation of cotton with crops such as tomatoes that are in the same family (Solanaceae) as nightshade. The majority of the cotton acreage is treated with a dinitroaniline herbicide as a preplant incorporated treatment. Annual weeds, including barnyardgrass and many broadleaf weeds such as pigweed (*Amaranthus spp.*) are effectively controlled, but weeds in the Solanaceous family are tolerant. Hairy and black nightshade are prevalent species infesting thousands of acres of cropland.

An Acala cotton field infested with nightshade was divided into plots and replicated four times in a randomized complete block design. Pyrithiobac (DPX-PE350) was applied over the top of Maxxa cotton in the cotyledon to 1-true leaf stage with a second application made when cotton was 6 inches tall in three treatments. Broadcast and 12 inch band applications were evaluated. All treatments were applied with a power driven sprayer at 30 psi applying 20 gpa. After cotton harvest on October 29, 1993 and completion of the efficacy study, normal seedbed operations occurred. Cotton was shredded, the field disced three times (once with the rows and twice at an angle), beds were listed perpendicular to the previous cotton beds, then mulched and shaped previous to planting. Barley, wheat, alfalfa and sugarbeets were planted on December 21, 1993, 230 days after the initial pyrithiobac application (DAT). Onions were planted on January 5, 1994, 245 DAT; tomatoes, March 9, 1994, 308 DAT; corn on May 12, 1994, 372 DAT (double cropped behind wheat) and cotton on May 26, 1994, 393 DAT. Rotation crops were again planted the second year after the pyrithiobac application to cotton as follows: barley, wheat, onions and alfalfa December 1, 1994, sugarbeets December 6, 1994 and tomatoes April 4, 1995.

Excellent black and hairy nightshade control is achieved with pyrithiobac either by itself or when used in combination with preplant incorporated and/or layby herbicides. Nightshade control has ranged from 80 to 100% 50 DAT. There has been no difference in control when pyrithiobac is applied broadcast or band, at 1, 1.5 or 3 oz/A, but applications must be made when nightshade is a small seedling, ranging from cotyledon to four to six leaves. Cotton injury symptoms are evident with all rates of pyrithiobac tested 3 to 4 days after application, but nonexistent 21 to 38 days after treatment. Cotton yield data has shown no reduction in lint per acre when compared to hand weeded control plots.

Pyrithiobac adversely effected growth, development and yields of several rotational crops tested (barley, wheat, alfalfa, onions, sugarbeets, tomatoes, corn and cotton). In general, reductions increased with increasing pyrithiobac rates and was greatest in broadcast treatments when compared to band treatments. Barley was more sensitive than wheat. Tomatoes and corn were more tolerant than most crops with onions and sugarbeets being the most sensitive. There was no effect to cotton growth and development when planted back the following year. When the same crops were planted back, 2 years after the initial pyrithiobac applications, there were no adverse effects on growth, development and yield of all crops studied except onions and sugarbeets. Yields of both were significantly reduced when compared to the control, indicating the sensitivity of root crops to pyrithiobac.

WEED MANAGEMENT IN COTTON WITH CLOMAZONE AND PYRITHIOBAC. Peter A. Dotray and J. Wayne Keeling, Assistant Professor and Associate Professor, Department of Plant and Soil Science, Texas Tech University, Lubbock, TX 79409-2122 and Texas Agricultural Experiment Station, Lubbock, TX 79401.

Abstract. On the Texas Southern High Plains, weed population dynamics coupled with rapid and extreme changes in environmental conditions make weed management very challenging. Current weed management systems in cotton rely heavily on dinitroaniline herbicides. Dinitroaniline herbicides do not effectively control lanceleaf sage, devil's-claw, Venice mallow, morningglory species, prairie sunflower, and puncturevine. Weed escapes, such as Palmer amaranth, occur throughout the growing season in dinitroaniline-treated soils, which interfere with mechanical harvesting. The registration of clomazone and pyrithiobac offer new opportunities for weed management in cotton. Field experiments were conducted near Lubbock in 1993 to 1995 to evaluate annual broadleaf weed control with clomazone and pyrithiobac and cotton tolerance. Soil types ranged from an Olton clay loam to an Amarillo loamy fine sand. Clomazone at 1 lb/A controlled common cocklebur, eastern black nightshade, lanceleaf sage, prairie sunflower, and Venice mallow by at least 95%. Palmer amaranth and devil's-claw control by clomazone was unacceptable. Pyrithiobac at 0.063 lb/A applied EPOST controlled Palmer amaranth and devil's-claw by at least 95% and puncturevine, lanceleaf sage, common cocklebur, and red morningglory by at least 79%. In silty clay loam and sandy clay loam soils, visual cotton injury (1 to 5%) was observed at 4 WAT, but not at 10 WAT or in yield. Severe cotton injury (up to 90%) from clomazone-treated soils was observed improper in-furrow placement of phorate occurred. Pyrithiobac caused visual injury (1 to 5%) in a limited number of studies, but no effect on cotton yield or fiber quality was observed. These studies indicate that proper use of clomazone and pyrithiobac will improve weed management on the Texas Southern High Plains.

VARIETAL DIFFERENCES IN RESPONSE OF COTTON TO PROMETRYN. Martina W. Murray[1], Tracy M. Sterling[1], and William T. Molin[2], Graduate Research Assistant, Associate Professor, and Associate Professor, [1]Entomology, Plant Pathology and Weed Science Department, New Mexico State University, Las Cruces, NM 88003 and [2]Department of Plant Sciences, University of Arizona, Tucson, AZ 85721.

Abstract. Prometryn is a photosynthetic inhibitor which blocks electron transport at the Q_B binding site of the D1 protein. Prometryn is registered for use in cotton, but can cause injury when used on coarse-textured soils, and is not registered for use on glandless cotton. Previous research in this project has demonstrated a differential tolerance to prometryn among cotton varieties. Pima cultivars (*Gossypium barbadense*) and Acala cultivars of Upland cotton (*G. hirsutum*) were more tolerant than Deltapine cultivars (*G. hirsutum*). Previous research also indicated that differences in prometryn tolerance between Deltapine 5415 and Pima S-7 were not due to differences in uptake, translocation, or metabolism of prometryn. In addition, no difference was found in electron transport inhibition as evaluated by paraquat-induced electrolyte leakage or electron-transport-dependent nitrite reduction by leaf disks. The ultimate objective of this project is to elucidate the mechanism of prometryn tolerance of cotton. The first objective of this study was to demonstrate differential tolerance among selected cultivars in both sandy loam and clay loam soils. The second objective was to test whether differences in prometryn tolerance are correlated with the ability to maintain photosynthetic electron transport by isolated thylakoid membranes of selected cultivars. The cultivars evaluated included several cultivars not previously tested and glandless cultivars, which are generally sensitive to prometryn. Cultivars included two Pima-type (Pima S-7, NMSI 1331), two glanded Acalas (Acala 1517-91, Acala 1517-95), two glandless Acalas (Acala g2711, Acala g2791), and one Delta and Pine Land Company cultivar (Deltapine 90). In evaluating prometryn tolerance, seeds were planted in both clay loam and sandy loam soils into which six rates of prometryn had been incorporated (0, 0.7, 1.3, 2.7, 5.4, and 13.4 kg/ha). The plants were rated visually for injury after 4 weeks, and fresh and dry weights of shoots were recorded. NMSI 1331 showed only minor injury in both soils, except at the highest rate of prometryn. Pima S-7 had only minor injury except at the highest rate in both soils and at 5.4 kg/ha in sandy loam. Deltapine 90, Acala 1517-91, and Acala 1517-95 injury was greater in sandy loam, with significant injury at rates as low as 0.7 to 1.3 kg/ha. Acala g2711 and Acala g2791 had the greatest injury,

with substantial injury at 2.7 kg/ha in clay loam and 0.7 kg/ha in sandy loam. The effect of prometryn on the electron transport of thylakoid membranes will be tested using membranes of 3- to 5-week-old plants. Electron transport will be assayed by DCPIP (2,6-dichlorophenolindophenol) reduction, measured spectrophotometrically at 600 nm. The effect of prometryn on electron transport will be presented, and the results will be compared to tolerance at the whole plant level.

EVALUATION OF DIMETHENAMID EFFICACY IN NO-TILL SUNFLOWER. Drew J. Lyon, Assistant Professor, University of Nebraska, Panhandle Research and Extension Center, Scottsbluff, NE 69361.

Abstract. Residue retention for conservation compliance is a major issue for dryland sunflower producers in the central Great Plains. Most herbicides labeled for use in sunflower require mechanical incorporation. Dimethenamid does not require mechanical incorporation and may provide a PRE option for no-till sunflower production. A sequence of four annual field investigations was begun in the spring of 1992 near Sidney, NE to determine the potential of dimethenamid for no-till sunflower production. In 1992, 30 sunflower cultivars were screened for tolerance to dimethenamid applied at the rate of 1.25 and 2.5 lb/A. Sunflower appeared to have adequate tolerance to dimethenamid. Visual injury was evident three weeks after planting, but injury became less noticeable with time and grain yield was not reduced by either herbicide rate. No differences in cultivar tolerance to the herbicide were observed. Over the next three years, several dimethenamid rates, tank mixtures, and application timings were investigated. Dimethenamid applied alone did not provide adequate control of many weeds commonly found in the sunflower fields, i.e., kochia, Russian thistle, and pigweed species. A tank mixture of 1.5 lb/A dimethenamid plus 1.5 lb/A pendimethalin applied early pre-plant or PRE provided consistently good weed control with only a slight risk for crop injury.

DIMETHENAMID: A NEW HERBICIDE FOR GRAIN SORGHUM. John M. Fenderson, Mark C. Boyles, Ken L. Smith, and D. L. Geis, Product Development, Sandoz Agro Inc., Des Plaines, IL 60018.

Abstract. Dimethenamid is a new chloroacetamide herbicide for preemergence control of annual grasses and some small seeded broadleaf weeds. Dimethenamid is currently registered in corn and soybeans, but has shown tolerance in several other crops including grain sorghum. Sandoz Agro has been testing dimethenamid in grain sorghum since 1986 in over 125 trials. Federal registration for dimethenamid in grain sorghum is currently pending. Research results in sorghum indicate excellent crop tolerance to preemergence dimethenamid when sorghum is treated with Concep II or Concep III seed safener. Sorghum has exhibited good tolerance to post applications of dimethenamid as well. Unsafened sorghum is sensitive to soil applications of dimethenamid and has resulted in severe sorghum stand reduction, stunting, or both. Grain sorghum yields indicate no negative effects when dimethenamid is applied preemergence or postemergence to the crop, up to twice normal use rates. Dimethenamid performance has been excellent on economically important sorghum weeds such as crabgrass and pigweed. Preemergence applications of dimethenamid at 0.94 to 1.41 lb/A has provided good to excellent residual control of most annual grasses and pigweed species across all soil types. Dimethenamid will offer sorghum producers an effective and economic alternative for weed management in grain sorghum.

DRY EDIBLE BEAN TOLERANCE TO DIMETHENAMID AND METOLACHLOR. Dennis J. Tonks[1], Bart A. Brinkman[2], and Charlotte V. Eberlein[1], Post Doctoral Fellow, Field Scientist, and Professor, [1]University of Idaho Aberdeen Research and Extension Center, Aberdeen, ID 83210 and [2]Sandoz Agro, Inc., 5130 2nd Ave. S.E., Salem, OR 97306.

Abstract. Chloroacetamide herbicides have been used for weed control in dry edible beans. Dimethenamid is currently being evaluated for use in dry beans. Preliminary studies have shown there can be differential response of dry bean classes to herbicides. Field studies were conducted in 1994 and 1995 to evaluate the response of four dry bean classes to dimethenamid and metolachlor applied preplant incorporated (PPI), preemergence (PRE), or postemergence (POST). Experiments split-plot design with a factorial arrangement subplots. Main plot factors were application timing and subplot factors were four dry bean classes, kidney, navy, pink, and small red; two herbicides, dimethenamid and metolachlor at three rates with four replications. Rates for dimethenamid and metolachlor were equivalent to 0, 1X and 2X rates for each herbicide based on soil type. The experimental area was maintained weed free by hand weeding. Data collected included visual injury evaluations and yield.

Injury ranged from 3 to 6%, 2 to 5%, and 8 to 21% for PPI, PRE, and POST applications, respectively, averaged over herbicide treatments and bean classes. Navy, pink, and small red were more sensitive to POST treatments than kidney. Doubling the herbicide rate did not increase injury with PPI and PRE treatments and doubling the rate for POST applications increased slightly increased injury. Plants quickly recovered from injury. Dry bean yield was not reduced by application timing, herbicide, or rates.

KOCHIA RESPONSE TO PGR, SU, AND TRIAZINE HERBICIDES. Philip Westra, Scott Nissen, Tim D'Amato, Kirk Howatt, and John Foster, Associate Professor, Assistant Professor, Research Associate, and Research Graduate Assistant, Department of Plant Pathology and Weed Science, Colorado State University, Ft. Collins, CO 80523 and Sandoz Agro. Inc., Ft. Collins, CO 80523.

Abstract. Several large scale greenhouse tests have been conducted in Colorado from 1993 to 1996 on a total of 385 kochia accessions to assess a) the response of all accessions to 0.125, 0.25, and 0.5 lb/A of dicamba, and b) the response of 75 accessions to 1 oz/A of chlorsulfuron and 1.25 lb/A of atrazine. This testing was prompted by the need to develop a better regional understanding of the response of kochia to these herbicides, especially in light of the fact that widespread occurrence of sulfonylurea (SU) resistant kochia in small grains has forced adoption of herbicide tank mix strategies which rely heavily on dicamba for kochia control. Forty five field kochia samples from KS, CO, and NE collected in the fall of 1994 (each sample consisted of seed from 10 plants) exhibited an average of 73% control with atrazine and 50% control with chlorsulfuron while 30 samples collected in the fall of 1995 exhibited an average of 81% control with atrazine and 73% control with chlorsulfuron. Several samples in each year exhibited total resistance to either atrazine or chlorsulfuron. We have also used kochia cuttings from Montana and other states to generate new plants which were triggered to produce seed which was used to produce seedlings for inclusion in our testing program.

The most tolerant field kochia samples to date came from two farm fields represented in the 94 field sample data base (Table 1). When the samples from these two fields is removed from the data base, the average kochia response is similar to the historic averages. When the kochia response was averaged over all three dicamba rates, only one sample (out of 385 accessions tested) rated less than 50% (40 to 49%) control. Three additional samples averaged 50 to 59% control, and four other samples averaged 60 to 69% control. These would be categorized as tolerant to moderately tolerant accessions based on our testing procedures, but represent plant samples from only five fields in the western United States. Seventy seven percent of all 385 samples tested averaged 90% or better control. Fourteen percent of all samples were 100% controlled at all dicamba rates. This preliminary research has confirmed 1968 research results from work conducted in North Dakota by Nalewaja and Bell showing that kochia populations can exhibit variable response to PGR herbicides including dicamba. To date, a very low proportion of kochia samples tested exhibit elevated tolerance to dicamba. A very small number of fields have produced kochia samples with varying levels of tolerance to dicamba. All

accessions, however, exhibit a typical dose response to dicamba, and even tolerant plants show typical dicamba injury symptoms which they survive and eventually outgrow.

Table. The response (% control) of kochia accessions from 385 sites evaluated in 5 large studies for their response to three rates of dicamba.[a]

Study	Dicamba 0.125	Dicamba 0.25	Dicamba 0.50	Average
Historic data 1963 to 1994	88 (59)		96 (15)	
200 CO sites	87	97	99	94
51 SU res. samples	82	89	98	90
94 field samples	76	87	94	86
95 field samples	89	93	98	93
95 field cuttings	86	91	96	91

[a]Historic data are from the number of field studies indicated in parenthesis.

EXP31130A: A NEW PREEMERGENT HERBICIDE FOR CORN. Charles P. Hicks and Tom E. Vrabel, Field Development Representative and Technical Development Manager, Rhone-Poulenc AG Company, Research Triangle Park, NC 27709.

Abstract. EXP31130A is a member of a new class of isoxazole herbicides that provide selective control of both grasses and broadleaf weeds in corn. Extensive field trials since 1992 have demonstrated that EXP31130A, applied alone preemergence, controls many important weeds, including: velvetleaf, common lambsquarters, redroot pigweed, smooth pigweed, kochia, barnyardgrass, green and giant foxtail, field sandbur and wild proso millet.

WEED CONTROL IN SUGARBEETS WITH FALL HERBICIDE APPLICATIONS IN A FALL COVER CROP. Stephen D. Miller and K. James Fornstrom, Professor and Professor, Department of Plant, Soil and Insect Sciences and Civil Engineering Department, University of Wyoming, Laramie, WY 82071.

Abstract. Fall application of preplant incorporated herbicides eliminates the need for spring tillage and allows an earlier start for sugarbeets in the spring. Fall herbicide applications; however, increase the risk of soil erosion. Studies were conducted at Torrington, WY from 1992 to 1995 on a light textured sandy loam soil (79% sand, 11% silt, 10% clay with 1.1% organic matter) to compare the efficacy of fall and spring herbicide applications in sugarbeets established in a living winter wheat mulch. The living mulch system employs conventional tillage followed by winter wheat planting between the future sugarbeet rows in late September. The sugarbeets are planted in mid April and the winter wheat sprayed out before the sugarbeets emerge with glyphosate. Preplant herbicide treatments are applied in a band centered over the future sugarbeet rows and incorporated with a pto driven rotary incorporator.

Weed control was similar to slightly better and sugarbeet injury less (4 out of 5 studies) with fall compared to spring preplant herbicide applications. Little herbicide movement out of the treated band was observed with any of the herbicide treatments regardless of when applied as winter wheat growth was unaffected. Cycloate-ethofumesate combinations were more effective than either herbicide applied alone.

To compensate for herbicide loss in the fall treatments during the winter months, application rates were increased 25 to 33%. Early preplant herbicide applications (21 to 28 days) prior to sugarbeet planting caused 5%

less sugarbeet injury than applications at planting while maintaining similar weed control levels at comparable herbicide rates. Combining fall herbicide applications with the living mulch concept on light textured soils is a feasible means for maintaining adequate crop residue and minimizing soil erosion during the winter months. (Published with the approval of the Wyoming Agricultural Experiment Station.)

IMPACTS OF REPEAT APPLICATIONS OF THIAZOPYR TO ALFALFA ON CROPS PLANTED IN ROTATION. Robert F. Norris and John A. Roncoroni, Associate Professor and Research Associate, Weed Science Program, University of California, Davis, CA 95616.

INTRODUCTION

Alfalfa is a perennial forage crop that is typically grown for several years. Herbicides that persist in the soil and provide weed control over extended periods thus have advantages for weed management in the crop over those that do not persist. If persistent herbicides are used the possibility exists that such a herbicide could be accumulated in the soil and remain at the time of crop destruction. Such a carryover presents a threat to crops grown in rotation following alfalfa.

Thiazopyr is a recently developed herbicide that shows promise for control of summer annual grasses, and other weeds, selectively in established alfalfa. Applications made in the late fall provide control of summer annual grasses throughout the next growing season. The season-long control obtained from a single application is very useful in alfalfa, but suggests that the herbicide could build-up in the soil with repeat use and still be present when the crop is plowed out.

Thiazopyr was applied to established alfalfa over a 3 yr period at a combination of rates and application years to evaluate possible carry-over of the herbicide in the soil that might impact crops grown in rotation. A secondary goal was to evaluate weed control and the impacts of weed control on alfalfa stand persistence.

MATERIALS AND METHODS

The experiment was conducted at the University of California, Davis on an established alfalfa (cv. Yolo) field used by the Animal Science Department for hay production. The alfalfa was seeded in Feb. 1989. The soil was a Yolo silt loam (thermic mollic xerofluvents). All production practices were typical for alfalfa hay in the Central Valley of California.

Thiazopyr was applied at 1.1, 0.55, or 0.28 kg/ha in various combinations of rates in 1992 and 1993; the treatment list and dates of application are shown in Table 1. On Jan. 28, 1992 a hand pulled ground-driven Gandy granule applicator was used; on Nov. 11, 1992 and Nov. 15, 1993 a tractor pulled Gandy air-carrier granule applicator was used. The plot size was 15 m by 9 m, and treatments were laid out in a randomized complete block design with three replications. Weed control was visually evaluated in July in 1992 and 1993. At the termination of the alfalfa in October 1994 percent cover of alfalfa, yellow foxtail and bare soil was estimated using 0.5 m^2 quadrats at two locations in each plot. In the untreated plots and those that received 1.1 kg/ha of thiazopyr each year alfalfa crowns were exhumed from 0.5 m^2 quadrats at six locations in each plot.

Ten 2.5 cm diam soil core samples were taken in each plot to a depth of 30 cm using a 'W' sampling pattern immediately prior to each thiazopyr retreatment, and at termination of the alfalfa crop. The samples for each plot were composited and bioassayed for herbicide activity. The soil was dried and crushed to pass through 7 mm mesh screen. The soil was then placed in 15 by 20 cm flats, and 25 barnyardgrass seeds were scattered on the soil surface and the lightly covered with more soil. The flats were placed in a greenhouse maintained at 22 C with natural light, and were sub-irrigated. The barnyardgrass height was measured, the number of plants determined, and dry weights of the plants obtained after the plants in the soil from the untreated plots reached a height of about 40 cm. An additional set of calibration plots were treated on Nov. 11, 1995 with 0.28, 0.55 or

1.1 kg/ha of thiazopyr. These plots were sampled on Dec. 4, 1992 using the same soil core technique outlined above and were bioassayed using the same protocol.

The alfalfa was disked out on March 30, 1995 and soil plowed on April 11, 1995. The ground was disked again on April 25, 1995 and then land-planed. The final soil preparation was a spring-tooth harrowing followed by bed listing. The beds were shaped and crop seeds planted on May 24 to 26, 1995. The initial irrigation was on May 31, 1995. All cultural practices for the remainder of the season were typical for the crops. The field was cultivated between the rows on June 20, 1995, and the whole experiment was hand weeded over a period of July 11 to July 31, 1995. Visual evaluation of crop vigor was made in mid-September and again in mid-October. Cotton and sugarbeets were harvested from 6 m of the center of two rows per plot on October 17 and 20, 1995, respectively. The samples were weighed fresh; no attempt was made to obtain dry weights.

Yellow foxtail was the primary summer weed in the field. In 1992 thiazopyr provided complete grass control regardless of rate applied (data not shown). In 1993 yellow foxtail control was 100% for all plots that were retreated with thiazopyr. Yellow foxtail control was 80% for the one treatment that was not retreated in November 1992 which reflected residual activity or reduced seed bank.

Table 1. Impact of three years of various sequences of thiazopyr on alfalfa and yellow foxtail vegetation cover. Data collected 11 Oct. 1994.

Thiazopyr application			Alfalfa		Yellow foxtail		Bare ground	
28 Jan 92	11 Nov 92	15 Nov 93	Mean	SE	Mean	SE	Mean	SE
	kg/ha							
1.1	1.1	1	66.5	7	0	0	33	7.3
1.1	1.1	0.55	50.8	7.1	1	0.8	43.5	6.5
1.1	1.1	0.28	62.5	6.6	0.8	0.8	30.7	3.4
1.1	1.1	No app.	39.8	1.3	14.2	6.5	42.8	4.9
1.1	0.55	0.55	53.8	3.1	0.2	0.2	43.3	4.4
1.1	0.55	0.28	42.2	9.8	0.8	0.8	51	9.3
1.1	0.55	No app.	35	11.3	45.7	19.3	18	8
1.1	No app.	No app.	20.8	3	78.8	3.2	0	0
0.55	0.55	0.55	51	3.8	2.5	1.4	42.2	6.6
0.55	0.55	0.28	53	8.1	1.5	0.8	39.3	5.3
0.55	0.55	No app.	24.7	7.4	63.8	10.8	5.8	1.7
0.55	0.28	0.28	49.2	8.7	1.3	0.7	39.7	5.5
0.55	0.28	No app.	13.3	5.1	77.3	9.5	8.3	4.2
Untreated control			14.8	2.6	83.8	3.7	0.8	0.8

RESULTS AND DISCUSSION

Prior to the last cutting before crop destruction percent cover of alfalfa varied between 13% and 66% (Table 1). The alfalfa cover was negatively correlated with yellow foxtail cover ($r^2 = 0.74$; $p = <0.001$). Repeat applications of 1.1 kg/ha of thiazopyr completely controlled yellow foxtail (Table 1). All treatments that included an application in November 1993 had less than 2% yellow foxtail cover, which equates to over 98% control. Yellow foxtail was present in all plots that had not been retreated in November 1993; the percent cover increased as the rate of thiazopyr applied in the first 2 years decreased. The treatment that received either 0.28 kg/ha of thiazopyr in November 1993 or was not retreated had yellow foxtail cover that was not different from the untreated check. These data showed sufficient yellow foxtail seed remained, or was reintroduced, to create an infestation even when control had been essentially complete in the preceding year. Development of yellow foxtail in previously treated plots suggested that thiazopyr was not persisting beyond one season.

Alfalfa stand was 22.2±1.6 (mean±SE) crowns/m^2 for the yellow foxtail-free plots retreated with 1.1 kg/ha of thiazopyr each year. The stand in the untreated control plots was 11.0±1.4 crowns/ m^2. These data provide additional evidence that yellow foxtail contributes to increased alfalfa stand loss, and suggest that good control of this summer weed can prolong alfalfa stand persistence. There are few other studies that show that weed control can help to prolong alfalfa stands.

Barnyardgrass was used as a bioassay to evaluate presence of thiazopyr in the soil. Data for weight per barnyardgrass plant were utilized for the bioassay evaluation as this partially corrected for the variation in germination that occurred. Soil samples collected within one month of applying thiazopyr in November 1992 showed a strong correlation between rate applied and growth of barnyardgrass (Figure 1). Barnyardgrass growth thus detected thiazopyr over the range of rates applied, and rates of about 0.1 kg/ha should be detectable.

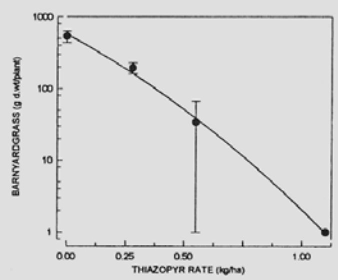

Figure 1. Relationship between thiazopyr application rate and response of barnyardgrass as bioassay plants based on samples from calibration plots treated on Nov. 11, 1992 and sampled on Dec. 4, 1992. Note use of logarithmic scaling of plant size; $y = 2.76-1.74X-0.71X^2$: $p=0.04$ when X = thiazopyr rate.

Table 2. Barnyardgrass bioassay plants grown in soil collected from alfalfa treated with various rates and sequences of thiazopyr in the preceding season(s).

Thiazopyr application			Barnyardgrass growth					
			Nov. 1992		Nov. 1993		Nov. 1994	
Jan 92	Nov 92	Nov 93	Mean	SE	Mean	SE	Mean	SE
kg			mg d.wt/plant					
1.1	1.1	1	355	50	36	15	74	71
1.1	1.1	0.55	393	58	57	3	343	165
1.1	1.1	0.28	192	81	62	17	294	6
1.1	1.1	No app.	377	70	48	5	259	125
1.1	0.55	0.55	313	60	117	9	403	103
1.1	0.55	0.28	311	17	113	40	354	26
1.1	0.55	No app.	289	54	122	27	214	135
1.1	No app.	No app.	349	77	137	40	339	38
0.55	0.55	0.55	498	49	111	22	384	38
0.55	0.55	0.28	388	51	111	21	459	102
0.55	0.55	No app.	372	15	98	20	115	89
0.55	0.28	0.28	365	43	88	18	441	99
0.55	0.28	No app.	389	28	132	19	76	39
Untreated control			338	25	108	8	270	65

Bioassays of soil samples collected prior to thiazopyr reapplication in November 1992 showed little evidence of persistence as barnyardgrass growth was not reduced by an treatment (Table 2). All treatments that had been retreated with 1.1 kg/ha in November 1992 showed suppressed barnyardgrass growth when soil samples collected in November 1993 prior to reapplication were assayed (Table 2). There was no evidence of barnyardgrass growth suppression when thiazopyr was reapplied at 0.55 or 0.28 kg/ha . The bioassay data for soil samples taken in the fall of 1994 after three years of repeat applications of thiazopyr were variable (Table 2). No clear-cut relationship between thiazopyr application and the growth of the barnyardgrass was present. Apparent activity in treatments of 0.55 + 0.55 + 0 kg/ha of thiazopyr and 0.55 + 0.28 + 0 kg/ha of thiazopyr over the three application dates are not consistent with data derived from the earlier assays, and are considered to be anomalies. The low barnyardgrass growth in soil from the plots treated each year with 1.1 kg/ha of thiazopyr suggest that a residue of the herbicide may have persisted at the sampling date, but in light of the apparent activity in the treatments noted above this conclusion is tenuous.

Table 3. Visual evaluation of growth of summer crops on October 6, 1995 planted in rotation following plow-out of alfalfa treated with thiazopyr for up to three seasons.

Thiazopyr application			Beans		Tomato		Cotton		Sugarbeet		Melon	
Jan 92	Nov 92	Nov 93	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
kg/ha			visual evaluation (0 = dead, 5 = normal)									
1.1	1.1	1	5	0	4.8	0.2	4.8	0.2	5	0	5	0
1.1	1.1	0.55	4.7	0.3	4.5	0.5	4.5	0.5	5	0	4.7	0.6
1.1	1.1	0.28	5	0	5	0	5	0	5	0	5	0
1.1	1.1	No app.	5	0	5	0	4.8	0.2	5	0	5	0
1.1	0.55	0.55	5	0	4.8	0.2	5	0	5	0	5	0
1.1	0.55	0.28	5	0	5	0	5	0	5	0	5	0
1.1	0.55	No app.	5	0	4.3	0.3	5	0	5	0	5	0
1.1	No app.	No app.	5	0	4.5	0.5	5	0	5	0	5	0
0.55	0.55	0.55	5	0	4.5	0.3	5	0	5	0	5	0
0.55	0.55	0.28	5	0	5	0.0	5	0	5	0	5	0
0.55	0.55	No app.	5	0	4.8	0	5	0	5	0	5	0
0.55	0.28	0.28	5	0	4.7	0.3	4.7	0.3	5	0	5	0
0.55	0.28	No app.	5	0	4.3	0.7	5	0	5	0	5	0
Untreated control			5	0	5	0	5	0	5	0	5	0

Table 4. Sugarbeet and cotton biomass on October 15, 1995 planted in rotation following plow-out of alfalfa treated with thiazopyr for up to three seasons.

Thiazopyr application			Sugarbeets			Cotton		
Jan 92	Nov 92	Nov 93	Mean	SE	%	Mean	SE	%
kg/ha			g.fwt/6m			g.fwt/6m		
1.1	1.1	1	21.7	0.7	121	9.7	1.0	103
1.1	1.1	0.55	22.5	0.9	125	9.4	1.4	100
1.1	1.1	0.28	21.9	2.4	122	7.5	0.5	80
1.1	1.1	No app.	22.2	2.7	124	7.0	1.3	75
1.1	0.55	0.55	25.9	1	144	9.4	0.7	100
1.1	0.55	0.28	16.6	3.3	92	8.7	1.0	93
1.1	0.55	No app.	19.4	1.9	108	7.8	0.5	83
1.1	No app.	No app.	16.4	3.6	91	8.1	0.9	87
0.55	0.55	0.55	21.9	1	122	11.0	0.5	117
0.55	0.55	0.28	21.9	1.1	122	9.5	1.1	101
0.55	0.55	No app.	19.6	2.2	109	6.3	1.0	67
0.55	0.28	0.28	18.5	1.1	103	10.1	0.4	108
0.55	0.28	No app.	17.1	0.7	95	8.2	0.2	88
Untreated control			18	0.4	100	9.4	0.9	100

Visual evaluations of kidney bean growth, melon growth, and tomato growth indicated no impact of thiazopyr on these crops (Table 3). Similarly plant growth or sample biomass of sugarbeets did not show any differences between that from untreated and thiazopyr treated plots (Tables 3 and 4). Cotton growth showed no visual impact of thiazopyr treatments (Table 3) and although cotton biomass was variable it showed no consistent relationship between thiazopyr rate or application sequence (Table 4). Thus reestablishment of yellow foxtail when thiazopyr application was stopped, the lack of any consistent impact of thiazopyr on barnyardgrass grown as a bioassay in soil samples, and the lack of differences between rotational crops of melons, cotton, sugarbeets, tomatoes, and kidney beans all indicate that thiazopyr did not persist beyond one year.

CONCLUSIONS

Thiazopyr applied to alfalfa in the late fall provided almost complete control of yellow foxtail for the entire following cropping season. A high level of yellow foxtail control was able to delay the onset of alfalfa stand loss brought about by invasion of the grass into the crop. Soil bioassays employing barnyardgrass as the test species did not show any consistent carry-over of thiazopyr beyond one growing season at rates of 0.28 or 0.55 kg/ha. The barnyardgrass bioassay indicated that repeat applications of 1.1 kg/ha possibly persisted beyond 12 months from application. Growth of kidney beans, cotton, melons, sugarbeets and tomatoes planted in the spring following thiazopyr applications made 18 months earlier showed no effect of the herbicide at any rate up to 1.1 kg/ha.

EXTENSION, EDUCATION, AND REGULATORY

BRINGING CRP BACK INTO CROP PRODUCTION. Douglas K. Ryerson, Local Development Manager, Monsanto, St. Louis, MO 63167.

Abstract. Since 1986, 36.4 million A of eligible crop land have been retired from production through the Conservation Reserve Program (CRP). The CRP program has been highly publicized and is viewed very positively by environmental, wildlife, and agricultural interest groups. From an agricultural stand-point, leaving the soil idle and under a permanent vegetative cover has reduced the levels of wind and water erosion dramatically. It is estimated that the CRP program US wide has reduced soil erosion by approximately 700 million tons/year, or roughly 19 tons/acre/year. Along with saving soil there also has been an increase of soil organic matter which improves soil tilth, making these soils potentially more productive.

As contracts expire, many of these idled acres could be brought back into crop production. Much of the land in the CRP program is considered highly erodible. Methods used to bring these acres back into crop production should be targeted at minimizing the potential of soil erosion and maintaining organic matter and soil tilth gained during the CRP contract.

During the winter of 1993-94 discussions were held between growers, NRCS, Extension, and Monsanto personnel in Montana to develop a program that would examine the most effective ways to bring CRP acres back into crop production. Field demonstrations were subsequently established to evaluate suggested approaches developed during these planning sessions. Factors considered included ways of managing existing residues coupled with different cultural and chemical control practices. Demonstrations have been carried through one complete cropping cycle and have provided useful insight concerning the challenges facing a grower who decides to bring these acres back into crop production. The use of glyphosate to manage existing vegetation will play a key role in helping to bring CRP acres back into crop production while minimizing soil and water erosion.

EXTENSION AND TECHNOLOGY TRANSFER: IT'S AS EASY AS WWW. Brian M. Jenks, National Jointed Goatgrass Extension Coordinator, University of Nebraska, Scottsbluff, NE, 69361.

Abstract. Advances in computer and video technology will enhance the efficient transfer of information between research and extension personnel and the public. Access to local, regional, and national information can be made available in a variety of formats and media. Several options are now available for information transfer such as via the World Wide Web (WWW), electronic bulletin boards, CD-ROM, satellite, and videotape. Examples were presented on how these technology transfer methods are, or will be, utilized as part of the National Jointed Goatgrass Research Initiative. A discussion followed on the requirements for different methods and their advantages and disadvantages. The major focus was on the jointed goatgrass World Wide Web page which contains information on jointed goatgrass identification, biology, genetics, control methods, publications, upcoming meetings, and much more. The WWW page address is: http://ianrwww.unl.edu/ianr/jgg/index.htm. Software that converts word processor documents into HTML format makes the preparation of a web page relatively simple.

IDENTIFICATION AND MONITORING OF NEW ALIEN WEED SPECIES IN IDAHO. Timothy W. Miller and Robert H. Callihan, Extension Support Scientist and Extension Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83844-2339.

Abstract. The spread of weeds is, by nature, difficult to monitor. Introduction of new species alien to the region where they were detected are of particular interest to weed science. These species often possess weedy characteristics: they may be competitive with native vegetation or agricultural, horticultural, or silvicultural plantings, they may persist within the area of introduction, and they may be invasive, freely colonizing new sites. New weed arrivals often go unnoticed for years, making ultimate eradication of these species unlikely or impossible. Since 1984, plants from various sources have been submitted to the University of Idaho's Weed Diagnostic Laboratory (WDL) for identification. 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 (PNW); all were submitted because they were unknown. Also among these unknown plants have been several alien species not previously reported to exist in the PNW, the state of Idaho, or the county in which they were found. In addition to identification, determinations of weedy potential have been made, and detailed records maintained to document the spread of, and facilitate planning of control strategies for, new alien weed species.

A total of 2224 specimens have been submitted to the WDL from county Extension faculty or weed superintendents, or were found by University of Idaho weed scientists. Of these, 24 have been species new to the PNW, 46 have been species not previously reported to grow in Idaho, and 213 have been the first documented record of a species in one of 44 Idaho counties. Six examples of weedy species which have apparently been recently introduced and are expanding their range in Idaho are white bryony, orange hawkweed, blueweed, small bugloss, scentless chamomile, and hedgeparsley.

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

INFLUENCE OF SOIL MOISTURE AND CHLOROACETAMIDE HERBICIDE ON WILD PROSO MILLET (*PANICUM MILIACEUM* L.) CONTROL. Patrick A. Miller and Philip Westra, Graduate Research Assistant and Associate Professor, Department of Plant Pathology and Weed Science, Colorado State University, Ft. Collins, CO 80523.

Abstract. In addition to contributing to crop productivity, irrigation/rainfall quantity and timing greatly influence herbicide behavior. An understanding of the influences of soil and water on the agronomic performance of herbicides is critical to their further success as components of weed management systems in irrigated and dryland agriculture. The purpose of this evaluation was to determine the influence of soil moisture status and herbicide on the preemergence efficacy of three chloroacetamide herbicides.

A laboratory study was initiated and arranged as a factorial design with soil moisture, herbicide and soil texture being considered the primary, secondary and tertiary factors, respectively. Wild proso millet was used as an indicator species to assess the influence of soil moisture, herbicide and soil texture on the preemergence efficacy of metolachlor, dimethenamid and acetochlor. Air-dried soils were passed through a 2 mm sieve and transferred to an aluminum cylinder. These cylinders were filled to approximately 1 cm from the top of the cylinder and placed onto ceramic-plate pressure extractors. Soils were subsequently equilibrated to one of six soil moisture contents, approximating soil moisture tensions of 0, -33, -100, -250, -500, -1000 kPa. Following equilibration to the desired soil moisture content, the cylinders were removed from the pressure extractors. The uppermost 1 cm of cylinder was filled with herbicide-treated soil (prepared at an equivalent soil moisture content), and bioassayed for herbicidal activity.

These studies indicated the efficacy of the herbicide treatments to vary profoundly with soil moisture status and soil type (as determined by initial bioassay). Initial hypotheses suggested that herbicide physico-chemical characteristics (e.g., solubility and vapor pressure) are influential in predicting the agronomic behavior of chloroacetamide herbicides in soils. Although this supposition may generally be true, the findings reported here suggest herbicide physico-chemical characteristics are important, but not exclusively responsible for controlling herbicide behavior in the soil environment.

SOIL ADSORPTION/DESORPTION CHARACTERIZATION FOR CHLOROACETAMIDE HERBICIDES. Patrick A. Miller, Philip Westra, and Scott J. Nissen, Graduate Research Assistant and Associate Professors, Department of Plant Pathology and Weed Science, Colorado State University, Ft. Collins, CO 80523.

Abstract. Herbicide adsorption and desorption processes are largely responsible for herbicide behavior in soils. The extent to which an herbicide is sorbed onto the soil solid-phase drives the ultimate fate of herbicides. Degradation, volatilization, leaching, and plant uptake are all potential avenues for herbicide dissipation, and are thought to be controlled most profoundly by soil sorption phenomena. The procedures described herein will examine the sorption characteristics of three chloroacetamide herbicides in soils differing in clay and organic matter content.

Batch-equilibria experiments were conducted with these differing soils at a soil:solution ratio of 1:2 (w:v). Duplicate 50 ml screw-top centrifuge tubes were spiked with 200 μl of herbicide dissolved in methanol. Initial solution concentrations for these experiments ranged from 0.1 ug μl^{-1} to 2.5 ug μl^{-1}. Following 24 hours of agitation by wrist-action shaking, the tubes were centrifuged at 2,500 rpm for 15 min. An aliquot of the

supernatant was loaded onto pre-conditioned, C-18 solid phase extraction (SPE) cartridges. The samples were eluted with 3 ml toluene, quantitatively transferred to 5 ml volumetric flasks, and analyzed using an HP5890 gas chromatograph equipped with a mass selective detector.

Data collected for these herbicide treatments were expressed as either a distribution coefficient (K_d) or as a Freundlich isotherm coefficient (K_f) and were used to compare the relative strength of herbicide sorption among the three chloroacetamides. The experimentally determined K's for adsorption ranged from 0.05 to 5.0 cm^3 g^{-1} for acetochlor, 0.04 to 5.0 cm^3 g^{-1} for dimethenamid, and 0.06 to 6 cm^3 g^{-1} for metolachlor. The experimentally determined K's for desorption were generally two to three times greater than those values calculated for an equivalent adsorption experiment. These data indicate soil texture and organic matter are important in herbicide sorption processes, and that desorption is relatively difficult (as indicated by the higher distribution coefficients for desorption as compared to adsorption).

GENETIC VARIABILITY OF SAFENER-INCREASED GLUTATHIONE S-TRANSFERASE LEVELS IN WHEAT GERMPLASM. Dean E. Riechers, Ken Yang, Gerard P. Irzyk, Stephen S. Jones, and E. Patrick Fuerst, Graduate Research Assistant, Undergraduate Student, Postdoctoral Research Associate, Assistant Professor, and Associate Professor, Department of Crop and Soil Sciences, Washington State University, Pullman, WA 99164-6420.

Abstract. Chloroacetamide herbicides have potential for selectively controlling annual grass weeds, specifically jointed goatgrass and downy brome, in winter wheat. Wheat is only marginally tolerant to chloroacetamide herbicides; however, wheat can be partially protected from chloroacetamide herbicide injury through the use of herbicide safeners. 'Madsen' wheat has been used in previous studies with seed-applied herbicide safeners in the field and greenhouse to examine safening from the herbicide dimethenamid. This research has shown that the level of safening achieved may not be adequate for use of dimethenamid in the field to control annual grass weeds.

Laboratory studies have shown that increased dimethenamid metabolism (via glutathione conjugation) occurs in response to safener treatment. Increased dimethenamid metabolism in response to safener treatment is correlated with increases in the activity of glutathione S-transferase (GST) isozymes capable of utilizing dimethenamid as a substrate. The objective of our research was to screen various wheat lines and wheat relatives to determine if genetic variability exists among wheat germplasm for either constitutive GST levels or safener-increased GST levels. Identification of wheat germplasm with either high constitutive or safener-increased GST levels might allow for the development of a wheat variety with increased tolerance to the herbicide dimethenamid.

We used two methods to screen approximately 80 wheat lines and relatives for constitutive and safener-increased GST levels: 1) a GST activity assay using dimethenamid as a substrate, and 2) an enzyme-linked immunosorbent assay (ELISA), which we developed to detect GSTs in wheat protein extracts. The ELISA consisted of an antibody capture immunoassay, and utilized an antibody raised against maize GSTs that also detects wheat GSTs. In general, little or no GST activity was detected in unsafened wheat lines and relatives. The wheat safener cloquintocet-mexyl (CGA 185072) increased GST levels and activities several fold, and the safener fluxofenim increased GST levels and activities even further. Variability existed among wheat lines and relatives, mainly in their response to the two safeners. Several wheat lines had safener-increased GST levels and activities greater than 'Madsen' wheat. Both screening methods consistently detected safener-increased GST activities (GST-dimethenamid assay) and GST levels (ELISA), and generally correlated well in quantifying the magnitude of these increases for a given line. Whole plant greenhouse studies will determine if wheat lines or relatives with high GST levels are more tolerant to dimethenamid injury than 'Madsen' wheat.

PHOTODEGRADATION OF PICLORAM WITHIN PLANT EPICUTICULAR WAX. Roland L. Maynard and Tracy M. Sterling, Graduate Student and Associate Professor, Department of Entomology, Plant Pathology and Weed Science, New Mexico State University, Las Cruces, NM 88003.

Abstract. Photodegradation is an important mechanism for pesticide degradation in the environment. Very little is known about the photodegradation of pesticides while they reside on the leaf surface or within the leaf cuticle. In this study, photodegradation of picloram was examined in isolated epicuticular wax. Afghan pine (*Pinus eldarica* Medw.) wax was extracted from leaf tissue using a chloroform rinse procedure. Photodegradation of four picloram solutions was compared over time (0, 6, and 24 h solar exposure) in wax or dried on glass. The four 0.4 mM solutions were: analytical grade picloram in methanol, analytical grade picloram in water with KOH (pH 11.4), analytical grade picloram in methanol with KOH, and commercially formulated picloram in water. In addition, picloram photolysis in wax from four species, prickly pear cactus (*Opuntia polyacantha* L.), agave (*Agave americana* L.), sorghum (*Sorghum bicolor* L.), and pine (*Pinus eldarica* Medw.) was compared after 18 h solar exposure with one solution (analytical picloram 0.4 mM in methanol). Picloram remaining after treatment was recovered off glass using methanol rinse and out of the wax layer using a 1:1 chloroform/water (pH 11.4) partition. The picloram and potential photolysis products in solution were then separated using HPLC with a C_{18} column with a mobile phase of methanol/4% aqueous acetic acid (45:55; v/v) and quantified with a UV detector.

Picloram loss was faster when in wax (46.5% reduction) then when dried on glass (32.3% reduction) over 24 h. Photodegradation products were also resolved although they are currently unidentified. Formulation also had an effect on picloram loss when combined with the presence of wax. The presence of the wax layer increased the loss of analytical grade picloram dissolved in methanol by 22% (vs. glass only) while it increased the loss of picloram in commercially formulated product by only 1%. The picloram also degraded slower in the sorghum wax (24%) then the other three types of wax (33%) over 18 h. Apparently, picloram photolysis is affected by the epicuticular wax layer.

CROSS RESISTANCE PATTERNS OF ALS FROM KOCHIA BIOTYPES WITH DIFFERENT MUTATIONS FOR ALS-INHIBITOR RESISTANCE. Roger Baerg and Charlotte Eberlein, Postdoctoral Research Associate and Professor, University of Idaho, Aberdeen Research and Extension Center, Aberdeen, ID 83210.

Abstract. Acetolactate synthase (ALS) assays were used to assess cross resistance patterns of kochia collected from various sites across western North America. Previous research has shown that six of the nine chlorsulfuron resistant (R) biotypes had point mutations in the codon for the proline residue in Domain A, which resulted in alanine, arginine, glutamine, leucine, serine, or threonine substitutions; the other three biotypes had at least one non-Domain A (nonA1, nonA2, and nonA3) mutation site. Nonlinear regression was used to determine the inhibition patterns of ALS isozymes from nine R and five susceptible (S) kochia biotypes by six sulfonylurea (SU), three imidazolinone (IM), one triazolopyrimidine (TP), and one pyrimidinyl oxybenzoate (POB) herbicides. The I_{50}s of the S biotypes were between 7 and 58 nM for the SUs, between 6200 and 9000 nM for the IMs, 640 nM for flumetsulam (TP), and 340 nM for POB. The R/S ratios varied from 17 to 1583 for the SUs, depending on the herbicide and the ALS isozyme. Averaged over ALS isozymes, metsulfuron and primisulfuron gave the lowest and highest R/S ratios, respectively, among the SUs. For all the SUs, the ALS isozymes with the leucine and glutamine substitutions, and the nonA mutation had the lowest R/S ratios compared to the other isozymes. The R/S ratios for the ALS isozymes varied from 4 to 23 for flumetsulam, and between 0.6 and 2.0 for POB. R/S ratios for the IMs ranged from 0.8 to 12.2, depending on the herbicide and isozyme. The ALS isozyme with the leucine substitution gave the highest R/S ratios for imazethapyr and imazapyr. No R/S ratios were greater than 1.5 with imazaquin. For all these kochia mutations, the high, moderate, mixed, and no level of ALS insensitivity to SU, TP, IM and POB, respectively, is consistent with the response of ALS from prickly lettuce with a proline to histidine substitution. These data show that the type of proline substitution in Domain A effects the cross insensitivity of ALS from kochia.

THE MECHANISM OF TRIALLATE RESISTANCE IN WILD OATS (*AVENA FATUA* L.). Anthony J. Kern, Erica K. Miller, Dwight M. Peterson, Tracey M. Myers, and William E. Dyer, Graduate Research Assistant, Undergraduate Student, Postdoctoral Research Associate, Undergraduate Student, and Associate Professor, Department of Plant, Soil and Environmental Sciences, Montana State University, Bozeman, MT 59717-0312.

Abstract. Continuous use of triallate in several areas of the United States and Canada has selected for resistant wild oat populations. We previously hypothesized that resistance was due to a significantly reduced rate of herbicide sulfoxidation (activation) in resistant plants. Further evidence has since been obtained that strongly supports this idea. Triallate sulfoxide was synthesized *in vitro* and applied to resistant and susceptible plants in order to determine their relative sensitivity levels. Both types were equally sensitive, indicating that the biochemical lesion conferring resistance occurs at or prior to the conversion of triallate to its sulfoxide. Further, pretreatment of susceptible plants with tetcyclasis, a known inhibitor of cytochrome P450-mediated reactions, induced significant levels of triallate resistance. This result confirms that triallate resistance can be achieved by inhibition of this class of enzymes, and supports the idea that a dysfunctional triallate sulfoxidase confers resistance in wild oats. Tetcyclasis pretreatment also caused marked alterations in patterns of ^{14}C-triallate metabolites from both resistant and susceptible plants, as determined by HPLC. The inheritance of triallate resistance was determined by screening F2 progeny from reciprocal crosses of resistant and susceptible wild oat lines (crosses made by Dr. Bruce Murray, Saskatchewan, Canada). Preliminary results indicate that resistance is controlled by two recessive genes.

EFFECTS OF PANICLE POSITION IN THE CROP CANOPY ON THE GERMINATION, DORMANCY AND VIABILITY OF WILD OAT SEED. Sharon S. White, Monica A. Brelsford, William E. Grey, and Bruce D. Maxwell, Undergraduate; Research Assistant, Department of Plant, Soils and Environmental Sciences; Research Assistant Professor, Department of Plant Pathology; and Assistant Professor, Department of Plant, Soils and Environmental Sciences, Montana State University, Bozeman, MT 59717.

INTRODUCTION

Wild oat is a persistent and costly pest in many agriculture fields throughout the world. In Montana, a series of experiments were established at three locations over three years (1992 to 1994) to develop an understanding of the population dynamics of wild oat and how it might be managed for the long-term in an economically efficient way. During these experiments, it was noted that wild oat seedlings that emerged 7 to 14 days after the barley, set seed below the barley canopy, whereas the wild oats that emerged before or at the same time as the barley produced seed above the canopy. The research then focused on determining if wild oat seed maturing below the canopy had a different viability, dormancy or germination than seeds that matured above the canopy. Seeds from above and below canopy were tested from all three sites. Understory seed was significantly less viable from all sites and years. Dormancy was variable and no consistent differences were found between overstory and understory seed. It was hypothesized that seed from the understory may have a higher frequency of seedling pathogens than overstory seed. This hypothesis was based on the observation that understory wild oat seed had more fungal infection during the germination test than did seed from the overstory. Our objective was to isolate fungi and bacteria from wild oat florets and test the effects of these organisms on the germination, viability and dormancy of wild oat seed.

MATERIALS AND METHODS

Fungi isolation. Twenty understory and 20 overstory seeds were surface sterilized with 10% chlorox, 1 drop Tween 20 and placed on the stirrer for 3 minutes. Seeds were placed, under sterile technique, on a growth media consisting of acidified potato dextrose agar (PDA) (Difco) petri plates, 5 seeds/plate. These plates were then observed daily for the growth of fungi. The mycelium of the growing fungus was transferred to a clean

PDA plate. A pure culture was grown on autoclaved oat kernels that served as a food base for the fungi. The colonized kernels were allowed to dry and used as inoculum for germination tests on blotter paper in petri dishes.

We also isolated fungi from the caryopsis and the seed coat of the wild oat seed. We tested 5 seeds from each of the following categories; two field experiments from Bozeman and overstory/understory seed for a total of 20 seeds. The caryopsis and seed coat were separated and surface sterilized as described previously. Each tissue was separately placed on acidified PDA and observed for fungal growth. The fungal isolates were grown on autoclaved oat kernels and used as inoculum. Fungal isolates were identified based on conidial morphology and colony growth on PDA (W. Grey, pers comm).

Wild oat germination inoculated with fungi. Firm plump wild oat seeds were separated from combine harvested barley. Two experiments were conducted with two inoculation rates of each fungal treatment with 5 seeds per germination dish and four replications. In the first experiment we used seven fungi and in the second experiment we retested two of the fungi. The treatments included a control (no fungi), one colonized kernel per wild oat seed, and two colonized kernels per wild oat seed. The seeds were placed in a growth chamber at 19 C. Daily observations were made on the seeds and germination of the seed was counted by the appearance of a coleoptile at least 3 cm in length. At the end of the 30 days, the seed that had not germinated were tested for viability using the tetrazolium assay. A seed was considered dormant if, after soaking in tetrazolium for 12 hours, the embryo turned a shade of red. The seed was considered dead if the embryo and the endosperm both stained red from the tetrazolium or there was not a solid caryopsis in the seed coat.

Bacteria isolation. During the germination tests, we also observed bacterial growth on seeds. Therefore, we isolated bacteria from 1994 combine seeds which was not separated in overstory and understory seeds. One half of the seeds were surface sterilized (as described in fungi isolation), placed in phosphate buffer, and stirred for two minutes. The buffer was decanted and new buffer added. This was repeated three times. The other half were not surface sterilized and placed directly in phosphate buffer. A sterile loop of bacterial solution was streaked on nutrient agar and Kings B medium to obtain individual bacterial colonies. Bacterial growth was only observed from the unsterilized seeds on the nutrient agar and Kings B. The bacteria isolates were increased and used as the inoculum in the wild oat germination test. Five of the bacteria were identified by Dr. Ann Kennedy using the MIDI test.

Wild oat germination inoculated with bacteria. Firm plump wild oat seeds were separated from the combine grain sample and used in the germination tests. We used 5 wild oat seeds/germination dish with four replications of each treatment. Again we ran two experiments. The treatments included a control and four bacteria and a control and five bacteria. The control seeds were soaked in phosphate buffer and placed in the dish. Phosphate buffer (40 ml) was added to the bacteria media and then used to coat the seeds. Seeds were placed in the germination dishes. The dishes were placed in a growth chamber at 19 C. Daily observations and documentation was made regarding germination of the seeds. At the end of the 30 days, the seeds that had not germinated were tested for viability using the tetrazolium assay, as described above.

RESULTS AND DISCUSSION

Seven fungi and 7 bacteria isolates were grown from wild oat seeds (Table 1). Fungal isolates were only found on the seed coat and not the caryopsis. Bacterial isolates were only taken from the seed coats.

Wild oat germination, dormancy or viability was not affected by the presence of the fungi in experiment 1 (Table 2). In experiment 2, we retested F3 and F6 and found that F3 had significantly more dead seed than the control (Table 3). This result is consistent with previous research done on fungal infestation of seeds where the *Fusarium* spp. was seen to be frequently isolated and was pathogenic on wild oat. This research also noted that *Cladosporium* was nonpathogenic on wild oats (1). The fungal germination treatments included one colonized kernel per wild oat seed and two colonized kernels per wild oat seed. Because there were no significant differences between the treatments, they were combined for the evaluation of the data.

Table 1. Identification and source of microflora isolated from wild oat seed.

Microflora	Organism	Source of seed
Fungi		
Understory		
F1	Dark mycelium fungus[a]	understory
F3	*Fusarium poae*[a]	understory
Overstory		
F2	*Bispora* spp.[a]	overstory
F5	Dark mycelium fungus[a]	overstory
F6	*Cladosporium*[a]	overstory
F7	*Fusarium culmorum*[a]	overstory
Combine		
F4	*Nigrospora*[a]	combine
Bacteria		
Understory		
B7	*Pantoea agglomerans*[b]	understory - green
Overstory		
B5	*Pseudomonas cichorii*[b]	overstory - green
B6	*Pseudomonas putida*[b]	overstory - green
Combine		
B1	Unidentified	combine
B2	Unidentified	combine
B3	*Ochrobactrum anthropi*[b]	combine
B4	*Stenotrophmonas maltophilia*[b]	combine

[a]Identified by Dr. William E. Grey, Research Assistant Professor, Department of Plant Pathology, Montana State University-Bozeman,
Bozeman, MT 59717

[b]Identified by Dr. Ann C. Kennedy, Soil Scientist, USDA-ARS-Land Management and Water Conservation Research Unit, Washington
State University, Pullman, WA 99164

Table 2. Experiment 1: Percent germination, dormancy and dead in wild oat seed using fungi as the inoculum.

Microflora (F=fungi)	Germination	Dormant	Dead
		%	
Control (n=4)	75	25	0
Understory			
F1 - Dark mycelium fungus (n=8)	65	35	0
F3 - *Fusarium poae* (n=8)	63	35	2
Overstory			
F2 - *Bispora* spp. (n=8)	65	35	0
F5 - Dark mycelium fungus (n=8)	58	42	0
F6 - *Cladosporium* (n=8)	45	55	0
F7 - *Fusarium culmorum* (n=8)	78	22	0
Combine			
F4 - *Nigrospora* (n=8)	58	37	5

Table 3. Experiment 2: Fungi as the inoculum, a retest of possible pathogens from experiment 1.

Microflora (F=fungi)	Germination	Dormant	Dead
		%	
Control (n=4)	85	15	0
Understory			
F3 - *Fusarium poae* (n=8)	68	17	15*ª
Overstory			
F6 - *Cladosporium* (n=8)	70	30	0

ª*Means within a column are different from the control at the 0.05 level of significance using Dunnett's T test.

In experiment 3, we looked at the effects of four bacteria on wild oat seed. We found that all four bacteria significantly reduced the germination of the wild oat seed (Table 4).

In experiment 4, we retested bacteria B3 and B4, along with three additional bacteria isolates from green wild oat seed hand harvested from an irrigated field, using 50 seeds for each treatment (5 seed/dish). Again, B3 and B4 along with B7, significantly reduced germination by 46%, 42%, and 58% respectively when compared to the control. All bacteria significantly increased dormancy when compared to the control, ranging from 36% to 60%. (Table 5).

Table 4. Experiment 3: The percent of germination, dormancy and dead in wild oat seed using bacteria as the inoculum.

Treatment (B=bacteria)	Germinated	Dormant	Dead
		%	
Control (n=4)	65	30	5
Combine			
B1 - unidentified (n=4)	15*[a]	20	65
B2 - unidentified (n=4)	25*	50	25
B3 - *Ochrobactrum anthropi* (n=4)	0*	55	45
B4 - *Stenotrophmonas maltophilia* (n=4)	5*	70	25

[a]*Means within a column are different from the control at the 0.05 level of significance using Dunnett's T test.

Table 5. Experiment 4: Bacteria as the inoculum, testing three new bacteria and retesting two bacteria from experiment 3.

Treatment (B=bacteria)	Germinated	Dormant	Dead
		%	
Control (n=10)	78	4	18
Understory			
B7 - *Pantoea agglomerans* (n=10)	20*[a]	64*	16
Overstory			
B5 - *Pseudomonas cichorii* (n=10)	42	46*	12
B6 - *Pseudomonas putida* (n=10)	52	40*	8
Combine			
B3 - *Ochrobactrum anthropi* (n=10)	32*	54*	14
B4 - *Stenotrophmonas maltophilia* (n=10)	36*	54*	10

[a]*Means within a column are different from the control at the 0.05 level of significance using Dunnett's T test.

SUMMARY

These experiments demonstrated that the microflora located in the overstory and understory affected the germination, dormancy, and viability of the wild oat seed. One understory fungal isolate, *Fusarium poae*, demonstrated a high percentage of dead. Three bacteria, *Ochrobactrum anthropi* and *Stenotrophmonas maltophilia* from combine sample and *Pantoea agglomerans*, understory, caused reduced germination and increased dormancy. However, at least two overstory bacteria, *Pseudomonas cichorii* and *P. putida* were not seed pathogens and had no effect on germination but nonetheless significantly increased dormancy. Microflora may increase dormancy of wild oats without causing seed death.

ACKNOWLEDGMENTS

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QUANTIFYING COMPETITION BETWEEN SPRING BARLEY AND WILD OAT WITH AN INDIVIDUAL-PLANT GROWTH SIMULATION MODEL. William J. Price, Bahman Shafii, and Donald C. Thill, Research Associate, Director, Statistical Programs, Professor, Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83844.

Abstract. Traditional plant competition models have been based on population or stand level responses. These models can be considered to either reflect average population responses or they assume that individuals within the population are homogenous and uniformly spaced. Additionally, stand level modeling must explicitly account for population level competitive effects between plants and species. An alternative approach to modeling competition is the individual-based paradigm which focuses on single plants. With this technique, simulated populations are composed of individuals with unique growth characteristics and spatial arrangements. These populations can implicitly develop competitive behaviors, such as density dependent biomass accumulation, which accurately mimic real data. This paper introduces a simple individual-plant model for spring barley and wild oat competition.

DEVELOPMENT OF A BIOECONOMIC MODEL FOR JOINTED GOATGRASS. Bruce D. Maxwell, Monica A. Brelsford, Marie Jasieniuk, Randy L. Anderson, John O. Evans, Drew J. Lyon, Stephen D. Miller, Don W. Morishita, Thomas F. Peeper, Phillip Stahlman, and Philip Westra, Assistant Professor, Research Assistant and Research Associate, Plant, Soil, and Environmental Sciences Department, Montana State University, Bozeman, MT 59717; Associate Professor, Central Plains Research Center, USDA-ARS, Akron, CO 80720; Professor, Plant, Soils and Biometeorology Department, Utah State University, Logan, UT 84322; Associate Professor, Agronomy Department, University of Nebraska, Panhandle Research/Extension, Scottsbluff, NE 69361; Professor, Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY 82071; Associate Professor, Twin Falls Research and Extension Center, Twin Falls, ID 83303; Associate Professor, Agronomy Department, Oklahoma State University, Stillwater, OK 74078; Professor, Agricultural Research Center, Kansas State University, Hays, KS 67601; and Associate Professor, Plant Pathology and Weed Science Department, Colorado State University, Ft. Collins, CO 80523.

Abstract. Jointed goatgrass is a winter annual weed that infests over 5 million A of land in winter wheat production in the western United States. Weed scientists from eight western states have joined to study the biology and develop management strategies for jointed goatgrass. The absence of herbicides for control of jointed goatgrass in winter wheat has created a demand for integrated weed management. The development of a bioeconomic model has been initiated to centralize jointed goatgrass biology information and integrate it with information on management to identify economic optimum management practices. Yield loss functions were developed from weed threshold density experiments in Colorado, Idaho, Montana, Nebraska, Oklahoma, Utah and Wyoming. Jointed goatgrass seed bank mortality, emergence, seedling mortality and seed production functions were derived from data produced in Colorado, Idaho, Kansas, Montana, Nebraska and Wyoming. Sensitivity analysis on the model under a winter wheat/fallow system indicated that maximum tiller production, maximum percent emergence, maximum seed produced per tiller and the parameter controlling the rate of emergence were most important jointed goatgrass biological factors impacting net profit. Continued assessment of the model performance and sensitivity analysis under different cropping systems will be conducted to help in prioritizing and coordinating multi-state jointed goatgrass research projects.

The jointed goatgrass bioeconomic model includes three major components: 1) a jointed goatgrass demographic model, 2) a crop model, and 3) an economic model (Figure). The jointed goatgrass demographic model is initiated by providing jointed goatgrass seed bank density after seed rain and before fall seedling emergence. The density of seedlings in the fall and spring, and the density of reproductive tillers and seed produced are predicted using transition parameters or functions. The density of jointed goatgrass reproductive tillers are used to predict the impact of the weed on the crop yield. The mature crop plant density and the jointed goatgrass reproductive plant density as well as the time difference (days) between jointed goatgrass and winter wheat emergence are used to predict jointed goatgrass seed production.

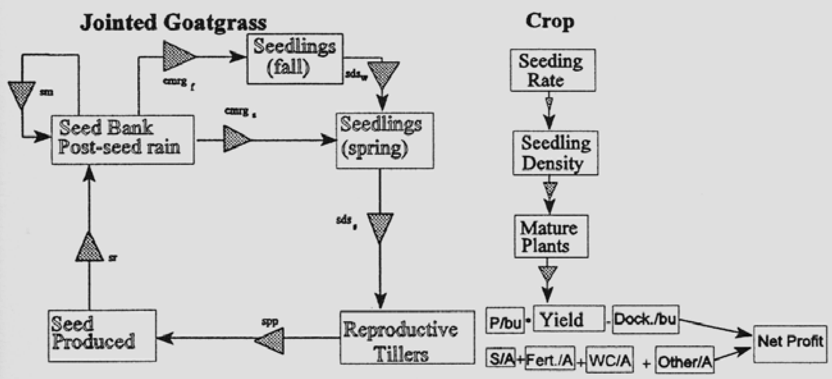

Figure. Diagrammatic representation of the jointed goatgrass bioeconomic model including state variables (boxes) and rate variables (triangles).

Sensitivity analysis of biological parameters in the bioeconomic model was conducted under the assumption of a crop fallow system starting with 600 jointed goatgrass seeds/m^2 in the seed bank in a crop year (Table). Sensitivity values were calculated as follows:

$$SV = \frac{\Delta ANR/ANR_0}{\Delta parm/parm_0}$$

where SV was the sensitivity value, ΔANR was the change in annualized net return (\$), ANR_0 was the original annualized net return with no change in the parameter value, Δparm was the change in parameter value (10% change), and $parm_0$ was the original default parameter value.

The sensitivity values were converted to elasticity values by making all values relative to the parameter with the highest sensitivity value for each scenario (crop year and fallow year).

The preliminary assessment of the model indicates that jointed goatgrass biology and ecology research should focus on factors associated with seedling emergence and seed production to improve the accuracy of the model.

Table. Relative sensitivity of biological parameters in the jointed goatgrass bioeconomic model.

Plant	Variable code	Crop year	Fallow year
Jointed goatgrass			
Seed mortality	sm	18	22
Emergence	k_w	69	68
	$PEmax_w$	92	92
Seedling survival	sds_w	42	40
Tiller production	til_{max}	100	100
	til_a	13	17
	til_c	11	13
Seed yield	spmax	42	41
	a_j	3	1
	b_j	37	35
	c_j	3	1
Seed rain	sr	42	41
Winter Wheat parameters			
Seeding rate	csrate	3	0
Emergence	$PEmax_c$	22	0
	k_c	22	0
Yield loss	a	3	0
	b	3	0

SOUTHERN ROOT-KNOT NEMATODE INTERACTION WITH PURPLE NUTSEDGE. A. N. Sultana, J. Schroeder, S. Thomas, L. Murray, E. Higgins, Research Assistant, Associate Professor, Associate Professor, Associate Professor, and Research Specialist, Department of Entomology, Plant Pathology, and Weed Science and Department of Experimental Statistics, New Mexico State University, Las Cruces, NM 88003-0003.

Abstract. Chile peppers grown with purple nutsedge (PNS) and Southern root-knot nematode (*Meloidogyne incognita*) (RKN) host higher levels of RKN and produce lower biomass than chile pepper grown with PNS alone. PNS, a known host of RKN, was therefore subjected to greenhouse experiments to determine the impact RKN has on PNS growth and tuber production. A single germinated PNS tuber was planted in 15.2 cm pots containing a 2:1 sand/soil mix (Anthony-Vinton sandy loam, 76 % sand, 11% silt, 13% clay, 0.8% O.M., pH 7.9). Experimental plants were inoculated with 17 RKN egg treatment levels ranging from 0 to 20,000 eggs per 500 cubic cm of soil when emerged plants ranged from 1 shoot (3 leaves) to 3 shoots (10 leaves). Pots were placed in two greenhouses each with a randomized complete block design in three replications. Light was supplemented on a 16 hr photoperiod at 340 $\mu E\ m^{-2}\ sec^{-1}$ PPFD. PNS leaves and shoots were counted approximately every 14 d from the time of RKN inoculation. Pots were harvested at 76 d after inoculation and data included shoot number, leaf number, tuber number, leaf area, above and below ground shoot dry weight, and RKN eggs per g of root plus tuber weight. Data analysis indicates that increasing RKN inoculation levels within this range do not significantly affect PNS shoot, leaf, tuber production, leaf area, or root growth. In the first greenhouse experiment, the 0 RKN inoculated PNS generated an average total of 45±8 tubers and the 20,000 RKN inoculated PNS generated an average total of 36±4 tubers. In the second greenhouse experiment, the 0 RKN egg inoculated PNS generated an average total of 46±4 tubers and the 20, 000 RKN egg inoculated PNS generated an average total of 45±7 tubers. Results imply that PNS can sustain RKN with no significant effect on reproductive rates of PNS as measured by tuber production and that initial inoculum levels of RKN do not significantly impact extractable eggs/g of root plus tuber material after two RKN generations.

ALTERNATIVE METHODS OF WEED CONTROL

DEVELOPMENT OF A HOST SPECIFICITY PLANT LIST FOR SCOTCH THISTLE BIOCONTROL AGENTS.
Jennifer L. Birdsall, P. Chuck Quimby, Jr., and Norman E. Rees, Botanist, Plant Physiologist, and Entomologist, USDA-ARS Rangeland Weeds Laboratory, Bozeman, MT 59717.

Abstract. Host specificity information must be gathered before USDA-APHIS Plant Protection and Quarantine will consider approving a foreign biological control agent for introduction into the United States. Host specificity tests are conducted to determine the potential host range of a candidate biological control agent without testing all plant species. The candidate biocontrol agent is exposed to plant species selected from a centrifugal (concentric circle) plant matrix. The target weed is in the center of the matrix and representatives from species in the same subgenus as the weed constitute the first ring. Each subsequent ring consists of plants which are less closely related to the target weed. The centrifugal host specificity screen includes tests in the following categories: 1) the target weed and varieties of the target weed; 2) species in the same subgenus as the weed; 3) species in various subgenera in the same genus as the weed; 4) species in various genera in the same tribe as the weed...and so on; 5) other recorded host plants of the agent no matter how dubious the record; 6) unrelated plants with biochemical characteristics in common with the target weed; 7) crop and ornamental plants grown within the migratory range of the candidate agent; and 8) host plants of species closely related to the candidate biocontrol agent. The degree of specificity which needs to be demonstrated and the level of risk which is acceptable depend on the presence of non-target species closely related to the weed which may be at risk of attack.

Introduced thistles cause economic and environmental losses by competing with native and forage species and contaminating wool. Introduced thistles presently being studied for biological control include species in the genera *Carduus*, *Cirsium*, *Onopordum*, and *Silybum*. We are developing a plant list for host specificity testing of Scotch thistle. Development of this list is complicated by the existence of numerous threatened, endangered, and sensitive native *Cirsium* species and by the confused taxonomy of *Cirsium*.

A COMPARISON OF INOCULATION METHODS FOR *SUBANGUINA PICRIDIS*, A NEMATODE FOR THE CONTROL OF RUSSIAN KNAPWEED.
Robert L. Lavigne, John L. Baker, Nancy A. P. Webber, and Terry Henderson, Professor, Univ. of WY, Plant, Soil & Insect Sci., Laramie, WY 82071, Supervisor and Research Associate, Fremont County Weed and Pest Control Dist, Lander, WY 82520, and Land Operations Manager, BIA, Ft. Washakie, WY 82514.

Abstract. *Subanguina picridis*, a gall forming nematode, was first identified in 1966 and its use for the control of Russian knapweed is practiced in Russia. Investigations on the organism began in Canada in 1976. In 1992, it was cleared for open release in the United States. No data has been published on site sensitivity or methods of inoculation. Gall material was collected in Turkey in 1993 and 94. Nematodes were separated from the plant material by USDA/ARS in Bozeman, MT, and placed on a sterile soil medium. The nematode was released on the Wind River Indian Reservation in Wyoming. Randomized block experiments were conducted to evaluate different methods of inoculation including tillage, soil amendments of manure and peat moss, burying and surface application with and without incorporation. Additional releases were made at 12 different sites to determine the impact of soils, moisture, timing, inoculation rate and plant density to establishment and gall formation. Under poor rainfall conditions in 1994 less than half of the points of release had galled plants while in 1995, with high rainfall, every point of release had galled plants. *S. picridis* appears to be insensitive to inoculation methods or site considerations, tolerates drought for at least one year, and responds positively to spring rain as distinguished from irrigation and sub-irrigation. Impact of the nematode on Russian knapweed across all sites showed a plant size reduction of 21%, a reduction in flowering of 51%, and at some sites there was a reduction in stand of 20%.

PERFORMANCE OF *BRASSICA* GREEN MANURES FOR WEED AND EROSION CONTROL IN POTATOES. Mary J. Guttieri, Charlotte V. Eberlein, and Matthew J. Morra, Support Scientist and Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Aberdeen, ID 83210 and Associate Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83843.

Abstract. *Brassica* green manures have shown potential for disease and nematode suppression in potato production as a consequence of their biofumigant properties. Isothiocyanates released upon glucosinolate degradation in damaged *Brassica* tissue also may destroy weed seeds in soil. Moreover, acreage in potato production is subject to severe wind erosion prior to potato planting, and a *Brassica* green manure potentially could provide valuable ground cover through the winter and early spring. The utility of *Brassica* green manures for weed and erosion control in potato production in southern Idaho was evaluated in 1994 and 1995 at Aberdeen, ID. In August, 1993 and 1994, the cultivars 'Humus', 'Bridger', 'Cascade', 'Aspen', and 'Dwarf Essex' were seeded and grew through the fall and early spring. A weedy control and a standard herbicide treatment (pendimethalin plus metribuzin applied preemergence) were included in both years. Green manures were mechanically incorporated by rototilling prior to seeding potatoes in May 1994 and 1995. Half of each plot (except the pendimethalin plus metribuzin control) was treated with a low rate of rimsulfuron plus metribuzin postemergence.

Weed populations were relatively heavy in 1994, and relatively light in 1995. In 1994, weed dry weight biomass at the end of August in the weedy control was 1288 g/m^2, with the predominant species being redroot pigweed (780 g/m^2) and common lambsquarters (500 g/m^2). In 1995, weed dry weight biomass at the end of August in the weedy control was only 4 g/m^2. In 1994, the *Brassica* green manure treatments, overall, had 30% lower weed biomass at the end of the growing season than the weedy control. In 1995, 'Dwarf Essex' and 'Aspen' green manure plots had 90 and 98% lower weed biomass, respectively, at the end of the season than the weedy control. In both years of the study, green manures combined with a low rate of rimsulfuron plus metribuzin provided excellent weed control.

Above-ground *Brassica* dry matter immediately prior to incorporation averaged 310 g/m^2 in 1994 and 532 g/m^2 in 1995. The nitrogen contribution of incorporated above-ground winter *Brassica* dry matter ranged from 71 to 129 kg/ha in 1994, and from 138 to 264 kg/ha in 1995. The *Brassica* green manures also provided substantial ground cover prior to incorporation. For example, in 1995, the winter *Brassica* treatments averaged 85 to 91% ground cover at the end of March.

In 1994, under heavy weed pressure, U.S. #1 tuber yield in the weedy control was reduced 71%, relative to the herbicide-treated check, and U.S. #1 tuber yields in the green manure treatments were reduced an average of 49%, relative to the herbicide-treated check. U.S. #1 tuber yields in the 'Humus' and 'Bridger' treatments were more than twice that from the weedy control in 1994. Weed populations in the 1995 experiment were not sufficient to reduce the U.S. #1 tuber yield of the weedy control plots relative to the herbicide-treated control. U.S. #1 tuber yields from treatments with green manures in combination with rimsulfuron plus metribuzin were comparable to U.S. #1 tuber yields with rimsulfuron plus metribuzin alone (no green manure) or the pendimethalin plus metribuzin standard.

WEED SPECIES CHANGES AFTER SEVEN YEARS IN FOUR FARMING SYSTEMS. W. Thomas Lanini, Extension Weed Ecologist, Department of Vegetable Crops, University of California, Davis, CA 95616.

Abstract. In 1988, a farming system study was initiated to compare four farming systems. Three of the systems had a four-year crop rotation, consisting of tomatoes, safflower, corn, and beans double cropped after wheat or an oats/vetch mix. The fourth system used a 2-year rotation of tomatoes and wheat. This study is arranged in a split-plot design replicated four times, with farming systems as the main plot and crop as the subplot. Each subplot is approximately 0.12 ha in size. The short rotation system designated as conventional-2 and the 4-year

rotation system designated as conventional-4, used common weed management practices for the crops involved, including herbicides, cultivation, and hand weeding. A third system designated as low input used primarily cultivation and hand weeding, but occasionally herbicides were used. The fourth system, designated as organic, used only cultivation or hand weeding. Systems were individually managed using best farming practices. Weed cover has been assessed visually on each plot on a monthly basis, with predominant weed species being noted.

Weed species varied by farming system and crop. In all systems, redroot pigweed escaped control in tomatoes, corn, and safflower in some years. In the conventional-2 system, field bindweed is not controlled, particularly following wheat. In the three, 4-year rotation systems, common lambsquarters escaped control in safflower. In the conventional-2 and -4 systems, black nightshade is escaping control efforts in tomatoes. In the low input and organic systems, barnyardgrass is a common escape weed in tomatoes and corn. Several other weed species have proliferated during the initial 7 years of this project, but have been reduced to much lower population levels by changes in control practices.

EDUCATION AND REGULATORY

SUMMER AGRICULTURAL INSTITUTE. Monica Pastor, Executive Director, Maricopa County Farm Bureau, Phoenix, AZ 85040.

Abstract. Agriculture in the Classroom is a nationwide program coordinated through the United States Department of Agriculture. Many agricultural organizations within Arizona have developed and are utilizing their own Agriculture in the Classroom programs.

The Arizona Agriculture in the Classroom Taskforce is composed of representatives from agricultural organizations, government institutions, and other interested individuals in agriculture. The Taskforce coordinates a Summer Agricultural Institute for teachers. The concept is based on institutes coordinated in several other states.

The Institute is five days and is scheduled during the third week in June. We will hold our sixth Institute in June, 1996. Teacher applicants pay $85 registration fee and receive food, lodging, transportation and materials. Actual cost is $350 per participant. The balance is funded by donations from the agricultural industry. Participants are eligible to receive up to three graduate level credits from the University of Arizona. The participant pays the corresponding course cost.

The Institute provides the teachers with factual information about the agriculture industry in Arizona. The majority of the information is provided by industry representatives on field trips to agriculture operations. The remainder of their information is provided from video presentations and hand-outs.

Throughout the week, time is set aside to allow participants to break into small groups to develop curriculum from the information they have been given. The focus of the Institute is to give the teachers the opportunity to incorporate agriculture into their existing curriculum.

CROP DOCTOR™ PROGRAM. Michelle B. Anderson, President, Arizona Foundation for Agricultural Education, Phoenix, AZ 85034.

Abstract. The Arizona Foundation for Agricultural Education presents the CROP DOCTOR™ educational supplement as a hands-on program to bring Arizona agriculture into the classroom. The CROP DOCTOR™ program emphasizes the importance and the contributions of the agricultural industry. The CROP DOCTOR™ program is designed to assist educators in teaching about farming in Arizona. Elementary school children in grade levels 3 to 5 engage in interactive projects to enhance core curriculum areas of science, math, social studies, and language arts.

The following CROP DOCTOR™ program is provided FREE of charge to educators:

- Seven lesson plans, each plan relates to core curriculum requirements and provides suggested class activities.
- Five of the seven lesson plans are classroom experiments in a kit that students conduct to learn about the scientific method and understand some key elements of crop protection.
- A Crop Doctor visit to the classroom that includes the showing of a 17-minute videotape and hands-on demonstration of tools of the profession.
- Activity sheets (with answers) for students to clearly understand the complexities of farming and agriculture in general.

The lesson plans focus on the key elements of crop production/protection - crop fertility, weed, disease, and pest control. The highlight of the CROP DOCTOR™ program is the actual classroom visit by a licensed professional pest control advisor. Direct dialogue with the Crop Doctor enables students to gain better understanding of the complexities involved in farming to produce a safe and plentiful food supply.

USING LIVE INSECTS IN ELEMENTARY CLASSROOMS FOR EARLY LESSONS IN LIFE. Robin Roche, Program Coordinator, Center for Insect Science Education Outreach, University of Arizona, 800 E. University Blvd., Ste 300, Tucson, AZ 85721.

Abstract. The Center for Insect Science at the University of Arizona is an interdisciplinary research and training center focusing on insect sciences. The Center's Education Outreach program has focused on developing a curriculum, **Using Live Insects in Elementary Classrooms for Early Lessons in Life,** funded by the National Institutes of Health, Science Education Partnership Award. The Program introduces health and science topics to children in kindergarten through third grade via lessons integrated with children's literature, math activities, and using live insects. We chose to direct our efforts towards K-3 educators since we felt that it was important to get children excited about science at an early age. Even though the lessons are directed towards K-3 educators, they are a valuable resource to other classroom teachers, workshop coordinators, extension agents and educators who include insect studies in their programs.

Teams of teachers and scientists from Arizona and Massachusetts along with CISEO staff collaborated to create the lessons. Teachers provided the ideas for the lessons and made sure lessons were appropriate for classroom use while the scientists ensured that the content was scientifically accurate. Twenty lessons were created in all with five lessons for each of the grades K through third. Activity sheets are provided in each lesson to assist the student's discovery. Information sheets are also provided with natural history about the insects and how to care for them in the classroom. In the fall of 1992, 177 teachers in Arizona, Massachusetts, Missouri and Mississippi pilot tested the lessons in their classrooms. The final publication reflects the pilot teacher's comments and pilot testing experiences. During this pilot the publication proved to be a valuable student motivator and teaching tool. In the fall of 1994, we received an additional three years of funding from the National Institutes of Health - Science Education Partnership Award to disseminate our materials nationally.

At present, distribution of the publication is through training institutes. Master Teachers participate in a 1 to 3 day institute with background information about arthropods, hands-on interactions with live arthropods, first-hand experience with activities from the lessons, and guidance on how to present their own insect science workshop for teachers in their school or district. All institute participants receive the program's publication, a kit of materials, and a stipend. In addition, the publication is available for purchase through the Center for Insect Science Education Outreach. To date we have trained over 500 teachers in 14 states and we are now in the 5th printing of our publication.

With a grant from Eisenhower Mathematics and Science Award, all twenty lessons have been translated into Spanish. These Spanish materials are incorporated into the national dissemination in states where there are bilingual classrooms.

A Sample Lesson. One of the first grade lessons, *Little Me in a Big World,* addresses the health concept of self-esteem. The students place different obstacles on ant trails and predict, observe and report how the ants overcome the. Through discussions, role-play and charts the students share obstacles in their own lives and explore strategies when confronted with these obstacles.

The lesson begins by reading *Two Bad Ants* by Chris Van Allsburg. From the story, the teacher introduces the meaning of the word obstacle. Through discussion and review, the teacher lists the obstacles encountered by the ants in the story and the strategies they used to overcome them. Following this introduction, the teacher uses several suggested books to initiate exploration of natural history facts and background information about ants and their behaviors. In a discussion process the students contribute what they know about ants. The teachers are encouraged to provide background information about ants and allow time for students to explore other fiction/non-fiction books about ants before, during and after the lesson. An extensive bibliography assists in identifying resources.

At this point the students have established a foundation from which to observe natural ant behavior. The class discusses how to observe ants including what to look for and how to record observations. Team building skills and cooperative learning techniques are encouraged. In teams the students locate ant nests outside a their school site. After finding ant nests, students return to the classroom to brainstorm different kinds of obstacles they could put in front of the ants. They list and classify the obstacles and choose which ones to use in their experiments. While gathering the obstacles, the students predict what they think the ants will do with them. Using activity sheets to facilitate observations and note taking, the student teams perform the experiment and observe what the ants do. A classroom discussion follows where the students share their observations of the ants overcoming obstacles.

To further explore the concept of self-esteem and obstacles, the teacher reads, *I Can't, Said the Ant* by Polly Cameron. This rhyming lyrical story, explores ways of using ingenuity when confronted with obstacles. From the story the discussion is lead to address obstacles the students have or will have to overcome in their own lives (e.g. reaching the sink, crossing the road, etc.). Reinforcing the human problem solving and self-esteem issue, the book *Happy Birthday, Sam* by Pat Hutchins is also read. It discusses the obstacles a young boy encounters because he is not tall enough to open doors, turn on lights ore each the sink. The gift of a foot stool gives him the additional height he needs to complete these tasks without asking for help. Following discussion and responses to the story the students are given scenarios with obstacles and role-play how to respond to these situations. For a closure activity, the students learn the song *High Hopes*. Additional activities are listed in an extension section along with vocabulary which may surface during the lesson.

This project begins to explore the possibilities of using live insects to teach science and health in the elementary classroom. We have found that the training institutes are essential in familiarizing the teachers with insects, challenging myths, stereotypes and discomfort levels and introducing the interdisciplinary nature of the lessons. Teachers who have participated in our program and use the lessons in their classrooms report that using live insects in the classroom creates a contagious enthusiasm and inquiry for the students and for themselves. One participating 6 year old Tucson participant describes it this way: "We're discovering crickets to see what they are doing. We're going to look at them very closely. It's science we are doing, and science is what you can find out....some things you just want to know."

WEED SCIENCE AND THE LAW- A REALITY CHECK. Wayne K. McNeil, Frilot, Partridge, Kohnke and Clements, L.C., New Orleans, LA 70163.

Abstract. An interactive discussion concerning the legal obligations of weed scientists from initial sale through the filing of a lawsuit and the discovery process including the use of experts was presented. The presentation began with a general but brief overview regarding: (1) the anatomy of a lawsuit; and (2) typical legal defenses such as FIFRA preemption, and Article 2 of the Uniform Commercial Code and use inconsistent with the label. Particular emphasis was placed on the role of willing and unwilling experts. Audience participation was encouraged through spontaneous role playing and two hypothetical fact scenarios involving dealers, custom applicators, chemical company sales/technical representatives and university personnel. The first hypothetical began with a farmer seeking an appropriate herbicide for a crop uncommon to the area. The farmer approached his local dealer who in turn sought assistance from the State Extension Service and a company sales representative. The product does not provide adequate weed control and the farmer brought suit. The second hypothetical involves a company sales representative who mishandled a drift complaint. The interactive discussion was intended to educate weed scientists and provide a greater understanding of a weed scientist's role in the legal system.

SYMPOSIUM

ECOLOGICAL IMPACTS OF INVASIVE PLANTS IN NATURAL RESOURCE AREAS. Laura F. Huenneke, Associate Professor, Department of Biology, New Mexico State University, Las Cruces, NM 88003.

INTRODUCTION

Agricultural weeds have been recognized as management problems for centuries. In contrast, environmental weeds -- species invading natural or semi-natural environments -- have earned attention only relatively recently. Recognition and discussion by both scientists and land managers have exploded since the early 1980's, stimulated in part by several international efforts to synthesize what was known at the time of the biology of invasive species. In the US a major report from the congressional Office of Technology Assessment in 1993 dramatized the magnitude of the problem and the economic impacts of species' introductions. Why should land managers be concerned when non-native species invade an ecosystem? What sorts of effects are noted when a new species enters a plant community? I will talk today of the ecological impacts that the introduction of a non-native plant can have. The evidence is convincing: the addition of new species, or the replacement of natives by non-natives, CAN make a difference to the structure and function of natural communities.

Most of my examples come from the semi-arid vegetation of the western US, or from similar environments elsewhere. I will discuss a number of ecological effects that introduced species can have, point out some lessons to be drawn from ecological studies of invaders, and then close with some ways in which plant invasions relate to other aspects of recent global change.

ECOLOGICAL IMPACTS OF NON-NATIVE PLANTS

Direct exclusion of native plant species. The simplest effect of some invasions is the displacement of native plant species, by simple crowding, by competition for resources, or by other mechanisms. Many invasive plants form broad-leaved rosettes or in some other way shade out neighbors. Dense stands of some species (for example, downy brome, *Bromus tectorum*) can outcompete native vegetation for soil moisture. And some non-native plants apparently have allelopathic effects; that is, chemical compounds exuded by the plant, or released by decomposition of its litter, have negative effects on the growth or the germination of other species. My own work in the Sacramento Mountains of south-central New Mexico has demonstrated strong potential for interference between *Cirsium vinaceum*, a federally-listed threatened species endemic to the Sacramentos, and *Dipsacus sylvestris* or teazel. Evidence from several vegetation types suggests that the decrease in native species' cover often exceeds the increase of the invader; that is, total plant cover and biomass may decline after invasion.

Negative effects on animal species. The displacement of native species may reduce food, cover, or nest sites for particular native animals. Numerous studies demonstrate reduced numbers and/or diversity in birds, reptiles, small mammals, and insects in stands of non-native species. Where annual plants replace a mixed or perennial vegetation, the system's capacity to support grazing may be diminished. Spiny plants such as thistles may reduce animal access to forage plants that remain in the community.

Increases in soil erosion. In our semi-arid climate, the brief but intense rainfalls make the landscape vulnerable to erosion. The alteration in vegetative cover or structure can change the amount and patterns of runoff, thereby changing the rate of erosion of surface soils. For example, the replacement of fairly homogeneous grassland by scattered shrubs or broad-leaved herbs may result in increased erosion in the bare inter-plant spaces. Tap-rooted plants may fail to anchor soils to the extent that grasses do.

Alteration of soil chemistry and of nutrient cycles. If an invasive species has unusual tissue chemistry, its litter may influence soil chemistry considerably. Salt cedar or tamarisk can increase the salinity of surface soil considerably. Many other species produce litter that is not readily decomposed, with resulting effects on soil organic matter and nutrient availability. The most dramatic examples of alteration of nutrient cycles come from the introduction of legumes or other nitrogen-fixing species to systems that have lacked them. For example, Vitousek and co-workers published a report in Science (1987) demonstrating that the invasion of a nitrogen-fixing tree to successional Hawaiian ecosystems increased the annual rate of nitrogen additions to the soil several-fold. The resulting increase in the development of soil fertility has implications for all other plants in the successional sequence.

Alteration of hydrology and streamflow. Possible increases in runoff and erosion were mentioned above. The replacement of perennial vegetation with annual species (e.g., downy brome) can alter the seasonal use of soil water. In a few cases, the introduction of a deep-rooting shrub (e.g., salt cedar or tamarisk) has resulted in such high rates of transpiration from the ground water that surface springs and seeps disappeared. Invasion of salt cedar has also altered the trapping of sediments and the behavior of channels in river systems. A recently published example describes how the establishment of Bermuda grass stabilized the bottoms of arroyos and desert streams so completely that the usual scouring of sediments during floods failed to occur, with negative impacts on the many organisms adapted to that scouring.

Alteration of disturbance: fire. Fire is one of many types of disturbance that occur in natural ecosystems, and the vegetation of particular regions is usually adapted either to the absence of fire or to its frequent occurrence. Many grasses tolerate fire well, and around the world there are many examples of the so-called "grass-fire cycle." When these grasses invade an area that historically has not experienced high fire frequency, the establishment of heavy loads of fine fuel (grass litter) may increase the chances for hot fires that travel well. The resulting damage to fire-sensitive native plants, and the enhanced growth of the tolerant grasses, increases the grasses' dominance even further, and the entire system is altered to one of high fire frequency. Downy brome, Lehmann lovegrass, and many other species have been implicated in these shifts in both temperate and tropical ecosystems.

LESSONS FROM ECOLOGICAL STUDIES

Ability to predict invasiveness. There have been many attempts to develop a predictive understanding of what makes species invasive, starting with Baker's list of the characteristics of successful weeds. Detailed comparisons of successful versus failed introductions, or of invaders versus natives, have failed to achieve this level of understanding. Currently the single best predictor of invasiveness is the species' previous behavior in introductions elsewhere; unfortunately, the world is still filled with examples of plant introductions proceeding despite clear indications of invasive behavior by the same species in other parts of the globe. Australia and New Zealand have led the way in attempting to develop schemes for the evaluation of potential introductions.

Absence of disturbance is no guarantee against invasion. While some invasive species benefit from human disturbance and activities, others are capable of establishing themselves in virtually undisturbed ecosystems. National parks and nature reserves are being invaded despite careful limitations of soil disturbance or other human actions. And once established, many invasive plants can persist for decades despite the cessation of grazing or other activities. For most ecosystems, the erection of fences or the elimination of human action (even if it were feasible) would not be sufficient to prevent or to reverse the spread of non-native species.

By the time we recognize the severity of an invasion, it is too late for any effective control measures. Species' invasions typically follow a pattern of very slow increase after initial establishment; this initial "lag" phase may last for decades (even centuries, based on European data). It is unclear whether this time represents an actual lack of spread, prior to some environmental trigger or genetic change in the plant, or whether it is simply the initial slow stages of exponential growth. We usually recognize an invasion only after it has entered an explosive phase, with existing populations growing rapidly and the number and geographical extent of populations increasing also. Unfortunately, by this stage, it is difficult or impossibly expensive to control the increase of the invader. Effective control (or even eradication) depends on early detection of, and response to, potential invasive species. Another message from this is that large numbers of species that until now have appeared innocuous may in fact prove to be invasive later.

OUTLOOK FOR INVASIONS IN THE CONTEXT OF GLOBAL CHANGE

Peter Vitousek has pointed out that the global environment is changing in many ways, driven by human population growth, and that there is direct evidence for most of these changes occurring on a shorter time scale than the oft-cited climate change and losses of biological diversity. Chemical constituents and abundances in the atmosphere are changing; the amount of nitrogen cycling through ecosystems has been increased tremendously by human activity; habitat fragmentation and land use changes are everywhere; and transportation of humans, other organisms, and material goods is increasing rapidly. Most of these changes can be expected to exacerbate the problem of species invasions over the next few decades. For example, as trade and transportation become ever more rapid and efficient, the chances for accidental introductions will increase. Disturbance of natural systems by human activity, and "fertilization" of ecosystems by increasing carbon dioxide and nitrogen concentrations, appear to be favoring the growth of robust weedy species in previously infertile habitats. The rapid transport of species around the globe, and the resulting homogenization of the earth's biota, is itself one of the most powerful agents of global change.

I do not mean to exaggerate the magnitude of the problem. Only a fraction of all introduced species become invasive in natural systems, and not every "invader" in a system will cause dramatic changes. Invasions of a novel growth form, a different phenology, a new physiology are the most likely to result in observable differences in ecosystem function. But the problems are real -- there are dozens of plant species here in the west causing drastic changes in our rangelands, wetlands, and forests, and doubtless many more will emerge over time. We need to make more deliberate choices NOW about whether and how we wish to regulate the composition and structure of our natural environments.

ECOLOGICALLY-BASED RANGELAND WEED MANAGEMENT. Roger L. Sheley[1], Tony J. Svejcar[2], Bruce D. Maxwell[1], and James S. Jacobs[1], Extension Noxious Weed Specialist, Assistant Professor, Research Associate, and Supervisory Range Scientist, [1]Department of Plant, Soil and Environmental Sciences, Montana State University, Bozeman, MT 59715 and [2]USDA-ARS, Eastern Oregon Agricultural Center, Burns, OR 97220.

INTRODUCTION

Over the past several decades, many rangeland managers and owners have focused weed management on controlling weeds, with limited regard to the existing or resulting plant community. The appropriateness and effectiveness of rangeland weed management practices are being questioned because of environmental, ecological, and economical concerns. Therefore, it is becoming increasingly clear that weed management decisions must consider environmental and ecological principles as well as economical ones. The development of future weed management practices must be based on our understanding of the biology and ecology of rangeland ecosystems. Furthermore, weed management education will most effectively focus on providing land managers the principles and concepts on which to base their decisions, rather than providing a prescription for weed control. The purpose of this publication is to present a conceptual, ecologically-based framework to aid in making economically and ecologically sound weed management decisions.

Before weed management decisions can be made, land-use objectives must be developed. Once the uses of the land are determined an integrated weed management plan can be designed. This implies that strictly killing weeds is an inadequate objective in most situations, especially for large-scale infestations. However, a generalized objective could be to develop a healthy plant community that is relatively weed-resistant, while meeting other land-use objectives, such as forage production, wildlife habitat development, or recreational land maintenance.

A healthy, weed-resistant plant community consists of a diverse group of species which occupies all the niches by capturing a large proportion of the resources in the system, keeping the resources from weeds. The soil resources, particularly those associated with soil moisture, are most limiting in the shortgrass prairies and intermountain regions. Therefore, in these regions, we need to pay more attention to developing plant communities that effectively use the soil resources over time and space. Although little is known about the role of many species within the plant community, it is generally accepted that maximum diversity is optimum for energy flow through the system, as well as nutrient and water cycling. Once the desired plant community has been determined an ecologically-based weed management system may be developed.

DISCUSSION

To understand ecologically-based rangeland weed management, it is useful to remember the basic ecological principle on which rangelands have been managed during the past 60 years. This principle states that plant communities change over time until they reach a final and stable composition, called climax. This is termed succession. Secondary succession occurs after a site has been disturbed. Immediately after a disturbance, the plant community is comprised of fast-growing, short-lived species, typically annual and biennial plants. As succession progresses, these species alter the site enough to allow the establishment and colonization of short-lived perennial plants. Soon these short-lived perennial species dominate and alter the site favoring long-lived perennial plants, eventually producing a stable, climax plant community.

Rangeland managers have condition classed, monitored, and managed rangelands based on succession for decades. Plant communities dominated by early-successional species have been considered in poor condition, whereas the condition of those rangelands composed mostly of late-successional species have been considered excellent.

Rangeland managers have used grazing as their major management tool. The objective of rangeland management has been to balance stocking rates to be equal and opposite to natural successional tendency at an acceptable successional condition, such as good or excellent. Stocking rates are then adjusted based on short-term climatic variation to compensate for minor vegetation fluctuations and is a continual process. Managing rangelands using this ecologically-based system has worked well in many cases, but only in the absence of invasive alien weeds.

When alien or noxious weeds invade native rangeland, they throw the successional pattern into disorder. Many of these weeds evolved in old world countries where a long history of very intensive disturbance has selected for very competitive species. In addition, they have often been introduced without the natural enemies that help control their abundance in their place of origin. These factors allow alien weeds to dominate over native species. So, how do we manage rangelands dominated be these aggressive weeds?

Ecological weed management systems must be developed that are based on our understanding of the causes of succession or community dynamics. Although we know little about the processes and mechanisms that cause succession, a conceptual model for weed management can be developed based on the general causes of succession: site availability, differential species availability, and differential species performance (Luken, J. O. 1990. Directing Ecological Succession. Chapman and Hill, London).

In order for succession or community dynamics to occur a site (niche) must be available for desirable species and unavailable for undesirable ones. A site is an area that meets the plants requirements for successful establishment, growth and reproduction. Disturbance creates available sites. Human caused disturbance includes activities that are initiated to create or eliminate site availability and are aimed at initiating and controlling succession. Thus, succession can, in part, be controlled by altering the size, severity, frequency, and patchiness of disturbance in a manner favorable to desirable species. Historically, weed management strategies have included designed disturbance, such as cultivation, timed grazing, burning, and herbicide applications. However, in an ecologically-based weed management system, the disturbance is used to alter the processes driving succession in a desirable direction which minimizes the need for continuous high-energy inputs. The usefulness of any disturbance will depend on the range site, plant community type, invading weed species, history of the site, and climate.

Once sites are available for desirable species, they must be occupied before the weeds establish. From a weed management standpoint, this may be termed "controlled colonization". Controlled colonization includes methods used to alter the availability and establishment of plant species within the community and are implemented to intentionally affect succession. Processes that must be exploited are seed dispersal and vegetative reproduction. Introductions of desirable species must be enhanced, while those of the weeds must be limited. Procedures which shift seed banks are also important in controlling colonization. Factors affecting establishment or encouraging germination and seedling survival may also be used to favor desirable species. Using techniques to prevent weed encroachment or altering environmental or managerial conditions to exploit dispersal mechanisms or germination requirements may favor establishment of desirable species. This puts the emphasis on encouraging the desired species rather than simply controlling weeds.

When sites for desirable species are created, and they become established, species performance (controlled species performance) must be altered to favor desirable species over weeds. Controlled species performance includes using methods to alter growth and reproduction of specific plant species, thus contributing to a desirable shift in the plant community. This requires understanding the factors that influence competitive balance, such as grazing, disease, resource availability, allelopathy, predators, growth rates, and their complex interactions.

Shifting the plant community from weedy to desirable plants requires understanding the stages in the weed's life cycle that are most vulnerable to stress or control, and understanding those stages and procedures in the desirable species life-cycles that can enhance their performance. In many cases, controlling species performance requires repeated applications, such as repeated grazing.

This conceptual model forms the ecological basis for developing integrated rangeland weed management strategies (Figure 1). The three mechanisms causing succession (disturbance, colonization, and performance) must be considered as a package. Designing disturbances to either create sites for desirable species alone, controlling colonization without making sites available, or increasing their relative performance without making them available, is unlikely to shift the plant community in the desired direction. Designing successful rangeland weed management strategies will require carefully integrating techniques aimed at addressing each of the three general causes of succession: site availability, differential species availability, and differential species performance. Management strategies must be carefully chosen to ensure that one technique is complementary to the other. Once this is achieved, succession from a weedy plant community to a desirable one can occur.

When developing an ecologically-based weed management plan, options can be placed in categories of designed disturbance, controlled colonization, and controlled species performance (Figure 1). Carefully consider and test each technique as to its effectiveness in directing plant succession and determine if the proposed procedures complement one another. Integrated weed management systems can be designed, tested and documented using this ecologically-based conceptual model. In many cases, there will only be bits and pieces of research on these topics. Information on integrating techniques is very limited.

Several schematics using this ecologically-based weed management planning system are shown for spotted knapweed infested rangeland in Figure 1. In these examples, the plant community prior to weed management is composed of 1) 98% spotted knapweed with a very suppressed understory of cheatgrass or bluegrass, and 2) 50% spotted knapweed, 30% suppressed native plants, and 20% cheatgrass and/or bluegrass. Two successional weed management systems are tested for each situation. These examples show how integrating various weed management systems direct successional processes, resulting in different successional patterns and usefulness to range managers. Clearly, the plant community after implementation is dependent on the weed management system and the plant community prior to weed management. Climatic variation introduces a random element that can influence the short-term outcome. Weed management actions should be based on your land use objectives, desired degree of energy inputs, and economics.

CONCLUSIONS

The successional weed management model presented in this paper allows for integration of currently available tools. Unfortunately, with conceptual models of this type, there are seldom large comprehensive research projects that have tested all possible options for a particular plant community. Development of successional weed management plans will require use of existing research information, management experience, and monitoring of successes and failures to adjust future plans.

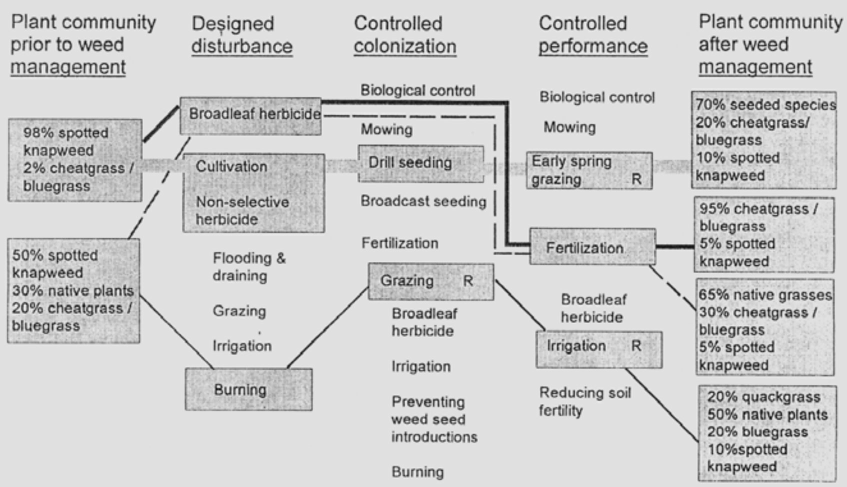

Figure 1. Examples of ecologically-based spotted knapweed management systems. R refers to repeated applications.

BIOLOGICAL WILDFIRE: APPLYING FUNDAMENTALS OF WILDFIRE MANAGEMENT TO IMPROVE NOXIOUS WEED CONTROL. Steven A. Dewey, Extension Weed Specialist, Utah State University, Logan, UT 84322-4820.

Noxious weeds create serious problems for land managers. Yellow starthistle, spotted knapweed, leafy spurge, and dozens of other "alien" plants cause enormous economic and ecological damage when they invade. In addition their impact on agriculture, noxious weeds cause severe ecological damage to wildlands, including forests, wilderness areas, national parks, recreation sites, and wildlife management areas. Millions of acres have been invaded or are at risk, and the problem is getting worse. More than 4600 new A of public lands are being taken over every day by noxious weeds, and the rate is accelerating. The noxious weed situation in the United States has been described "a biological wildfire, raging out of control". Indeed, noxious weeds and wildfires do have much in common, and their similarities can provide useful new perspectives into the weed problem.

Among the many parallels between wildfires and weeds are three basic elements: impacts, spread or behavior, and principles of management or control. We will examine each of these in detail. Parallels between the impacts of wildfire and weeds help put into perspective the need for noxious weed control. Unwanted wildfire can drastically affect the land's appearance and productivity. In addition to economic losses, wildfire causes a dramatic change in plant communities and wildlife populations, increased soil erosion and other damage to watersheds, and negative impacts on recreation. Noxious weeds affect lands in much the same way. They change plant communities by crowding out native and other desirable plants. As plant communities are changed so are the wildlife populations that depended on the native plants. Noxious weeds can increase soil erosion and thereby damage watersheds. And, the economic impacts of weeds on recreation total millions of dollars annually.

There is one very important differences between the impact from wildfires and noxious weeds. Wildfire is a natural part of most ecosystems and its negative effects are usually temporary. Most lands affected will eventually return naturally to their pre-wildfire condition. This is not true of noxious weeds. They are not a natural part of the plant communities they invade, and infested lands are not able to rid themselves naturally of weeds and return to their original pre-invasion condition. If weeds are allowed establish and spread, the damage they cause may be permanent. Its no surprise, then, that many land managers regard a noxious weed invasion as an emergency of equal or greater concern than even a wildfire.

Similarities with the spread and behavior wildfire help to demonstrate how crucial it is to discover and control small weed problems before they becomes large. Typically, a wildfire begins as a small spot, growing slowly at first, as its perimeter expands in many directions. As the fire becomes larger and hotter, embers are scattered ahead of the main fire front. These create spot fires which enlarge, and eventually merge with each other and the main fire. Growth becomes exponential as fire consumes more and more acres at an ever-increasing rate. If not stopped soon, the fire becomes a raging inferno, out of control and spreading over thousands of acres. Noxious weeds spread slower than fire, but in much the same pattern. Like a wildfire, weed problems typically begin as a single plant or small patch. Infestations gradually get larger as their perimeter expands in many directions. Seeds spread ahead of the main advancing front create new "spot" infestations which grow and eventually merge with each other and the main infestation. Infestations enlarge at an exponential rate. If not stopped early, one tiny weed patch can become a raging "biological wildfire", out of control, and spreading over thousands of acres.

Understanding and applying principles of modern wildfire management can make noxious weed control efforts more effective. Successful wildfire management is based on the four key elements of: prevention, detection, suppression (control), and revegetation. These are the same four elements of effective weed management, as taught all basic weed science courses. An integrated balance of all four elements is essential for success, whether speaking of wildfires or weed management. A typical wildfire management budget includes a large appropriation for prevention. Another significant portion goes for detection. Control represents the biggest expenditure, approximately 60% of the overall amount. Rehabilitation or revegetation makes up the remainder. Wildfire management would be ineffective without all of these key elements. Successful weed management requires the same kind of balanced effort with significant efforts in all four categories.

Prevention receives a high priority in wildfire management. It is considered the first line of defense. The same should be true for noxious weeds. The old adage "an ounce of prevention is worth a pound of cure" applies perfectly to both problems. Promoting wide-spread awareness and concern is the key to successful wildfire prevention. It is achieved through a two-pronged approach of education and regulation. Fire prevention messages appear in a variety of forms and places to educate and remind people of the critical role everyone plays in this effort. Laws and regulations, such as campfire or smoking restrictions, also contribute to effective wildfire prevention. Weed prevention means placing a priority on preserving and protecting lands not presently infested. Education and regulation are the keys, just as in wildfire prevention. Through education, informed hikers, campers, hunters, bikers, 4-wheelers, and other recreationists could do much to help land managers prevent the spread of weeds. Regulations, like those prohibiting the use of weed-contaminated hay on public lands, represent the other side of the weed prevention effort.

The primary objective of detection is to minimize wildfire damage and control expense by finding, reporting, and mapping the location of all wildfires as quickly as possible. Wildfire detection is the primary duty of assigned individuals, but all field personnel within land management agencies are expected to assist by watching for and reporting wildfires. The general public also plays an important role in reporting wildfires. Finding, reporting, and mapping invasive weed species is just as important to control as these steps are in fighting wildfires. Early detection is crucial if weed infestations are to be controlled effectively and economically. Weed management personnel should conduct regular field surveys, but other field personnel should assist with detection by learning to recognize targeted noxious weeds, and reporting them to weed managers. Ways should be explored to involve the public, including volunteer groups, recreationists, and other public land users, in noxious weed detection and reporting.

The third management element for weeds and wildfires is control. Wildfire control is called suppression. To accomplish suppression, fire fighters follow a proven step-wise process of (1) rapid response, (2) size-up, (3) containment, and (4) mop-up. Suppression efforts may fail if all four steps are not followed in proper sequence. These same four steps are also the formula for effective weed control.

The need for rapid response is obvious when dealing with wildfires. Controlling fires when they are small reduces costs and minimizes resource losses. Usually an initial attack crew is dispatched within minutes of a reported fire. On a typical National Forest, suppression activity begins before most new wildfires exceed 0.1 A in size. Only under very rare circumstances do wildfires become larger than a few acres before control activities begin. A similar response pattern should exist for control of new weed infestations. Unfortunately, this is frequently not the case. Control of new noxious weed infestations often is postponed until the problem has covered hundreds or even thousands of acres, well beyond any hope of eradication. In a survey of county weed programs in the intermountain west, control begins on only 11% of new weed infestations before they exceed 0.1 A in size. Even more disturbing is the fact that over 50% of new noxious weed infestations reach 100 to 1000 A in size before any action is taken. Clearly, a greater sense of urgency is needed in addressing new weed infestations. Ignoring a tiny isolated patch of noxious weeds is far more serious than ignoring a small spot fire if one considers the long-term consequences.

The first task of fire fighters arriving at a fire is called size-up. It involves gathering all information needed to develop and execute an effective plan of attack. Size-up must be completed before control begins. When all necessary information is gathered, options for control are evaluated, plan is developed which is best suited to the circumstances and management goals. Equally careful planning must be a part of every weed management effort. All pertinent information must be gathered and weighed to develop the best weed management plan for a specific site. Bypassing the size-up step in weed control is an invitation to inefficiency and failure.

The initial objective in fire suppression is containment -- protecting unburned areas by stopping further spread. Efforts focus on the fire's advancing perimeter, not on the core. Spot fires or other "escapes" outside the containment line are considered emergencies and are controlled immediately. If control begins when a fire is small, containment is relatively easy. If efforts are delayed, or the fire moves too fast, containment becomes much more difficult. Still, the objective is the same -- stop the spread before dealing with the interior. If weed infestations become too large for eradication, the first objective should be containment -- stopping further spread. This is done by focussing control efforts on the advancing perimeter, with special emphasis on likely escape corridors (such as roads, streams, trails, etc.) and any spot infestations discovered outside the containment zone. Spot infestations constitute an emergency situation, just as if they were spot fires outside of a fire line.

In weed situations resembling a large fire, containment sometimes is overlooked. Control efforts may be directed at the large and highly visible core area of the infestation instead of at the edges. This faulty strategy makes as much sense as directing all fire suppression efforts at the center of a massive wildfire and ignoring the edges. The result would be a fire that perhaps was controlled in the center, but was expanding on the perimeter as if there had been no fire fighting effort at all. Don't begin attacking a weed problem at its center. As with fire fighting, directing efforts at the center, without regard to containment, is a waste of time and money.

The final step in fire suppression is called "mop-up" --- finding and extinguishing every live ember within the containment zone. Workers search the ashes with bare hands looking for hot spots. Though it is a long and tedious process, mop-up is absolutely essential. Until it is completed, a fire is not considered controlled; and it may flare up and escape, canceling all previous efforts and expense. In weed management, mop-up means eradication. It involves the elimination of every weed and exhausting the soil of all its seeds. It is also long and tedious, requiring years of persistence and dedication to complete. The time and effort needed for eradication may be practical only on relatively small patches, or along containment edges of larger infestations. But remember, failure to fully mop up any weed infestation guarantees its eventual re-establishment and spread.

The last fundamental step in fire management is revegetation; making sure that desirable vegetation is restored on a burned site. Sometimes it will occur naturally, but other times it must be assisted. Revegetation is part of every fire operation. Planning begins even before most fires are controlled. Weed managers should never overlook the importance of replacing noxious weeds with competitive desirable plants to help keep weeds from re-establishing. As with fires, plans for revegetation should be made before control is finished.

Nearly every aspect of wildfire management has a close weed management parallel. Wildfire management can be an excellent teaching tool, as well as a source of ideas or models to promote and improve noxious weed control efforts. Applying the parallels is easy. Just think of weeds as a slow-moving wildfire, then act accordingly. You will be surprised at how much more clearly you see from this new perspective.

A LANDSCAPE APPROACH TO WEED MANAGEMENT IN THE SALMON RIVER CANYON, IDAHO. Leonard Lake, Nez Perce National Forest, Grangeville, ID 83530.

Central-Idaho with its mixture of land ownership, existing wildlands and wildernesses, and relatively natural habitats is an important contributor to the state' s plant and animal diversity. It is this combination of mixed ownership and wildlands that is drawing people from all over the west. People want to live and work close to the natural resources and recreate in the last remaining wildlands; to be a part of one of the last best places in the Northwest. But, as is the case in many places across the west, all is not right in paradise. Until recently a significant ecological threat to our non-wilderness, wilderness, and wild and scenic rivers has gone unnoticed by the general public. As society argues over how best to sustain the area' s natural resources from development and traditional uses, noxious weeds are quietly changing the character of many of our wildlands. Weeds are no longer an agricultural problem. Idaho no longer has just farm weeds. The region is experiencing a serious threat from wildland weeds.

Federal and State agencies are attempting to allocate more funds, research continues to develop valuable tools and techniques, laws are being amended and policies changed; all to assist in the struggle against invasive exotic plants moving across our wildlands. For this effort to achieve a level of success, it must come together at a place, a geographic area, one of the last best places. Therefore, my intent is to discuss a weed management program in one of those last best places. Weed management across a landscape: the lower Salmon River canyon landscape.

The Salmon River canyon in North-Central Idaho from Riggins to Whitebird hill is a sparsely populated area with a multitude of federal, state, county and private jurisdictions. The canyon is 61% National Forest, 6% Bureau of Land Management, 1% Park Service, 5% State lands, and 27% private lands. It is a rugged and dissected landscape with an elevation gradient of 1,500 feet to approximately 10,000 feet above sea level and a wide ranging precipitation regime (15 to 40 inches/year). The great elevation and precipitation variation creates a long growing season lasting from March through November. The canyon has a complex of habitats varying from hot-dry bunchgrass grassland and moist montane grasslands, to pine savannas and wet-warm fir forests, to subalpine forests and parklands. All this provides for a diverse and ever changing landscape.

The area has a great number of plants and animals and provides significant summer and winter habitat for deer, elk, bighorn sheep, cougar and bear. The canyon provides habitat to regionally endemic plants such as broad-fruit mariposa (*Calochortus nitidus)* and the federally listed Macfarlane's four-o'clock (*Mirabilis macfarlanei*). The undammed rivers still provide critical habitat for steelhead and endangered salmon. The canyon is a main access point to the largest roadless/wilderness complex in the lower 48 states. The area trails, roads and rivers provide access to the Frank Church-River of No Return Wilderness, Gospel-Hump Wilderness, Hells Canyon Wilderness and Hells Canyon National Recreation Area. The Snake River, Salmon River and Rapid River have been congressionally designated Wild and Scenic Rivers. It is big river country; the waters and canyon dominate and define the area. Thousands of people come to the canyon and adjacent country every year to enjoy the wildland recreation, and use the natural resources the area provides.

Susceptible habitats such as canyon grasslands and open ponderosa pine stands dominate the lower elevations, and it is these habitats along with frequently disturbed sites; such as, riparian zones, and transportation networks, that invasive weeds are aggressively moving across. The adjacent wildernesses also have thousands of acres that are susceptible to numerous noxious weeds. The success or failure of weed management in the Salmon River canyon will have lasting implications to the wildernesses that surround the Salmon River. The Salmon River canyon has an abundance of invasive and noxious weeds. Sixteen state noxious weeds are found in the canyon with numerous invasive weeds currently not listed as noxious. Landowners are battling many of the same weeds causing problems across the west. However, the plant that is currently causing the greatest concern is yellow starthistle. It begins as small spot infestations in relatively inaccessible canyon slopes, spreads and coalesces to become the dominate plant over thousands of acres. It is the concern over this plant that has motivated landowners to search for another approach to weed control.

The social and environmental complexity of the Salmon River canyon has made effective and efficient weed control a significant challenge. It is not that we didn' t know how to kill weeds; but that we failed to maintain long term focus on widely established weed populations; we responded slowly to check new invaders and we lacked information needed to approach the problem in a logical and organized manner. There were overlapping efforts, and in many areas of the canyon there was a lack of action. Agencies stated that weed control was important but focused on other priorities. Due to an absence of understanding, many inside and outside land managing agencies viewed exotic species as the lesser of two evils, with herbicides and even biocontrol agents assigned a greater environmental risk than the infestations. As a result, management and treatment were haphazardly and inconsistently applied across the canyon. Weeds were managed by complaint, and a significant amount of time and energy was spent trying to force agencies and individuals to control weeds with varying degrees of success. This atmosphere developed mistrust and conflict rather than cooperation.

We realized that we needed to change the approach to weed control in the canyon. Officials from Idaho County and the Nez Perce National Forest met to look at options. County and Forest officials decided to try the weed management area concept - a landscape approach to the planning, treatment and management of noxious weeds. We were to focus on the place or geographic area in developing strategies and management options, not property lines or organizations. The *Guidelines for Coordinated Management of Noxious Weeds in the Greater Yellowstone Area* was used as a guide, and modified to fit our particular area. Boundaries were established within the lower Salmon River canyon along logical watershed breaks with minor adjustments for social and logistical reasons. The exterior boundaries were quite flexible and mainly used to focus people' s attention.

To begin the process, area meetings with the landowners in the canyon were conducted to determine if there was interest in the area concept. We developed a working group of key people, made up of county personnel, land management agencies and local landowners. The group was limited to 10 to 12 committed individuals and was balanced between agency' s personnel and landowners. We actively sought the involvement of major landowners in the canyon. It needs to be highlighted that this was not an agency led process, nor was it specifically designed to fit federal agencies. It was approached as a collaborating effort among partners with a common purpose. The working group developed goals, management objectives, priorities and actions for the entire weed management area. The working group submitted a draft to the general populous for comments and changes.

It quickly became obvious that the working group was missing important information on weed species in the canyon. Everyone involved knew a weed problem existed; knew generally where the weeds were distributed; but lacked specific information on location, size, density and movement. No one on the committee had complete knowledge of the extent and location of weed species across the canyon. Without specific information across the entire canyon, effective integrated strategies could not be developed. The first action of the committee was to complete an initial inventory of the Salmon River canyon. A database for all weed infestations regardless of ownership was created and stored at one location. The information was accessible to everyone. It is critical to the landscape approach that everyone work from the same information; that everyone know the location of the weed free zones as well as the weed infestations. It can not be over emphasized that an inventory across all properties integrated into a single database is the "glue" that holds the weed management area together. The inventory provides the basis for realistic objectives and is the key to coordinated use of limited crews and funds. The maps, created from the database, develop common expectations and understanding between the working committee and the general public.

The integrated database allows the cooperators to assess the entire landscape and assign management objectives for each species based on location, extent, susceptible habitats, invasiveness and available funding. Established and widespread infestations are stratified into management zones, with each zone assigned an objective. Cost share assistance and the sharing of crews and equipment are based on the objectives and management zones. Management actions are applied along lines-of-attack and follow the weed infestations, not property lines. Bio-control agents are released and monitored along containment zones of core infestations.

Prevention measures are being developed for the entire management area. These measures can be viewed as managing disturbance and dispersal agents across a geographic area. It is far more efficient and effective to develop and implement prevention measures across the landscape than at the ownership level, since these processes do not recognize property lines or political jurisdictions. Building and applying prevention as a cooperative venture also reduces the need for enforcement. Management actions applied along lines-of-attack in one area of the canyon are prevention measures for those zones without weeds. This is particularly true for the thousands of acres of susceptible habitats in the adjacent wildernesses.

Ultimately, weed management must be integrated into land restoration and land stewardship. Local land management prescriptions must be developed that maintain ecosystems and reduce the risk of noxious weed invasion. Degraded habitats must be returned to a condition that is less susceptible to weeds. To break the cycle of replacing one noxious weed with another, the cooperators are establishing feasibility plots to test techniques that are designed to reestablish perennial vegetation. These plots attempt to develop local solutions to the management of steep rocky canyon slopes where the use of heavy equipment is very limited.

By using a landscape approach, land managers have gained a new perspective for the control of noxious weeds. The entire area is assessed before treatment strategies are developed; trade-offs and priority areas are readily portrayed; political boundaries are blurred allowing for the efficient use of limited manpower; actions are organized around weeds rather than ownerships; and, the cooperating land managers are concerned for all lands and are working freely off site. Many eyes with the same objective equates to an improved early alert system for new invaders. The landscape approach builds awareness through the necessary interactions of many partners. This may be one of the most important benefits of the approach; with awareness comes individual commitment.

The cooperators working in the Salmon River canyon are serious about a full integrated approach across the landscape. Control, management, prevention, monitoring and feasibility testing of potentially useful prescriptions are being applied in an organized coordinated effort across the canyon. As one landowner stated "it used to be that weed control was an after thought in my decision making, now I realize that weed management must be integrated into every decision I make".

Weed management must be built from a long term and broad scale perspective. Managers must build on the commonality of the area, focus on the place, increase awareness, keep actions realistic, work together for the common purpose and find ways to help each other succeed. This is what's happening in the lower Salmon River canyon: one of the last best places in the Northwest.

A PUBLIC LAND WEED CONTROL PROGRAM ON THE BUREAU OF LAND MANAGEMENT FARMINGTON DISTRICT, NEW MEXICO. Sterling White, Bureau of Land Management, Farmington, NM.

Paper not submitted for publication.

1996 TO 1997 WESTERN SOCIETY OF WEED SCIENCE OFFICERS AND EXECUTIVE COMMITTEE
Seated (L to R): Rod Lym, Research Chairman; Barbra Mullin, President-Elect; Charlotte Eberlein, President; Wanda Graves, Treasurer/Business Manager; Jill Schroeder, Member-At-Large. Standing (L to R): Gus Foster, Immediate Past President; Paul Ogg, WSSA Representative; John Evans, CAST Representative; Wayne Belles, Secretary; and Jack Schlesselman, Education and Regulatory Chairman.

RESEARCH PROJECT MEETINGS

PROJECT 1: WEEDS OF RANGE AND FOREST

Chairperson: Steve Dewey

Subject 1: Certified Hay Programs and Weed Prevention on Public Lands

Noxious weed prevention on public lands in several western states has centered around restricting movement of plants or weed seeds and training federal workers and users to identify and report problem weeds. Closure orders on Forest Service lands prohibit the use of hay or other feed materials for livestock that have not been certified as weed free. All land users, both federal and private, are required to follow these closure orders when they exist in designated areas. Instances of violation has resulted in confiscation of hay and citations. Much discussion was generated concerning additional measures that might be taken to further prevent the spread of weeds in and around wilderness and primitive areas. Staging areas and trailheads were identified as spots that can serve as points of spread for weeds. Controlling weeds around these areas was suggested as a way to keep stock and people from moving seeds further into uncontaminated lands. Also, using weed-free seed for erosion control after wildfires was offered as another approach to slow weed movement.

Several discussion questions were posed that offered insight into federal weed prevention efforts. Feed quality was discussed and its importance in weed movement. Pelletized feed was preferred over cubed feed because it is ground and then pelletized. The combination of grinding, heat and pressure help to destroy seed viability. Cubed feed is simply compacted and does not eliminate seeds. Containing livestock in holding areas prior to moving them onto federal lands was suggested as a way to prevent weed movement from animals. There is no formal federal policy on doing this, but increasing attention is being placed on weed movement from staging areas.

Training workers and the public in weed identification was targeted as another way that weed spread can be slowed. Some effort has been made to train trail and fire crews to help recognize and report noxious weeds. There is no formal training requirement in the Forest Service or BLM, but more on site training is being done. Some effort has been made to get interested user groups such as hunters and ATV riders involved in reporting weed problems. It was suggested that universities can play a larger role in emphasizing weed ecology in many interdisciplinary courses such as wildlife and fisheries, recreation, ecology, forestry and others.

Subject 2: Adjusting Weed Research To Changing Public Land Policies

New Forest Service strategies focus on ecosystems and ecosystem management with increasing emphasis on non-commodity values. In order to incorporate these strategies increased information on weed ecology will be needed according to discussion group consensus. Particular concerns center around management strategies that help native species and understanding the ecosystem impacts of exotic species on natural systems. Understanding the effects of alternatives to herbicides such as fire are also needed.

Additional information is needed on IPM for weeds. Little data exists for individual weeds, and potential overseas threats that are not yet in this country need to be understood. Developing weed management principles in the context of new weeds was suggested as a research priority.

Economics of the impact of exotic weeds was clearly identified as a high priority research item. Impacts should be documented so that funding for research can be obtained and budgets can be justified. Currently little economic data exists. Inventory of existing weed infestations is also recognized as a major focal point. Inventory coupled with economic impacts was suggested as a way to prioritize weed problems.

Evaluating and documenting biodiversity changes was identified as a research need that is important but little funding is currently available for these activities. Building a constituency to help support and document ecosystem work was offered as a way to increase understanding of the problem.

Subject 3: What Role Should WSWS Play When Public Agencies Increase Weed Management Efforts

New interest in weed management is occurring throughout the country in many federal and state agencies. Forest Service, BLM, Fish and Wildlife, ARS, APHIS, and some states are working separately and together on weed management strategies and plans. Interest is starting to occur from the top down.

The strength of WSWS may be in education and training when coordinating with diverse agencies. WSWS currently sponsors biological weed control handbook and other publications. There may also be opportunities to teach or sponsor courses at universities or use other outreach methods such as satellite courses. WSWS may also be able to act as a clearing house to assist in finding funding for private groups in weed management. The Internet was suggested as a mechanism to promote weed management and possibly find other sources of funding. WSWS currently has a committee working on it. A final suggestion was the development of ecosystem restoration guidelines that could assist agencies in their restoration work.

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PROJECT 2: WEEDS OF HORTICULTURAL CROPS

Chairperson: Carl E. Bell

Subject: Making the Connection Between Research and Growers, and are Economic Thresholds Relevant to Horticultural Crops.

The discussion section of Research Project 2 was cancelled because of lack of attendance. The five people who did attend, including the Chair and Chair-Elect participated in the discussion in Project 3.

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PROJECT 3: WEEDS OF AGRONOMIC CROPS

Chairperson: Phil Stahlman

Subject: Public vs. Private Research: Who Should Be Doing What

More than 50 persons listened to prepared comments given by Harvey Tripple, Bob Zimdahl, and Steve Miller (for Frank Young), who represented industry, university, and USDA-ARS perspectives, respectively. Harvey's comments summarized discussions with representatives of five agrochemical companies. Bob's comments reflected his own thoughts as well as authors and several levels of university administration. Steve's comments mostly represented the opinions of Frank Young. It can not be assumed that Frank's opinions represent the thinking and priorities of USDA administrators. The thought-provoking presentations and lively, self-sustaining discussion that followed revealed as many areas of disagreement as agreement. Major points of the presenters and the discussion that followed are summarized below.

Industry Perspective. Government funding priorities and public pressures are encouraging basic research that has limited immediate application to agriculture or product development. Consequently, industry funding of academic research has and likely will continue to decrease. Industry does not want or rely on basic research by public scientists and won' t pay for it. Industry does not use academic data to support early decisions on product direction or labeling because of confidentiality, patent protection, and business strategy considerations. Few in the academic community can, will, or are capable of conducting GLP studies. Also, university overhead charges and intellectual property rights claims make the public scientist noncompetitive with private contract scientists. Money is not unlimited. The inability or reluctance of the public scientist to sign confidentiality agreements also favors private contract researchers. The capability of the academic community to conduct "state-of-the-art" research is limited by lack of up-to-date equipment, instrumentation, and resources.

Industry expects academia a) to be proactive in recruiting students and training prospective future employees; b) have knowledge of local agronomic practices, competitive products, be able to identify and help manage problems (e.g. resistance, etc.) before they develop; c) provide unbiased evaluations, recommendations, and information on how best to use a product (optimization and fit); d) accept industry data as being valid, and; e) explore new market opportunities.

Academia should provide students (i.e. prospective employees) with training in communication and interpersonal skills, a broad versus narrow background of applied, technical and computer skills, and an understanding of the customer and agriculture. Applied scientists are desired over basic scientists. Weed science majors generally are preferred over majors in other disciplines because weed scientists generally have broader backgrounds.

University Perspective. University and USDA-ARS should be engaged in some level of efficacy research, but because they are publicly supported, there is an implied obligation to conduct research that is in the public' s interest. Because commercial interests are part of the public, public agencies have a duty to assist private entities, but there is a minimal level that should be publicly supported. All research costs, including overhead, should be paid by the contracting entity. Public scientists must not become agents of commercial interests, be driven by the priorities of private enterprise, or allow the research agenda to be driven solely by the source of funds. Shrinking public funding and the resulting necessity to seek funds from other sources makes this increasingly difficult. The public scientist is expected to create new knowledge, develop new techniques, minimize damage to the environment, and be involved in scholarly works, even though the latter may not immediately or knowingly benefit agriculture or society.

Public agricultural research must consider societal goals, ethics, and national and global values in deciding what/how research is done. For example, should technologies be developed that benefit only segments of the populations, displaces workers, reduces employment, changes income distribution, or increases the production efficiency of tobacco, etc. Society has the right to hold the public scientist responsible for what they do, but they can not be blamed for all ills. Don' t assign all of technology' s faults to its developers.

Structural change is needed to reverse the trends toward large scale agriculture that demands and uses short-term solutions to immediate problems. Public scientists should return or be involved in more long term research, but funding is needed. The lack of funding for long term research may be because it is not of sufficient importance to the elected representatives of the democracy, or we are not sufficiently proactive in asserting the importance of our activities.

USDA-ARS Perspective. There is little recognition of weed science as a discipline within USDA and weed science research funding continues to be cut. The current research agenda is not what is happening in the field. The three areas of USDA-ARS weed science research in increasing order of importance are: a) weed biology and ecology including weed-crop interactions and bioeconomic modeling; b) integrated weed management, i.e.

alternatives to chemicals; and c) cropping systems research. Cropping systems are the most critical because they focus on farming systems, and also are the most underfunded.

It is essential that cropping system studies be conducted long-term (two or more cycles) to monitor and detect change over time and that they be conducted on a large-plot scale using farm equipment. They also should have grower involvement to increase validity and grower acceptance. There are many benefits of such research including: involvement of teams of interdisciplinary scientists; allows study of interactions between pests, tillage, crops, rotations, etc.; provides for more accurate assessment of economic impacts; identifies gaps or problems more quickly than component research; provides a single site to observe results; identifies scientific strengths and weaknesses; and it is long term. Shortcomings include study complexity, lack of funding, and the coordination, commitment, and dedication needed scientists and administrators, and lack of appreciation (recognition) of accomplishments. Evaluations systems are based on publications and do not value long term research. Three years is considered long term within USDA-ARS.

Discussion. This is not a new debate. There are both perceived and real fundamental differences in the goals of public and private research programs. Academia is mission-driven, whereas industry is profit-driven. Most public scientists have teaching or extension as well as research responsibilities and are obligated to serve the public first and industry second. The public overwhelmingly associates the public scientist with teaching rather than research.

There was general agreement that public scientists should engage in more long term systems research than currently is being done. The main reasons this is not happening are the lack of funding, commitment, and appreciation, and evaluation and promotion criteria that emphasize publications, i.e. short term research. It is difficult for young scientists to obtain tenure by conducting only long term research. However, depending on the nature of the research, it is sometimes possible to publish on components before completing the research. Evaluation systems must recognize the complex nature of long term systems research and reward accomplishments accordingly. This will require change in evaluation criteria and more than lip service from administrators.

Public scientists took exception to some of the presented industry viewpoints and other practices. Most universities permit scientists to enter into short term (1 to 2 yr) confidentiality agreements as long as any data can be published (made public) eventually. Also, most universities accept unrestricted gifts up to a certain amount in lieu of grants, for which there are no overhead charges. Not all universities charge overhead on small grants (usually <$5,000). Industry has an ethical obligation to accept some responsibility (ownership) and take an active roll in managing issues that result from product use, e.g. weed resistance, groundwater contamination, etc. Industry was criticized for often misusing or misrepresenting university data. Marketing commonly shows university data without significance levels or uses only selected data to imply a result that might not be significant. The scientists interpretation of the data frequently is ignored when it is not to the company's benefit. This is contrary to industry's desire for unbiased evaluations.

Recruitment and training of students is expensive. Industry was encouraged to be more proactive in funding graduate student research projects to increase the pool of prospective employees, and as a way to provide more input into the students research.

Despite the different view points and opinions expressed, it was pointed out that industry generally has a better working relationship with public weed scientists than public scientist of other disciplines. Our short term goals may differ, but we have similar global objectives and we are in this together. We have accomplished much and there is much more to be done, together. Future discussions might include what public scientists desire from industry.

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PROJECT 4: EXTENSION, EDUCATION, AND REGULATORY

Chairperson: Dr. Beverly R. Durgan

Subject: The Role of Weed Science in IPM Extension, Education, and Research

Dr. Gerrit Cuperus, Oklahoma State University, Dr. Carol Mallory-Smith, Oregon State University, and Dr. Beverly R. Durgan, University of Minnesota led the project discussion.

The topics for discussion included:

Subject 1: The Role of a State IPM Coordinator

Subject 2: IPM at The State Level

Subject 3: IPM at The National Level

The session began with a discussion focusing on the role of a state IPM coordinator. Dr. Cuperus pointed out the role of the IPM Coordinator is one of bringing people together to address the broad issues associated with production agriculture. The state IPM program is interdisciplinary and reaches out to scientific groups plus producers through the different commodity groups within a particular state. In order to have a successful state program, it is necessary to have resources; not just dollars, but also people. Coordination among the different groups is critical in addition to having people who are willing to work together. His final point for a successful program was listed as having someone dedicated to the effort of building "teams" within the state.

An important point to consider is the fact that many of the Western states do not have individuals who wear only an IPM Coordinator hat. Within many states the work of IPM Coordination is added to an already full plate of responsibilities making it difficult to accomplish the goal of focused direction. It was also pointed out that very few states have IPM Coordinators with a Weed Science background.

Dr. Carol Mallory-Smith began with the notion that the IPM Initiative is viewed as a social contract with the American Public. She stated that in the minds of the public and political arena, the reduction of pesticides will result in a reduction in risk. Yet, to the producer, the reduction in pesticides can be translated into a reduction in cost. Within this IPM Initiative, Implementation Teams are being formed that are commodity based; interdisciplinary; include growers, processors, and end users; and will develop implementation strategies. With this direction, she asked the following questions:

1. How will these goals be met when 70 to 75% of pesticides used are herbicides?

2. How many weed scientists are commodity based?

3. Where will we find enough trained weed scientists to fill the needed members on the "team"?

4. How do we weed scientists capitalize on this opportunity to be recognized as a discipline that is absolutely necessary to meet the goals of the IPM initiative?

The discussion focused on how do we get Weed Science more involved in this critical process. Since few Weed Scientists are involved as state IPM Coordinators or members of IPM Teams, it will be difficult for this area to be adequately addressed. In closing the plea was made for more Weed Scientists to consider getting involved as this process unfolds.

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

Chairperson: Bob Callihan

Subject 1: Barriers to Practicing Good Weed Control

Bob Eplee of APHIS, stated that policy makers and implementors may not realize that the biology of a weed is not negotiable, that it will do what it wants, regardless of bureaucratic doings. One cannot start a spray program until the money comes, and therefore we often 'miss the boat'.

George Hittle of INWAC, discussed policy, leadership and cooperation. He said that a noxious weed is defined by law someplace. We need to clean up laws that are on the books. Arizona and New Mexico do not have statewide weed laws. Inconsistency among states is another barrier to good weed control.

Ron Crockett of Monsanto, said that the Process - NEPA, CEPA and EIS - takes a long time and weeds do not wait. One person who opposes an action can stop the entire process.

Other points raised during the discussion were:

- There is infighting among agencies to get top position to dictate permits and policy, and therefore nothing gets done.
- Bureaucrats do not always follow state regulations and laws, because of 'fear of the public'.
- We should worry about protecting an ecosystem rather than about herbicides.
- We need to look at the ultimate use of the land in 50 years, e.g. for grazing.
- Biological control agents for spotted knapweed and leafy spurge are limited because those agents may affect agronomic crops.

Sean Furniss, US Fish and Wildlife Service, talked about the issuance of 404 permits under the Endangered Species Act, and the variability of approach from region to region. The FWS is decentralized and regions operate separately. The solution is education within the FWS, coupled with review at the Regional or National level.

Subject 2: Opportunities to Aid Good Weed Control Practice

Sean Furniss explained that FICMNEW was a committee of 16 federal land-owning agencies whose purpose was to improve coordination with each other, and also with outside groups. He sees the need for a national set of databases on weed control.

Mario Rodriguez, APHIS, said that there were 400 established exotic weeds in the US, and that we need to develop a model to prioritize these weeds and then send the model out to the states for comments. The top 20 rangeland, aquatic and environmental weeds could then be identified.

Hank McNeil of the BLM, stated that FICMNEW has no teeth, but that they may not need teeth. Under current laws and regulations, Agencies can pool dollars as well as efforts for weed control.

Bob Eplee raised the concept of a "national weed fund" from which agencies could pull for special, specific projects, as is the case with the National Fire Center.

Randy Westbrooks, APHIS, said that the perception of 260 million Americans is that weeds are not important. Basketball is more important. We need better Public Relations to get the public to understand that nothing is registered by EPA that is bad. The country has an overzealous ethic to protect ourselves from chemicals.

Larry Lass, suggested links to the World Wide Web Site.

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PROJECT 6: BASIC SCIENCES

Chairperson: Pat Fuerst

Subject: Managing Weeds by Manipulating the Weed Seed Bank

Lori Wiles, USDA-ARS Great Plains Systems Research, Donn Thill, University of Idaho, and Robert Kremer, USDA-ARS Columbia, MO, introduced the key topics for the Basic Sciences discussion session.

Lori Wiles introduced the topic of spatial distribution of weed seed banks. Dr. Wiles reviewed key weed seed bank processes, pointing out that it would be desirable to decrease seed rain and to increase seed mortality by physical death, germination without emergence, predation, and microbial decay. Dr. Wiles presented some of the results of an ongoing research project in Colorado in which weed seed populations were intensively sampled in 8 irrigated corn fields. In some fields, weed seedling counts were not well correlated with seed counts. Seed count data were highly variable. In some fields, it was possible to detect patterns of distribution parallel to the direction of the corn rows. This work was facilitated by setting up direct data entry from the seed counting operation at the microscope. Weed seed counts could be used to predict herbicide regimes for areas of fields. Important concerns in sampling the seed bank include the number and size of soil cores and the sampling pattern. Better information to correlate the seed densities with seedling densities is needed.

The second area of discussion, introduced by Donn Thill, was weed seed population dynamics in a long-term IPM system in wheat. Donn Thill reported on some of the results of a long-term IPM study conducted in Washington State under the leadership of Frank Young, USDA-ARS. This study investigated crop rotations, tillage systems, and weed management intensity levels to develop improved management systems and assess the economics of alternative management systems. Soil samples were collected from the 0-3 inch depth, 3-6 inch depth and 6 to 12 inch depth. Minimum weed management intensity treatments caused an increase in the wild oat seed bank; while the moderate and maximum weed management intensity treatments caused a decline in the wild oat seed bank. Seed densities in the 6 to 12" depths were not strongly affected by management. Dr. Thill suggested that if he were to do this type of study in the future, he would limit the soil cores to 8", the depth of the plow layer. Challenges identified in this work included the variability of weed seed density measurements, the limited predictability of weed populations based on weed seed counts, the patchiness of weed distributions, and the cost of sampling entire fields.

The final area of discussion, introduced by Robert Kremer, was enhancing seed degradation via biological agents. A percentage of seeds in the seed bank are "persistent", i.e. they are dormant but remain viable. Biological agents may be an effective tool for reducing the persistent seed bank. With 1 x 10^6 to 1 x 10^9 bacteria per g of soil, which may comprise up to 1 x 10^4 different species, there is tremendous potential to exploit bacterial agents for seed decay. Soil microflora have been identified that reduce root growth of velvetleaf and foxtail between 10 and 90%. Interactions of physical and environmental parameters with soil microflora are important and not fully understood. Moreover, seeds may release phenolic toxins that inhibit soil microflora. Chemical and cultural practices also may limit colonization of seeds by soil microflora. Use of microbial decay for weed control may be combined with other control methods; for example, insects may be effective delivery mechanisms for microflora. Also, cover crops and green manures may promote the growth of soil microbes and enhance microbial seed decay.

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PROJECT 7: ALTERNATIVE METHODS OF WEED CONTROL

Chairperson: Kassim Al-Khatib

Subject: Crop Rotations and Weed Management

Approximately 25 people attended. Dan Ball led off the session with a historical perspective of crop rotations for weed management. Inexpensive nitrogen, price supports and chemical control have reduced the use of crop rotations. The ensuing discussion focused on current practices, crop rotations, impacts on weed populations in dryland areas and how growers have adapted to serious weed problems through crop rotations.

1. Rotation studies were outlined in Alberta that included rotation systems across two tillage levels. Growers only grow winter wheat once in three to four years because of downy brome. Winter wheat and silage removal help with wild oat problems. In Idaho, long-term rotations have lowered downy brome populations. Two to three years may be needed to begin to see effects of rotations.

2. Impact of tillage systems on rotations. Plowing has generally decreased in the last 40 years, driven by economic concerns such as equipment and time on tractor. In higher yield areas, no-till has been resisted because of difficulty dealing with residue.

3. Straw dispersal is important for no-till planting. Is it better to concentrate the residue or disperse it from a weed management perspective? Concentrating residue would allow a return to specific areas to manage weeds, whether killed with broadcast herbicides or removed for fodder. N immobilization is a concern.

One grower tried to blow chaff into the ground and cover it with soil. Concentrated weeds may compete for herbicides and reduce effectiveness.

4. Macroeconomics and farm supports. What will happen to current rotations when the freedom to farm act is passed? Reducing price supports may encourage rotations in the long run because base acreage requirements will be removed. Farmers live from crop to crop rather than long-term planned rotations. New equipment is entering the market to deal with reduced tillage situations. Conservation tillage districts are/could facilitate this.

   What is the impact on rural populations of government policies? How will rotations change as the price of wheat increases? Herbicide programs are primarily driven by resistance at this point. Some rotations are enforced by rental agreements and can have a big impact on perennials (increasing populations), but not annuals.

5. Research questions. Do we need to document the benefits of CRP in relation to weed control? In all soils on the farm rather than the poorest soils? Where do long-term studies fit it?

Rick Boydston gave an introduction to the use of green manures to manage weeds. Mustards and rape were fall planted, then worked into the soil in the spring. Mustard typically does not overwinter. Mustard green manures reduce nematodes significantly and may reduce initial weed emergence by 50 to 90%. Works best on sandy soils and low pH may reduce effectiveness.

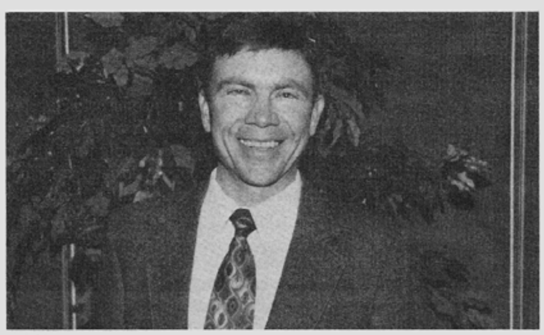
The discussion centered around experiences of participants with regard to effectiveness, practicality and other potential uses. Tarping broccoli or cabbage residues was very effective in reducing weed emergence.

Weed shifts are apparent in these systems. Both rye and mustard cover crops had similar yields of potatoes. Weed suppression may be related to soil microbes because fungicides may reduce impact partially.

1997 Officers of Project 7:

Chairperson: Ed Peachy
Horticulture Dept.
Oregon State University
Corvallis, OR 97331
(503) 737-5435

Chairperson-elect: Steven Askelsen
WSU Tri-Cities
100 Sprout Road
Richland, WA 99352-1643
(509) 372-7000



1996 WESTERN SOCIETY OF WEED SCIENCE PRESIDENTIAL MERIT AWARD RECIPIENT
Steve Dewey

MINUTES OF THE 49th ANNUAL BUSINESS MEETING
WESTERN SOCIETY OF WEED SCIENCE
ALBUQUERQUE HILTON HOTEL
ALBUQUERQUE, NEW MEXICO
MARCH 14, 1996

The meeting was call to order by President Gus Foster at 7:10 a.m. The President reported that Dr. Bob Zimdahl will be serving as Parliamentarian for the meeting and has been provided a whistle to keep the membership in line. Minutes of the 1995 General Business Meeting were approved as printed in the 1995 WSWS Proceedings.

COMMITTEE REPORTS

Program Committee. Charlotte Eberlein

a. A special thanks was extended to the Program Committee members, Kai Umeda and Jill Schroeder.
b. Breakdown of papers.
    1. General Session - Charlotte Eberlein, Chair
       - 4 invited presentations, including the Presidential Address
    2. Poster Section - Tracy Sterling, Chair
       - 33 volunteered papers, including 6 student competition posters
    3. Education and Regulatory Section - Kai Umeda, Chair
       - 4 invited papers
    4. Research Section - Jill Schroeder, Chair
       - 72 volunteered papers, including 15 student competition papers
    5. Special Symposium: *Weed Management in Natural Resource/Wildland Areas* - Vanelle Carritthers and Barbra Mullin, Co-Chair
       - 5 invited presentations
c. Special Discussion Sessions
    1. *Changes in the Workplace: Will You Be Competitive?* - Phil Banks, Moderator
       Panel - Phil Banks, Sheldon Blank, Steve Dewey, Jill Schroeder
    2. What's New in Industry/Weed Management - Jeff Tichota, Moderator
       - 10 presentations
d. Sponsored Activities
    1. Member Welcome and Retirees Reception - Monsanto
    2. Refreshment Breaks - Sandoz
    3. Graduate Student Breakfasts - Bayer, CIBA
    4. Accompanying Persons Breakfasts - Zeneca
    5. WSWS Business Meeting Breakfast - DowElanco
    6. Affiliation Partners Dinner - American Cyanamid

Education and Regulatory Section Committee. Kai Umeda

a. Two sessions were organized for this session:
    1. "Growing Agriculture in the Classroom - Children's Education Programs"
       - 3 invited papers
       - this topic generated a very good discussion
    2. "Weed Science and the Law - A Reality Check"
       - 1 invited paper
b. The Board of Directors is considering a name change for Project 4: from "Extension, Education, and Regulatory Research Section" to "Teaching and Technology Transfer Research Section" to prevent the confusion that seems to be generated by two similarly named but different sections.

Local Arrangements Committee. Keith Duncan

a. The committee provided host ribbons for graduate students and technicians to help answer questions and provide help in contacting the hotel staff, etc. This system worked well and helped the meeting run smoothly.
b. There was some confusion about local arrangements due to the time lapse between the site selection and the meeting date. The chairman pointed out the importance of having a local arrangements contact on the site selection committee.
c. President Gus Foster presented Keith Duncan with an appaloosa statue in thanks for stepping into the breach and making sure the meeting was well organized.

State of the Society. Wanda Graves, Business Manager

a. 347 members registered for the meeting, up significantly from past meetings [304 in 1995, 301 in 1994]. There were 286 preregistered, with 30 graduates students and 12 spouses registered.
b. Thanks to Mary Moore, with Sandoz, for her help at the registration desk.
c. The Society is in good financial standing with $183,000, including three special project revolving accounts.
d. Wanda requests that the members leave their name tags for future use. Don't forget to inform her of any address changes.

WSSA Representative Report. Paul Ogg

a. The 1997 WSSA meeting will be held February 3 to 6 in Orlando, Florida.
b. The Society seems to be having some budget problems, with a net loss of $47,455 for this year. Membership dues were increased from $60 to $75.
c. WSSA, with support from regional societies, sponsors the Congressional Science Fellow program. There are currently two half-time fellows providing contacts in Congress.
d. AESOP Washington Liaison is also sponsored by WSSA with support from regional societies. They are active in following research bills proposed or introduced into Congress.

CAST Representative Report. Jack Evans

a. CAST is a very dynamic organization that has recently redirected their efforts to meet the needs of their membership.
b. Meetings were sponsored on "Sustainable Agriculture and the 1995 Farm Bill" and for leaders in agricultural science and technology professional societies [WSWS took part] to develop strategies to help in the new work environment.
c. CAST plans to publish more and shorter documents [facts sheets and issues papers] rather than task force reports in the future. These seem to serve the membership need better.
d. WSWS members are encouraged to join CAST as individual members.

Immediate Past President Report. Tom Whitson

a. The New Members and Retirement Reception was held on Monday evening and had a large attendance. Retirees Chuck Stanger, Ed Schweizer, and Pete Fay were honored. Thanks to Doug Ryerson and Monsanto for their sponsorship.
b. Invited affiliate groups attended a dinner sponsored by WSWS and American Cyanamid. This is the second year that representatives from states and federal agencies met to discuss issues of mutual concern, including economic information, ecology, and integrated systems approaches to weed management. They will be invited to join WSWS again in Portland for the 1997 meeting.

Member-at-Large Report. Joan Campbell

a. The Operating Guidelines are in the process of being updated. They are now on disk and the final draft, with input from all committees and officers, will be presented to the Executive Board at the Summer, 1996 meeting. This project will continue through 1996 as an Ad Hoc Committee with Joan Campbell, Paul Ogg, and Mary Guttieri as members.

b. An Internet Ad Hoc Committee has also been formed to investigate how WSWS can best use the resources available on Internet and World Wide Web. The committee includes Joan Campbell, Tim Prather, and Dan Ball.
c. Joan was thanked for doing an excellent job as member-at-large and bringing other issues of concern by the membership to the notice of the Executive Board.

Resolutions Committee Report. Mark Ferrell
a. The 1995 resolutions were published in the 1995 proceedings.
b. Resolution 1.

WHEREAS; The 1996 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.

THEREFORE, be it resolved that the Western Society of Weed Science expresses its appreciation to Charlotte Eberlein and the Program Committee, Keith Duncan and the Local Arrangements Committee, and to the management and staff of the Albuquerque Hilton Hotel.

Mark Ferrell moved to accept the resolution, seconded by Bob Zimdahl, and passed.

Site Selection Committee. Bob Zimdahl for Frank Young
a. The Site Selection Committee has chosen Colorado Springs, Colorado for the site of the 1999 WSWS annual meeting. The hotel will be determined at a later date. Air travel will be good to Colorado Springs, with many flights bypassing Denver.

Student Paper and Poster Judging Contest. Dan Ball
a. A total of 21 students made presentations, 6 posters [up from 5] and 15 oral [up from 11]. The oral presentations were split into two groups, basic and applied.
b. Winners of the student paper contest were:
Poster Presentations
First Place - Justin Knight, New Mexico State University
Second Place - Joyce Payne, New Mexico State University
Third Place - Asuncion Rios-Torres, New Mexico State University

Oral Presentations [Applied]
First Place - Michael Wille, University of Idaho
Second Place - Stephen Enloe, Colorado State University
Third Place - Jessie Strobbe, Montana State University

Oral Presentations [Basic]
First Place - Dean Riechers, Washington State University
Second Place - W. Mack Thompson, Colorado State University
Third Place - Patrick Miller, Colorado State University
c. Winners received $100, $75, and $50 respectively, a plague, and a gift certificate for a WSSA monograph.

Nominations Committee Report. Jeff Tichota

a. Officers for the 1996-97 WSWS year were elected from 142 returned ballots .
   President-Elect - Barbra Mullin
   Secretary - Wayne Belles
   Research Section Chair-Elect - Don Morishita
   Education & Regulatory Section Chair-Elect - Rick Arnold
b. Members are encouraged to return their ballots as soon as they are received. It was noted that sending the membership stamped, return addressed ballots did not significantly impact voting response.

Awards Committee Report. Steve Dewey

a. Outstanding weed Scientist Awards were presented to:
   Donald C. Thill, Public Sector, University of Idaho
   Neal R. Hageman, Private Sector, Monsanto Company
b. Revised operating guides were approved by the WSWS Executive Board.

Fellows and Honorary Members Committee Report. Paul Ogg

a. Two individuals were selected as WSWS Fellows for 1996 - Donald Colbert and Robert Parker.
b. No Honorary Member was selected for this year.

Student Education Enhancement Committee Report. Phil Stahlman

a. Six individuals have applied for participation in the 1996 program and all six have been placed. Students from North Dakota State University, Kansas State University, Colorado State University, and New Mexico State University will be teamed with representatives from Phone-Poulenc, CIBA, American Cyanamid, Monsanto, Rohm & Haas, and FMC Corporation.
b. Applications for the program will be sent to interested students as well as faculty to make sure that information about the program is adequately distributed.
c. Curt Howell and Steve Seefeldt gave a brief overview of their participation in the program in 1995.

WSWS Research Progress Report. Steve Miller

a. The 1996 report contains 105 reports from 91 authors with 146 total pages. Two hundred and fifty copies were printed.
b. Section chairs need to make sure that guidelines are followed and index files are completed. All reports need to be submitted in a timely manner.
c. Steve will continue as editor for 1997 and 1998. The Society will need to find a new editor by 1999.

WSWS Proceedings Report. Rod Lym

a. Volume 48 of the WSWS Proceedings contained 77 papers on 110 pages. Cost per page was $.06. The low number of pages relates to fewer authors expanding their abstracts to full papers.
b. The postcard author notification worked well and should be continued. The revised index outline and call for papers worked well but could use a few minor improvements, including adding a poster check box to the "Submitting for" section.

Herbicide Resistant Weeds Committee Report. Steve Seefeldt

a. The Herbicide Resistance video was reviewed at the meeting and will be completed by April, 1996.
b. A summer workshop will be sponsored by Montana State University at Big Sky, Montana in the summer of 1996.
c. The Executive Committee will be asked to review a committee proposal to change from ad hoc to standing committee status at the summer meeting.

Legislative Committee Report. George Beck

a. The chairman was active, through INWAC, in participating in weed meetings held in Denver and Ft. Lauderdale in the fall of 1995. INWAC continues to sponsor a yearly trip to Washington, DC. They are currently working on amendments to the Federal Noxious Weed Act.
b. WSWS has determined that they would like the Legislative Committee to develop an expanded role and more

proactive approach to areas of legislative concern to the Society. George will work with a new committee and chairman.

Noxious Weed Management Short Course Committee Report. Barbra Mullin

a. The Noxious Weed Short Course for 1996 is full and has a waiting list of 7 people. The current course cost is $350 and covers the cost to sponsor the course.

b. A special thanks to Celestine Duncan for organizing the course each year and to all of the instructors over the years, Steve Dewey [USU], Rod Lym [NDSU], Roger Sheley [MSU], Pete Fay [MSU], Peter Rice [UofM], Jim Bauder [MSU], Rick Arnold [NMSU], Rich Hansen [APHIS], Bret Olson [MSU], Don Morishita [UofID], Rose Wallander [MSU], Bill Dyer [MSU], Bruce Maxwell [MSU], and Tom Whitson [UofWY].

Finance Committee Report. Gil Cook

a. The committee met with Wanda Graves and reviewed the books, investments portfolios, and investment reports. All finances are in order.

b. Wanda is to be commended for an excellent job.

Necrology Committee Report. Shafeek Ali

a. The committee reported the death of William E. 'Ed' Albeke.

Placement Committee Report. Carol Mallory-Smith

a. The placement room had a high level of activity through the meeting.

b. The committee recommends to the Executive Board that the placement books be located in the same room used for the graduate student breakfasts.

c. Both potential employees and employers should get information to the 1997 chairman [Dennis Scott] before the meeting so all information can be included in the placement book.

Poster Committee Report. Tracy Sterling

a. There were 33 posters this year, up from 20 in 1994 and 25 in 1995.

b. Thanks to Paul Ogg, for building boxes and transporting the boards and easels; Steve Miller, Pat Renner, and Steven Van Vleet for transporting the boards; and Bob Parker for taking the boards to Washington to hold for the Portland meeting.

Public Relations Committee Report. Jack Schlesselman

a. The committee continues to provide advance notice of the meeting in area publications.

b. All states requiring continuing education have now approved a standardized sign-up sheet.

c. Thanks to new committee members Mark Ferrell and Tim Miller.

Publications Committee Report. Steve Dewey

a. *Weeds of the West* underwent it's 5th printing in 1995. A total of 70,000 copies have been printed with a retail value of $1.4 million.

b. WSWS co-sponsored publication of the new reference *Biological Control of Weeds in the West*. Thanks to the Montana Noxious Weed Trust Fund for underwriting the printing costs of this publication. Three thousand copies were printed, with 1500 pre-sold.

c. The committee continues to plan a WSWS brochure.

d. The committee elected Dave Cudney to serve as current chairman.

Sustaining Membership Committee Report. Neal Hageman

a. The Society currently has 18 sustaining members, down from 21 in 1995. The committee contacted 46 companies.

President Gus Foster thanked all of the committees for their continued hard work and dedication.

NEW BUSINESS.

Ron Crockett invited the WSWS membership to come to Portland for the 1997 annual meeting March 11 to 13. The "City of Roses" may not be in full bloom, but the "City of Bridges" is always ready to welcome guests. Ron provided a video and written materials on Portland.

Roland Schirman moved that the 1999 meeting date be moved from March to start the fourth Tuesday of February. The motion was seconded. Discussion included: the move would help avoid field season; some graduate students can take advantage of attending during spring break at the later date; there may be a number of conflicts that we are not currently aware of; and we need to see how the majority of the membership feels about a move. Bob Zimdahl moved to table the motion. Seconded by Rod Lym and did not pass. A show of hands showed the group was fairly evenly divided on the issue. Don Morishita moved to refer the motion to the Executive Committee for further considerations and polling of the membership. Seconded by Joan Campbell and passed.

President Gus Foster presented Business Manager-Treasurer Wanda Graves with her own personal Energizer bunny for her tireless work for the Society.

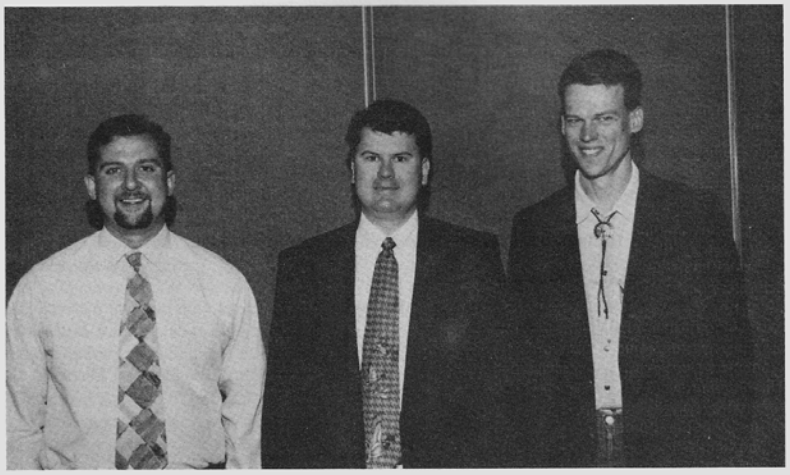
President Gus Foster turned control of the meeting over to incoming President Charlotte Eberlein. Gus was presented a plaque and thanked for his work for the Society.

The meeting adjourned at 8:50 a.m.

Respectfully submitted,

Barbra Mullin, Secretary

1996 WSWS STUDENT POSTER WINNERS
(L to R): Joyce B. Payne (2nd) and Asuncion Rios-Torres (3rd).
[No photograph for Justin L. Knight (1st)]



1996 WSWS STUDENT PAPER WINNERS IN BASIC RESEARCH
(L to R): Dean E. Reichers (1st), W. Mack Thompson (2nd) and Patrick A. Miller (3rd)

1996 WSWS STUDENT PAPER WINNERS IN APPLIED RESEARCH
(L to R): Michael J. Wille (1st), Stephen F. Enloe (2nd) and Jessie A. Strobbe (3rd)

WESTERN SOCIETY OF WEED SCIENCE
FINANCIAL STATEMENT
APRIL 1, 1995 THROUGH MARCH 31, 1996

CAPITAL			
1994-1995 Brought Forward	$198,358.24		
Current Loss	-22,570.21		
	$175,788.03		
DISTRIBUTION OF CAPITAL			
Mutual Funds	$117,875.00		
Certificate of Deposit	18,040.09		
Money Market Savings	33,402.98		
Checking Account	6,469.96		
	$175,788.03		
INCOME	1995		1996
Conference Registration	$480.00		$18,775.00
Membership Dues	1,179.00		60.00
Proceedings	1,836.09		2,952.50
Research Progress Report	1,331.91		2,298.00
Weeds of the West	104,286.52		
Noxious Weed Mgmt Short Course	6,283.93		8,750.00
Bank Interest	2,080.89		
Sustaining Membership Dues			6,000.00
Bio Weed Control Reference Book	49,394.00		
History Book			20.00
		$205,727.84	
EXPENSES			
Postage, Shpg, Box Rent & Bulk Mail Permit Fee	1,876.77		
Telephone	346.41		
Office Supplies/Equipment	2,177.25		
Business Manager	5,100.00		
Tax Accountant	175.00		
Franchise Tax Board & Secretary of State	15.00		
Noxious Weed Mgmt Short Course	9,119.62		
WSSA Congressional Fellow/AESOP	4,000.00		
Weeds of the West	160,579.76		
Printing-Stationery	644.41		
Proceedings	2,009.16		
News/Call For Papers	729.48		
1996 Programs			1,386.35
Speaker Expense	651.00		475.00
Preconference Tour	25.92		
Grad Student Awards	280.78		675.00
Poster Session	1,081.35		535.22
Conference Board & Planning Meetings	851.92		659.78
CAST Membership Dues	600.00		
CAST Workshop Travel Expenses	333.22		
Proceedings Editor Travel Exp			234.00
Bio Weed Control Reference Book	26,830.00		
Award Plaques			117.45
Refund of Registration Fees			300.00
Misc Expenses (bank chgs, mileage)			55.40
Audio Visual - 96 Conference			2,533.57
Awards Luncheon - 96 Conference			3,489.23
Student Room Subsidy - 96 Conferene			410.00
		228,298.05	

1996 FELLOW AWARD
WESTERN SOCIETY OF WEED SCIENCE

Donald R. Colbert

Donald Colbert is employed by American Cyanamid Co. in Lodi, CA as a research and development representative. He has completed 30 years in the weed science profession, beginning with his employment by Stauffer Chemical Company, Penwalt, Oregon State University and American Cyanamid Co.

During that period of time he has stressed job satisfaction as his primary focus leading to numerous accomplishments. As a Cyanamid research representative, he has been instrumental in the registration of Pendulum (pendimethalin) on ornamentals and container plants with over forty different species on the label. His long standing effort to push for the registration of Pursuit herbicide in alfalfa has paid off in this registration being granted last year. His personal relationships with colleagues in the public and private sector have provided the greatest stimulus in striving for excellence. These contacts have led to several cooperative projects that have provided answers to weed management systems. Truly a "team player" he has given and received from these types of successful efforts. Overcoming internal and external obstacles, his determination and colleague support provided the necessary ingredients for this to happen.

Don has continued to maintain a strong link between industry and university. He is highly regarded by University of California farm advisors and specialists for his knowledge on weed science, his cooperation, and his integrity. He avoids the limelight, so he is not often noticed, however, he is the one behind the scenes making whatever happens a success.

Don has been active in several professional societies including the California Weed Control Conference and the Western Society of Weed Science. He has served on numerous WSWS committees and was Member-at-Large in 1991-92. He was instrumental in the revision and updating of the WSWS Operations Guide by including the new committees formed, updated the responsibilities of each office and committee in the organization.

Donald Colbert's career as a weed scientist has been illustrative of a person committed to the profession. His willingness to be of service to others and his professional integrity are his trademarks.

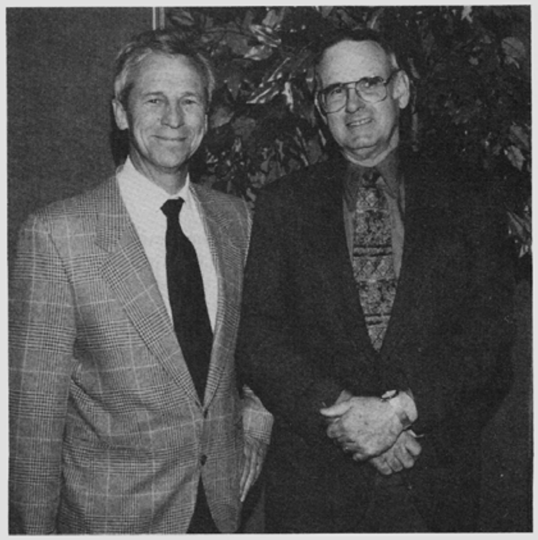
1996 FELLOW
WESTERN SOCIETY OF WEED SCIENCE

Robert Parker

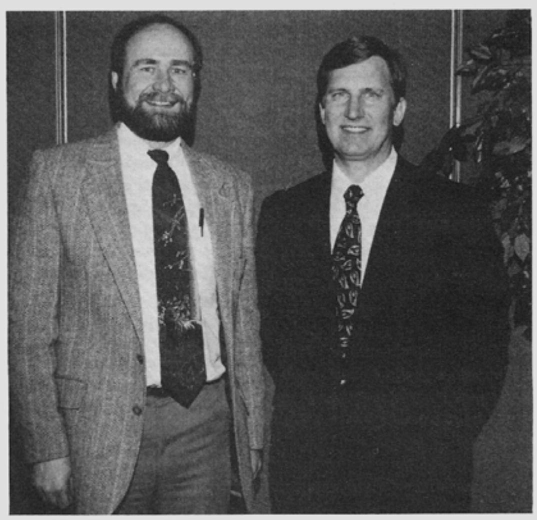
Robert Parker has served as an Extension Weed Specialist with Washington State University at Prosser since 1978 and has been an active member of the Western Society of Weed Science since 1967.

Bob has served on numerous WSWS committees including the Executive Board, Finance, Placement, and Local Arrangements, and chaired the Weeds in Horticultural Crops project, and Education and Regulatory Section. Bob co-authored *Weeds of the West* which has significantly improved public education in weed identification and has helped place the WSWS in good financial standing.

On the national level, Bob has served as local arrangements chairperson at the 1995 WSSA meeting in Seattle, and has served on numerous WSSA committees and activities including Awards Committee, Extension Committee, Program Committee, Teaching and Extension section chairperson, and Photo Contest subcommittee. Bob authored the outstanding paper in Weed Science in 1974.



1996 WESTERN SOCIETY OF WEED SCIENCE FELLOWS
(L to R): Don Colbert and Bob Parker



1996 WESTERN SOCIETY OF WEED SCIENCE OUTSTANDING WEED SCIENTISTS
(L to R): Donn Thill and Neal Hageman

Bob has served on the Board of Directors for the Washington State Weed Association as secretary from 1983 to the present and has served as Vice-President and Program Chairperson and President. He is the ex officio Director of the Oregon Society of Weed Science (1985-present). Bob has been a major contributor to the annually updated *Pacific Northwest Weed Control Handbook*, which is one of the most comprehensive and useful weed control handbooks published. It is used by extension agents, commodity and dealer field personnel, growers, commercial applicators, and county and district weed supervisors in Oregon, Idaho, Washington, and other states. He has issued or assisted with extension publications covering more than 15 agricultural crops, plus lawns and home gardens. He has authored, co-authored, or contributed to over 200 publications in his career and averaged over 35 oral presentations a year.

Despite his active role in extension, Bob has conducted numerous research projects on weed control in alfalfa, cereals, hops, mint, and seed crops. In addition, he has conducted residue trials and efficacy data to support new herbicide registrations in minor crops. Bob has also conducted research on herbicide drift in central Washington helping to alleviate problems between cereal growers and nearby residents growing herbicide sensitive crops.

Dr. Parker in both his public and private sector, has always put the customer first and given unsparingly of himself. Bob exemplifies what being a public servant is all about and has done an excellent job in transferring weed science technology to the clientele he serves.

1996 OUTSTANDING WEED SCIENTIST AWARD
PRIVATE SECTOR

Neal R. Hageman

Dr. Neal Hageman received his B.S. degree in Soil Science from South Dakota State University, and his M.S. and Ph.D. in Soil Management and Conservation from Iowa State University. He is an ARCPACS certified professional agronomist and professional in weed science, and a SSSA certified soil scientist. He has served on numerous committees within WSWS, North Central Weed Science Society, WSSA, and the American Society of Agronomy. He makes regular presentation of papers at both regional and national weed science society meetings. Neal began his career with USDA/SCS in South Dakota and USDA/ARS in Ohio. For the past 15 years he has been a Product Development Representative with Monsanto Company in Nebraska and Colorado.

Neal has received numerous honors and awards within Monsanto, including Special Recognition and Achievement Awards for: Ammonium Sulfate Enhancement of Glyphosate; Development of Bulk Micro-Tech Systems for Lasso; Field Computer Assessment; and Improved Ramrod/Atrazine Formulations. He has been instrumental in the development of reduced rate Roundup technology; encapsulated alachlor technology to reduce environmental concerns under irrigated systems and to improve performance under high crop residue situations; and the registration of Harness, Harness Plus, and Permit for western corn production systems. He has been actively involved in research and development of Monsanto's genetically engineered crop as coordinator for research and development of biotechnology products in the Great Plains. He is the author of numerous fact sheets, training materials, and other publications.

Neal represents agriculture and the agricultural chemical industry in a positive professional manner, and takes great pride in his profession. He is described by his peers as a strong team member and leader within the Monsanto Product Development Group. He also is a very active young scientist in the weed science societies. 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.

Neal's concern for students is recognized and appreciated by all those who know him. He takes time to talk to students, to understand their research, to encourage them, and to socialize with them. They see a very positive role model working well in the private industry. He has a reputation as one who always conducts himself in business and personal relationships in an outstanding manner, and always is a gentleman in relationships with people.

1996 OUTSTANDING WEED SCIENTIST AWARD
PUBLIC SECTOR

Donald C. Thill

Dr. Donn Thill earned his B.S. and M.S. in Agronomy at Washington State University, and his Ph.D. in Crop Science at Oregon State University. He has excelled as a weed science researcher and teacher at University of Idaho for the past 16 years.

Donn has played a key role on numerous committees within WSWS, WSSA, and the IWCA. He has served as secretary, president-elect, president, and immediate past president of WSWS; secretary of WSSA; and associate editor for Weed Technology. He is a WSWS Fellow, and has received the Outstanding Young Weed Scientist Award from WSSA, and the University of Idaho Award for Research Excellence.

He has authored or coauthored seven book chapters, seven technical research, bulletins, 47 peer reviewed journal articles, over 145 abstracts of papers presented, and over 350 regional publications or research progress reports. He has advised 25 graduate students and served on the committees of an additional 36 graduate students, many of whom are now excellent weed scientists in their own right.

Don is recognized by his weed science peers as an excellent leader, an innovator, teacher, and contributor to weed science principles and agricultural production. He has made significant contributions to weed science in his research efforts. He addresses weed science problems in a sound and scientific manner. He has developed a strong laboratory <u>and</u> field research program, which is unique in addressing the basic and applied aspects of weed science. His research on wild oat control in spring barley and understanding the mechanisms of wild oat interference is truly outstanding. Dr. Thill has gained international recognition for his research on the mechanisms of controlling the development and spread of herbicide-resistant weeds and the control of sulfonylurea resistant weeds. He holds a patent on sulfonylurea herbicide resistant plants.

Excerpts from Letters:

"Of the 252 full-time faculty in the college, Dr. Thill has ranked among the top four individuals in every category (research, teaching, and leadership) for past several years. No other faculty member has had such a sustained level of productivity and positive impact on their discipline, the institution, and the state and region as Dr. Thill."

"Dr. Thill is truly a gifted and talented scientist dedicated to enriching the lives of young people, improving the quality of life of society in general, and specifically assisting agricultural producers to grow a safe and nutritious food supply for the world population."

"Dr. Thill is truly an outstanding weed scientist and is very deserving of this award.
His contributions and achievements in weed science will be a measure for future recipients of this award."

1995 NECROLOGY REPORT

William E. ' Ed ' Albeke, age 64, died on December 31, 1995. Ed was born in New York City, New York on January 9, 1931. From 1951 to 1953 Ed served in Korea and was honorably discharged with the rank of sergeant. In 1961 Ed graduated with a Bachelor of Science Degree in Agriculture from Oregon State University. In 1963 he received his Master's of Science in Agronomy. Ed worked for PPG Industries from 1962 to 1984 and for Tri-River Chemical from 1984 to 1995. Ed was Past President of the Washington State Weed Association and the recipient of the Weed Warrior Award in 1993. Ed is survived by his wife, Shirley; two sons, a daughter, a brother, a sister, and five grandchildren.

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