PROCEEDINGS

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WESTERN SOCIETY OF WEED SCIENCE

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1992

PROCEEDINGS

OF

THE WESTERN SOCIETY OF WEED SCIENCE

VOLUME 45

PAPERS PRESENTED AT THE ANNUAL MEETING

MARCH 10, 11, 12, 1992

SALT LAKE HILTON - DOWNTOWN

SALT LAKE CITY, UTAH

PREFACE

The Proceedings contain the written summary of the papers presented at the 1992 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.

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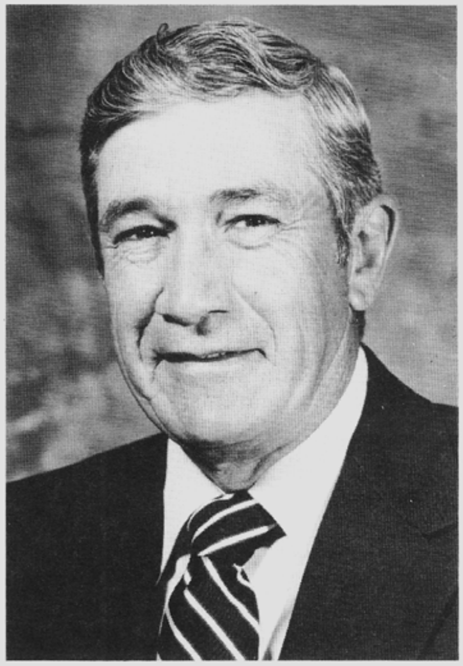

HAROLD P. ALLEY

The Western Society of Weed Science dedicates this 45th Edition of the Proceedings of the Western Society of Weed Science to Dr. Harold P. Alley in recognition of his outstanding contributions to weed science. Dr. Alley served as Extension Weed Specialist and Professor of Weed Science at the University of Wyoming for almost 30 years. Harold published over 500 articles in state, regional and national journals and served as major professor to 38 graduate students many of whom are active leaders in the Western Society of Weed Science today. Harold served the society in many capacities as secretary, research chair, and president, 1970. In addition, he was instrumental in organizing the Wyoming Weed and Pest Council which is often used as an organizational model by other states.

After graduating from Cokeville High School in 1942, he served in the armed services as a paratrooper from 1942 to 1946. Upon his return he attended the University of Wyoming where he received a bachelor of science in 1949 and a master of science in 1955. He received a doctor of philosophy from Colorado State University in 1964.

Dr. Alley began his career at LaGrange High School as vocational agriculture instructor and basketball coach. Upon his appointment to the faculty of the University of Wyoming in 1955 he was responsible for research, teaching and extension program in weed science. He retired from the University of Wyoming November 30, 1984. Dr. Alley received many awards during his distinguished career including the Outstanding Educator of America in 1971, Alvah Elledge Award for outstanding service to the State of Wyoming in 1972, honorary member Western Society of Weed Science Society 1973, Outstanding Extension Worker Award Weed Science Society of America 1976, Fellow Weed Science Society America 1979, George Duke Humphrey Award Outstanding Faculty Member at UW 1980 and was the first recipient of the Distinguished Harold P. Alley Award from the Wyoming Weed and Pest Council in 1984.

After retirement he and his wife Jeanne spent their summer months in Laramie and winter months in Casa Grande, Arizona. Those close to Dr. Alley will remember him as an excellent golfer, and one who would nearly always make a winning bet.

GENERAL SESSION

PRESIDENTIAL ADDRESS

Paul J. Ogg
American Cyanamid Co.
Longmont, CO 80501

Welcome ladies and gentlemen to the 45th meeting of the Western Society of Weed Science. It is a pleasure and a privilege to come before you and express my thanks to many for allowing me to serve as your president. I would like at this time to tell you about your Society and what has taken place this year. Then I would like to talk about what I feel could be a total system for weed science and production agriculture.

I would like to thank the program committee, Stephen Miller, Edward Schweizer, and Thomas Whitson for what appears to be an excellent general session and discussion topics throughout this conference. In the program there are 22 posters, 16 graduate student papers and a total of 64 presented papers. It is always encouraging to see this number of graduate students participating, this is the future of weed science. An excellent program for the next several days.

The Society has grown in size with three new states becoming members in the Western Society of Weed Science. Kansas, Nebraska, and North Dakota are sincerely welcome and will bring new thoughts, ideas, interest, and challenges with them to our Society. We welcome them.

The Executive Committee has unanimously agreed to have this years PROCEEDINGS dedicated to Harold P. Alley who passed away last summer. He was a weed science professor at the University of Wyoming throughout most of his career. He was an excellent researcher, teacher, educator, and friend to many of us. He was a driving force behind this Society and served in almost every capacity within this Society including President and as a Fellow. It is a fitting tribute to dedicate this Proceedings to Harold for the many contributions he has given to the Society and weed science.

Two years ago, we voted to have sustaining membership in the Society. It has significantly contributed to the well being of the Society and I want to sincerely thank the following organizations and companies for their support: Agrolinz, Inc., American Cyanamid Co., Ciba Geigy Corp., Dow Elanco, DuPont, Hoechst Roussel Agri-Vet Co., ICI Americas, Inc., ISK Biotech Corp., Monsanto Co., R & D Sprayers, Rhone Poulenc Ag. Co., Rohm & Haas Co., Sandoz Crop Protection, Uniroyal, and Wilbur Ellis Co. It is all our responsibility to thank and support these participating companies and encourage other companies, organizations, Universities, commodity groups, and yes, individuals to become a Sustaining Member of our Society.

I would like to take this time and recognize several individuals of our Society who have been elected to the WSSA. Alex G. Ogg, Jr. was elected Vice President, Donald C. Thill elected Secretary, and Peter K. Fay elected Member-At-Large. These individuals should be congratulated and I'm sure they will serve the National Society with Western culture and enthusiasm.

The Executive board has approved financial support for the Congressional Science Fellow. This Congressional Science Fellow is currently sponsored by the WSSA, SWSS, NCWSS, and the NEWSS. The WSWS has agreed to help financially to continue on with this most worthy cause. I would encourage a new weed scientist, an individual who is in mid career who is thinking about a sabbatical leave to strongly consider this fellowship. It would be a tremendous experience and would in turn help weed science and agriculture. Those possibly interested, please contact myself or any past president of the Society.

Last but sincerely not least I want to thank the Local Arrangements Committee, Steve Dewey, Chairman, for his diligence, time, and effort for arranging for this meeting. The facilities and arrangements have been excellent. This is the current "State of the Society" during this past year, 1991 to 1992. Please attend the Business meeting on Thursday for other items.

I would now like to spend some time talking with you regarding a balanced approach to weed science. I do not wish to distract from the other speakers, only to express changes to consider for the future. PEER, defined as one that is of equal standing with another. I use these letters to explain a total system for weed science for the future. POLITICAL SCIENCE plays a vital role in decisions made in agriculture. The ENVIRONMENT is an ever increasing topic and weed science and agriculture are an important part. EDUCATION has always been essential for information transfer of scientific knowledge and technology. Educating students and informing the general public is becoming much more pertinent. RESEARCH has always been our strong point in weed science but it may be time that we take a look at an entire system.

I will take each topic separately and not in any particular order. RESEARCH continues to be our main thrust and it should be. We must maintain scientific research of high quality and integrity. Our research creditability must never come in question. We need to evaluate our main objectives and goals in future research to utilize the limited funds and people that are available today. It may not be necessary to reinvent the wheel everytime we look at some new theory, but to review and redefine what has been accomplished in the past. Time has always been a limiting factor in research and now it is even more critical. The main thrust now, is next quarter profits or publish or perish mentality which makes time even more critical. Long-term research and goals are critical to maintain sound science and direction.

I mention these RESEARCH items to bring us to what has been accomplished over the years, which is a multitude of research objectives which have evolved due to modern technology. Our fathers and forefathers thrived on crop rotation, cultural control, and livestock enterprises. Those were extremely effective tools for that time and even today. Plant breeding has been a tremendous technique for increased production. Weed control by crop competition and cover may have suffered by breeding dwarfed wheat and upright corn leaves. Herbicides have been the main stay for weed control during the past 40 years. Weed resistance has been around for years with atrazine (triazine) resistant weeds and now the newer chemistry - sulfonylureas and imidazolinone chemistry. Herbicide tolerant crops are a new tool to be placed in our arsenal of items to use. Microbial and Biological control are relatively new technologies and the benefits from these will take time to define and perfect. All these have taken time to develop and are essential for efficient agriculture production. We must continue to evaluate these tools and our objectives to make sound research decisions. We must not forget about cultural control and livestock grazing for weed management. We must maintain registration on old products, atrazine, and 2,4-D and develop new chemistry to have the necessary tools for continued agricultural production.

The ENVIRONMENT has always been an important aspect of weed science. I believe growers and the agricultural communities have always tried to protect there environment. We have always conducted degradation studies, persistence studies, and crop residue studies. Sometimes a lack of knowledge and long term consequences cannot be predicted. Food quality has reached the public eye recently by orchestrated news media reports. I will leave this topic for further discussion by Dr. Bruce Ames in his presentation. Ground water and surface water is probably the most pursued topic currently in agriculture because of surface water contamination with herbicides. I strongly urge everyone working together, industries, universities, and other groups involved in ground and surface water to strive for the reduction and environmentally safe concentration of herbicides in our water system. It is time for all agricultural chemical companies to work together to resolve this concern and strengthen our creditability. I will leave this topic to Dr. Richard Fawcett who has worked for years on water quality.

Equipment technology for more effective and efficient application of herbicides are extremely important. Safer mixing, loading, and application of herbicides are necessary for more environmentally sound procedures. We need to develop more and better handling systems and reduce the disposal of numerous containers. We must continue to develop equipment for effective application and container management to protect the environment. We must continue to develop other pieces of equipment for weed control, not necessarily herbicide/chemical related.

EDUCATION is the future of this country and to weed science. We need to educate and inform our customers on the proper timing and use of herbicides. Our clients deserve to be informed on all tools available for realistic, effective, and economically sound weed management strategies. It is time for agricultural chemical companies, Universities, extension, and ourselves to inform and educate the non-agricultural public on what we are doing, how and why we continue to develop better technology to provide them with bountiful and wholesome food. We have a tremendous story to tell, why don't we tell them.

I feel we have an obligation that we give our students the best education possible. The education in the classroom is some of the best, however, practical experience is lacking in many cases. It would be beneficial to provide additional experiences in a broad background of disciplines, plant pathology, engineering, and others. I would be willing to train a student for several weeks regarding an industry representative's position and requirements. I would be receptive to providing funds or a summer intern to work with a University professor to gain valuable experience regarding their research or discipline.

Personally are we taking advantage of educational opportunities around us. An example is the Nebraska Crop Injury Workshop which was extremely educational and very beneficial. Field researchers or graduate students would gain valuable knowledge from such short courses. Education is vital to everyone.

POLITICAL SCIENCE is a field all in itself. I put the science on political hoping to bring some science to this system. I place administration and management into the same category. When changes are made is efficiency and effectiveness considered into the decision making process. Are priorities set with sound research and objectives in mind. We are all managers of some aspect of our time and efforts. I feel it is time for management, administrators and ourselves to consider the above items in all decisions made. Have we conditioned ourselves by outside factors to just look good to appease the higher ups even though that may not be the correct system?

The government programs on conservation reserve, set aside acreages, and government subsidies have increased the problems of production agriculture. The government, several years ago advocated farming fence row to fence row destroying grass water ways, hedge rows, and buffer areas around ponds and streams. CRP will cause a shift in weed spectrum and more noxious weed infestations. Now we are concerned about soil erosion, water contaminated by herbicides, and others that were in part, due to government programs favoring mono culture and the lack of sound production practices.

It is not a wonder that the public's perception and concerns are increasing when we look at some decisions made by management and government programs which were not sound agricultural practices. It is time to consider the political implications and work toward a more proactive approach to solving our challenges and not allowing people who don't understand agriculture to control our destiny.

We have an opportunity in our profession to use a total system approach. We must take into consideration the political, environmental, educational, and research systems we have to solve the challenges before us. We must co-exist with our PEERS in this country. We must not ignore our research priorities, our educational strengths, the environment, or the political system for future growth. A balanced system will provide a strong future for weed science and production agriculture. A total system approach will allow us to survive and thrive in our profession.

I want to sincerely thank you for allowing me to serve you as your president for the year. It has been enjoyable and a pleasure working with you. Thank you.

WATER QUALITY: SOLVING THE RIGHT PROBLEMS. Richard S. Fawcett, Fawcett Consulting, Huxley, IA 50124.

Ground water. Preventing contamination of wells by pesticides and nitrate requires an understanding of how contaminants reach the well, so that appropriate corrective actions can be taken. Misidentifying the cause or route of contamination can lead to the adoption of inappropriate and ineffective protection practices, costing money, and causing hardships for farmers, without correcting the problem. Recent research and monitoring results have helped to improve our understanding of ground water and well contamination and to direct efforts at effective solutions.

When pesticides and nitrate are detected in wells, often the first cause to be blamed is leaching of contaminants from treated farm fields. This nonpoint contamination can happen with nitrate and with certain pesticides under the right conditions. However, more and more, it is becoming clear that many cases of contamination by pesticides and nitrate are caused by activities very near the well, and may be in part due to construction of the well itself.

Determining the source of nitrate in wells can be difficult as nitrate is naturally occurring and comes from many sources. Consistently elevated nitrate concentrations in shallow ground water have occurred in some vulnerable settings such as the Platte River Valley of Nebraska, apparently due primarily to nonpoint sources. However, in many areas, wells exceeding the drinking water standard have been affected by their location near point sources of contamination such as livestock feedlots, septic systems, or fertilizer handling or disposal sites. As we will see later, evidence is also building that not only well siting, but well construction can explain some high nitrate concentrations.

Pesticides vary tremendously in their physical and biological properties. Some pesticides break down quickly and/or are very strongly held by soil particles and have very low risk of leaching to ground water. Products which are more persistent and/or are weakly held by soil particles have a greater leaching potential. Certain products have specific label restrictions against use in highly permeable soils where the ground water is shallow. Direct conduits from the soil surface to the ground water, such as natural sinkholes in karst topographies, or unplugged, abandoned wells can carry any pesticide to ground water, either adsorbed to eroded soil or dissolved in runoff water.

While nonpoint leaching of detectable amounts of certain pesticides is possible, recent studies have implicated point sources at pesticide storage, mixing, and disposal sites as causes of many cases of well contamination. In 1987, all public well systems in Iowa were tested for the presence of pesticides. Eight percent had a pesticide detected. All detects were of a few specific herbicides, except for one case of an insecticide. Levels detected were generally well below health standards, with the exception of three wells which exceeded a Lifetime Health Advisory or MCL. Many of the wells with pesticides had subpart per billion concentrations of atrazine, a herbicide found more frequently in ground water due to its greater persistence and moderate mobility. Some of these wells apparently contained atrazine due to nonpoint sources, either leaching from fields in small amounts, or more likely due to surface runoff and erosion into rivers, followed by interaction of the surface water with underlying shallow, alluvial aquifers. But for all other pesticides detected, a totally different pattern emerged. Over 80% of all public wells with pesticides other than atrazine had a pesticide mixing-loading site near the well, often a few hundred feet away.

Illinois monitoring has traced all cases of public well detections of pesticides to point sources. This data led the Illinois EPA to conclude in a December 1989 report: "There is no indication from the sampling carried out to date that the field application of pesticides is affecting Illinois' community well systems."

The soil will normally adsorb and degrade most pesticides and prevent measurable leaching. But if extreme concentrations are added to the soil, the system is overloaded and leaching can occur. Unfortunately, there are many places where extreme concentrations of herbicides have been added to the soil. This occurs where herbicides have been mixed and sprayers rinsed over the years. Repeated small spills or occasional large spills add to the soil. Ag chemical dealers and custom applicators mix and handle large quantities of herbicides and fertilizer at their plant sites in town. If the town well is near one of these sites and is shallow, contamination may occur.

Although farmers do not handle the large quantities of chemicals processed by commercial chemical supply businesses, they have unfortunately often handled chemicals in the worst of possible places in the past - immediately adjacent to the farm well. Because of convenience and lack of an understanding that this kind of practice threatens well contamination, this activity has gone on for many years at the farm well site or near it. Handling chemicals near wells is especially risky if the well is not properly constructed or maintained and contaminated surface water can directly enter the well.

Confining all pesticide mixing activities to water-tight pads, where all spills and rinsate are contained for proper disposal, is one solution to this problem. In fact, states are beginning to require commercial pesticide storage and handling sites to install such secondary containment systems. This technique will work on farms as well, but simply divorcing the activity from the well to instead conduct all mixing and rinsing activities in the field may be the most practical solution. That way one site is not continually exposed to chemicals and the chemical ends up on the intended field, avoiding any disposal problem. Divorcing pesticide activities from the well also avoids any chance of backsiphoning when filling sprayers.

A systematic survey of Iowa rural wells throws considerable light on not only the extent of well contamination by nitrate and pesticides, but its causes. Six-hundred-eighty-six rural wells were monitored. Eighteen percent of wells exceeded the nitrate drinking water standard, and one percent exceeded a standard for a herbicide. Thirteen percent of wells had a detect of some pesticide, again almost entirely comprised of a few herbicides. The most striking result was the fact that 45% of the rural wells had unsafe levels of coliform bacteria. The presence of coliform bacteria is often evidence of contaminated surface water entering the well system due to construction problems. If a bacteria can get into the system with surface water, a herbicide molecule certainly can as it is much smaller.

The fact that many rural wells are not properly sealed from surface contamination makes it all the more important that farmers change practices to divorce chemical handling from the well site. But ultimately solving the bacteria and nitrate problem will often require improvements in the well itself.

A recent study of rural wells in Kansas by Kansas State University illustrates the strong correlation of well site and construction to detections of nitrate and pesticides. Nitrate concentrations averaged lower the closer the well was to a field and the farther it was from the farmstead. Similarly pesticide detections were least likely when the well was closest to a crop field and most likely if the well was close to the farmstead. The problem of pesticide detects and elevated nitrate concentrations wasn't coming from the crop fields, but from activities on the farmstead - pesticide mixing and disposal and livestock feedlots and septic systems.

The EPA National Survey of Pesticides in Drinking Water Wells, completed in 1991, provided the first comprehensive systematic evaluation of pesticides in wells across the U.S. Over 1300 rural and community or urban wells were monitored for 126 different pesticides and metabolites. Sixteen compounds were detected.

It is interesting to note that community or urban wells were more than twice as likely to contain a pesticide residue, compared to rural wells. The EPA study concludes that about 10.4% of community wells are expected to contain a detectable pesticide, compared to 4.2% of rural wells. Less than 1% of wells are estimated to exceed drinking-water standards.

Part of the reason that urban wells were so much more likely to contain residues was the fact that a metabolite of DCPA, which is often used in urban settings, was the most freguent detect, found in 6.4% of urban wells and 2.5% of rural wells. All detections of DCPA were far below the drinking-water standard. But the agricultural herbicide atrazine was also more than twice as likely to be detected in an urban well compared to rural wells. Atrazine was found 1.7% of urban wells and 0.7% of rural wells. This is despite the fact that atrazine has no urban uses and that rural wells are often shallower and more poorly constructed than urban wells. The reason for this apparent discrepancy can be traced to the presence of commercial pesticide storage and mixing sites in towns in agricultural areas.

Point sources aren't the only cause of well contamination by pesticides, but they are often the biggest one. Nonpoint sources, which vary greatly depending on product and site, need to be addressed. Increasingly, farmers will need to consider groundwater vulnerability of each field before making pesticide use decisions. And because crops must be supplied with nitrogen, nitrate can easily leach, and all nitrogen sources end up as nitrate, improvements in efficiency of use of all sources of nitrogen, along with other management changes, will be necessary to reduce nitrate leaching potential. But concentrating on nonpoint sources to the exclusion of point sources, as has happened in some states, will ignore the most important cause of standard-exceeding well and ground water contamination by pesticides.

Surface water. Surface water is far more vulnerable to pesticide and nitrate contamination than ground water. In the 1987 testing of all Iowa public water supplies, 8% of well systems had a detected pesticide, with 0.5% exceeding a health standard. Over 60% of drinking water supplies utilizing surface water had a pesticide detect, with 4% exceeding a health standard.

Many cases of pesticide contamination of wells, thought by some to be caused by non-point sources, have turned out to be caused by point sources - pesticide mixing and disposal sites. But surface water contamination is largely a non-point contamination problem. As soil erodes and water runs off fields, pesticides are either adsorbed to soil particles or dissolved in water.

Nitrate can be lost in a similar manner, but since it is water soluble, most enters the soil with infiltrating water before it can run off. If it is not used by crops or denitrified by soil bacteria, it may reach subsurface water flow or drainage tiles and come back out into surface water.

Phosphorus is the other nutrient of environmental concern, since it can increase algal blooms and speed eutrophication. It reaches streams with soil erosion and runoff. Municipal sewage contributes to both nitrate and phosphorus levels in surface water.

A considerable amount of research has been conducted over the last 3 decades on the extent of pesticide, nitrate and phosphorus movement to surface water and ways to reduce it. Ironically, with changing priorities, much of that research was dropped mid-stream. As public concern returns to surface water, surface water research and protection efforts will become more important.

Practices that reduce soil erosion and water runoff can reduce pesticide runoff. These include many soil conservation practices, such as conservation tillage, terraces, contour planting, strip cropping, grassed waterways, and filter strips. These practices are all common in Conservation Plans required by the Conservation Compliance provisions of the 1985 Farm Bill. Conservation Compliance will not only reduce soil erosion, but will do more than anything done before to protect surface water from chemical contamination. It couldn't come at a better time, as public concern about surface water rises.

Conservation tillage holds considerable promise as a practical way farmers can reduce both erosion and chemical runoff. Controlled studies usually have documented reductions in herbicide runoff with various types of conservation tillage, with reductions in runoff sometimes exceeding 90% with no-till. Long-term no-till research is particularly intriguing. As soil structure changes with reestablishment of macropores in the absence of tillage, water infiltration has sometimes increased dramatically.

Dr. Bill Edwards of the USDA, Coshocton, Ohio, compared total water runoff from a 0.5 ha watershed with 9% slope that had been farmed for 20 years in continous no-till corn to a similar conventionally tilled watershed. Over 7 years, runoff was more than 99% less under the long-term no-till. Edwards attributes this dramatic reduction to numerous macropores created by earthworms. Such reductions in surface runoff could have major implications for surface water quality.

If a significant percentage of agricultural land was returned to an untilled state more like the original prairies and forests, the water cycle would also return to a more natural state. With less water runoff and more infiltration, streams would be fed more by subsurface flow rather than surface runoff. This would allow better use of water and nutrients by crops and would allow soil colloids and biological activity to filter the water before it became surface water. Surface water would more closely resemble shallow ground water than it does today.

Another specific pesticide application practice that can protect surface water is mechanical incorporation. This places much of the pesticide below the soil surface and away from overland water flow. The trade-off is that tillage used for incorporation buries crop residue and may increase erosion risk. Work is under way to develop techniques that can place herbicides (and fertilizers) below the soil surface while leaving a protective cover of crop residue.

These practices should help greatly in reducing pesticides reaching surface water, but should not be expected to solve the nitrate problem due to the ground-water link. Any practice that increases efficiency of use of nitrogen from all sources should help. New soil testing techniques, such as late spring nitrate tests for corn production, promise to allow reductions in fertilizer use by allowing credit to be taken for naturally occurring and carryover nitrogen. Nitrogen applicators that test soil for nitrate on-the-go will be the ideal solution, allowing fertilizer rates to be varied according to varying needs within the same field. Tissue tests are also useful in some cropping systems to fine tune nitrogen fertilizer rates. Changes in application timing, use of nitrification inhibitors, testing irrigation water for nitrate content, and fall cover crops to recycle nitrate are other nitrogen management techniques.

Manure management is particularly important in areas of the country with dense livestock populations. Reducing feedlot runoff and improvements in manure application techniques can protect surface water from nitrate and phosphorus loading. Treating manure as a resource rather than a waste should be encouraged. Farmers may not always take adequate credit for nitrogen and phosphorus present in manure, and often do not test manure for nutrient content.

Just as improvements in efficiency of use of nitrogen sources can help to protect surface water, similar improvements in pesticide use efficiency can help. Sprayers that accurately deliver more of the pesticide to the intended target could reduce application rates. Educational programs that improve sprayer calibration and pesticide application decisions can help. Use of Integrated Pest Management techniques of scouting for pests and use of economic thresholds, and including pesticides only as a part of a more varied pest management approach can reduce the quantities applied.

New chemistry is also reducing water contamination potential, as many new products are applied at rates of grams per acre instead of kilograms per acre. Rapid degradation and strong soil adsorption reduce both surface and ground water contamination risk.

Even with adoption of all of these practices, agricultural chemicals will continue to be detected in water, as laboratory detection techniques continue to improve and zero vanishes. The public may not demand zero detections, but they want to know that progress is being made in agriculture to reduce contamination.

PROGRESS, PERCEPTIONS, AND CHALLENGES OF WEED SCIENCE. Gary A. Lee, Director, Idaho Agricultural Experiment Station and Associate Director for Agricultural Research, Moscow, ID 83843.

When Dr. Stephen D. Miller, WSWS President - Elect and Program Chairman, contacted me to provide some thoughts about the progress, challenges, and perceptions of weed science, I accepted the assignment with enthusiasm. As I pondered the topic, it seemed that the subject should be the focus of a multi-day symposium rather than a half-hour presentation. Thus, I have exercised the prerogative to limit the scope of my remarks primarily to the academic programs and weed science as a discipline. It would be presumptive of me to assess the progress and challenges facing the commercial industries and regulatory aspects related to weed science other than in a cursory way. My intention is to focus on the weed science programs within the universities of the western United States and to provide a perspective on needs for weed science to remain a healthy and viable discipline.

A glance back through history indicates that weeds have limited food supplies of entire civilizations, even our modern society. The first book of the Bible (Genesis 3:17-18) makes reference to weeds and the resulting toil that man faced in order to glean food from the land. The scriptures have correctly predicted that weeds would be a problem in cultivated agriculture up to and including modern times. F. L. Timmons (5) in his review of the history of weed control speculated that removal of unwanted plants was a rare practice as late as Roman times even though records indicate that primitive hoes were utilized as early as 6000 B.C. The philosophy that weeds were a curse for which there was little remedy persisted until the beginning of the twentieth century. The advancements of science and technology which have allowed agriculture production to evolve to unprecedented levels have been greater in the past 50 years than all previously recorded time. Coincidentally during the same period, weed science as a discipline has been recognized by the academic community and has contributed significantly to agricultural production efficiency and subsequently to the most abundant and varied food supply in the world.

Weed science as an academic discipline has developed primarily in the land grant universities of this nation. Much of the fundamental research on weed biology, ecology, weed management systems, biological control, and herbicide application methodology has been done within public institutions. Herbicide behavior in plants and the environment and practical application to solving agriculture's needs have received a great deal of attention throughout the 70's and 80's. Much of the research has been done in cooperation with private industry and in many instances, the expertise and leadership has come from the private sector. The collaborative efforts between private industry and public institutions has been clearly evident in weed science throughout the evolution of the discipline.

No matter what criteria is used to measure weed science progress, remarkable positive changes have occurred at an even accelerating rate. Herbicide application rates have been reduced from hundreds of pounds per acre to a fraction of an ounce per acre, herbicide selectivity has become extremely precise, crop protection compounds are more environmentally safe and less toxic, weed management systems are being developed that integrate a number of weed control tactics, and much has been learned about herbicide influence on plant metabolism, transport, and growth. The joint effort between the public and private sector has produced remarkable results that directly benefit agricultural producers. Perhaps we have been too successful. Even though the land grant universities have a clear mandate, critics have attacked scientists and the state agricultural experiment station systems for the approach taken to develop new technologies. In *Silent Spring*, Carson (2) accused the land grant universities of catering to a small clientele and allowing scientists to develop a pesticide-dependent food production system. In *Hard Tomatoes, Hard Times*, Hightower (4) depicted the state experiment stations and the scientists as working for the interests of an elite group of agribusinesses. The land grant system has become a tax-supported subsidy for a very few at the expense of the public's interest. Doyle (3) has argued in *Altered Harvest* that the land grant system has become a partner with powerful multi-national corporations that dominate the agricultural research system, and thus, manipulating the world's food supply. While these and other critics have not caused immediate and radical policy changes in public institutions, they have sown seeds of doubt and mistrust in a significant portion of the general public.

How have we progressed in the area of public relations? How have we done in telling our story? Nearly 20 years ago, Dr. Donald L. Burgoyne (1) in his presidential remarks to this society addressed the problem of public perception and the need to get involved. Since that time, WSWS has established a public relations standing committee to encourage communication with the media and public. Dr. Homer LeBaron as President of WSSA organized a delegation of weed scientists to visit congressional representatives and federal agencies to discuss weed science issues and enhance communications with policy makers. A series of position papers have been developed and distributed to key individuals at the national level. As a society, we are making progress in informing the public and shaping opinions, and yet, as individuals, we are failing miserably. As chairman of the WSSA Speakers Bureau Committee, I can tell you that there is little individual commitment and interest in becoming a spokesperson for weed science. After 2 years of actively recruiting individuals to volunteer as speakers on behalf of weed science, we now have less than 20 out of the entire WSSA membership. How many of you have talked to a civic group, chamber of commerce meeting, grade school or high school class, garden club, or other non-agriculture audience in the past year? We, as professional weed scientists, must share the responsibility to inform the public.

In assessing the progress of weed science in the west, there are other areas which deserve attention. During the past 56 years, WSWS has served a broad range of interests related to weed science. It is most gratifying to see enthusiastic participation of representatives from county weed districts, state departments of agriculture, private consultant firms, academic departments, graduate student, and crop protection product companies. The forum for exchange of ideas and information has continued to improve over the years. The relatively constant growth in membership attests to the service provided by the society. The financial stability of WSWS in recent years is a measure of progress and a welcome change from the mid-60's when the organization was unable to pay conference expenses.

There is a number of criteria that can be used to measure progress of an academic discipline. I have chosen to concentrate on two essential ingredients for the major portion of my presentation today. These components are the academic scientists and the graduate student. The agenda for weed science as a discipline is reflected through research and educational programs and the priorities for future direction will have profound influence on the development of new agriculture technologies and practices. My intent is to establish a base line from which we can compare the dynamics of the discipline in the future and to initiate the discussion for some unity in direction.

For a basis of this discussion, an extensive survey was prepared and sent to WSWS members involved in academic research. The return rate was 78% which exceeded expectations but is sincerely appreciated. Results of the survey reflect the status of a majority of the weed science programs in the western United States. After summarizing the individual responses, there are a number of interesting conclusion that can be drawn from the study. Some aspects are positive and other areas indicate that we should have concern and take corrective action.

Any academic program or discipline is as good as the individuals working in the profession. Thus, a profile review of the faculty and their comparative productivity is an indicator of the discipline's status (Figure 1.). Over 59% of the weed science faculty have been in their professional positions 20 years or less and 72% of the individuals have earned tenure. Salary level can be used as a relative measurement of contentment among faculty. The survey indicates that about 25% of weed scientist command high salaries compared to colleagues and 75% have average salaries for time in rank and service. There appears to be a long-term stability of faculty in institutions with less than 26% anticipating retirement in 10 to 15 years. Although faculty positions are predominantly filled by males (93%) at the present time, a greater gender balance is anticipated to occur in the future as more females obtain Ph.D.'s in weed science. Over the past 5 years, faculty positions in weed science have remained stable throughout the west. College administrations appear to appreciate the importance of maintaining the level of expertise at the present time. However, many states are experiencing extreme financial difficulties and state agricultural experiment stations may be forced to reduce the size and scope of research capabilities. No guarantees can be given to save weed science programs even with external political pressure generated. However, productive and active programs will be the last to be eliminated.

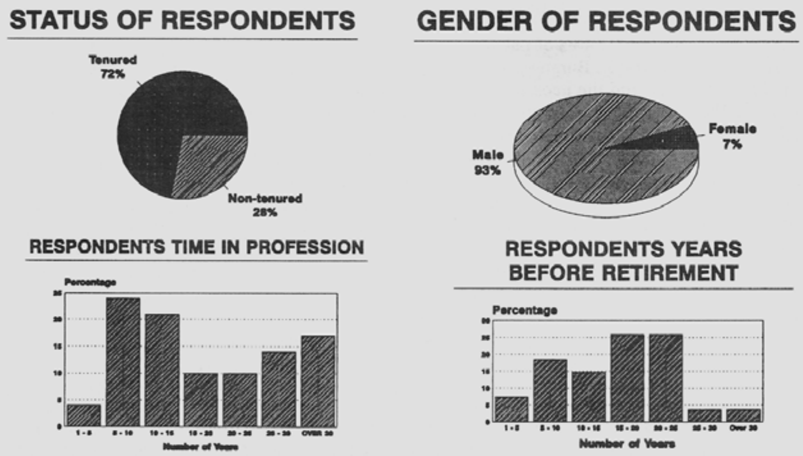

Figure 1. Profile of weed science faculty in public institutions in the western United States.

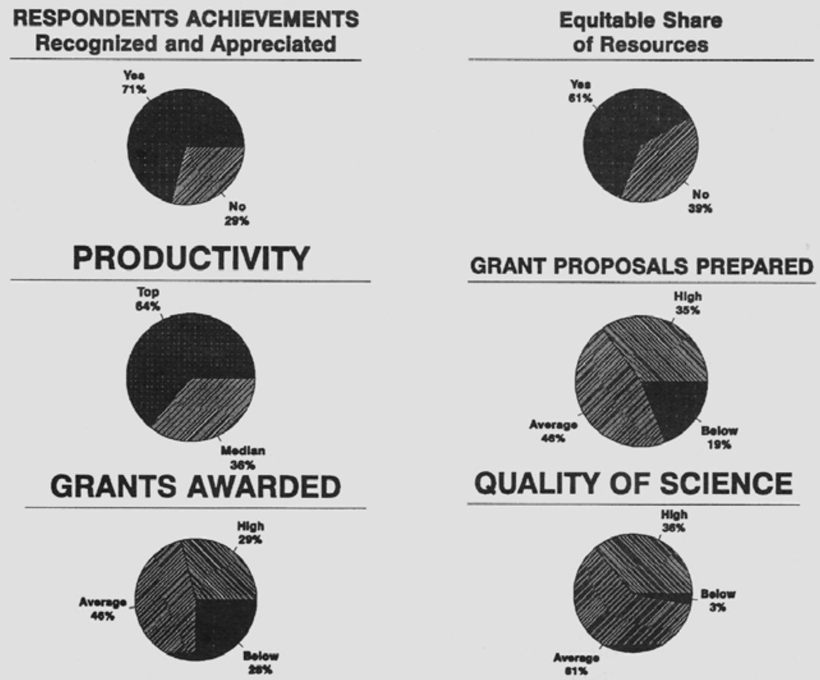

Figure 2. Contributions of weed science faculty compared to peers within academic departments in the western United States.

Accountability of weed science programs compared to other academic disciplines within an institution is a measure of productivity, stability, and future growth. The survey indicates that the faculty work hard. An average of 50 hr/week is spent on assigned responsibilities. Over 70% of the individuals indicate that their efforts and achievements are recognized and appreciated by the institution's administration (Figure 2.). A lesser number of academic scientists (61%) feel that they are receiving an equitable share of allocated resources from their department or college. A factor that may be directly related to distribution of resources is relative ranking of productivity. Approximately 64% of the respondents ranked their productivity among the top in their department compared to other programs. The remaining 36% of the researchers perceive their productivity to average among peers and no one felt that their contributions were below average.

Public institutions no longer have the capability to fully fund research programs. The most generous support usually consists of salaries for faculty, a support position, and modest operational budgets. The faculty is clearly expected to generate extramural funding to finance the remainder of the program depending on the percentage of time committed to fundamental or applied research activities. Compared to departmental peers, 35% of the weed scientists are among the most active in preparing grant proposals and 29% are among the highest level for receiving grant awards (Figure 2.). One-quarter of the scientists rank themselves as being below average in receiving external financial support. Most scientists agree that state funding, chemical company grants, and non-profit organization funding will either remain static or diminish over the next 5 years (Figure 3.). Competitive grants and commodity commission funding will likely be the best source for support in the future. Approximately 60% of the respondents indicated that the total annual financial support including salaries and operational budgets is $100,000 or less. Only 17% of the scientists reported resources in excess of $200,000 per year.

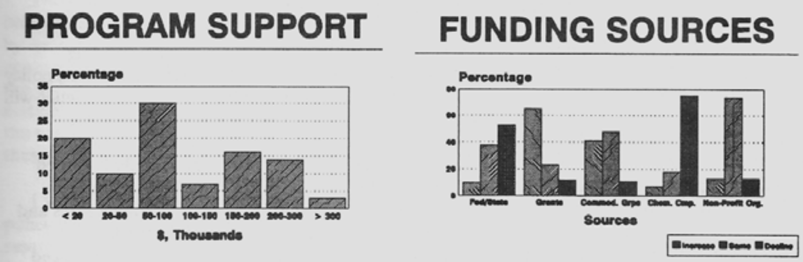

Figure 3. Resources for weed science program support.

In presenting an overview of program emphasis, it is not possible to distinguish those scientist with various split appointments and those with only research responsibilities. The division of responsibilities influence the types of programs pursued by western weed scientists. Collectively, 15% of the research effort is basic or fundamental (Figure 4.). An additional 40% of the research is classified as applied or demonstrational areas which directly relates to problem solving activities. The typical faculty member spends slightly less than one-quarter of the time doing extension or service type work. About 12% of the time is dedicated to undergraduate teaching or graduate student education. Nearly all scientists indicated a split appointment between teaching, research, and/or extension. Despite the difficulty in financing weed science programs, nearly two-thirds of all the scientists feel that their contributions to agriculture are among the top compared to other disciplines and that the quality of science of over one-third of the programs rank among the top of their individual department.

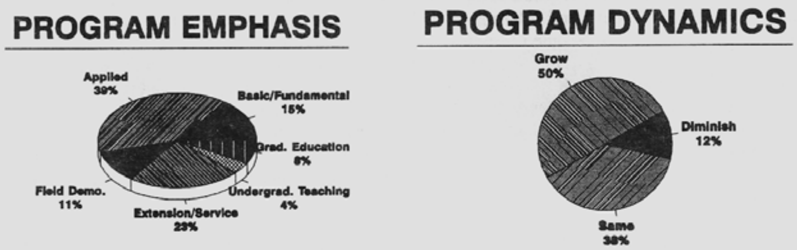

Figure 4. Weed science program emphasis in the western United States.

Many institutions are encouraging multi-disciplinary approaches to solving complex research problems. Weed science has been a model from which other research programs have been designed. The nature of the weed science discipline necessitates drawing information and knowledge from a number of other disciplines. In turn, weed science has the potential to significantly contribute to those disciplines. Scientists participating in the survey listed 21 other disciplines that they are actively cooperating including the most frequently listed as entomology, crop management, plant pathology, soil science, and biology/molecular biology. Ninety percent of the scientists indicated that they are participating in team research projects. A vast majority of individuals indicated that research emphasis will shift over in the next 5 years. More emphasis will be placed on weed ecology/competition, sustainable agriculture, integrated weed management, and genetics/economics/social concerns. About half of the weed science programs are expected to grow while 12% of the programs will diminish in size or scope.

An important measure of any discipline's future is the quantity and quality of individuals being attracted into the field. The students of today will be the researchers, educators, product managers, policy makers, and leaders of tomorrow. The information provided by the survey indicates that weed science will be in good hands in the future. Although the picture is not complete, responding institutions have graduated a total of 129 post-baccalaureate students in the past 5 years and there are 114 students presently enrolled in graduate programs (Figure 5.). There is an excellent career opportunity for weed science graduates in private industry. Approximately 35% of the graduates are employed in product research and development in the private sector while slightly over 25% are engaged in product sales and agricultural services. About 1 in 5 graduates have joined university faculty or are employed as USDA-Agricultural Research Service scientists. An equal number of individuals are pursuing advanced degrees or post-doctoral experiences before entering a career track position. The remaining 4% of the graduates are working in technical support positions for research projects. Whether students enter graduate school at the same or different institutions where they earn a bachelor degree, the background for weed science tends to be the same. The primary source of students is from agronomy and soils. Outside of agricultural sciences, the most students are recruited from biological sciences. Nearly half of the individuals enter graduate school immediately after completing a B.S. degree. However, over 30% of the student return to graduate school after working 2 or more years. Thus, it is important to design recruitment programs in the future that reach potential students in private industry and other non-traditional sources.

There are a number of conclusions which can be formulated from the survey. In general, weed science programs are stable, efforts are underway to meet the needs of a changing agriculture and society, and contributions are equal to or greater than other disciplines supporting western United States food and fiber industries. There are, however, concerns which will be addressed later.

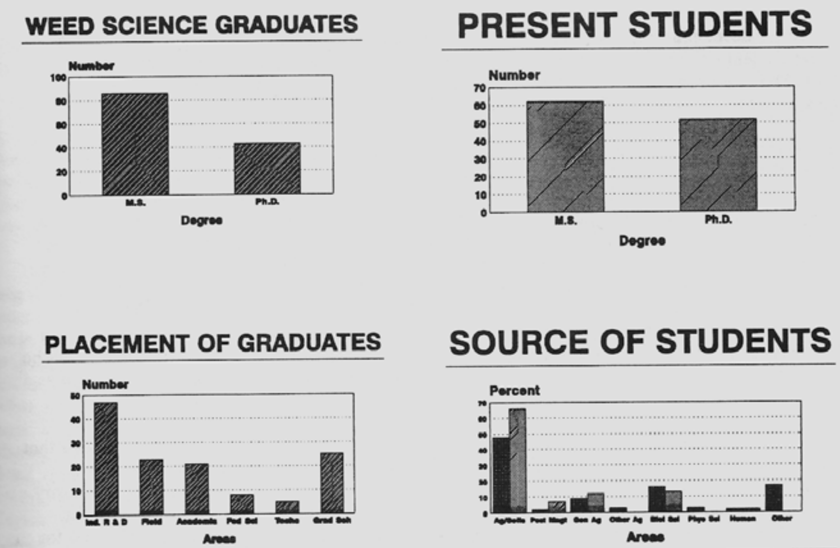

Figure 5. Graduate student programs in the western United States.

There are a few brief points I wish to make regarding public perception of weed science. I have often been puzzled at the statement "herbicides and pesticides" and "weeds and pests" which is commonly made by agriculturalists as well as people in other businesses. I will not psychoanalyze the statements but there appears to be a general separation of weed science from all other pest management related disciplines in the minds of the public. This may be both a blessing and a curse. The grape growers in Washington certainly have their opinions and biases, but there has been less "bad press" regarding herbicide impact on the environment, wildlife, and human health than with insecticides, fungicides and nematocides. Because there have been fewer problems, there may be a less defined opinion about weeds and weed science.

I worry there is a great deal of apathy toward weed science in a number of sectors where funding and policy decisions are made. I have carefully reviewed a number of documents which reflect national research agendas for integrated pest management. Weed science either receives a cursory mention or is totally ignored. Why has this happened? I can only speculate that there are precious few weed scientists in federal agencies, administrative roles, and representatives on task force committees that make priority decisions. IPM programs evolved around entomological and phytopathological problems and representatives from those disciplines are firmly entrenched in decision making positions.

Nearly 20 years ago, there was an effort to establish "Weed Science Departments" in colleges of agriculture throughout the United States. I believe that in the west, Colorado and North Dakota are the only departments with weed science as part of the title. In hind sight, I believe it was a mistake not to pursue the effort with more vigor. Our discipline has no identity other than as a program within another department.

I perceive that there is a great deal of apathy within weed science. I cite again the lack of response to be spokespersons for the discipline and to educate non-traditional clientele regarding the need to control weeds and to develop environmentally sound practices. As a scholarly group, we have not clearly defined what we are about and what we stand for. There have been no initiatives generated by the society to support national and regional programs. Other societies and disciplines are actively pursuing funding for research and education programs to support and sustain their interests. A number of you are to be commended for developing a new western regional coordinating committee that was approved by the western experiment station directors last year. However, there was nearly a 15 year period where no formal weed science projects existed in the west. The lack of recognition of organized weed science research appears to affect our ability to compete for other IPM funding as well.

I perceive that weed science is vulnerable for outside interest groups to influence the direction and priorities of the discipline. For example, Senator Leahey, has proposed legislation to ban federal funding for use to develop herbicide resistant crops. To my knowledge, no weed science expertise was sought in evaluating the rationale for such radical action. In addition, the Cooperative State Research Service has initiated the development of a symposium to inform congressional staffers, agency personnel, and other policy makers in and around the nation's capital about weed science and its direction. A position paper critical of weed science has been published and will be presented. The symposium planning was done without the involvement WSSA or any regional societies. It is my personal view that such activity is inappropriate and not justified. The debate on and final decision on the direction for weed science as a discipline must be from within the membership. No one individual has the answers, but everyone must be willing to discuss and develop a course of action that will strengthen weed science as a discipline and as a society.

A number of challenges could be presented, but it seems appropriate to identify only a few issues that might be remembered and accomplished in the foreseeable future. First, the society must develop a strategic plan that defines a comprehensive course of action for research, extension, teaching, regulatory, and private industry involvement in weed science as a discipline. It is not enough to develop position papers on issues for congressional briefings. A wide distribution of what we are and what we can do for the public at-large is an essential function of WSWS.

Second, we must all assume an active role in building coalitions with other agricultural interest groups. We must develop a unified message that can be presented to non-agricultural groups.

Third, academic scientists must develop organized research projects which can involve state, federal and private participation. In order to support a full-time researcher, $250,000 is required annually. Based on that fact, less than 20% of our state researchers are receiving adequate funding. Initiatives must be presented to regional and federal agencies which reflect the needs and direction of research programs. Without such activities, funding sources and opportunities will continue to erode. Political support must be generated from commodity groups and private industry. Research programs support graduate programs, and thus, we must ensure the legacy of the science and society is carried on into the future.

Fourth, we must jealously guard our own destiny as a science and society. It is the right and duty of the collective membership to establish the priorities, agenda, and direction of weed science. Do not let apathy take from you what is yours as a professional weed scientist.

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HUMAN CANCER: ARE PESTICIDES RESPONSIBLE. Bruce Ames, University of California, Division of Biochemistry and Molecular Biology, Berkeley, CA 94720.

In the last several decades, there has been a persistent widespread belief among many groups in this country that nature is benign and that man-made things - i.e., modern technology -have destroyed our benevolent relationship with nature. This yearning for a time when man was happily in harmony with nature is a yearning for a time that never existed: In reality, life before the modern industrial era was for most people, even in Thomas Hobbes' time, "nasty, brutish, and short". Disease and malnutrition ensured a very short average life expectancy, an early end to the misery of life in a natural world.

The history of agriculture is one of a nonending contest with pests such as insects and fungi. Fields of crops, which often have been bred to have low levels of natural plant defensive chemicals in order to be more edible for human consumption, are easy sources of food for thousands of species of insects and fungi. Infestation of crops by pests can have dramatic impacts on human life: Last century, the potato fungus *Phytophthora infestans* wiped out the potato crop of Ireland, which led to the deaths of over a million people due to malnutrition (which made people susceptible to disease) and starvation. The relationship between pesticides and disease is significant. DDT, the first synthetic pesticide, eradicated malaria from many parts of the world, including the United States. It was so effective against many diseases because (1) it was lethal to many vectors of disease, e.g., mosquitos, tsetse flies, lice, ticks, and fleas; and (2) it was lethal to many crop pests, and so significantly increased the supply of food and lowered the cost of food, making fresh nutritious foods accessible even to relatively poor people. In Ceylon, for example, in less than 20 years of DDT use, the number of cases of malaria decreased from 2,800,000/yr to 17. (After Ceylon stopped using DDT, the number of malaria cases increased again.)

Some ideologists have twisted the story of pesticides: Instead of pesticides freeing us from disease, they assert, pesticides are bringing us disease. There are many misconceptions about the relationship between environmental pollution and human disease, particularly cancer, and these can lead to errors in risk perception, which in turn can lead to counterproductive regulatory policies. Accurate science is crucial for assessing public risk from environmental hazards. As scientific information about a subject increases, public risks often need to be reassessed and public policy refined.

The attempt to prevent cancer by regulating low levels of synthetic chemicals by "risk assessment," using worst-case, one-in-a-million risk scenarios, is not scientifically justified. Testing chemicals for carcinogenicity at near-toxic doses in rodents does not provide enough information to predict the excess numbers of human cancers that might occur at low-dose exposures. In addition, this cancer prevention strategy is enormously costly; it is counterproductive because it diverts resources from much more important risks, and, in the case of synthetic pesticides, makes fruits and vegetables more expensive, thus serving to decrease consumption of foods that help to prevent cancer.

The regulatory process does not take into account: (1) that the natural world of chemicals makes up the vast bulk of chemicals humans are exposed to; (2) that the toxicology of synthetic and natural toxins is not fundamentally different; (3) that about half of the natural chemicals tested chronically in rats and mice at the maximum tolerated dose are carcinogens; (4) that testing at the maximum tolerated dose frequently can cause chronic cell killing and consequent cell replacement (a risk factor for cancer that can be limited to high doses), and that ignoring this greatly exaggerates risks; and (5) that an extrapolation from high to low doses should be based on an understanding of the mechanisms of carcinogenesis.

The causes of cancer. The main causes of cancer appear to be mutagenesis (DNA damage) and mitogenesis (cell division). Normal rates of mutagenesis in mammals are high. Mutagens (chemicals that damage DNA) cause cancer by mutating the DNA of cells in ways that cause them to proliferate in an uncontrollable fashion. It is generally agreed that several mutations are necessary to convert a normal cell to a cancer cell capable of uncontrolled growth. Mutagens are often assumed to be exogenous agents (coming from outside the body), e.g., synthetic chemicals; however, many endogenous mutagens (produced inside the body) are formed naturally during normal metabolic processes, such as oxygen utilization, which produces DNA-damaging oxidants. Thus, in a sense, breathing oxygen is equivalent to irradiating the body. Studies in our laboratory have shown that normal metabolism causes chronic massive oxidative DNA damage: we estimate that the number of oxidative hits to DNA per cell per day is about 100,000 in rats and 10,000 in humans. All mammals have numerous defenses to counter this damage, such as enzymes that repair damaged DNA, but this repair is imperfect. DNA damage in somatic cells accumulates with time because a considerable proportion of an animal's resources is devoted to reproduction at a cost to maintenance. Proteins can become oxidized as well, and other laboratories have shown that normal protein oxidation is extensive and that oxidized proteins accumulate with age, contributing to brain dysfunction. Thus, oxidative damage appears to be a major contributor to many of the degenerative diseases of aging, including cancer, because not all the DNA damage is repaired.

Mitogenesis (cell division) increases mutagenesis and carcinogenesis because DNA adducts are converted to mutations when a cell divides. Dividing cells are much more at risk than are nondividing, quiescent cells. Agents that cause chronic cell division are, therefore, indirectly mutagenic (and commonly carcinogenic). Saccharin, for example, is not itself a mutagen, but high doses of saccharin given to rodents cause sufficient cell division to be carcinogenic. Low doses, however, would be expected to have no carcinogenic effect. Agents that cause chronic cell division (e.g., by irritation and inflammation of tissues) appear to be important in many of the known causes of human cancer: estrogen, for example, which causes cell proliferation in breast tissue, is a risk factor for breast cancer; hepatitis B and C viruses and alcohol, which induce cell wounding and subsequent cell proliferation in the liver, are risk factors for liver cancer; high salt intake and *Helicobacter* bacterial infection, which induce chronic irritation of the stomach lining, are risk factors for stomach cancer; papilloma virus, which can cause chronic infection and proliferation of cells of the cervix, is a risk factor for cervical cancer; asbestos and tobacco smoke, which irritate the lungs, are risk factors for lung cancer. For the chemicals associated with occupational cancer, worker exposures usually have been at near-toxic doses that would be likely to cause cell proliferation.

A marked decrease in age-specific cancer rates has accompanied the marked increase in life span that has occurred in the last 60 million years of mammalian evolution. For example, cancer rates are high in 2-yr-old rodents, but extremely low in 2-yr-old humans. Cancer incidence increases with approximately the fifth power of age, both in short-lived species such as rats and mice and in long-lived species such as humans. Thus, cancer is one of the degenerative diseases of old age, although exogenous factors can substantially increase it (e.g., cigarette smoking in humans) or decrease it (e.g., calorie restriction in rodents). One important factor in longevity appears to be basal metabolic rate, which is much lower in humans than in rodents and could markedly affect the level of endogenous mutagens produced by normal metabolism.

According to the National Cancer Institute's 1987 statistics review, "The age adjusted mortality rate for all cancers combined except lung cancer has been declining since 1950 for all individual age groups except 85 and above." Although incidence rates for some cancers have been rising, trends in recorded incidence rates may be biased by improved registration and diagnosis. Even though mortality rates for cancers for particular sites can be shown to be increasing (for example, non-Hodgkin's lymphoma, melanoma) or decreasing (for example, stomach, cervical, rectal), establishing causes remains difficult because of the many changing aspects of our life-style. Life expectancy continues to increase every year.

Cancer clusters in small geographical areas are expected to occur by chance alone, and epidemiology lacks the power to establish causality in these cases. It is important to show that a pollution exposure that purportedly causes a cancer cluster is significantly greater than the background of exposures to naturally occurring rodent carcinogens.

Dietary pesticides: 99.99% natural. Daniel H. Janzen of the University of Pennsylvania wrote, "Plants are not just food for animals...The world is not green. It is colored lectin, tannin, cyanide, caffeine, aflatoxin, and canavanine."

Nature's pesticides are one important subset of natural chemicals. Plants produce toxins to protect themselves against fungi, insects, and animal predators. Tens of thousands of these natural pesticides have been discovered, and every species of plant analyzed contains its own set of perhaps a few dozen toxins. When plants are stressed or damaged, such as during a pest attack, they may greatly increase their natural pesticide levels, occasionally to levels that can be acutely toxic to humans. We estimate that Americans eat about 1.5 g of natural pesticides per person per day, which is about 10,000 times more than they eat of synthetic pesticide residues.

Concentrations of natural pesticides in plants are usually measured in parts per thousand or per million rather than parts per billion, the usual concentration of synthetic pesticide residues or of pollutants in water. We estimate that the human diet contains roughly 5,000 to 10,000 different natural pesticides and their breakdown products. For example, 49 natural pesticides (and metabolites) are ingested when cabbage is eaten. Only 2 have been tested for carcinogenicity. Lima beans contain a completely different array of 23 natural toxins that, in stressed plants, range in concentration from 0.2 to 33 parts per thousand fresh weight. None appears to have been tested yet for carcinogenicity or teratogenicity. Many leguminous plants contain canavanine, a toxic arginine analog that, after being eaten by animals, is incorporated into protein in place of arginine. Feeding alfalfa sprouts (1.5% canavanine dry weight) or canavanine itself to monkeys causes a lupus erythematosus-like syndrome. Lupus in humans is characterized by a defect in the immune system that is associated with autoimmunity, antinuclear antibodies, chromosome breaks, and various types of pathology. The toxicity of nonfood plants is well known. Plants are among the most commonly ingested poisonous substances for children under 5 years of age.

Surprisingly few plant toxins have been tested for carcinogenicity. Among 1052 chemicals tested in at least one species in chronic cancer tests, only 52 are naturally occurring plant pesticides. Among these, 27 are carcinogenic. Even though only a tiny proportion of the plant toxins in our diet has been tested so far, the 27 natural pesticides that are rodent carcinogens are present at levels above 10 ppm in the following foods: anise, apple, basil, Brussels sprouts, cabbage, caraway, carrot, cauliflower, celery, cherries, cloves, coffee (brewed), comfrey herb tea, dill, eggplant, endive, fennel, grapefruit juice, grapes, honey, horseradish, lettuce, mango, mushrooms, mustard (brown), nutmeg, orange juice, parsley, parsnip, pear, pepper (black), plum, potato, rosemary, sage, sesame seeds (heated), tarragon and thyme. In addition, the following foods contain these 27 natural pesticides at levels below 10 ppm: apricot, banana, broccoli, cantaloupe, cinnamon, cloves, coca, collard greens, currants, guava, honeydew melon, kale, lentils, peach, peas, pineapple, radish, raspberries, tea, tomato, and turnip.

Thus, it is probably that almost every fruit and vegetable contains natural plant pesticides that are rodent carcinogens. The levels of these 27 rodent carcinogens in the above plants are commonly thousands of times higher than the levels of synthetic pesticides.

Caution is necessary in interpreting the implications of ingesting natural pesticides that are rodent carcinogens. It is not argued here that these dietary exposures are necessarily of much relevance to human cancer. What is important in our analysis is that exposures to natural rodent carcinogens may cast doubt on the relevance of far lower levels of exposures to synthetic rodent carcinogens. Particular natural pesticides that are carcinogenic in rodents can be bred out of crops if studies of mechanism indicate that they may be significant hazards to humans.

Residues of pesticides. The U.S. Food and Drug Administration (FDA) has assayed food for 200 chemicals, including the synthetic pesticide residues thought to be of greatest importance, and the residues of some industrial chemicals, such as polychlorinated biphenyls. FDA found residues for 105 of these chemicals. The United States intake of the sum of these 105 chemicals averages about 0.09 mg per person per day, which we compare with an intake of 1500 mg of natural pesticides. Thus, the average intake of pesticides is 99.99% natural. Other analyses of synthetic pesticide residues are similar.

About half (0.04 mg) of this daily intake of synthetic pesticides is composed of four chemicals that are not carcinogenic in rodent tests: ethylexyl diphenyl phosphate, chlorpropham, malathion, and dicloran. Thus, the intake of known or potential rodent carcinogens from synthetic residues is only about 0.05 mg a day.

The cooking of food is also a major dietary source of potential rodent carcinogens. Cooking produces about 2000 mg per person per day of mostly untested burnt material that contains many rodent carcinogens - for example, polycyclic hydrocarbons, heterocyclic amines, furfural, nitrosamines - as well as a plethora of mutagens.

Thus, the number and amount of total synthetic pesticide residues, including those that are carcinogenic, appear to be minimal compared to the background of naturally-occurring chemicals in the diet. Roasted coffee, for example, is known to contain 826 volatile chemicals; 21 have been tested chronically and 15 are rodent carcinogens. Caffeic acid, a nonvolatile rodent carcinogen, is also present. A typical cup of coffee contains at least 10 mg (40 ppm) of rodent carcinogens (mostly caffeic acid, catechol, furfural, hydro-quinone, and hydrogen peroxide). Thus, the 10 mg of known natural rodent carcinogens in a cup of coffee (only a few percent of the chemicals have been tested) would be equivalent in amount ingested to a year's worth of synthetic pesticide residues (assuming half of the untested synthetic residue weight turns out to be carcinogenic in rodents).

The evidence on coffee and human health has been recently reviewed, and to date it is insufficient to show that coffee is a risk factor for cancer in humans. The same caution discussed above about the implications for humans of natural rodent carcinogens in the diet apply to coffee and the products of cooked food.

Similar toxicology. It is often assumed that because plants are part of human evolutionary history, while synthetic chemicals are recent, the mechanisms that animals have evolved to cope with the toxicity of natural chemicals will fail to protect us against synthetic chemicals. An example of this view is the statement of Rachel Carson: "For the first time in the history of the world, every human being is now subjected to contact with dangerous chemicals, from the moment of conception until death." We find this assumption flawed for several reasons.

Defenses that animals have evolved are mostly of a general type, as might be expected, because the number of natural chemicals that might have toxic effects is so large. General defenses offer protection, not only against natural but also against synthetic chemicals, making humans well buffered against toxins. These defenses include the following: (1) The continuous shedding of cells exposed to toxins - the surface layers of the mouth, esophagus, stomach, intestine, colon, skin, and lungs are discarded every few days. (2) The induction of a wide variety of general detoxifying mechanisms, such as antioxidant defenses or the Phase II electrophile-detoxifying systems. Cells that are exposed to small doses of an oxidant, such as radiation or hydrogen peroxide, include antioxidant defenses and become more resistant to higher doses of oxidants, whether synthetic or natural. Natural or synthetic electrophiles induce Phase II detoxifying enzymes that are effective against both. (3) The active excretion of planar hydrophobic molecules (natural or synthetic) out of liver and intestinal cells. (4) DNA repair, which is effective against DNA adducts formed from both synthetic and natural chemicals, and is inducible in response to DNA damage.

Anticarcinogenic chemicals in the diet, such as antioxidants, help to protect humans against carcinogens but do not distinguish between synthetic and natural carcinogens. It has been argued that synergism between synthetic carcinogens could multiply hazards, but this is equally true of natural carcinogens.

The fact that defenses are usually general, rather than specific, for each chemical makes good evolutionary sense. The reason that predators of plants evolved general defenses against toxins is presumably to be prepared to counter a diverse and ever-changing array of plant toxins in an evolving world. If a herbivore had defenses against only a set of specific toxins, it would be at great disadvantage in obtaining new foods when favored foods became scarce or evolved new toxins.

Various natural toxins, some of which have been present throughout vertebrate evolutionary history, nevertheless cause cancer in vertebrates. Mold aflatoxins, for example, have been shown to cause cancer in trout, rats, mice, monkeys, and possibly in humans. Eleven mold toxins out of 15 tested have been reported to be carcinogenic. Many of the common elements, such as salts of lead, cadmium, beryllium, nickel, chromium, selenium, and arsenic, are carcinogenic or clastogenic (agents that break chromosomes) at high doses, despite their presence throughout evolution. Selenium and chromium, nevertheless, are essential trace elements in animal nutrition.

Humans have not had time to evolve into a "toxic harmony" with all of the plants in their diet. Indeed, very few of the plants that humans eat would have been present in an African Hunter-gatherer's diet. The human diet has changed drastically in the past few thousand years, and most humans are eating many recently introduced plants that their ancestors did not - for example, cocoa, tea, potatoes, tomatoes, corn, avocados, mangoes, olives, and kiwi fruit. In addition, cruciferous vegetables, such as cabbage, broccoli, kale, cauliflower, and mustard were used in ancient times primarily for medicinal purposes and spread as foods across Europe only in the Middle Ages. Natural selection works far too slowly for humans to have evolved specific resistance to the food toxins in these newly introduced plants.

DDT bioconcentrates in the food chain as a result of its unusual lipid solubility. However, natural toxins can also bioconcentrate. DDT is often viewed as the typical dangerous synthetic pesticide because it persists for years. It is representative of a class of chlorinated pesticides. Natural pesticides bioconcentrate if lipophilic. For example, the teratogens from potato, solanine (and its aglycone solanidine), and chaconine are found in the tissues of potato eaters. Although DDT is unusual with respect to bioconcentration, it is remarkably nontoxic to mammals, has saved millions of lives, and has not been shown to cause harm to humans.

To a large extent DDT, the first major synthetic insecticide, replaced lead arsenate, a major pesticide used before the modern era. Lead arsenate is even more persistent than DDT, and although natural, both lead and arsenic are carcinogenic.

These arguments undermine many assumptions of current regulatory policy and necessitate a rethinking of policy designed to reduce human cancer. Minimizing pollution is a separate issue and is clearly desirable for reasons other than effects on public health. There is a sizeable literature on why focussing on worst case, one-in-a-million risks, rather than major risks, impedes intelligent risk reduction.

It is by no means clear that many significant risk factors for human cancer will be discovered by screening assays. Dietary imbalances, such as antioxidant and folate deficiencies, are likely to be major contributors to human cancer, and understanding these should be, but is not, a major priority of research. Understanding why caloric restriction dramatically lowers cancer and mitogenesis rates and extends life span in experimental animals should also be a major research priority. More studies on mechanisms of carcinogenesis should also be of high priority.

Synthetic pesticides have markedly lowered the cost of vegetables and fruit, thus increasing consumption. Other than giving up smoking (causing 30% of cancer and 25% of heart disease) eating more fruits and vegetables and less fat may be the best way to lower risks of cancer and heart disease.

In conclusion, the attempt to prevent cancer by regulating low levels of synthetic chemicals by traditional "risk assessment," using worst-case, one-in-a-million risk scenarios, is not scientifically justified. This does not mean that chemical regulation *per se* is undesirable. The question is how best to regulate pollution, such that tradeoffs are efficiently factored into regulatory policy. One way is by putting pollution control in the realm of the free market, for example, by auctioning off pollution licenses or taxing polluters depending on the amount of pollution produced. According to A.S. Blinder (*Hard Heads, Soft Hearts*, Addison-Wesley, Reading, MA, 1987), "The secret [of the market's success] is the market's unique ability to accommodate individual differences - in this case, differences among polluters...the profit motive will automatically assign the task of pollution abatement to the low-cost firms - something no regulators can do." This solution would partition economic tradeoffs most efficiently. Firms that can relatively inexpensively reduce their pollution will have a strong incentive to do so to avoid paying the pollution tax. Even if the risks of a particular type of pollution are initially overestimated, it is the firms that can cost-effectively change their pollution habits that have the incentive to do so, inflicting the lowest overall cost on the consumer. As new scientific information leads to the reassessment of these risks, or as the values of a society change, the tax on different types of pollution can be raised or lowered.

It is the inexorable progress of modern technology and scientific research that is likely to lead to a decrease in cancer death rates, a decrease in birth defects, a decrease in pollution, and an increase in the average human life span.

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POSTER SESSION

POSTEMERGENCE NIGHTSHADE CONTROL IN COTTON WITH DPX-PE350. Ron Vargas and Steve Wright, Farm Advisors, University of California Cooperative Extension, Madera County, 328 Madera Avenue, Madera, CA 93637 and Tulare County, 2500 W. Burrel Avenue, Visalia, CA 93291.

Abstract. The most persistent and difficult weeds to control in cotton have evolved due to herbicide tolerance and the rotation of cotton with crops such as tomatoes and peppers which are in the same family as nightshade (Solanaceae). The majority of the cotton acreage in the San Joaquin Valley is treated with a dinitroaniline herbicide. Barnyardgrass and many broadleaf weeds such as pigweed are effectively controlled, but weeds in the Solanaceae or potato family are resistant. Hairy nightshade and black nightshade are major weed species infesting thousands of A within the San Joaquin Valley. These two members of the Solanaceous family can cause lint yield losses in excess of 50%.

Acala cotton fields infested with nightshade were divided into two rows by 25 foot plots and replicated four times in a randomized complete block design. DPX-PE350 was applied early postemergence (EP) over the top of cotyledonary cotton when the hairy nightshade was in the 2- to 4-leaf stage. A sequential late postemergence (LP) over the top application was applied when the cotton was nine to ten inches tall and the hairy nightshade 12 to 16 inches tall and flowering (Table 1). In a second study (Table 2), DPX-PE350 was applied early postemergence over the top of 2- to 6-inch tall cotton when black nightshade was one to six inches tall. A sequential late postemergence directed spray, contacting the lower two-thirds of the cotton plant, was applied when the cotton was 16 inches tall and the black nightshade 6 to 16 inches tall. All treatments contained 0.25% X-77.

Table 1. Hairy nightshade control.

			Control	
Treatments	Timing[a]	Rate	50 DAT	100 DAT
		-oz/A-	%	
DPX-PE350	EP	0.25	56	0
DPX-PE350	EP	0.50	56	0
DPX-PE350	EP	1	76	56
DPX-PE350	EP	2	90	80
DPX-PE350	EP + LP	0.25	50	40
DPX-PE350	EP + LP	0.50	56	63
DPX-PE350	EP + LP	1	76	90
DPX-PE350	EP + LP	2	90	100
Control		-	0	0

[a]EP - early postemergence, LP - late postemergence.

Table 2. Black nightshade control.

			Control	
Treatments	Timing[a]	Rate	50 DAT	100 DAT
		-oz/A-	%	
DPX-PE350	EP	0.25	30	50
DPX-PE350	EP	0.50	58	66
DPX-PE350	EP	1	76	82
DPX-PE350	EP	2	86	93
DPX-PE350	EP + LP	0.25	28	42
DPX-PE350	EP + LP	0.50	46	81
DPX-PE350	EP + LP	1	76	86
DPX-PE350	EP + LP	2	81	92
Control		-	0	0

[a]EP - early postemergence, LP - late postemergence.

There was a direct relationship with increasing rates of DPX-PE350 and increasing nightshade control. The single early postemergence applications of 0.25 and 0.5 oz/A exhibited unacceptable control at both 35 and 100 days after treatment. The single 1 oz/A early postemergence application exhibited fair control whereas the single 2 oz/A rate provided acceptable control of both hairy and black nightshade at 90 and 82% control, respectively.

Sequential applications increased control in all cases, except the 0.25 oz/A application to hairy nightshade. Sequential applications of 0.25 and 0.5 oz/A rate provided poor to fair control. The 1 oz/A sequential application was providing 90% control of hairy nightshade 100 DAT and 86% control of black nightshade 50 DAT. Best control was obtained with the 2 oz/A sequential application with hairy nightshade being controlled 100% 100 DAT and black nightshade 92% 50 DAT.

Cotton phytotoxicity and injury symptoms were insignificant. All treatments exhibited slight interveinal yellowing and leaf crinkling when evaluated 7 days after the EP application. Injury symptoms were non-existent 35 to 50 days after application. Cotton plant map data indicated no effect to plant height or vigor.

SWEET CHERRY RESPONSE TO SIMULATED DRIFT FROM SELECTED HERBICIDES.

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INTRODUCTION

Cherry production in south central Washington represents about 10% of the total production in the United States. Some of the cherry industry in the area is located along the foothills of a cereal production zone where about 90,000 ha of dryland wheat is grown. Often cherry trees are in fairly close proximity to wheat; thus herbicides used on wheat may contact cherry plants by drift or accidental direct application.

Chlorsulfuron, thifensulfuron, bromoxynil, 2,4-D, and glyphosate are used extensively to control weeds in the wheat/fallow cropping system, and the application of these herbicides usually coincides with early spring growth of cherry when plants are metabolically active and generally sensitive to herbicides. As a consequence, there are many allegations that herbicides used in the cereal production zone are drifting into cherry orchards causing crop damage.

The allegations of herbicide drift in cherries in south central Washington are usually based on visual symptoms. However some herbicide symptoms are similar to those caused by disease, nutrient deficiency, insect damage, or adverse weather. Therefore any judgment of herbicide damage must based on as much information as possible about the pattern and the symptoms of each herbicide on the crop.

While herbicide injury symptoms are well documented in many deciduous fruits, the symptoms of bromoxynil, chlorsulfuron, thifensulfuron, 2,4-D, and glyphosate have not been thoroughly documented. Therefore, this work was conducted to study the susceptibility of young cherry trees to these herbicides and gather detailed information about herbicide injury symptoms to aid in diagnosing herbicide drift.

MATERIALS AND METHODS

One-yr-old cherry ('Rainier') trees were planted on April 19, 1989 and April 11, 1990 at the Irrigated Agriculture and Extension Center, Prosser, Washington. Plants were spaced with 2.7 m between trees and 3.6 m between rows. Trees were used 1 or 2 yr after planting. The experimental design was a split plot with three replications. The main plots were the six herbicides and the five subplots were the rates of each herbicide. Individual plots contained two trees.

Herbicide treatments were made when the fourth leaf was fully emerged (April 20, 1990 and May 9, 1991). Herbicides were applied with a CO_2-pressurized knapsack sprayer equipped with three 8006 flat fan nozzles and calibrated to deliver 374 L/ha at 103 kPa. Herbicides were applied with the boom perpendicular to the ground on one side of 1-yr-old established cherry trees during 1990 and 1991 and 2-yr-old established cherry trees in 1991 by positioning the spray boom to direct the spray towards the center of the plants. Rates used were 0.26, 0.88, 2.63, and 8.75 g/ha for thifensulfuron and chlorsulfuron; 4.26, 14.20, 42.6, and 142 g/ha for bromoxynil and glyphosate; 11.22, 37.4, 112.2, and 374 g/ha for 2,4-D; and 3 + 3, 10 + 11, 29 + 32, and 96 + 105 g/ha for 2,4-D + glyphosate. The 2,4-D + glyphosate combination is widely used in south central Washington to control weeds in fallow. Rates represent 0.01, 0.03, 0.1, and 0.3 of the maximum use rate. All spray mixtures included nonionic surfactant at 0.25% (v/v). Herbicide injury symptoms were evaluated every 3 days, and injury rating was based on a scale 0= no injury, and 100 = complete kill.

Four months after herbicide treatments, a photoelectric meter was used to measure leaf area for leaves that developed after treatment on three branches on the treated side of the tree. Node length was determined on the same branches. Plant height and stem diameter was determined at the beginning of the growing season and 4 months after herbicide treatment. The change in the height and diameter for each growing season was calculated as the difference between the two readings.

RESULTS AND DISCUSSION

Herbicide injury and symptoms. Cherry trees responded differently to various herbicides. At 1/10 of the use rate, all herbicides showed significant injury 14 days after treatment (DAT). Chlorsulfuron and 2,4-D caused the greatest whereas bromoxynil and thifensulfuron caused the least injury (Table 1). Only chlorsulfuron caused a significant injury at the lowest rate (1/100 of the use rate). Chlorsulfuron and 2,4-D symptoms were more apparent at 30 DAT than 14 DAT. Plants treated with bromoxynil and thifensulfuron recovered over time and eventually no symptoms were observed at the highest rate (Table 2). In the middle of the growing season, chlorsulfuron, 2,4-D, glyphosate, and glyphosate plus 2,4-D continued to show significant injury (data not shown). At the end of the 1990 growing season the three highest rates of chlorsulfuron and highest rate of 2,4-D continued to show significant injury, whereas in 1991 all rates of chlorsulfuron, the highest rate of 2,4-D, the highest rate of glyphosate and 2,4-D plus glyphosate continued to show significant injury (Table 3). In general, 2-yr-old cherry trees express lower sensitivity to all herbicides than 1-yr-old trees, but the pattern of injury was the same in all trees (Table 4 vs 2).

Injury symptom varied among herbicides. Chlorsulfuron symptoms varied depending on the rate. At the highest rate, leaves were wilted, chlorotic, and the veins discolored. The leaves rolled and shoot tips started to die followed by stem dieback. Some leaves below the dead stem developed a purple color. In general, treatments of chlorsulfuron at 1/10 and 1/33 rates developed the same pattern of symptoms as in the highest rate, but were less severe. The leaves however did not turn purple or drop. Symptoms at the lowest chlorsulfuron rate included bright chlorotic spots and leaves crinkling on the treated side. Few shoot tips died and regrowth on these shoots had many branches. Chlorotic spots began fading 30 DAT and eventually disappeared.

Symptoms caused by thifensulfuron was resembled symptoms caused by the low rate of chlorsulfuron. Leaves were crinkled with few chlorotic spots and growth was relatively slow. No thifensulfuron treatment killed any shoot tips. Bromoxynil caused slight to moderate chlorotic spots and leaf crinkling 2 to 4 DAT. However, new growth continued and appeared normal. Few of the chlorotic spots became necrotic. Leaf rolling was observed a few hours after 2,4-D treatment at all rates. Stem and petiole twisting and bending developed 3 to 7 DAT. Developing leaves were narrow, curled, cupped, and the veins were chlorotic. The veins were parallel and interveinal growth stopped. The symptom severity intensified with increased herbicide rate. The highest rate also caused the death of shoot tips with cracks and gum on the stems.

Table 1. Visual estimate of percent injury to 1-yr-old cherry trees 14 DAT with six herbicides applied in the spring of 1990 and 1991.

Herbicide	Date applied	Treatments: Rates (fraction of the maximum use rate) 1/100	1/33	1/10	1/3
		% injury			
	April 1990				
Chlorsulfuron		18	23	37	62
Thifensulfuron		2	5	8	18
Bromoxynil		0	2	7	12
2,4-D		3	12	22	47
Glyphosate		0	3	8	17
2,4-D + glyphosate		3	7	13	47
LSD(0.05) for rates within same herbicide		4			
LSD(0.05) for herbicides within same rate		4			
	May 1991				
Chlorsulfuron		11	21	23	30
Thifensulfuron		2	2	7	15
Bromoxynil		0	0	5	13
2,4-D		1	3	10	23
Glyphosate		0	0	5	18
2,4-D + glyphosate		1	2	5	17
LSD(0.05) for rates within same herbicide		3			
LSD(0.05) for herbicides within same rate		4			

Table 2. Visual estimate of percent injury to 1-yr-old cherry trees 30 DAT with six herbicides applied in the spring of 1990 and 1991.

Herbicide	Date applied	Treatments: Rates (fraction of the maximum use rate) 1/100	1/33	1/10	1/3
		% injury			
	April 1990				
Chlorsulfuron		18	32	47	73
Thifensulfuron		0	0	5	17
Bromoxynil		0	2	4	5
2,4-D		5	10	23	52
Glyphosate		0	0	5	12
2,4-D + glyphosate		3	7	17	33
LSD(0.05) for rates within same herbicide		5			
LSD(0.05) for herbicides within same rate		5			
	May 1991				
Chlorsulfuron		18	41	50	63
Thifensulfuron		0	0	5	12
Bromoxynil		0	0	3	12
2,4-D		0	3	15	37
Glyphosate		0	0	15	25
2,4-D + glyphosate		0	0	3	28
LSD(0.05) for rates within same herbicide		3			
LSD(0.05) for herbicides within same rate		4			

Table 3. Visual estimate of percent injury to 1-yr-old cherry trees 120 DAT with six herbicides applied in the spring of 1990 and 1991.

Herbicide	Date applied	Treatments: Rates (fraction of the maximum use rate) 1/100	1/33	1/10	1/3
		% injury			
	April 1990				
Chlorsulfuron		2	13	27	72
Thifensulfuron		0	0	0	0
Bromoxynil		0	0	0	0
2,4-D		0	0	5	23
Glyphosate		0	0	0	5
2,4-D + glyphosate		0	0	0	8
LSD(0.05) for rates within same herbicide		7			
LSD(0.05) for herbicides within same rate		8			
	May 1991				
Chlorsulfuron		10	42	53	67
Thifensulfuron		0	0	0	0
Bromoxynil		0	0	0	0
2,4-D		0	0	13	50
Glyphosate		0	0	5	23
2,4-D + glyphosate		0	0	3	22
LSD(0.05) for rates within same herbicide		7			
LSD(0.05) for herbicides within same rate		7			

Table 4. Visual estimate of percent injury to 2-yr-old cherry trees 30 DAT with six herbicides applied in the spring of 1991.

Herbicide	Treatments: Rates (fraction of the maximum use rate) 1/100	1/33	1/10	1/3
	% injury			
Chlorsulfuron	12	23	43	57
Thifensulfuron	0	0	3	8
Bromoxynil	0	0	0	5
2,4-D	0	3	10	23
Glyphosate	0	0	4	20
2,4-D + glyphosate	0	0	3	20
LSD(0.05) for rates within same herbicide	5			
LSD(0.05) for herbicides within same rate	6			

Glyphosate symptoms developed relatively slowly compare to the other herbicides. No symptoms were observed at the lower two rates. Symptoms on developing leaves included chlorosis, crinkling, stunting, narrow, curling down and slowed growth. The combination of 2,4-D and glyphosate showed symptoms similar to those caused by 2,4-D alone. However, 30 DAT new growth at the highest rate of the combination exhibited mild symptoms of glyphosate.

Effect of herbicide on growth and development. The height of cherry trees at the end of the growing season was significantly reduced at the three highest chlorsulfuron rates and the highest 2,4-D and glyphosate rate (Table 5). The plant height reduction was mainly due to reduce growth rates and reduction in the node length (Table 6). Chlorsulfuron and glyphosate at the highest rate reduced node length by 27 and 10%, respectively. Higher chlorsulfuron, 2,4-D, and glyphosate rates reduced leaf area which would be expected to reduce photosynthetic capacity (Table 7). Treatments which reduced leaf area also reduced stem diameter (Table 8).

Table 5. Average percent change in the height (over yr) as affected by six herbicides applied to 1-yr-old cherry trees in the spring of 1990 and 1991.

	Treatments			
	Rates (fraction of the maximum use rate)			
Herbicide	1/100	1/33	1/10	1/3
	% of control			
Chlorsulfuron	85	71	51	15
Thifensulfuron	102	105	104	98
Bromoxynil	99	95	102	97
2,4-D	97	99	99	67
Glyphosate	101	98	93	92
2,4-D + glyphosate	98	96	98	92
LSD(0.05) for rates within same herbicide	17			
LSD(0.05) for herbicides within same rate	23			

Table 6. Average percent change in cherry node length (over yr) as affected by six herbicides applied on 1-yr-old cherry trees in the spring of 1990 and 1991.

	Treatments			
	Rates (fraction of the maximum use rate)			
Herbicide	1/100	1/33	1/10	1/3
	% of control			
Chlorsulfuron	100	100	94	73
Thifensulfuron	100	101	101	106
Bromoxynil	101	98	98	101
2,4-D	113	103	102	100
Glyphosate	99	101	97	90
2,4-D + glyphosate	110	106	104	107
LSD(0.05) for rates within same herbicide	16			
LSD(0.05) for herbicides within same rate	19			

Table 7. Average percent change in the cherry leaf area (over yr) as affected by six herbicides applied to 1-yr-old cherry trees in the spring of 1990 and 1991.

	Treatments			
	Rates (fraction of the maximum use rate)			
Herbicide	1/100	1/33	1/10	1/3
	% of control			
Chlorsulfuron	101	60	57	37
Thifensulfuron	100	100	100	97
Bromoxynil	99	107	103	104
2,4-D	102	98	90	70
Glyphosate	100	100	92	80
2,4-D + glyphosate	102	107	107	93
LSD(0.05) for rates within same herbicide	20			
LSD(0.05) for herbicides within same rate	15			

Table 8. Average percent increase in the cherry stem diameter (over yr) as affected by six herbicides applied to 1-yr-old cherry in the spring of 1990 and 1991.

	Treatments			
	Rates (fraction of the maximum use rate)			
Herbicide	1/100	1/33	1/10	1/3
	% of control			
Chlorsulfuron	92	80	55	18
Thifensulfuron	102	104	101	102
Bromoxynil	96	101	102	100
2,4-D	96	94	94	65
Glyphosate	101	95	91	81
2,4-D + glyphosate	111	112	102	95
LSD(0.05) for rates within same herbicide	18			
LSD(0.05) for herbicides within same rate	22			

SUMMARY

1. Cherry trees are sensitive to chlorsulfuron, 2,4-D, and glyphosate and these herbicides might cause significant damage if they drift on cherry trees in high concentrations.
2. All herbicides caused some characteristic symptoms, but some symptoms closely resemble those caused by diseases, mineral deficiency, and environmental stresses.
3. Because of the potential ambiguity of visual symptoms, any allegation about herbicide drift should be based on a report of all symptoms and should be supported by residue analysis.

DETECTION AND TRACKING OF AIRBORNE HERBICIDE BY USING BIO-INDICATOR PLANTS.
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INTRODUCTION

Herbicide drift can damage crops at considerable distance downwind. In south central Washington, damage to grape vineyards and other crops by 2,4-D has been reported since this herbicide introduced to the area in 1947 (1). Air samples in and around irrigated regions in south central Washington from April through June has been found to contain low concentrations of 2,4-D (2). The 2,4-D symptoms on many crops correlated with appearance of maximum atmospheric levels of 2,4-D.

Several herbicides (Table 1) are used extensively to control weeds in the dryland wheat production zone, and the application of these herbicides usually coincide with early spring growth of many crops. As a consequence, there have been allegations in south central Washington that herbicides drift from dryland wheat areas into the irrigated areas of the Lower Yakima Valley (Figure 1 shows the dry land cereal production zone and irrigated areas in south central Washington), even though the two cropping areas are separated by several km.

In response to this situation, Washington State Department of Agriculture (WSDA) has taken action over the yr to reduce the amount of damage caused by drift. In one part of south central Washington, a buffer zone (14 km wide) was established between the dryland and irrigated areas where herbicides can only be applied by ground. Nozzle size, spray pressure, herbicide formulation, volume, carriers, and time of application are also restricted. Despite these regulations, herbicide drift claims continued to grow, with dryland and irrigated farmers blaming each other as to the source of the drift.

The complaints of herbicide drift in south central Washington are usually based on visual symptoms. However, some symptoms developed on crops in the irrigated areas that appear unlike symptoms caused by chemicals which are applied to wheat. Such observations fuel arguments between farmers about the source of herbicide drift, especially when techniques to detect and establish the direction of herbicide drift are not available.

Air sampling procedures are widely used to detect herbicide drift (2, 3). However, this procedure cannot be used effectively to establish the direction of herbicide movement. In addition, this procedure can detect some herbicides (sulfonylureas) only at a concentration much higher than the amount which causes biological activity. Therefore, an efficient, accurate, and simple technique is needed to monitor herbicide movement.

While the use of indicator plants to detect airborne chemicals is not new, this very sensitive methodology has not been used effectively to address the herbicide drift problem in many areas. The objectives of this work was to develop a biological method to detect phytotoxic chemicals in the atmosphere and attempt to identify the source of these chemicals.

MATERIALS AND METHODS

Selection of bio-indicator plants and herbicides. Phytotoxic effects of a given herbicide depend on the efficiency at which it is captured and absorbed by plants, and its physiological and biochemical effect. From this, it is obvious that there may be marked differences in effect on different plant species. In the screening trials the following 11 plant species were tested to evaluate plant responses to different herbicides; corn, onion, alfalfa, safflower, rape, lentil, pea, pinto bean, sugar beet. cucumber, and wheat. All the herbicides which are commonly used to control weeds in the wheat production zone of south central Washington were tested (Table 1).

Susceptibility of different species to herbicides. Two to four plants were grown in 10 by 10 cm containers filled with 1 kg of soil and fertilized weekly with a solution containing 300 ppm N, 250 ppm P, and 220 ppm K. Plants were grown under greenhouse conditions at 22/18 C ± 4 C day/night temperature. Three weeks after planting and 2 days before herbicide treatment, containers were moved to a lathhouse to acclimate them to ambient conditions. Plants were treated with different herbicides (Table 1) at rates equivalent to 1/5000, 1/1000, 1/500, 1/100, 1/30, 1/10, and 1/3 of the maximum use rate. Herbicides were applied with a bench sprayer equipped with an 8002 flat fan nozzle calibrated to deliver 358 L ha^{-1} at 207 kPa. Immediately after treatment plants were returned to the lathhouse and observed for symptoms development. Percent of plants showing herbicide symptoms were reported 60 days after treatment, in addition all symptoms were reported for 60 days after treatment.

Plant exposure to airborne herbicides. Four pots of the selected species acclimated to ambient conditions were moved weekly to 24 sites in south central Washington from April 2, 1991 to October 3, 1991. Nine sites were distributed across approximately 50 km of dryland wheat area and 15 sites were located across 30 km irrigated valley area. Plants were kept 7 days at each exposure site then moved back to the IAREC-WSU lathhouse and monitored for 28 days for herbicide symptoms. One set of control plants were left in the lathhouse each week. Symptoms that developed on plants after exposure at the various sites were compared to symptoms produced on plants sprayed by different herbicides.

Identification herbicide drift source. All herbicide application records in south central Washington were provided to us by WSDA. In addition, weather data were obtained from nine weather station located across the dryland area (Figure 1). When herbicide symptoms developed, application record (herbicide rate, time of application, and area) and weather data were applied to a computer model developed by Guy Reisenauer at WSU to determine the possible direction and distance of herbicide movement.

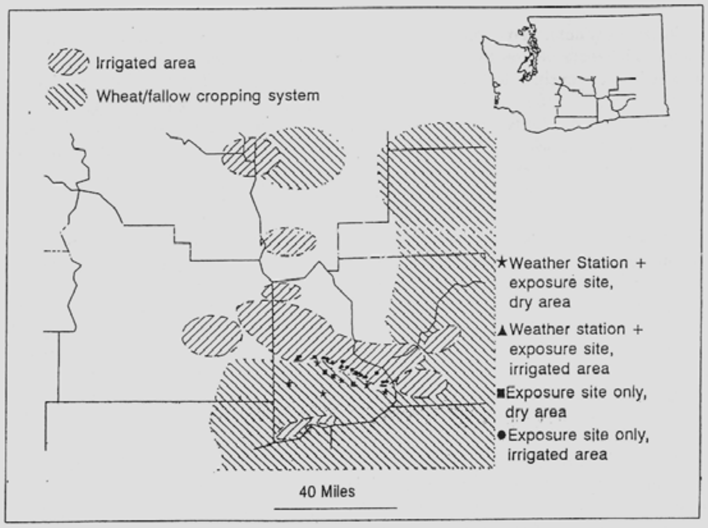

Figure 1. Map of south central Washington showing 1991 exposure sites, irrigated areas, and grain growing areas.

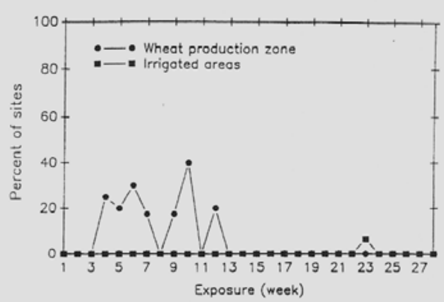

Figure 2. Appearance of 2,4-D symptoms on plants exposed at weekly intervals between April 2 and October 15, 1991.

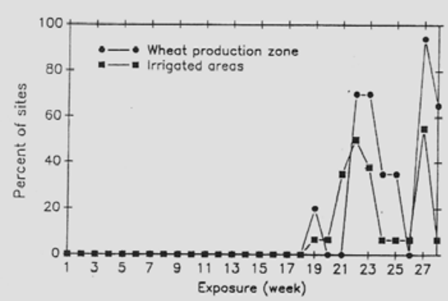

Figure 3. Appearance of paraquat symptoms on plants exposed at weekly intervals between April 2 and October 15, 1991.

RESULTS

Selection of bio-indicator plants. Plant treated with different herbicides revealed three patterns of response: 1) plants which were not sensitive to all herbicide tested and developed no visible symptoms (i.e. corn); 2) plants which were sensitive to herbicides tested but did not develop diagnostic symptoms, [effects were mainly slow growth with general chlorosis ultimate death of these plants (i.e onion, alfalfa, safflower, cucumber, and sugar beet)]; 3) plants sensitive and developed diagnostic symptoms. These included pea, bean, and lentil. These three species were subsequently used as indicator plants at all exposure sites during 1991. Table 2 showed the level of sensitivity of these plants to different herbicide whereas Table 3 describes the symptoms of these herbicides in pea, pinto bean, and lentil.

Exposure to airborne herbicides. Indicator plants placed at several exposure sites within the wheat production area during the period of May to June 1991 developed 2,4-D symptoms (Figure 2). This response was not surprising because these plants were only meters away from wheat field where 2,4-D was applied. However, indicator plants at exposure sites within the irrigated areas did not develop 2,4-D symptoms except one site on July 2. However, no 2,4-D applications were made in the wheat production zone during that exposure week. Indicator plants at several exposure sites within the wheat area and irrigated areas for the period from September to October developed symptoms similar to those caused by paraquat. The application records obtained from the WSDA showed that paraquat and diquat were applied during that period of time in both areas.

Sulfonylurea herbicides symptoms developed on indicator plants at only one exposure site during 1991. The efficiency of this biological detection system was affected by: 1) extreme environmental conditions, such as cold weather (frost) early in the spring or hot dry winds during the summer; 2) occasional lack of watering during one or more days of the exposure period; 3) damage by animals or birds. All these problem were considered minor and can be corrected. However, additional plant species should be selected for use during periods of very cold or very hot weather.

Table 1. Herbicides and maximum rates used in south central Washington in wheat production area.

Common name	Maximum use rate
	g ha^{-1}
Bromoxynil	426
Chlorsulfuron	26
Dicamba	140
Glyphosate	426
Metsulfuron	5
Paraquat	1122
Thifensulfuron	26
Tribenuron	26
2,4-D	1122

Table 2. Herbicide rates that cause diagnostic symptoms on pea, pinto bean, and lentil.

	Treatments		
	Rates (fraction of the maximum use rate)		
Herbicide	Pea	Pinto bean	Lentil
Bromoxynil	1/30	1/30	1/30
Chlorsulfuron	1/100	1/100	1/500
Dicamba	1/100	1/1000	1/100
Glyphosate	1/3	1/30	1/10
Metsulfuron	1/3	1/3	1/3
Paraquat	1/10	1/10	1/10
Thifensulfuron	1/100	1/100	1/100
Tribenuron	1/100	1/100	1/100
2,4-D	1/100	1/1000	1/100

Table 3. Description of symptoms of different herbicide on pea, pinto bean, and lentil. The severity depended on the herbicide rate.

Herbicide	Symptoms
Bromoxynil	Chlorotic spots and tan colored necrotic spots.
Chlorsulfuron	Leaf chlorosis with green veins, leaf twisting, stunting, lower side of leaves develop reddish color, leaf distortion, and shoot tip death.
Dicamba	Leaf cupping, rolling, epinasty, and stunting.
Glyphosate	Mottled chlorosis, general chlorosis with green veins, stunting, leaf distortion, shoot tip death.
Metsulfuron	Chlorotic spots, general chlorosis with green veins and leaf distortion
Paraquat	Tan colored necrotic spots and mild epinasty.
Thifensulfuron	Chlorosis with green veins, leaf twisting, stunting, leaf distortion, and shoot tip death.
Tribenuron	Chlorosis with green veins, leaf twisting, stunting, leaf distortion, and shoot tip death.
2,4-D	Shoot and petiole epinasty, cupping, stunting, curling, strapping, veins were discolored and anastomosing, and epinasty.

SUMMARY

1. The high sensitivity of pea, bean, and lentil plants to airborne chemicals illustrates that biological system can be used to monitor herbicide drift.
2. When exposure sites are dispersed over a broad area this system can identify the direction of herbicide drift spray. Spray application records and weather data, when available, provide support data.
3. While it is possible to distinguish symptoms of herbicides that belong to different chemical groups, symptoms of chemicals that belong to same family often overlap and can be very difficult if not impossible to differentiate. Therefore, the biological assay system is not very useful to discriminate specific herbicides that belong to same chemical group.
4. To develop a complete diagnostic system which can quantify and qualify herbicide drift, air sampling and bio-indicator plants should be employed at the same time.

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WILD PROSO MILLET INTERFERENCE IN DRY EDIBLE BEANS. R. G. Wilson, Professor, Department of Agronomy, University of Nebraska, Scottsbluff, NE 69361.

Abstract. Effects of wild proso millet interference with irrigated dry edible beans were evaluated in Nebraska over a 2-yr period. Dry edible bean yield reductions ranged from 11 to 32% from a wild proso millet density of 1 plant/ft^2. As density increased, dry edible bean yield reduction could be predicted with a rectangular hyperbola regression model. One wild proso millet/ft^2 growing with dry edible beans produced 2100 seed/ft^2. Dry edible bean yields were reduced 21% if wild proso millet removal was delayed five weeks after dry edible bean planting. Three weeks of weed free maintenance after bean emergence were sufficient to provide dry edible bean yields comparable to plots kept weed free all season.

DC X2-5309 IMPROVES CONTROL OF KOCHIA WITH BROMOXYNIL AND BENTAZON. Rick A. Boydston and Kassim Al-Khatib, Plant Physiologist and Research Associate, USDA- Agricultural Research Service, and Irrigated Agriculture Research and Extension Center, Prosser, WA 99350.

INTRODUCTION

The efficacy of postemergence herbicides is often improved by adding spray adjuvants that increase herbicide uptake or retention on the leaf surface. Silicone adjuvants have increased the rainfastness of several herbicides on selective species (1, 3, 4), and their usefulness as adjuvants with postemergence applied herbicides has been demonstrated (2). These studies were conducted to: 1) determine the effectiveness of DC X2-5309 silicone spray adjuvant with bentazon, bromoxynil, pyridate, and terbacil on kochia; 2) determine the effect of DC X2-5309 on bentazon and bromoxynil uptake by kochia; and 3) determine if DC X2-5309 improves the rainfastness of bentazon and bromoxynil on kochia.

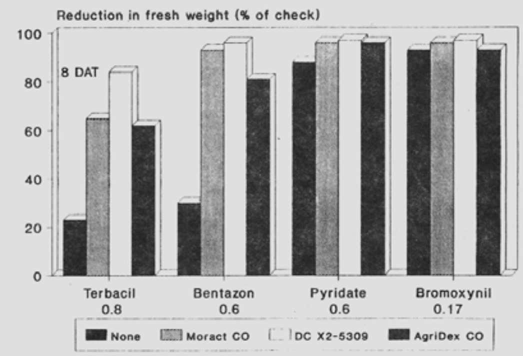
MATERIALS AND METHODS

Greenhouse trial. Kochia was planted in greenhouse potting soil in 500-ml plastic pots. After emergence, plants were thinned to four plants/pot. Postemergence herbicides were applied with a bench sprayer delivering 280 L ha^{-1}. at 140 kPa when plants were 5-cm tall and contained 15 leaves. Adjuvants were added at 1% (v/v) spray solution. Plants were harvested and fresh weight recorded at 8 days after treatment (DAT). Data reported are the means of three experiments with four replications each. A completely randomized design was used.

Rainfastness. Kochia was planted in greenhouse potting soil and thinned to one plant per 500-ml plastic pot. Postemergence herbicides were applied with a bench sprayer delivering 280 L ha^{-1} at 140 kPa when plants were 10 cm tall. Adjuvants were added at 1% (v/v) spray solution. Simulated rainfall (1.3 cm) was applied at 1, 3, or 6 DAT with multiple passes of an 8008 flat fan nozzle at 190 kPa. Plants were visually rated at 7 DAT on a scale of 0 = no symptoms to 5 = dead. Treatments were sequentially replicated four times in a completely randomized design.

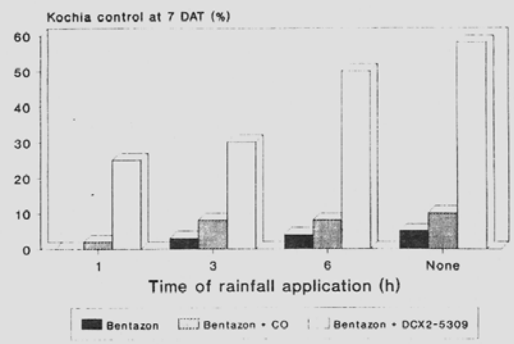
Herbicide uptake. Kochia was planted in greenhouse potting soil and thinned to one plant per 500-ml plastic pot. ^{14}C-bentazon or ^{14}C-bromoxynil (1.87 kBq) was applied in ten, 1-μL droplets to the five uppermost fully expanded leaves (two drops per leaf) of 10-cm tall kochia. Solutions contained commercial formulations of herbicides equivalent to 0.6 kg ha^{-1} bentazon or 0.17 kg ha^{-1} bromoxynil when applied in 280 L ha^{-1}. Adjuvants were added at 1% (v/v) spray solution. Plants were harvested at 1, 3, 6, and 24 h after herbicide application. Treated leaves were washed twice with chloroform and twice with water to remove any nonabsorbed herbicide. Plants were then dried, oxidized and the trapped ^{14}C was quantified by liquid scintillation counting. Treatments were sequentially replicated four times in a completely randomized design.

Field trial. Kochia was seeded in rows 15 cm apart on a Warden silt loam soil near Prosser, WA. Other weeds that emerged were removed by hand before herbicides were applied. When kochia was 30 to 60 cm tall, herbicides were applied with a backpack compressed air sprayer equipped with two 8002 flat fan nozzles delivering 280 L ha^{-1} at 275 kPa. Adjuvants were added at 1% (v/v) spray solution. Plots were 1.5 by 4.6 m. Kochia control was rated at 9 DAT on a scale of 0 = no control and 5 = dead. Data reported are means of two experiments each containing three replications. Treatments were arranged in a randomized complete block design.



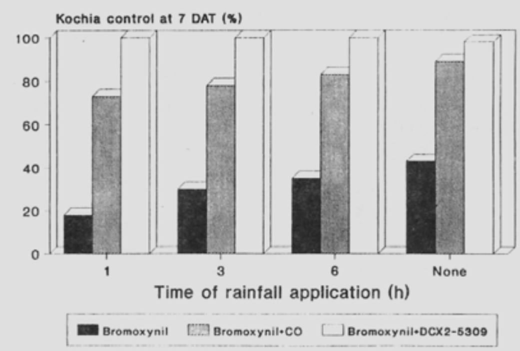
Adjuvants applied at 1% (v/v).

Figure 1. Kochia control in the greenhouse with four herbicides and three adjuvants.



CO = Moract applied at 1% (v/v).

Figure 2a. Kochia control with bentazon and a 1.3 cm simulated rainfall.



CO = Moract applied at 1% (v/v).

Figure 2b. Kochia control with bromoxynil and a 1.3 cm simulated rainfall.

RESULTS AND DISCUSSION

Greenhouse trial. Kochia fresh weight was reduced by all herbicides by 8 DAT (Figure 1). When DC X2-5309 was added, herbicide symptoms on kochia appeared sooner than when crop oils (CO) or no adjuvant was added. Adding DC X2-5309 with bentazon at 0.6 kg ha^{-1} reduced kochia fresh weight 8 DAT slightly more than adding CO (Figure 1). Applying CO with bentazon reduced kochia fresh weight much more than bentazon alone. All adjuvants added to pyridate at 0.6 kg ha^{-1} reduced kochia fresh weight more than pyridate alone, and there were no significant differences among the three adjuvants tested.

Bromoxynil at 0.17 kg ha^{-1} reduced kochia fresh weight equally at 8 DAT with or without adding an adjuvant. Herbicide symptoms appeared sooner on kochia when DC X2-5309 was included, but by 8 DAT all bromoxynil treatments were equally effective. Terbacil at 0.8 kg ha^{-1} reduced kochia fresh weight more when DC X2-5309 was added. CO's also increased terbacil effectiveness on kochia, but to a lesser extent than DC X2-5309 (Figure 1).

Rainfastness. Bentazon had very little effect on kochia by 7 DAT when no adjuvant was included regardless of rainfall treatment (Figure 2a). Adding crop oil tended to increase kochia control with bentazon slightly, but differences were not statistically significant. Adding DC X2-5309 to bentazon improved kochia control by 7 DAT and improved rainfastness at 1, 3, and 6 h after treatment.

Kochia control with bromoxynil decreased as the rain-free period after treatment decreased when no adjuvant was included (Figure 2b). Adding CO with bromoxynil improved rainfastness and kochia control when rain was applied at 1, 3, or 6 h after treatment. DC X2-5309 improved kochia control with bromoxynil more than CO at 7 DAT and reduced the rain-free period required to less than 1 h after treatment.

Herbicide uptake. Uptake of ^{14}C-bentazon by kochia increased from 1 to 24 h after application (Figure 3a). CO added at 1% (v/v) approximately doubled bentazon uptake at all times after application. DC X2-5309 increased bentazon uptake by four to five times more than bentazon applied without an adjuvant. Uptake of ^{14}C-bromoxynil increased from 1 to 24 h after application and was increased at 1, 3, and 24 h after treatment by adding CO (Figure 3b). DC X2- 5309 increased bromoxynil uptake by two to three times more than bromoxynil applied without any adjuvant.

Field trial. Bentazon and bromoxynil injury on kochia appeared quicker when DC X2-5309 was added than when no adjuvant was included or when CO was included. Bentazon controlled kochia better at 9 DAT when DC X2-5309 was added than when CO was added (Figure 4). Adding CO also increased bentazon activity on kochia, but less than DC X2-5309. Bentazon at 0.6 kg ha^{-1} plus DC X2-5309 controlled kochia similar to bentazon at 1.1 kg ha^{-1} plus CO.

Bromoxynil activity on kochia was not improved by adding CO to the spray solution at the two rates tested (Figure 4). However, adding DC X2-5309 increased bromoxynil activity on kochia at the 0.14 kg ha^{-1} rate. Kochia control with bromoxynil at 0.14 kg ha^{-1} plus DC X2-5309 was similar to that with bromoxynil at 0.28 kg ha^{-1} without an adjuvant (Figure 4).

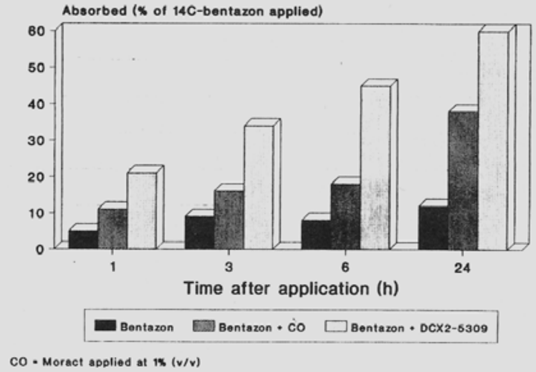


Figure 3a. Effect of two adjuvants on bentazon uptake by kochia.

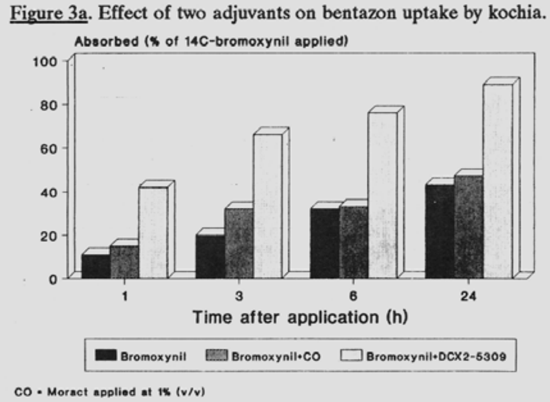


Figure 3b. Effect of two adjuvants on bromoxynil uptake by kochia.

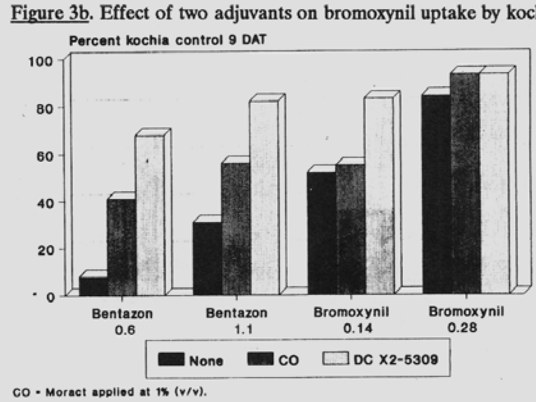


Figure 4. Kochia control in the field with two herbicides and two adjuvants.

SUMMARY

1. DC X2-5309 added at 1% (v/v) spray solution improved the control of kochia with bentazon, pyridate, and terbacil in greenhouse trials.
2. DC X2-5309 improved the rainfastness of bentazon and bromoxynil on kochia in greenhouse trials.
3. DC X2-5309 increased the uptake of ^{14}C-bentazon and ^{14}C-bromoxynil by kochia more than CO at 1, 3, 6, and 24 h after application in greenhouse trials.
4. in field trials DC X2-5309 added at 1% (v/v) improved control of kochia with bentazon and bromoxynil when herbicides were used at normally sublethal rates.

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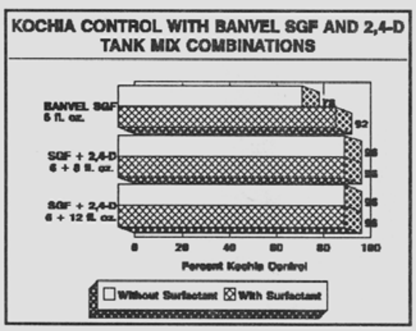
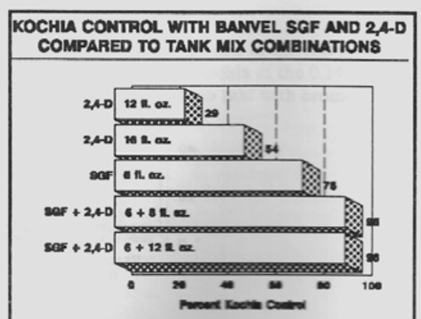
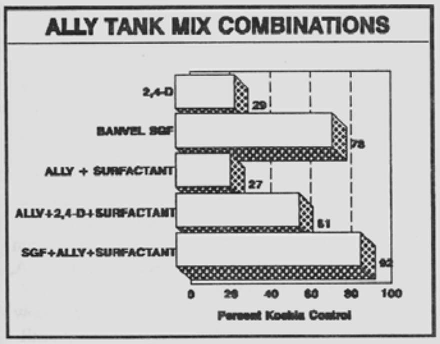
CONTROL OF SULFONYLUREA RESISTANT KOCHIA WITH DICAMBA. Product Development, Staff, Sandoz Agro North America, Englewood, CO 80111.

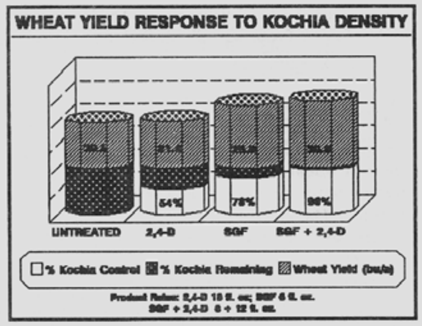
Abstract. Kochia is an annual broadleaf weed that infests small grain fields in the western United States and the prairie provinces of Canada. Repeated use of long residual sulfonylurea herbicides has shifted the kochia populations to biotypes in some areas which are not controlled with sulfonylurea herbicides.

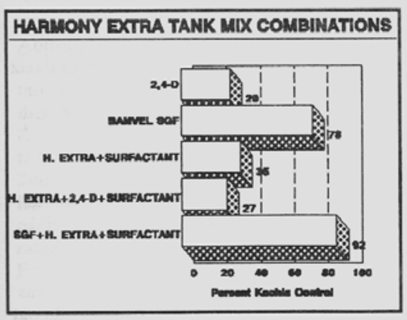
Trials conducted in 1991 show dicamba controls sulfonylurea resistant kochia (Figures). Dicamba alone at 0.094 to 0.125 lb/A gave fair to good kochia control, but dicamba tank mixes with metsulfuron methyl, thifensulfuron methyl plus tribenuron methyl, tribenuron methyl, or 2,4-D provide excellent control. Two-way tank mixes of dicamba plus sulfonylurea or 2,4-D control kochia as do three-way mixes of dicamba plus sulfonylurea plus 2,4-D. 2,4-D alone and in tank mixes with the sulfonylureas did not provide control of sulfonylurea resistant kochia. The continued increase of a kochia population resistant to sulfonylurea herbicides has resulted in dicamba for a resistant weed management strategy.






ALLY TANK MIX COMBINATIONS
2,4-D
29
BANVEL SGF
78
ALLY + SURFACTANT
27
ALLY+2,4-D+SURFACTANT
61
SGF+ALLY+SURFACTANT
92
0 20 40 60 80 100
Percent Kochia Control


WHEAT YIELD RESPONSE TO KOCHIA DENSITY
54%
78%
96%
UNTREATED
2,4-D
SGF
SGF + 2,4-D
% Kochia Control
% Kochia Remaining
Wheat Yield (bu/a)


HARMONY EXTRA TANK MIX COMBINATIONS
2,4-D
29
BANVEL SGF
78
H. EXTRA+SURFACTANT
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H. EXTRA+2,4-D+SURFACTANT
27
SGF+H. EXTRA+SURFACTANT
92
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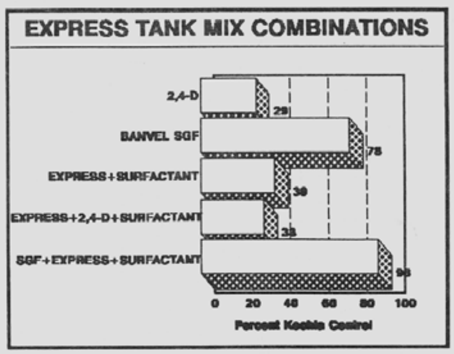
Percent Kochia Control


EXPRESS TANK MIX COMBINATIONS
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BANVEL SGF
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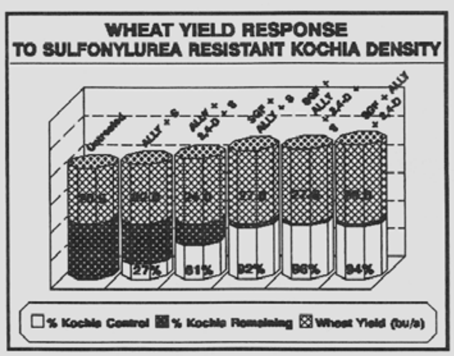
33
SGF+EXPRESS+SURFACTANT
96
0 20 40 60 80 100
Percent Kochia Control


WHEAT YIELD RESPONSE
TO SULFONYLUREA RESISTANT KOCHIA DENSITY
27%
61%
92%
96%
94%
% Kochia Control
% Kochia Remaining
Wheat Yield (bu/a)

AIR ASSIST SPRAYER ENHANCES WILD OAT CONTROL. J. M. Lish, and D. C. Thill, Research Associate and Professor, Plant, Soil, and Entomological Sciences Department, University of Idaho, Moscow, ID 83843.

Abstract. An air assist sprayer was evaluated against a conventional sprayer for wild oat control in small grains. The air sprayer has a power take off driven fan that moves air through a 6 inch aluminum pipe. The pipe has 1.25 inch holes on the bottom spaced every 7.2 inches A rubber grommet with a plastic deflector shield is inserted into each hole. Spray solution is carried into the side of each grommet and is directed onto the shield. The spray solution pressure is 4 psi. The air pressure is 21 inches of water at the grommet. The air pressure breaks the steady spray stream into small droplets. Spray volume was 5 gal/A. The conventional sprayer has 80°, flat fan, hydraulic nozzles spaced every 20 inches Delivery is 0.1 gal/min at 40 psi. Spray volume was 10 gal/A. Spray width was 15 ft for both sprayers. Diclofop at 0.5 and 1.0 lb/A, imazamethabenz at 0.23 and 0.38 lb/A, difenzoquat at 0.5 and 0.1 lb/A, and water (check) were applied with both the air assist and conventional sprayers at three locations. Spring wheat was the crop at Moscow (cv 'Edwall') and Greencreek (cv 'Owens'). 'Morex' spring barley was the crop at Nezperce. Diclofop and imazamethabenz were applied to wild oat with 1 to 4 leaves and difenzoquat was applied to wild oat with 3 to 5 leaves. Wild oat was evaluated visually and grain was harvested at maturity.

Wheat at Greencreek was chlorotic after diclofop and imazamethabenz treatments, but injury was no longer evident after 2 wk. Wheat at Moscow was chlorotic and stunted after diclofop and imazamethabenz treatments. The stunting was evident throughout the growing season. Injury was more severe with the air assist sprayer than conventional treatments. The injury difference between sprayers was more evident with low herbicide rates.

Wild oat control and wheat grain yield were not affected by sprayer type at Greencreek. This was the air assist sprayer premier test site and there were pressure control problems. The high volume hydraulic, centrifugal pump was replaced with a low volume, electric, roller pump that corrected the problem. Wild oat density was 1 to 3 plants/ft^2 and crop vigor was variable within the test area.

The wild oat infestation at Moscow was uniform at 36 plants/ft^2. Wheat grain from the check plots was 30 to 50% the grain yield of any other treatment. Single degree of freedom contrasts indicate that wild oat control, wheat test weight, and wheat grain yield were better with the air assist sprayer than the conventional sprayer. Wheat treated with difenzoquat had a lower grain yield than any other herbicide treatment.

The wild oat infestation at Nezperce was 3 to 20 plants/ft^2. The barley was competitive and most herbicide treatments resulted in good wild oat control. There were no differences between treatments. (Idaho Agricultural Experiment Station).

SULFONYLUREA-RESISTANT RUSSIAN THISTLE SURVEY IN WASHINGTON STATE.
G. P. Stallings, D. C. Thill, and C. A. Mallory-Smith, Graduate Research Assistant, Professor, and Post-Doctoral Research Fellow, Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83843.

Abstract. Herbicide-resistant weeds are rapidly becoming a new agricultural problem. The continuous use of sulfonylurea (SU) herbicides to control broadleaf weeds in small grains and right-of-ways has selected for herbicide-resistant Russian thistle populations. Currently, SU herbicide-resistant Russian thistle populations are found in several western states including Washington. A survey was initiated in March, 1991 to determine the distribution of SU-resistant Russian thistle in eastern Washington. The survey sample area was divided into 149 sectors and each sector was 374 km^2. The total sample area was 55,574 km^2. Seed was collected separately, by plant, from 30 plants at each site. There was one sample site per

sector. Site composite samples of 900 seeds were made from 30 seeds per plant. Composite sample seeds were planted in the greenhouse. Seedlings were screened for resistance with 105 g/ha chlorsulfuron at the 2- to 4-leaf stage. In 1991, 120 out of 149 sectors were surveyed. Seed was collected from plants in 55 sectors. The remaining 65 sectors contained no Russian thistle in 1991 but will be re-surveyed in 1992, along with the 29 unsurveyed sites. Resistant (R) plants were found in 22% of the sectors, 49% of the sectors had all susceptible (S) plants, and 29% of the sectors had a mixture of R and S plants. Studies are currently underway to determine the effects of seed-mediated gene flow between Russian thistle tumbleweed populations.

WEED MANAGEMENT IN A WHEAT, GRAIN SORGHUM, FALLOW, NO-TILL SYSTEM.
Jill Schroeder, Neal B. Christensen, and James D. Libbin, Assistant Professor, Assistant Professor and Professor, Department of Entomology, Plant Pathology and Weed Science, Agricultural Science Center at Clovis and Department of Agricultural Economics and Business, New Mexico State University, Las Cruces, NM 88003 and Clovis, NM 88101.

Abstract. Experiments were established in 1989 and 1990 at the Agricultural Science Center at Clovis, NM to evaluate the effectiveness of herbicides used for chemical fallow in a wheat, grain sorghum, fallow no-till farming system and the influence of fallow treatments on weed management in the following crop. The experiments are being repeated in 1991 and 1992. Experiments were established with a split-plot treatment arrangement in a randomized complete block design with four replications. Main plots were chemical fallow treatments and subplots were herbicide treatments in the following crop. Main plot size was 16 by 24 m and subplot size was 3 by 24 m. Each experiment was a component of the wheat, grain sorghum, fallow rotation; one experiment was initiated in the fallow period between grain sorghum and wheat and one in the fallow period between wheat and grain sorghum. During the fallow period, weed control was rated. Soil water content and soil nitrate content were measured just prior to planting the following crop. For each crop, data included visual ratings of injury and weed control and crop yield.

Experiment one was established after grain sorghum harvest in 1989. Fallow treatments were applied in May 1990, and included glyphosate plus 2,4-D as needed, chlorsulfuron plus 2,4-D, triasulfuron plus 2,4-D, metsulfuron plus 2,4-D, and an untreated control. All treatments controlled kochia and Palmer amaranth until planting. Soil nitrate and soil water content was similar in all plots prior to wheat planting. Wheat was planted in September 1990 and herbicides were applied to subplots. Subplot treatments included an untreated control, glyphosate at planting, glyphosate at planting followed by 2,4-D postemergence, and glyphosate at planting followed by 2,4-D plus metsulfuron postemergence. Weeds did not emerge in the wheat due to dry conditions and yields were less than 450 kg/ha.

Experiment two was established after wheat harvest in 1990. Fallow treatments were applied in July 1990, and included glyphosate plus 2,4-D as needed, atrazine, atrazine plus 2,4-D, atrazine plus metsulfuron, and an untreated control. Treatments containing atrazine controlled volunteer wheat but did not control kochia that emerged in spring, 1991. Glyphosate plus 2,4-D applied as needed controlled kochia. Soil nitrate and stored water tended to be lower in plots with poor kochia control prior to grain sorghum planting. Grain sorghum was planted in May 1991 and herbicides were applied to subplots. Subplot treatments included an untreated control, glyphosate at planting, glyphosate plus metolachlor at planting followed by atrazine postemergence, and glyphosate plus metolachlor at planting followed by atrazine plus dicamba postemergence. No grain sorghum emerged in plots with poor kochia control during fallow.

VARIABLE RESPONSE OF A POTENTIAL BIOCONTROL AGENT TO SNAKEWEED SPECIES. T. M. Sterling and D. C. Thompson, Assistant Professor and Assistant Professor, Department of Entomology, Plant Pathology and Weed Science, New Mexico State University, Las Cruces, NM 88003.

Abstract. Broom snakeweed (*Gutierrezia sarothrae*) and threadleaf snakeweed (*Gutierrezia microcephala*) are perennial half shrubs widely distributed in the western United States. *Gutierrezia sarothrae* and *G. microcephala* are closely related and can only be differentiated from one another during flowering. Snakeweeds negatively impact rangeland productivity and are target species for biological control efforts. Over 70 insect species are commonly found in association with broom snakeweed, including the native grasshopper, *Hesperotettix viridis*. *H. viridis* can defoliate snakeweed plants completely. Therefore, studies were initiated to determine if snakeweed species differences were detectable as measured by grasshopper preference, feeding and fitness. Second and third instar *H. viridis* were collected from field populations in southern Arizona and reared as a laboratory colony. Pairs of field-collected *G. sarothrae* and *G. microcephala* stems placed in a water-saturated florist block were set into separate cages and one adult female *H. viridis* was introduced to each cage. Water potentials for stems from each species were ca. - 0.4 MPa throughout the study. After 72 h, 17 grasshoppers were resting/feeding on *G. sarothrae* and only one was on *G. microcephala*. In addition, grasshoppers consumed more forage from *G. sarothrae* stems as compared to *G. microcephala* stems. However, development time of *H. viridis* was shorter and egg production was greater when fed *G. microcephala* as compared to *G. sarothrae* stems throughout the grasshopper life cycle. Despite an apparent preference for *G. sarothrae*, grasshoppers developed faster and had higher fecundity when fed *G. microcephala*. As a result, a snakeweed population consisting of *G. sarothrae* only may be suboptimal for *H. viridis* development and reproduction. This possibility should be explored before implementing biological control efforts such as augmentation of *H. viridis* on snakeweed infested rangeland.

DOWNY BROME AND FERTILIZER PLACEMENT EFFECTS ON RUSSIAN WHEAT APHID DAMAGE IN WINTER WHEAT. James M. Krall, Stephen D. Miller and Larry E. Bennett; Associate Professor, Professor, and Consultant, Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Downy brome has become a severe weed problem in several agricultural production systems in Wyoming, especially in winter wheat and rangeland. The spread and severity of downy brome in winter wheat has increased rapidly in recent years due to grower practices. As well as being competitive with winter wheat, downy brome also serves as a suitable alternative host for Russian wheat aphid (RWA). Wheat grown under conditions of elevated soil fertility maybe less effected by RWA as aphids are attracted to lighter shades of green. Wyoming winter wheat producers have faced a severe infestation of RWA 3 out of the last 5 yr.

Plots were established at the Research and Extension Centers at Archer in 1989 to 1991 and Torrington, Wyoming in 1990 to evaluate the effect of downy brome infestation and fertilizer placement on RWA damage in winter wheat. Plots were established under non-irrigation at Archer and sprinkler irrigation at Torrington and were 10 by 30 ft. with five replications arranged in a split-split plot. Winter wheat (var. Buckskin) was seeded in early to mid-September in all trials. Downy brome was seeded at the rate of 4 lb/A in infested plots and non-infested plots were hand weeded to remove volunteer downy brome. Fertilizer (40-20-0 and 80-40-0 lb/A at Archer and Torrington, respectively) treatments consisted of none, banding 0.5 inch below the wheat seed or broadcasting on the soil surface. Half of the experimental units were treated with insecticide (chlorpyrifos 0.5 lb/A) while the other half received none.

Downy brome infestations of 3.7 and 0.4 plants/ft^2 at Archer and Torrington respectively, increased RWA damaged winter wheat tillers over 200% at Archer under rainfed conditions and 34% at Torrington under irrigated conditions. Fertilizer tended (P=0.09) only to reduce RWA damaged winter wheat tillers

under rainfed conditions and reduced RWA damaged tillers under irrigated conditions. Limited moisture may have been a factor in the reduced response at Archer. Winter wheat yield and protein response to fertilizer placement was positive. Downy brome infestation influenced winter wheat at Archer where yields were 19 and 25 bu/A for infested and hand weeded plots, respectively. At Torrington, with a low level of infestation, no yield difference relating to downy brome was observed, although the low infestation level did result in increased RWA damaged tillers. The efficacy of chlorpyrifos in reducing RWA damage in winter wheat was not influenced by downy brome infestation or fertilizer placement. (Published with the approval of the Wyoming Agricultural Experiment Station).

DYER'S WOAD SEED PRODUCTION AND GERMINABILITY REDUCED BY SULFONYLUREA HERBICIDES. J. B. Asghari, J. O. Evans and S. A. Dewey, Research Assistant, Professor, and Associate Professor, Plants, Soils, and Biometeorology Department, Utah State University, Logan, UT 84322-4820.

INTRODUCTION

Dyer's woad is a rapidly spreading noxious weed of waste areas, rangelands and some crop settings in the intermountain region (1). Dyer's woad is a biennial or short lived perennial and is well suited to dry, rocky soils common to many hillsides of this region. Its native environment, Russia, is also similar to the intermountain region of America. These favorable conditions accelerated the expansion of the weed much faster than expected. From 1981 to 1989 the acreage infested in Utah increased 12-fold and the number of infested counties increased from 9 to 18. Most of the recent infestations occur in range and forests in the western states (1,2,3). These rapid expansions of dyer's woad coincide with reductions of other desirable plants. In addition to favorable soil and environmental conditions several plant biological characteristics and allelopathic compounds for competitive advantage make dyer's woad especially successful.

Extremely low application rates of metsulfuron may effectively inhibit dyer's woad pod formation and viable seed production as reported previously at these meetings (4). Dyer's woad fruits attach to branches by pedicels that leave distinct scars on the inflorescence branch when the fruit separates from its parent. The number of floral scars is perhaps the best induction of the potential number of fruits that can form along the branch and their numbers serve as base from which treatment affect can be measured.

The objectives of this study were to measure the extent to which metsulfuron inhibits seed production by treated dyer's woad plants; establish relationships between administered herbicide dosages and seed production; and determine viability of seed produced by treated dyer's woad plants receiving different herbicide dosages at various bloom stages.

MATERIALS AND METHODS

Two experimental sites were selected for this study, one on rangelands in North Logan where two tests were conducted adjacent to one another, and one in cropland in Mantua, Utah. Each experiment was established in a uniformly infested dyer's woad stand on June 5, 1990 in North Logan and June 6, 1991 in Mantua. The plots were 2.5 by 3 m and all treatments were replicated four times in a completely randomized design with six herbicide treatment rates. The rates of metsulfuron methyl for North Logan and Mantua were 0, 3, 5, 8, 12, and 16 g/ha, a second Mantua test contained 0, 1, 2, 3, 4, and 5 g/ha. Treatments were applied with a backpack CO_2 plot sprayer, calibrated to deliver 178 L/ha at 207 kPa pressure, when the average inflorescence was approximately at the mid blossom stage in each location.

Phenological and morphological changes in treated plants were compared with controls until harvesting. Each replication of treatments was harvested by randomly selecting three terminal branches from each of three inflorescence stalks and their number of floral scars, pods, and seeds determined. Hand threshed seed was germinated and the seedling root and shoot lengths determined.

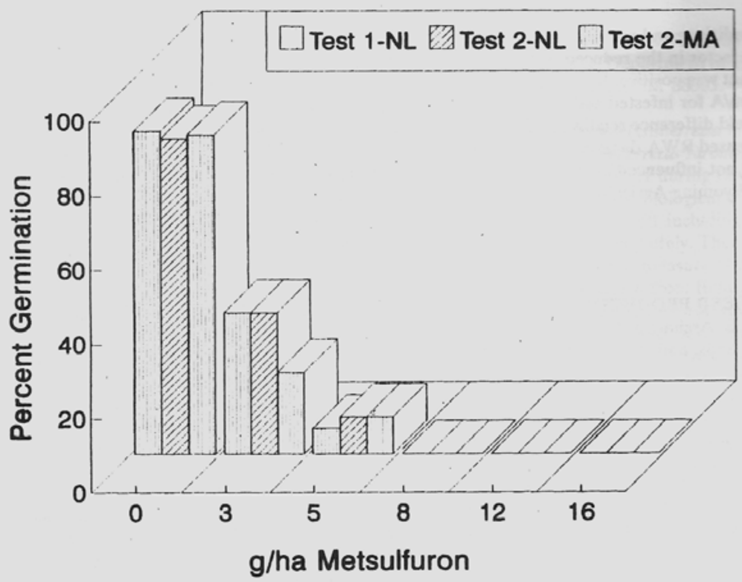


Figure 1. Germination of dyer's woad seed from plants treated with various dosages of metsulfuron in North Logan 1990, and Mantua, Utah, 1991.

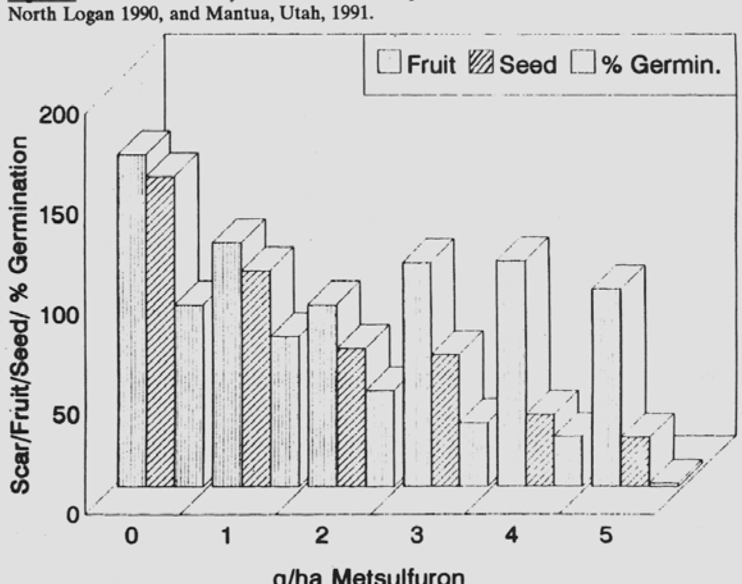


Figure 2. Fruit and seed formation and seed germination by dyer's woad plants treated with varying dosages of metsulfuron in Mantua, Utah, 1991.

RESULTS AND DISCUSSION

Compared with the controls, treated plants at both sites displayed stunted development, and the leaf color changed from green to dark purple and then yellowed and died. The degree of stunting and discoloration was dependant on herbicide dosage and inflorescence stage at herbicide application time. In plots receiving more than 5 g/ha herbicide, most dyer's woad fruits withered and dispersed before forming seeds, while seeds in fruits in control plots were still in the dough stage.

The average seed production of remaining fruits on selected inflorescence branches of treated plants was reduced by increasing the application dosage in all of the field trails (Table 1). Seed viability and germination was inversely related to herbicide rate in each experiment (Figure 1). Treated plants produced smaller and more malformed seed (Table 2). No seeds were produced in plots receiving more than 5 g/ha metsulfuron.

The inflorescence of dyer's woad is a panicle which divides to primary, secondary and tertiary branches or beyond depending on flowering vigor. Freshly harvested dyer's woad branches were examined and the number of floral scars recorded for each treatment. Floral scar initials were apparently formed prior to herbicide application since the number of scars was not altered even with elevated dosages of metsulfuron. The number of scars produced on branches harvested from each treatment provided the basis for percentage reduction of pods and seed due to metsulfuron application (Table 3). In the Mantua test where 0 to 5 g/ha metsulfuron was examined, an inverse relationship was observed between fruit and seed production and seed germination with level of herbicide applied (Figure 2). These results indicate that dyer's woad seed can be controlled in mid-blossom stages with 5 g/ha or more metsulfuron.

CONCLUSIONS

1. Metsulfuron may interfere with normal seed development of dyer's woad if applied at any generative stage.
2. Treating dyer's woad in flower with more than 5 g/ha metsulfuron inhibits viable seed production by reducing fruit formation, seed development and germinability of produced seeds.
3. Metsulfuron application during anthesis does not alter floral scar formation in dyer's woad.
4. Dyer's woad plants treated in blossom stage with less than 5 g/ha metsulfuron exhibits an inverse relationship between herbicide dosage and percent viable seed produced.

Table 1. Average number of fruit and seed produced by dyer's woad treated with metsulfuron in North Logan, 1990 and Mantua, Utah, 1991.

	North Logan					
	Test 1		Test 2		Mantua	
Treatment	Fruit	Seed	Fruit	Seed	Fruit	Seed
- g/ha -						
Control	141	124	154	141	138	125
3	91	53	7	37	95	46
5	42	10	36	11	39	6
8	33	4	27	2	36	4
12	14	1	12	1	16	1
16	17	0	10	1	16	0

Table 2. Average weight per 100 seed of metsulfuron treated dyer's woad in 1990 and 1991 field tests.

Treatment[a]	1990		1991	
	Test 1	Test 2	Test 1	Test 2
- g/ha -	mg			
Control	150	161	179	172
1	---	---	170	---
2	---	---	131	---
3	117	110	83	67
4	---	---	77	---
5	67	53	27	32

[a]Treatments with more than 5 g/ha did not produce sufficient seed to determine average weight.

Table 3. Percent fruit formation on metsulfuron treated dyer's woad plants in two tests in Mantua, Utah 1991.

Treatment	Test 1	Test 2
	Fruit/floral scar	Fruit/floral scar
- g/ha -		
Control	91	91
1	92	--
2	77	--
3	77	62
4	77	--
5	69	27
8	--	22
12	--	11
16	--	11

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A PLANT PROCESS MODEL FOR WEED MANAGEMENT IN ONIONS. C. M. Dunan and P. Westra, Graduate Research Associate and Associate Professor, Department of Plant Pathology and Weed Science, Colorado State University, Ft. Collins, CO 80523.

Abstract. Onions are a very important and currently profitable crop in Colorado ($50,000,000 annual revenue from 14,000 A) and other western states. Onion yields/A have increased during the last 15 yr from about 310 cwt/A in 1975 to 400 cwt/A in 1989. Improved weed management has been an important factor in this increased productivity. Due to the low ability of onions to compete with weeds, weed control operations constitute a high proportion of onion production input costs. The high rates of herbicides used in onions, and the use of large amount of hand weeding requires a more in depth assessment of the economic return of weed management strategies. Bioeconomic models for weed control provide a good framework to analyze different weed control management strategies. A plant process model is being developed in the Weed Science department of Colorado State University. The model simulates emergence, growth and competition of weeds and onions based on daily radiation and temperature. Yield estimations with and without weed control strategies are compared to determine the profitability of weed control strategies. Since onions require multi-weed control operations, the dynamic of competition is a requirement in the evaluation of weed management strategies. Weed and onion time of emergence, density, and duration of competition have been determined as important factors that affect onion yield and size. Because onion size affects onion price, weed competition has a major impact on onion price wich is considered a variable in the model. Reduction in herbicide applications and hand weeding operations, trade offs between early chemical control and phytotoxicity on the crop can easily be analyzed with the model.

WILD MUSTARD INTERFERENCE IN SUGARBEET. A. Mesbah, S. D. Miller, K. J. Fornstrom and D. Legg; Graduate Assistant, Professor; Department of Plant, Soil and Insect Sciences, Professor; Department of Civil Engineering and Assistant Professor; Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, Wyoming 82071.

Abstract. Field experiments were conducted at Powell, Wyoming, in 1990 and 1991 to determine the influence of various densities and durations of wild mustard competition in sugarbeet. Sugarbeet root yields decreased as wild mustard densities increased. At densities of 0.2, 0.4, 0.8, 1.6 and 3.2 wild mustard plants/m of row, root yields were reduced 13, 22, 19, 40, and 56%. Similarly, root yield decreased as weeks of competiton from 1.6 wild mustard plants/m of row increased. Root yields were reduced 7, 19, 19, 29 and 35% at 2, 4, 6, 8, and 10 weeks of competition after sugarbeet and wild mustard seedling emergence. Sugar content was not influenced by various densities or durations of wild mustard competition. Based on regression analysis the lowest density of wild mustard plants required to economically reduce root yield was 0.3 plants/m of row, while the time required to control wild mustard before realizing appreciable root yield loss was 0.9 weeks.

POSTEMERGENCE HERBICIDE PERFORMANCE IN SEEDLING ALFALFA. M. Canevari, D. Colbert, and J. P. Orr, Farm Advisor, University of California, Stockton, CA 95205, Research and Development, American Cyanamid, Lodi, CA 95202, and Extension Service, University of California, Sacramento, CA 95827.

Abstract. Weed control in seedling alfalfa is essential to produce high yielding, top quality alfalfa. Weeds compete with alfalfa for water, nutrients, and light. Increased stand establishment, stand life, and decreased drying time, which leads to faster baling thus reducing risk to inclement weather, are important reasons for good weed control. The presence of poisonous weeds, such as common groundsel and fiddleneck, results in unmarketable hay. The total impact of an excellent economic weed control system means the difference between profit and loss to the grower.

This progress report is an accumulation of weed management research conducted in San Joaquin and Sacramento Counties. The data is a summary of 10 yr of research evaluating postemergence herbicides currently registered or pending registration for use on newly planted alfalfa. This publication lists nine herbicides at different rates and the percent control that could be expected on 36 broadleaf weeds and eight grassy weeds. This information is illustrated in the form of a susceptibility chart. The contents also include yield and analysis of two herbicide trials in seedling alfalfa.

The intent of this publication is to provide information to growers, advisors, and managers for herbicide performances on certain weed species within a specific geographic boundary in the Central Valley of California. Copies can be obtained by writing to: Mick Canevari, University of California, Cooperative Extension, 420 South Wilson Way, Stockton, CA 95205.

ESTABLISHING EURASIAN ORIGIN(S) OF LEAFY SPURGE USING CPDNA MARKERS. Martha Rowe, Robert A. Masters, Scott J. Nissen, and Donald J. Lee, Research Associate, Range Scientist, Assistant Professor, and Assistant Professor, Department of Agronomy, University of Nebraska, and USDA-ARS, Lincoln, NE 68583-0915.

Abstract. Leafy spurge is recognized as the most serious non-endemic perennial weed on rangeland in the Central and Northern Great Plains. Long-term control of leafy spurge will require the use of biological control organisms. Present biological control efforts are ineffective because of a failure to match North American leafy spurge genotypes with appropriate biocontrol organisms from Eurasia. Chloroplast DNA (cpDNA) restriction fragment length polymorphisms were analyzed to assess genetic variation and relatedness among selected individuals representing North American and Eurasian leafy spurge and within populations of North American leafy spurge. Total DNA was extracted from young leaves and digested with the restriction endonuclease, Eco RI. CpDNA fragment patterns were determined by Southern blot analysis using mung bean (*Vigna radiata* L.) cpDNA probes. Each of the 14 mung bean cpDNA probes hybridized to digested DNA of accessions from Nebraska, Montana, Austria, Italy, and Russia. Seven of these probes revealed polymorphic fragments. Four of the probes that showed unique polymorphisms were used to assess cpDNA variation within leafy spurge populations from Colorado, Nebraska, North Dakota, and South Dakota. At least two cpDNA fragment patterns were found in these populations. Some populations exhibited only one type of cpDNA fragment pattern, while other populations contained a mix of DNA fragment patterns. Further research is needed to assess cpDNA variation within Eurasian populations of leafy spurge. Eurasian origins of North American leafy spurge genotypes can be determined once cpDNA variation has been quantified.

WEED SURVEY OF PEPPERMINT FIELDS IN THE FLATHEAD VALLEY, MONTANA. Kristi Carda, Pete Fay, R. N. Stougaard, and T. K. Keener. Graduate Research Assistant, Professor, Montana State University, Bozeman, MT 59717, Research Agronomist, and Research Specialist II, Northwestern Agricultural Research Center, Kalispell, MT 59901.

INTRODUCTION

Peppermint has been grown in the Flathead valley of Montana since 1968. The oil is sold primarily for human consumption, so the crop must be grown weed-free for flavor and color purposes. Few herbicides are registered for weed control in peppermint. Although numerous cultural and chemical control practices exist, weeds continue to be a problem for the peppermint producer.

A weed survey, based on the method of Thomas (1) was conducted in 34 of the 58 mint fields in the Flathead valley in June of 1991. In addition, producers completed a questionnaire for each field to provide background information on the weed control practices used in each field including cultural practices, herbicide use and crop rotations before and after peppermint production. Producers were asked to identify the weed they felt was the most troublesome weed problem in each mint field.

The purpose of this survey was to identify the weed species in peppermint fields, to determine which weed control practices were being used, and to determine the effectiveness of the various control practices.

MATERIALS AND METHODS

Thirty-four of 58 peppermint fields listed with the Western Montana Mint Growers Association of Kalispell, MT were surveyed in June of 1991. Peppermint is commonly grown in a given field for 5 to 6 yr, so an effort was made to select fields of each age in an attempt to record weed species shifts over time. Permission to survey fields was obtained from each peppermint producer prior to surveying fields. The survey method used was developed by Thomas (1). Twenty locations were surveyed in each field. The locations were selected by using an "M" pattern. At each location, weed species/m^2 were counted using a wire frame. Weed species were reported using common names accepted by the Weed Science Society of America. Weed populations were quantified using the seven measurements described.

Frequency. The number of fields in which a given species occurred at least once. Frequency is expressed as a percentage of the fields containing the weed out of 34 surveyed fields. The equation was:

$$F_k = \frac{\sum_{n=1}^{n} Y_i}{n} x\ 100$$

Where F_k = frequency value for species k
Y_i = presence (1) or abscence (0) of species k in field i
n = number of fields surveyed

Field uniformity. The number of individual sampling locations in which a species occurred. It was expressed as a percentage of the total number of sampling locations for all fields (34 fields by 20 sampling locations). Field uniformity is a valuable measurement in that it measures the distribution of a weed

Table 1. Frequency, occurrence, density, and relative abundance of 40 weed species common to mint fields surveyed in 1991.

Plant species	Frequency	Field uniformity	Occurrence field density	Mean field density	Mean occurrence field density	Relative abundance
	%	%	%	No. m^{-2}		%
Wild oat (*Avena fatua* L.)	55.9	18.8	42.7	2.4	4.4	47.5
Quackgrass (*Agropyron repens* L.)	44.1	11.9	21.3	0.5	1.2	28.3
Common groundsel (*Senecio vulgaris* L.)	55.9	10.1	23.0	0.5	0.85	29.3
Catchweed bedstraw (*Galium aparine* L.)	47.1	8.1	15.3	0.4	0.9	22.1
Dandelion (*Taraxacum officinale* W.)	35.3	6.5	10.0	0.1	0.3	19.9

Table 2. Frequency, occurrence, density, and relative abundance of 40 weed species common to first yr mint fields surveyed in 1991.

Plant species	Frequency	Field uniformity	Occurrence field density	Mean field density	Mean occurrence field density	Relative abundance
	%	%	%	No. m^{-2}		%
Wild oat (*Avena fatua* L.)	67.0	36.7	61.2	8.1	0.9	55.4
Barley (*Hordeum vulgare* L.)	78.0	19.4	48.5	0.5	5.6	42.0
Quackgrass (*Agropyron repens* L.)	56.0	22.8	28.5	0.9	10.0	32.4
Canada thistle (*Circsium arvense* L.)	67.0	13.3	22.2	1.0	11.1	26.0
Wheat (*Triticum aestivum* L.)	44.0	13.9	13.9	0.1	1.1	19.6

Table 3. Frequency, occurrence, density, and relative abundance of 40 weed species common to second yr mint fields surveyed in 1991.

Plant species	Frequency	Field uniformity	Occurrence field density	Mean field density	Mean occurrence field density	Relative abundance
	%	%	%	No. m^{-2}		%
Wild oat (*Avena fatua* L.)	75.0	21.9	54.7	0.7	0.1	74.5
Catchweed bedstraw (*Galium aparine* L.)	75.0	13.7	34.3	1.1	0.1	50.7
Common groundsel (*Senecio vulgaris* L.)	62.5	8.1	13.5	0.1	0.01	27.9
Meadow salsify (*Tragopogon pratensis* L.)	50.0	5.0	6.2	0.07	0.01	17.4
Russian thistle (*Salsola iberica* S&P)	25.0	7.5	6.2	0.2	0.03	16.9

species in all of the fields surveyed. High uniformity indicates that a weed species occurs frequently throughout all of the fields surveyed. The equation was:

$$U_k = \frac{\sum_{n=1}^{n} \sum_{n=1}^{20}}{20n} X_{ij} \ x \ 100$$

where U_k = field uniformity value for species k
x_{ij} = presence (1) or absence (0) of species in quadrant j in field

Occurrence field uniformity. The number of sampling locations in which a species occurred in a given field. It was expressed as a percentage of the total number of sampling locations of those fields where the species occurred. Occurrence field uniformity measures the distribution of a weed species throughout those fields where that species occurs. A high occurrence field uniformity indicates that a weed species occurs frequently throughout those fields where that weed species is found. This value is especially useful for farmers who do <u>not</u> have the weed. They should try to provide the management needed to prevent introduction of that weed into a given field. The equation used was:

$$UA_k = \frac{\sum_{n=1}^{n} \sum_{n=1}^{20}}{20 \ (n-a)} X_{ij} \ x \ 100$$

where UA_k = occurrence field uniformity value for species k
a = the number of fields in which the species is absent

Mean field density. Calculated by totalling each field density for a species and dividing by the total numberof fields surveyed. Mean field density measures the average density of a weed species throughout all of the fields surveyed. The equation used was:

$$D_i = \frac{\sum_{n=1}^{20}}{20} Z_j$$

where D_i = density (expressed as number/m^2) value of species in field i
Z_j = number of plants in quadrant j (a quadrant is 1.0 m^2)

$$MFD_k = \frac{\sum_{n=1}^{34}}{n} D_i$$

Table 4. Frequency, occurrence, density, and relative abundance of 40 weed species common to third yr mint fields surveyed in 1991.

Plant species	Frequency	Field uniformity	Occurrence field density	Mean field density	Mean occurrence field density	Relative abundance
	%	%	%	No. m^{-2}		%
Quackgrass (*Agropyron repens* L.)	60.0	3.2	8.0	0.9	0.2	56.7
Wild oat (*Avena fatua* L.)	40.0	2.2	3.7	0.2	0.04	32.8
Canada thistle (*Circsium arvense* L.)	60.0	2.0	5.0	0.7	0.14	39.1
Meadow salsify (*Tragopogon pratensis* L.)	60.0	1.4	1.5	0.1	0.02	23.6
Catchweed bedstraw (*Galium aparine* L.)	40.0	1.2	2.0	0.1	0.02	20.8

Table 5. Frequency, occurrence, density, and relative abundance of 40 weed species common to fourth yr mint fields surveyed in 1991.

Plant species	Frequency	Field uniformity	Occurrence field density	Mean field density	Mean occurrence field density	Relative abundance
	%	%	%	No. m^{-2}		%
Common groundsel (*Senecio vulgaris* L.)	71.4	15.0	37.5	1.1	0.2	64.5
Wild oat (*Avena fatua* L.)	57.1	10.0	16.7	0.5	0.1	37.4
Meadow salsify (*Tragopogon pratensis* L.)	71.4	5.7	14.3	0.06	0.01	32.2
Quackgrass (*Agropyron repens* L.)	12.8	11.4	14.3	0.3	0.05	29.7
Catchweed bedstraw (*Galium aparine* L.)	42.8	6.4	8.0	0.2	0.03	22.7

Table 6. Frequency, occurrence, density, and relative abundance of 40 weed species common to 6 yr and older mint fields surveyed in 1991.

Plant species	Frequency	Field uniformity	Occurrence field density	Mean field density	Mean occurrence field density	Relative abundance
	%	%	%	No. m^{-2}		%
Common groundsel (*Senecio vulgaris* L.)	100.0	30.0	150.0	1.2	0.2	77.7
Meadow salsify (*Tragopogon pratensis* L.)	80.0	18.0	90.0	0.3	0.1	49.2
Dandelion (*Taraxacum officinale* W.)	60.0	16.0	40.0	0.3	0.1	31.3
Kentucky bluegrass (*Poa pratensis* L.)	40.0	10.0	16.7	1.3	0.3	17.7
Prickly lettuce (*Lactuca scariola* L.)	40.0	5.0	8.3	0.1	0.03	11.3

Mean occurrence field density. Calculated by totalling each field density for a given species and dividing only by those fields where the species occurred. Mean occurrence field density measures the average density of a weed species in only those fields where it occurred. The equation used was:

$$MOFD_k = \frac{\sum_{n=1}^{n}}{n-a} D_i$$

where a = the number of fields in which species is absent

Relative abundance (RA). The RA is a composite value of the frequency, occurrence, and density for a species. Relative abundance has no units and is used to compare the relative abundance of one species to another. For example, a species with an RA of 36 would be twice as abundant as a species with an RA of 18.

The equation to calculate RA was:

$$RA = RF_k + RU_k + RD_k$$

where

$$RF_k = \frac{\text{frequency of species } k}{\text{sum of frequencies for all species}} \times 100$$

$$RU_k = \frac{\text{field uniformity of species } k}{\text{sum of uniformities for all species}} \times 100$$

$$RD_k = \frac{\text{mean field density of species } k}{\text{sum of MFD for all species}} \times 100$$

RESULTS AND DISCUSSION

The five most common weed species occurring in all 34 peppermint fields, in order, were wild oat, quackgrass, common groundsel, catchweed bedstraw and Canada thistle. The five most common weed species occurring in the nine first yr peppermint fields surveyed were, in order, wild oat, barley, quackgrass, Canada thistle, and wheat. In the eight second yr peppermint fields surveyed, wild oat, catchweed bedstraw, Russian thistle, common groundsel, and meadow salsify were most common. The five most common weed species in the five third yr peppermint fields surveyed were quackgrass, wild oat, Canada thistle, meadow salsify, and catchweed bedstraw. The most abundant five weed species in the seven fourth yr peppermint fields surveyed were common groundsel, wild oat, quackgrass, meadow salsify, and catchweed bedstraw. In the five peppermint fields surveyed that were six yr old or older, common groundsel, meadow salsify, dandelion, kentucky bluegrass and prostrate pigweed, were the most frequent weeds found.

ACKNOWLEDGEMENT

We would like to thank the Western Montana Peppermint Growers Association for providing the financial support for this survey. We appreciate the cooperation of each grower who permitted access to his fields.

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TEACHING WEED SEEDLING IDENTIFICATION TO PRODUCERS. Kristi M. Carda, Michelle R. Christenson, and Peter K. Fay, Research Assistant, Student, and Professor, Department of Plant and Soil Science, Montana State University, Bozeman, MT 59717.

INTRODUCTION

Many farmers in Montana cannot identify weed seedlings. Correct weed identification is important so that proper herbicides can be selected and applied in a timely manner. A weed seedling identification workshop was developed to provide producers with a "hands on" learning experience.

MATERIALS AND METHODS

A broadleaf seedling key, developed by Dr. James Nelson was used which features the 22 most common weed species of cultivated crops in Montana (Table). A planting date calendar was developed so that plants were in the two leaf stage for each workshop. The range of planting dates varied from 17 to 40 days before the transplanting date (Table). A letter was sent to each county agent in Montana offering the workshop to the first fifteen who responded. Workshops were conducted in April and May, 1991.

Eighteen species were grown for the workshops. Seedlings were transplanted into "cell packs", each containing six 4- by 4- by 6-cm deep cells approximately 1 week before each workshop to allow for recovery from transplanting. The first cell pack contained the six easiest species to identify. Individual plants in the next two six packs were progressively harder to identify. Cell packs were transported to workshops on a six shelf rack in the back of a covered pick-up truck.

The weed seedling identification workshop was conducted in 23 locations. At the beginning of the workshops the instructor introduced the key by presenting slides. The instructor helped participants with the first six plants but gave little or no help with the second cell pack. After each individual plant in the second cell pack was identified, results were verified with the key. The third cell pack was used as a quiz without help from the instructor. After seedling identification, a slide of each adult plant was shown in order to form a connection between seedling and mature plant.

RESULTS AND DISCUSSION

The weed seedling key was used successfully with a 95% correct identification rate by workshop participants. The workshop required minimal effort, and participants remained extremely attentive throughout the entire session. The participants left the workshop with confidence in their ability to use the weed seedling key.

Table. Planting time in days before transplanting for 18 weed species grown for weed seedling identification workshops in Montana.

Weed species	Planting time (Days before transplanting)
Shepherdspurse (*Capsella bursa-pastoris* (L.) Medic.)	40
Prostrate pigweed (*Amaranthus blitoides* S. Wats.)	40
Tumble mustard (*Sisymbrium altissimum* L.)	30
Field pennycress (*Thlaspi arvense* L.)	30
Redroot pigweed (*Amaranthus palmeri* S. Wats.)	30
Eastern black nightshade (*Solanum nigrum* L.)	30
Pinnate tansy mustard (*Descurainia pinnata* (Walt.) Britt)	25
Catchweed bedstraw (*Galium aparine* L.)	25
Wild buckwheat (*Polygonum convolvulus* L.)	25
Russian thistle (*Salsola iberica* Sennen)	23
Prickly lettuce (*Lactuca serriola* L.)	23
Common lambsquarters (*Chenopodium album* L.)	23
Cowcockle (*Vaccaria pyramidata* Medic.)	23
Corn gromwell (*Lithospermum arvense* L.)	23
Wild sunflower (*Helianthus annuus* L.)	23
Common mallow (*Malva neglecta* Wallr.)	20
Kochia (*Kochia scoparia* (L.) Schrad)	17
Wild mustard (*Brassica kaber* (DC.) Wheeler)	17

EVALUATING WILD OAT SEED COLLECTIONS FOR HERBICIDE RESISTANCE. Philip A. Trunkle, Peter K. Fay, William E. Dyer and Edward S. Davis. Student, Professor and Assistant Professors. Department of Plant and Soil Science, Montana State University, Bozeman 59717 and Central Montana Agricultural Research Center, Moccasin, MT 59462.

INTRODUCTION

Wild oat is troublesome throughout the world and is the number one weed problem in cereal grain crops in Montana. Wild oat herbicides have been used with good results since the mid-1960's, but control problems have been observed recently. Wild oat biotypes have been identified that are resistant to triallate in Canada and to diclofop methyl in Australia, Oregon and South Africa. A screening program was initiated at Montana State University in 1989 to screen weeds, including wild oat, for herbicide resistance to permit early detection. Early detection will provide time to institute herbicide resistance management strategies.

MATERIALS AND METHODS

Each spring letters are sent to farmers, chemical dealers and chemical company representatives encouraging them to collect wild oat seeds from plants suspected to be resistant to herbicides. Upon arrival, seed is cleaned and catalogued. To date, 112 lines have been collected.

Triallate greenhouse study. Seventy-one lines were screened with triallate. Seeds were imbibed in water for 24 hr in a petri dish and poked with a sterile needle in the midpoint of the dorsal side to stimulate germination. Soil (Bozeman silt loam: peat moss, 1:1 v/v) was treated with triallate (1.1 kg/ha) and incorporated in a soil mixer for 20 minutes. Ten seeds of each line were placed in single rows 5 cm apart in 33-cm by 51-cm by 9-cm deep flats filled with either treated or untreated soil. There were 9 rows per flat including one row of a susceptible biotype. There were three replications per treatment. Each line was rated for percent injury 21 days after treatment (DAT) and was harvested to determine dry matter production.

Diclofop-methyl and imazamethabenz methyl ester study. Three lines suspected to be resistant to diclofop-methyl and four lines suspected to be resistant to imazamethabenz methyl ester were screened. Ten seeds of each line along with a susceptible line were planted in separate rows as described above. Plants were sprayed at the 2- to 4-leaf stage with diclofop methyl (1.1 kg/ha) and imazamethabenz methyl ester (1.1 kg/ha). The lines were rated for percent injury 21 DAT.

RESULTS AND DISCUSSION

Triallate study. The collected lines were screened and placed into four categories to describe their reaction to triallate: strongly resistant (SR) with less than 30% injury, resistant (R) with 30 to 70% injury, susceptible (S) 70 to 90% injury and strongly susceptible (SS) 90 to 100% injury. Wild oat injury ranged from 0 to 100%. Some lines did not emerge from the soil and were therefore classified as strongly susceptible. The seed poking method worked well and germination was 70 to 80% of previously dormant wild oat seeds. The triallate rate used (1.1 kg/ha) is approximately a 4X rate in comparison to field efficacy. This rate is an effective single rate to use in a screen since the resistant plants survived with little injury, while the susceptible lines did not emerge. The screening technique has been used successfully to identify triallate resistant wild oat lines from Montana.

Diclofop methyl, imazamethabenz methyl ester study. To date, no lines of wild oat from Montana have been found that are resistant to either herbicide. Lines from Oregon resistant to diclofop methyl were used to serve as internal controls for greenhouse testing. The rates tested, 1.1 kg/ha of both herbicides worked well under greenhouse conditions.

CONCLUSIONS

There are four herbicides currently labeled for wild oat control in Montana. Wild oat lines have been collected in other areas of the world that are resistant to some or all of the wild oat herbicides. It is imperative that herbicide resistant lines are identified as quickly as possible so proper management and containment strategies can be devised or loss of the wild oat herbicides could occur.

A greenhouse screening technique which involves seed poking overcomes dormancy. A rate of 1.1 kg/ha of triallate, diclofop methyl and imazamethabenz methyl ester provided excellent control of susceptible wild oats, but did not injure triallate and diclofop methyl resistant lines significantly. This screening method can provide positive identification of resistant lines 30 days after viable seeds are collected.

WEED CONTROL USING CARBON DIOXIDE LASERS. A. J. Bayramian, P. K. Fay, and W. E. Dyer.
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INTRODUCTION

Carbon dioxide lasers can be used as effective weed control technology in a manner analogous to the rope wick applicator. Carbon dioxide lasers project straight beams of intense light which can be used like hedge trimmers to remove the tops of weeds above crops. A research project was conducted during the summer of 1991 to measure the laser energy levels needed to clip wild oat (*Avena fatua* L.) and volunteer rye (*Secale cereale* L.) heads. In addition, the response of both weeds to clipping once, twice, or three times was measured to determine the impact of clipping on reproductive potential.

Results of laser burn studies indicate that xylem and phloem translocation to wild oat and volunteer rye panicles can be blocked with 262 joules/cm^2 of tissue. Since peduncle diameters averaged 1.1 mm, and the beam diameter was 0.6 cm, a 1000 watt carbon dioxide laser would require 0.0173 seconds to cause lethal injury to a single wild oat panicle or volunteer rye spike. Cost estimates indicate that the power requirement of a 1000 watt laser to treat 1 A of land lightly infested with wild oats would be less that five cents. Results indicate that two clippings about two weeks after wild oat and volunteer rye heads emerged above the crop significantly reduced seed production, reducing reproductive potential to low levels.

MATERIALS AND METHODS

Laser burn studies. Burn studies were initiated in the spring of 1991 using a 10 watt carbon dioxide laser. Weed peduncles of various widths were placed in front of the laser beam for fixed amounts of time. Wattage of the laser was measured by a laser power meter, and timing was done with a stop watch. The peduncle widths were measured with a caliper and treated stems were labeled with the energy treatment level used and the peduncle width. Plants were then placed in the green house after treatment. After 1 week the effect of laser treatment on the tissue above the burned area was recorded based on the level of plant wilting. Results were then correlated with the laser energy used to estimate the energy needed to kill the developing seed head or panicle.

Seedhead clipping studies. Seed viability and plant response to simulated burning was tested using rye and wild oat. Heads were cut to mimic laser cutting. Each plant was cut with scissors just below either the spike (rye) or panicle (wild oat). The cut plant was flagged, and the detached plant material was placed in a bag and stored at room temperature. Plants were clipped every 3 to 5 days with eight replications. Just before grain harvest, flagged plants that were previously clipped were harvested, labeled and bagged. Finally, seed germination tests were performed on seed from each plant and from seed collected in the cut material from each plant.

RESULTS AND DISCUSSION

Laser burn studies. Burn studies were performed on several weed species in an attempt to determine the range of energies required to kill weeds. The most cost effective applications from an energy requirement standpoint were wild oat and rye. When stems were moved through the laser beam, 262 joules of energy were required per cm^2 of peduncle tissue to block translocation of water to the developing seeds. Since the average peduncle width was 1.1 mm, 17.3 joules of laser energy was needed per peduncle. It would take 1.73 seconds per peduncle using a 10 watt laser. The laser power needed to operate under field conditions would probably be at least 1000 watts therefore a 1000 watt laser could "kill" a peduncle in 0.0173 seconds.

Seedhead clipping studies. Clipping studies indicate that seed production per plant can be decreased dramatically with a single cutting. Both wild oat and rye plants did produce additional tillers after clipping so it was not possible to totally eliminate seed production by a single clipping.

CONCLUSIONS

Laser weed control appears to have potential for certain weed species, and may be cost effective. If utilized during certain critical time periods, CO_2 lasers could reduce wild oat and rye seed production.

POSTEMERGENCE HARROWING FOR WEED CONTROL IN SPRING WHEAT AND BARLEY.

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INTRODUCTION

Prior to the development of herbicides, mechanical implements were infrequently used for postemergence harrowing of cereals for weed control. These implements were only partially effective and were not specifically designed for weed control. Postemergence harrowing was used primarily for crop salvage and was rarely used after the advent of herbicides. A current focus in much of agricultural research is to reduce herbicide use. Postemergence harrowing of cereals may have potential as a weed control technique.

MATERIALS AND METHODS

Field plots were established to determine the efficacy of, and crop response to postemergence harrowing. 'Newana' spring wheat and 'Gallatin' barley were planted at a seeding rate of 90 and 79 kg/ha respectively, 5 cm deep in rows 15 cm apart on May 8, 1991 at the Post Research Farm, Bozeman. The plots were 2.1 m by 2.3 m with six replications.

The efficacy of a flextine harrow and a spiked tooth harrow were compared for weed control and crop injury. Plots were harrowed perpendicular to the seeded rows at the 3-, 5-, and 7- leaf stage of wheat and barley with a garden tractor operated at a speed of 6.4 km/h. Plots were harrowed once, twice, or three times. Additional treatments included an untreated control and a herbicide treatment using 0.28 kg/ha bromoxynil and 0.56 kg/ha MCPA isoocytl ester applied with a CO_2-pressurized backpack sprayer operated at 176 kPa in 30 L/ha. Weed response to treatments was measured by counting the plant number of each species in six 0.09 m^2 random locations per plot on June 20,1991. Crops were harvested on August 21, 1991 using a small plot combine.

RESULTS AND DISCUSSION

Crop yield. Harrowing up to three times did not reduce yield of spring wheat or barley (Figure 1). Harrowing spring wheat at the three leaf stage with a spiked toothed harrow increased yield 18%.

Crop injury. Visual injury was recorded on July 11 and August 6, 1991. Visual injury on July 11 was extensive in plots that were harrowed more than once. Significant visual injury was still noted 57 days after harrowing when spring wheat was harrowed two and three times with a spiked tooth harrow (Figure 2). The injury was not reflected in the final yield (Figure 1).

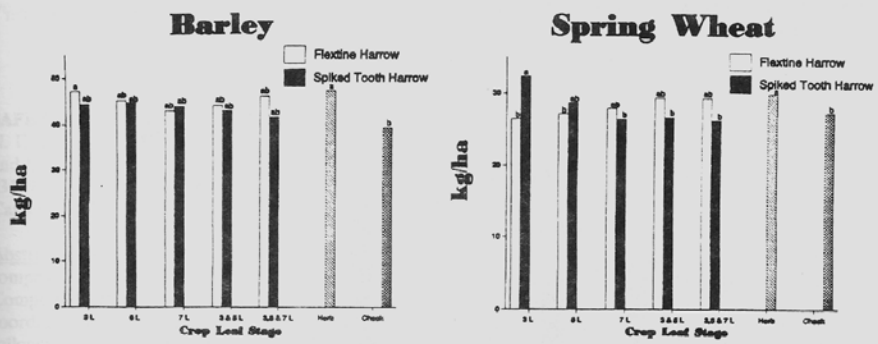

Figure 1. The yield of spring wheat and barley harrowed once, twice, and three times at the 3-, 5-, and 7-leaf stage with two harrow types.

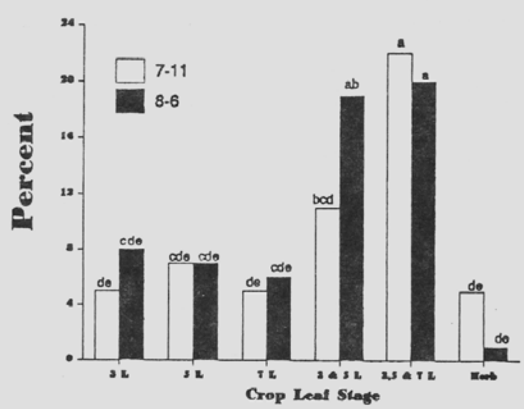

Figure 2. Visual injury of spring wheat on July 11 and August 6, 1991 that was harrowed once, twice, and three times at the 3-, 5-, and 7-leaf stage with a spiked tooth harrow.

Weed control. Harrowing at the 3 leaf stage of wheat and barley provided 66% and 62% control of kochia with the flextine and spiked tooth harrow respectively (Figure 3). Herbicide treatment provided 98% control. Harrowing more than once provided the most effective control. The spiked tooth harrow provided 82% control of kochia when harrowing was performed at the 3- and 5-leaf stage. The flextine harrow provided 66% control. Prostrate pigweed and green foxtail were also effectively controlled by harrowing Spiked tooth harrowing at the 3-leaf stage provided only 34% control of field pennycress while herbicide treatment provided complete control. The herbicide also provided 100% control of wild mustard, however harrowing provided less than 50% control. Cowcockle was not controlled by harrowing (Table 1).

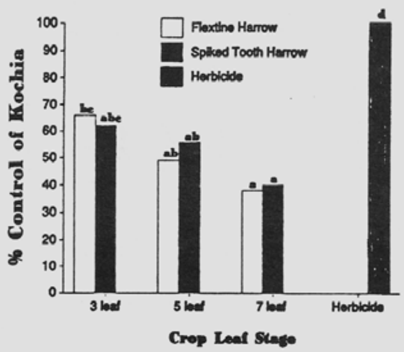

Figure 3. Kochia control by harrowing with two harrow types at the 3-, 5-, or 7-leaf stage.

Table 1. Percent weed control of green foxtail, prostrate pigweed, field pennycress, wild mustard, and cowcockle using two harrow types at 3 crop leaf stages of development.

Treatment	Crop leaf stage	Green foxtail	Prostrate pigweed	Field pennycress	Wild mustard	Cowcockle
		% control				
Flextine harrow	3	82	50	0	34	33
	5	91	70	0	44	0
	7	73	40	34	17	0
Spiked tooth harrow	3	55	80	0	34	0
	5	73	50	0	34	0
	7	91	40	0	34	0
Herbicide	-	82	70	100	100	100

CONCLUSIONS

While the results are preliminary, postemergence harrowing appears to hold promise for control of certain weed species in small grains. Improved control would be possible if new implements were designed that could discriminate between vigorous, well anchored small grain plants, and tiny, poorly, anchored weed seedlings when small grains are in the 3-, 5-, and 7-leaf stage.

SAFETY TEAM FOR ENVIRONMENTAL ACCOUNTABILITY AND LONG TERM HEALTH.

N. E. Jackson, A. J. Czajkowski, V. J. Lange, A. J. Cornelius, G. A. Dixon, D. G. Hanson, T. J. Peters, and L. W. Taylor, Product Development, Monsanto Co., Corona, CA 91719, St, Louis, MO, St. Louis, MO 63167, Atlanta, GA 30062, Houston, TX 77070, Horace, ND 58047, Fishers, IN 46038, and Delta, B.C. Canada, VYM 3T2.

Abstract. The Safety Team for Environmental Accountability and Long Term Health (S.T.E.A.L.T.H.) is composed of members of Monsanto's Product Development Department and the Monsanto Agricultural Company safety supervisor. S.T.E.A.L.T.H. was organized in 1989 with the objective to identify, solve and coordinate solutions that address safety, health and environmental issues. The initial focus was on the following: 1) design and implement safety training programs 2) develop programs to promote positive safety attitudes/culture within the organization 3) develop Standard Operating Procedures for the safe operation of equipment, chemical handling and use of protective equipment and 4) facilitate information transfer by interfacing Product Development with functional resources throughout the company.

EFFECT OF ADJUVANTS ON HERBICIDE ACTIVITY ON GORSE. Larry C. Burrill, Lynn E. Cannon, Ralph E. Duddles, and Arthur P. Poole, Extension Weed Specialist and Coos County Extension Agents, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331.

INTRODUCTION

Gorse is a dense, spiny, evergreen, legume shrub that grows up to 4 m tall. Branches are spreading, ending in a sharp spine, and have scalelike or rigid and prickly leaves. Gorse usually becomes established first on idle land and in places where mechanical control is difficult. Several herbicides are effective control options in spite of the plant characteristics that do not favor herbicide retention and absorption. Most commercial applications of herbicides to gorse include a surfactant or a small amount of diesel oil, but there is little research data to support these practices.

In studies preliminary to the experiments reported here (1) gorse control by glyphosate formulated as Roundup was better when either X-77 or Surphtac (33% X-114 surfactant, 20.4% monocerbamide dihydrogensulfate, and 46.6% water) was added to the spray mixture. In Hawaii, Silwet L-77 (polyalkyleneoxide modified polydimethylsiloxane) improved gorse control with metsulfuron, picloram, triclopyr amine, and triclopyr ester (2). Two nearly identical studies were conducted to examine the effect of three adjuvants on nine herbicides applied to gorse.

MATERIALS AND METHODS

Two field experiments about 1.5 km apart were conducted on unused land located about 16 km north of the town of Port Orford on the southern Oregon coast. An experiment was treated on June 8, 1989 and a nearly identical experiment was started on June 5, 1990.

Experiments were designed to test the effect of three adjuvants, Surphtac, Silwet L-77, and X-77, on gorse control with picloram, glyphosate, dicamba, triclopyr, triclopyr plus 2,4-D, 2,4-D LVE, imazapyr, and metsulfuron. Herbicides were applied at two rates selected to give sub-lethal activity on gorse. Each herbicide was applied without additional adjuvants and with the adjuvants at 0.5% v/v of the spray mixture. Treatments were replicated three times. The experiments differed only in the lower rates for triclopyr and triclopyr plus 2,4-D in the second experiment.

Herbicides and adjuvants were added to water to make 4 L of spray mix at the desired concentration. Application was through four 8004 flat fan nozzles pressurized with CO_2 on a hand-held boom that was moved over the gorse plants twice. The second pass was at a right angle to the first. Treatments were applied to single well-established plants but the amount of spray mixture actually used varied with plant size.

The test areas were heavily infested with gorse plants. Plants about 1 to 1.5 m tall that were standing somewhat alone were selected for treatment rather than plants crowded into a hedge-like group. Gorse was in the early post-bloom stage at the time of treatment.

Visual evaluations were made approximately 1 month, 6 months, and 12 months after treatment and are expressed on the tables as the average percent control across three replications. The second experiment was evaluated 19 months after application as well.

Table 1. Gorse control with herbicides and adjuvants, Cape Blanco Properties, Curry Co., Oregon.

Treatments applied June 8, 1989	Surf conc.	Herb conc.	Evaluation date 6-30-89	11-22-89	4-18-90
	-%-	-%-	% of control		
2,4-D LVE	0	0.5	23	92	93
2,4-D LVE	0	1.0	30	100	100
2,4-D + Surphtac	0.5	0.5	33	90	100
2,4-D + Surphtac	0.5	1.0	27	92	95
2,4-D + Silwet L-77	0.5	0.5	37	95	97
2,4-D + Silwet L-77	0.5	1.0	37	97	97
2,4-D + X-77	0.5	0.5	30	93	97
2,4-D + X-77	0.5	1.0	30	100	100
Imazapyr	0	0.75	7	25	50
Imazapyr	0	1.5	0	40	78
Imazapyr + Surphtac	0.5	0.75	0	35	82
Imazapyr + Surphtac	0.5	1.5	10	57	94
Imazapyr + Silwet L-77	0.5	0.75	10	83	97
Imazapyr + Silwet L-77	0.5	1.5	13	95	100
Imazapyr + X-77	0.5	0.75	10	40	77
Imazapyr + X-77	0.5	1.5	10	62	86
Metsulfuron	0	0.25 oz.	10	27	67
Metsulfuron	0	0.5 oz.	10	43	80
Metsulfuron + Surphtac	0.5	0.25 oz.	10	60	96
Metsulfuron + Surphtac	0.5	0.5 oz.	10	63	94
Metsulfuron + Silwet L-77	0.5	0.25 oz.	13	100	100
Metsulfuron + Silwet L-77	0.5	0.5 oz.	20	97	100
Metsulfuron + X-77	0.5	0.25 oz.	10	98	100
Metsulfuron + X-77	0.5	0.5 oz.	10	95	99
Picloram	0	0.25	23	62	82
Picloram	0	0.5	30	88	95
Picloram + Surphtac	0.5	0.25	33	90	94
Picloram + Surphtac	0.5	0.5	33	95	97
Picloram + Silwet L-77	0.5	0.25	37	90	97
Picloram + Silwet L-77	0.5	0.5	40	90	100
Picloram + X-77	0.5	0.25	40	90	97
Picloram + X-77	0.5	0.5	23	98	100
Triclopyr4-E[a]	0	0.5	37	100	100
Triclopyr4-E	0	1.0	30	100	100
Triclopyr4-E + Surphtac	0.5	0.5	30	98	100
Triclopyr4-E + Surphtac	0.5	1.0	30	100	100
Triclopyr4-E + Silwet L-77	0.5	0.5	40	97	100
Triclopyr4-E + Silwet L-77	0.5	1.0	100	100	100
Triclopyr4-E + X-77	0.5	0.5	40	100	100
Triclopyr4-E + X-77	0.5	1.0	20	100	100

Continued

Table 1. Continued.

Treatments applied June 8, 1989	Surf conc.	Herb conc.	Evaluation date 6-30-89	11-22-89	4-18-90
	-%-	-%-	% of control		
Triclopyr3	0	0.67	27	100	100
Triclopyr3A	0	1.3	20	100	100
Triclopyr3A + Surphtac	0.5	0.67	33	100	100
Triclopyr3A + Surphtac	0.5	1.3	33	100	100
Triclopyr3A + Silwet L-77	0.5	0.67	57	98	100
Triclopyr3A + Silwet L-77	0.5	1.3	100	100	100
Triclopyr3A + X-77	0.5	0.67	40	100	100
Triclopyr3A + X-77	0.5	1.3	20	100	100
Triclopyr + 2,4-D	0	0.5	37	90	99
Triclopyr + 2,4-D	0	1.0	40	97	99
Triclopyr + 2,4-D + Surphtac	0.5	0.5	37	100	100
Triclopyr + 2,4-D + Surphtac	0.5	1.0	37	100	100
Triclopyr + 2,4-D + Silwet L-77	0.5	0.5	40	97	100
Triclopyr + 2,4-D + Silwet L-77	0.5	1.0	40	100	100
Triclopyr + 2,4-D + X-77	0.5	0.5	30	100	100
Triclopyr + 2,4-D + X-77	0.5	1.0	30	100	100
Glyphosate	0	0.5	83	75	85
Glyphosate	0	1.0	87	75	87
Glyphosate + Surphtac	0.5	0.5	67	63	85
Glyphosate + Surphtac	0.5	1.0	93	82	85
Glyphosate + Silwet L-77	0.5	0.5	100	83	92
Glyphosate + Silwet L-77	0.5	1.0	97	88	94
Glyphosate + X-77	0.5	0.5	77	48	63
Glyphosate + X-77	0.5	1.0	97	88	94
Dicamba	0	0.5	20	50	85
Dicamba	0	1.0	20	85	96
Dicamba + Surphtac	0.5	0.5	23	50	60
Dicamba + Surphtac	0.5	1.0	30	72	98
Dicamba + Silwet L-77	0.5	0.5	37	82	95
Dicamba + Silwet L-77	0.5	1.0	37	82	96
Dicamba + X-77	0.5	0.5	23	40	80
Dicamba + X-77	0.5	1.0	30	57	94

[a]Triclopyr plus 2,4-D was a 1:2 mix marketed as Crossbow.

Table 2. Gorse control with herbicides and adjuvants, Cape Blanco Properties, Curry Co., Oregon.

Treatments applied June 5, 1990	Surf conc.	Herb conc.	Evaluation date 7-2-90	11-18-90	4-19-91	11-28-91
	-%-	-%-	% of control			
2,4-D LVE	0	0.5	20	20	33	0
2,4-D LVE	0	1.0	23	47	70	33
2,4-D + Surphtac	0.5	0.5	30	43	80	20
2,4-D + Surphtac	0.5	1.0	20	58	77	23
2,4-D + Silwet L-77	0.5	0.5	30	63	90	23
2,4-D + Silwet L-77	0.5	1.0	30	72	90	37
2,4-D + X-77	0.5	0.5	30	37	73	17
2,4-D + X-77	0.5	1.0	30	87	99	70
Imazapyr	0	0.75	20	23	80	47
Imazapyr	0	1.5	30	60	97	100
Imazapyr + Surphtac	0.5	0.75	20	80	99	100
Imazapyr + Surphtac	0.5	1.5	30	86	100	100
Imazapyr + Silwet L-77	0.5	0.75	27	93	100	100
Imazapyr + Silwet L-77	0.5	1.5	30	100	100	100
Imazapyr + X-77	0.5	0.75	23	63	93	87
Imazapyr + X-77	0.5	1.5	27	90	100	100
Metsulfuron	0	0.25 oz.	20	0	58	0
Metsulfuron	0	0.5 oz.	27	0	63	10
Metsulfuron + Surphtac	0.5	0.25 oz.	20	63	88	13
Metsulfuron + Surphtac	0.5	0.5 oz.	27	82	100	60
Metsulfuron + Silwet L-77	0.5	0.25 oz.	37	95	100	90
Metsulfuron + Silwet L-77	0.5	0.5 oz.	37	97	100	92
Metsulfuron + X-77	0.5	0.25 oz.	30	70	100	53
Metsulfuron + X-77	0.5	0.5 oz.	30	83	100	83
Picloram	0	0.25	38	99	100	100
Picloram	0	0.5	42	99	100	97
Picloram + Surphtac	0.5	0.25	33	99	100	100
Picloram + Surphtac	0.5	0.5	50	99	100	100
Picloram + Silwet L-77	0.5	0.25	37	99	100	100
Picloram + Silwet L-77	0.5	0.5	47	99	100	100
Picloram + X-77	0.5	0.25	50	100	100	100
Picloram + X-77	0.5	0.5	50	100	100	100
Triclopyr4-E[a]	0	0.18	40	82	95	33
Triclopyr4-E	0	0.36	57	99	100	80
Triclopyr4-E + Surphtac	0.5	0.18	60	95	100	57
Triclopyr4-E + Surphtac	0.5	0.36	60	98	100	81
Triclopyr4-E + Silwet L-77	0.5	0.18	57	98	99	85
Triclopyr4-E + Silwet L-77	0.5	0.36	78	100	100	93
Triclopyr4-E + X-77	0.5	0.18	67	100	100	100
Triclopyr4-E + X-77	0.5	0.36	57	97	100	93

Continued

Table 2. Continued

Treatments applied June 5, 1990	Surf conc.	Herb conc.	Evaluation date 7-2-90	11-18-90	4-19-91	11-28-91
	-%-	-%-	% of control			
Triclopyr3	0	0.25	28	37	83	0
Triclopyr3A	0	0.5	53	60	97	50
Triclopyr3A + Surphtac	0.5	0.25	50	85	100	73
Triclopyr3A + Surphtac	0.5	0.5	57	97	99	70
Triclopyr3A + Silwet L-77	0.5	0.25	68	100	100	100
Triclopyr3A + Silwet L-77	0.5	0.5	78	100	100	100
Triclopyr3A + X-77	0.5	0.25	67	100	100	83
Triclopyr3A + X-77	0.5	0.5	82	100	100	99
Triclopyr + 2,4-D	0	0.25	20	75	97	0
Triclopyr + 2,4-D	0	0.5	70	97	98	57
Triclopyr + 2,4-D + Surphtac	0.5	0.25	37	83	95	27
Triclopyr + 2,4-D + Surphtac	0.5	0.5	37	83	99	50
Triclopyr + 2,4-D + Silwet L-77	0.5	0.25	77	99	100	97
Triclopyr + 2,4-D + Silwet L-77	0.5	0.5	78	99	100	87
Triclopyr + 2,4-D + X-77	0.5	0.25	50	100	100	98
Triclopyr + 2,4-D + X-77	0.5	0.5	47	86	93	68
Glyphosate	0	0.5	47	20	20	0
Glyphosate	0	1.0	84	79	77	64
Glyphosate + Surphtac	0.5	0.5	88	60	70	27
Glyphosate + Surphtac	0.5	1.0	100	99	98	70
Glyphosate + Silwet L-77	0.5	0.5	96	67	82	63
Glyphosate + Silwet L-77	0.5	1.0	99	98	100	100
Glyphosate + X-77	0.5	0.5	75	67	67	27
Glyphosate + X-77	0.5	1.0	93	97	98	91
Dicamba	0	0.5	27	33	90	23
Dicamba	0	1.0	33	83	97	90
Dicamba + Surphtac	0.5	0.5	33	70	95	54
Dicamba + Surphtac	0.5	1.0	30	50	90	30
Dicamba + Silwet L-77	0.5	0.5	30	50	97	80
Dicamba + Silwet L-77	0.5	1.0	43	96	99	95
Dicamba + X-77	0.5	0.5	30	40	73	30
Dicamba + X-77	0.5	1.0	33	40	100	98

[a]Triclopyr plus 2,4-D was a 1:2 mix marketed as Crossbow.

RESULTS AND DISCUSSION

Each of the nine herbicides tested demonstrated potential to give good control of gorse for at least 1 yr. Rates selected for several of the herbicides were high enough to give nearly complete control of the gorse.

By observing the results across the three or four evaluation dates for both experiments, it becomes clear that performance of most of the herbicides was improved by addition of an adjuvant. In some cases the advantage of using an adjuvant was apparent only in the first evaluation. With 2,4-D, imazapyr, metsulfuron, and dicamba, differences were not obvious until the second evaluation. As time passed, the control became so good that differences were not visible. When there were differences between the adjuvants, it was usually Silwet L-77 that improved herbicide performance the most. In most of the cases where the evaluation averages are over 90%, it indicates that only one or two stems were still green. It is not clear if this is a result of incomplete coverage with the spray or an indication that the plant has started to recover from the treatment. We think that complete coverage with the spray is essential for good control, but we could not see how some of the green stems could have been missed by the spray. Readers should not compare the absolute effectiveness of the herbicides on gorse except at the rates used, because all of the herbicides were applied at lower than normal rates.

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BIGLEAF MAPLE CONTROL: BASAL THIN-LINE APPLICATIONS USING IMAZAPYR LIQUIDS AND GROUND APPLICATIONS OF IMAZAPYR GRANULES. Paul F. Figueroa, Thomas E. Nishimura, Weyerhaeuser Company, Centralia, Washington 98531, and American Cyanamid Company, Lake Oswego, Oregon 97034.

INTRODUCTION

Bigleaf maple is a hardwood common to the west side of the Cascades in the Pacific Northwest. It is a major competitor in conifer plantations and can have significant negative impact on conifer survival when under crown canopy, and growth even when it occurs in relatively low numbers. Bigleaf maple has the capacity to resprout vigorously from stumps following harvesting. Figueroa (5) reported average first-year stump sprout growth of 3 ft, while Cole and Newton (1) reported growth rates of 4.7 ft/yr. Wagner (11) reported bigleaf maple growth as high as 10 ft the first year following cutting.

A 30% reduction in Douglas-fir height growth after 5 yr for seedlings growing within 3 ft of bigleaf maple was reported by Graham (8). She also reported significant mortality of Douglas-fir due to bigleaf maple competition on trees planted within 1 ft of stump sprouts. Wagner (12) demonstrated that vegetation competition through overtopping, crowding and moisture depletion can impact Douglas-fir growth, although overtopping is the primary mode of action.

Thin-line is a primary application method for bigleaf maple control. Thin-line is a basal bark application method where a 1 to 2-inch-wide band of herbicide solution is applied to the bark such that each stem in the clump is banded with solution. Mortality rate is a function of herbicide coverage and dosage on stems. When coverage is poor, bigleaf maple control is reduced (5, 7, 9). As dosage drops below a specific threshold, control is also reduced (5, 13) using triclopyr to control bigleaf maple.

Imazapyr is registered for aerial application to control bigleaf maple. Imazapyr has shown to be effective for bigleaf maple control when applied as foliar or cut-stump treatments (11, 5, 6). Three additional imazapyr formulations had been recently developed for forest sites. Two liquid formulations include an oil soluble amine formulation (emulsifiable concentrate) and a ready-to-use (RTU) formulation for conventional basal bark application for hardwood control. An imazapyr granule product (5%) was developed for ground application for vegetation control on right-of-ways and testing for aerial application in the southeast United States. These new products would give applicators a broader selection opportunity for controlling bigleaf maple.

Several small field trials have demonstrated the effectiveness of undiluted imazapyr emulsifiable concentrate (EC) in controlling bigleaf maple. Additionally, a broadcast application of imazapyr granules has been shown to be effective in controlling bigleaf maple when applied to the ground surface directly below the crown line. However, the broadcast application of imazapyr granules out to the crown drip-line required substantially greater application time than other ground application methods. Comparing the labor costs of other ground control methods, spreading granules in this manner was determined not to be cost effective. If granular herbicides are to be considered for operational use, more effective methods of getting the product into the root systems have to be developed and employed.

None of the early product development trials tested solutions of imazapyr that would define the lowest level of imazapyr needed to control bigleaf maple. Based on the results of these efficacy trials of various imazapyr formulations, three formulations were selected for further study.

METHODS

A study was established to determine the threshold level of imazapyr emulsifiable concentrate for bigleaf maple control applied with the basal bark thin-line method. Additional treatments included a comparison with the imazapyr ready-to-use formulation and an evaluation of imazapyr granule treatments applied in a single spot directly on the uphill side of the cut stump. The hypothesis tested was imazapyr would not control bigleaf maple when applied using the basal thin-line application method.

The trial was located in Cowlitz County in western Washington on Weyerhaeuser's Southwest Washington tree farm. The test site was on an Abernathy soil series that is a deep, well-drained soil developing from siltstone and fine sandstone (3). Douglas-fir soil site is estimated at 130 ft at breast height age 50. The elevation is 400 ft and the topography is level.

The test area was tractor-logged in summer 1988 and broadcast burned during the winter. The study area was shovel-planted in April 1989 using 2 plus 1 Douglas-fir seedlings grown at the Weyerhaeuser Mima Nursery. Across the 40 A site, bigleaf maple density averaged 10 clumps/A. One yr later, at the time of study installation, the Douglas-fir averaged 1.7 ft (se 0.1) in height. Bigleaf maple averaged 6.7 ft (se 1.7) in height with a mean crown width of 6.3 ft (se 0.1) at treatment time.

Bigleaf maple clumps were blocked according to initial total height and crown volume size classes. Treatments were randomly assigned within each clump size class. Ten clumps were treated with each herbicide concentration, while seven clumps were treated for each of the granular treatments.

Mor-act was used as the diluent for all treatments. Mor-act is a paraffin-base petroleum oil product that as been used extensively and effectively for basal bark applications. Mor-act was found to be compatible ith the emulsifiable concentrate prior to this trial (data on file in Weyerhaeuser Company station records). All treatments were applied by a single individual with more than 5 yr of operational basal bark thin-line application experience.

Treatments were applied on February 26 and 27, 1990. No precipitation was recorded at the site for at least 24 hr post-application. The bigleaf maple was dormant having no active bud elongation. Initial bigleaf maple leaf-out was first noted on April 17, 1990.

The thin-line treatments were applied using a Weed Systems HQ300 CO_2 spray applicator. Pressure was regulated at 30 psi at the tank head using a Spray Systems TP-00015 zero degree nozzle tip. This spray system dispensed a solid stream of solution approximately 1 to 2 inches wide at a distance of 10 to 12 ft. Delivery volume average was 0.31 oz/sec for all solution strengths (range 0.27 to 0.33 oz/sec). Agmark Agricultural Dye Marker (P2) basal bark dye was added to the emulsifiable concentrate treatments at 0.0025% v/v. The ready-to-use product has a violet colored dye. Each clump was treated such that all stems were banded on at least two sides. Stems larger than 2 inches were banded to have a complete 360 degree herbicide coverage around each stem.

The granule treatments were pre-measured and placed in individual containers to facilitate application. The contents were then poured onto ground on the uphill side of the stump in a single location. This application method was chosen as a lower labor method to apply a granule treatment. To effectively market granules for bigleaf maple control, either a pre-measured herbicide volume in a water soluble container or other single application dispensing method would need to be developed.

RESULTS

Effects on bigleaf maple survival: thin-line treatments. Results of the Chi-square test showed significant differences among treatment survival rates after two years ($p=0.0001$). Bigleaf maple survival ranged between 0% and 70% 2 yr after treatment, (Table 1 and 2). There was no clear rate differentiation by concentration since the 5% concentration had lower survival than the 10, 20, and 30% concentrations. The ready-to-use product had lower survival than all concentrations below 40%.

Table 1. Effects of treatments on bigleaf maple survival for thin-line application -- second year results.

Treatment	Herbicide solution	Solution	Survival Year 1	Survival Year 2
	%	- ai/gal -	%	%
Check			100	100
Imazapyr EC	100	2.00	0	0
Imazapyr EC	50	1.00	0	0
Imazapyr EC	40	0.80	0	0
Imazapyr EC	30	0.60	0	40
Imazapyr EC	20	0.40	0	50
Imazapyr EC	10	0.20	10	40
Imazapyr EC	5	0.10	0	30
Imazapyr EC	3	0.06	10	70
Imazapyr (RTU)	100	0.25	0	0

Table 2. Effects of treatments on bigleaf maple survival for imazapyr granule treatments -- second year results.

Treatment	Product volume	Survival Year 1	Survival Year 2
	oz/clump	%	%
Check		100	100
5% Imazapyr granules	4.8	14	0
5% Imazapyr granules	3.2	43	43
5% Imazapyr granules	1.6	71	71

Several treatments had clumps that appeared to be dead during the first year that resprouted in the second year. It was difficult to determine when all leaves and buds were dead during the first year. Imazapyr can take up to 3 yr to completely kill bigleaf maple (personal observations by the authors). This appears to be more prevalent when imazapyr is applied close to the sub-lethal dose. As the dosage approaches the sub-lethal level, species will develop deformed buds and fasiculated leaves. Most of those buds and leaves have imperfect development, then die during the growing season. During the following growing season new buds and leaves develop having similar imperfect development. These shoots also can die back or produce very weak sprouts. Many species that recover from sub-lethal imazapyr doses have low vigor and grow at rates substantially less than their non-treated counterparts. Many of these with sub-lethal doses do not become conifer competitors due to reduced growth rates.

Historically, successful thin-line treatment was dependent on complete banding all stems. Some inconsistencies in mortality among treatments may have been the inability to completely band every stem. An evaluation of several stems that sprouted in the first year showed some small stems, usually less than 1 ft tall growing amongst many other larger stems that may have received less than full thin-line coverage. several stems were growing along the ground in the litter layer making treatment difficult. These branches had to be lifted out of the litter and banded. These factors may have been influential in producing the lower than expected mortality rates. It is incumbent upon the operator to ensure a quality application is done.

The ready-to-use imazapyr formulation had 100% mortality. The ready-to-use formulation uses a propylene glycol based carrier while Mor-act is a paraffin based petroleum oil product. The propylene glycol based carrier may give greater basal bark penetration than the paraffin based products for thin-line application.

Imazapyr threshold of bigleaf maple control: thin-line treatments. A key objective of this study was to develop the threshold to control bigleaf maple. Work done by Wagner (13) and Figueroa (5) developed a technique to relate herbicide volume and bigleaf maple crown area with bigleaf maple control. This work developed the basis of the threshold of bigleaf maple control using triclopyr. Figure 1 shows this relationship between imazapyr concentration (integrated with crown area) and 2 yr crown volume reduction. These data did not show a clear relationship between herbicide volume/crown area and bigleaf maple control.

Figure 2 plots control data by concentration level. This plot did not show any clear trends that any of the levels produced less control of bigleaf maple. It does show that bigleaf maple crown volume reduction was independent of concentration level. There was more variation at the 3% and 5% imazapyr levels, but other treatments at higher concentrations had individual clumps with substantial recovery. Possible causes of this variation could be related to the relatively small sample in each class, the difficulty to apply a complete herbicide band to every stem, and the tendency for bigleaf maple to continue to sprout and die back for 2 to 3 yr after imazapyr treatment.

There maybe several factors why a control threshold was not clear in this study. The number and sizes of stems in clump sprouts, sizes of original stump, were not measured. There may be other parameters relating to bigleaf maple biomass that may be key elements in the control threshold, such as root/shoot ratio. In addition to the biological mechanisms there are key mechanical control issues that may be equally important, such as stem coverage. These other parameters could not be addressed within the scope of this study.

DISCUSSION

A goal of all vegetation management programs is to apply only that level of herbicide necessary to control the targeted vegetation. Determining this control threshold is the critical factor in developing effective weed control measures. Another goal is to determine the level of competition and growth loss impacts that weed species exhibits within conifer plantations. In the past some land managers have accepted 100% weed mortality as a base line of treatment success. When herbicides, such as imazapyr, have the ability to reduce the long-term growth of plants, it may not be necessary, or desirable to kill all weeds. Eliminating a weed specie's ability to cause mortality or growth loss can be as effective as killing the weed. It is important to integrate knowledge of herbicide thresholds, and competition impact data to determine vegetation management objectives.

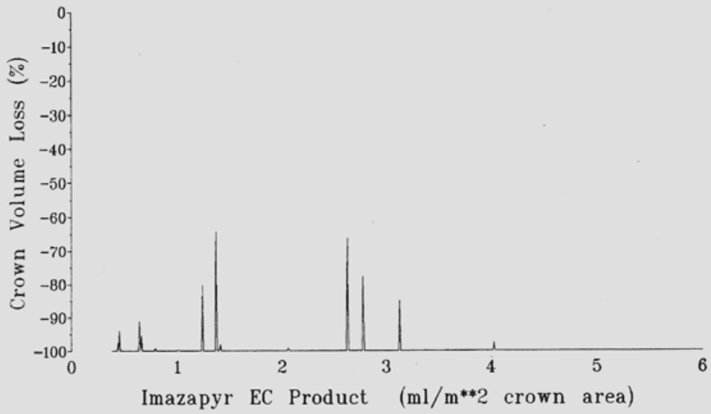

Figure 1. Crown volume loss: ml product / m**2 crown area thin-line control of bigleaf maple using imazapyr EC.

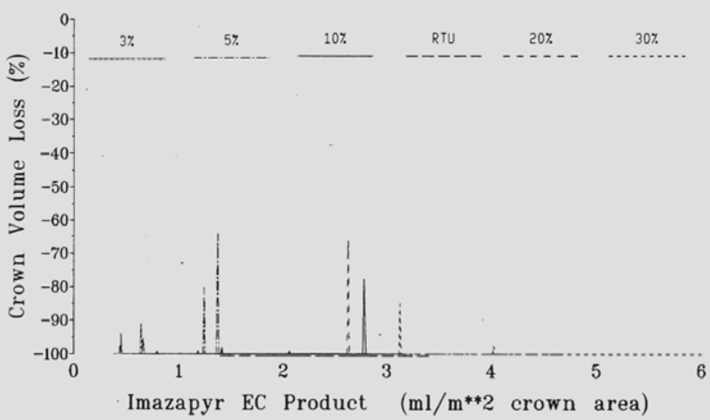

Figure 2. Crown volume loss: ml product / m**2 crown area thin-line control of bigleaf maple using imazapyr EC by solution rate.

Economic considerations are equally important. Table 3 shows the potential economic benefits of imazapyr if the threshold were fully developed for thin-line application for bigleaf maple. Potential treatment costs could be as low as $0.19 per clump and as high as $2.82 for undiluted imazapyr emulsifiable concentrate (based on the average 1.81 oz solution/clump for this study).

Table 3. Comparison of treatment cost based on 1.81 oz herbicide solution per bigleaf maple clump.[a]

Treatment	Herbicide solution	Solution concentration	Cost/ clump
	— % —	ai/clump	- $ -
Imazapyr EC	100	0.0281[1]	2.82
Imazapyr EC	50	0.0141	1.46
Imazapyr EC	40	0.0113	1.20
Imazapyr EC	30	0.0084	0.93
Imazapyr EC	20	0.0056	0.65
Imazapyr EC	10	0.0028	0.38
Imazapyr EC	5	0.0014	0.24
Imazapyr EC	3	0.0008	0.19
Imazapyr (RTU)	100	0.0035	0.38
5% Imazapyr granules	4.8 oz	0.0150	1.05
5% Imazapyr granules	3.2 oz	0.0100	0.70
5% Imazapyr granules	1.6 oz	0.0050	0.35

[a]Based on 1991 herbicide coses of imazapyr (EC) at $200.00/gal, imazapyr (RTU) at $72.00/gal, 5% imazapyr granules at $3.50/lb and Mor-act at $7.50/gal.

To fully understand these economics other factors have to be considered. Other elements can also effect bigleaf maple control. These include the relationships of imazapyr dosage by clump size, herbicide formulations, diluents, delivery methods, and stem banding techniques. The study results present a preliminary baseline of the effects of various levels of imazapyr that influence bigleaf maple mortality and vigor reduction.

After each clump was treated, an inspection was made to help insure each stem was completely banded. In many cases some of the smaller stems received splatter and not full banding. Complete stem banding appears to a factor in bigleaf maple control. An estimate of the differences between operational application techniques and research type application needs to be addressed.

There are operational trade-offs between contractor application costs and herbicide costs. Understanding operational quality and herbicide thresholds are essential to developing solution prescription recommendations.

There were substantial differences between the diluents used for the emulsifiable concentrate and ready-to-use formulations. During application we noted the propylene glycol based ready-to-use formulation coalesced around stems easier and quicker than the paraffin based petroleum diluent. The ready-to-use product appeared to flow more readily and form a better stem band. The paraffin based petroleum product took longer to flow around the stem. There may be differences in how each diluent assists herbicide penetration into bark and it's ease of uptake and translocation within the stem. However, this needs to be more thoroughly investigated.

The time required to spread low volumes of granules under the drip line of bigleaf maple would be prohibitive compared to standard basal bark application methods. This study has shown that concentrating a granular application at a single spot near the stump can be effective controlling bigleaf maple. Observations will need to be made on this treatment to determine if they will resprout. While the 4.8 oz treatment is more costly than several of the liquid treatments, the granules can provide a cost trade-off with lower labor costs in certain situations.

In plantations on steep slopes, with heavy logging debris or slash, or other difficult competing vegetation to traverse, the use of a packaged granular (or low volume) herbicides could have a substantial cost savings over conventional basal or thin-line applications. Contractor costs for thin-line application can vary between $0.75 to $2.00/clump (4). Factors that influence those costs are thenumber of stems per acre, and difficulty of traversing the site. Difficulty in traversing thesite includes the difficulty of obtaining 100% stem banding due toslash, debris, vegetation, and how easily the operator can walk around each clump. A delivery system that allows the operator to place herbicides in a single location could substantially lower contractor costs.

FOLLOW-UP WORK

This work could be enhanced by expanding to additional tests to complete the primary objectives to develop the imazapyr threshold level to control bigleaf maple. Additional data is needed to increase the sample size, particularly at the low concentration levels and at rates lower than those tested in this study. There needs to be additional tests to define that diluents provide the greatest degree of bark and stem penetration.

Current timing targets the dormant season for bigleaf maple thin-line application. Figueroa and Carrithers (7) have shown that there are substantial differences between triclopyr thin-line applications during bigleaf maple dormant season. Testing needs to be done to describe adequately the optimum treatment window.

Imazapyr granule treatments need to be further explored to develop rate and timing applications with a larger data base over a broader range of clump sizes. Development of water soluble bags or other delivery methods needs to be further developed and tested.

CONCLUSIONS

Imazapyr emulsifiable concentrate is an effective herbicide for bigleaf maple control applied during the dormant season. Levels of imazapyr emulsifiable concentrate above 30% solution in Mor-act gave 100% bigleaf maple mortality after 2 yr. Imazapyr gave effective crown volume reduction as low as 94% and greater after two years down to concentrations of 3%.

Imazapyr ready-to-use is an effective herbicide for bigleaf maple control applied during the dormant season giving 100% mortality.

The propylene glycol diluent in imazapyr ready-to-use may promote greater bark penetration or herbicide absorption into the stem than paraffin based petroleum diluents.

Imazapyr granules can be effective for bigleaf maple control applied in a single-spot ground application immediately adjacent to the cut stump. However, rates below 4.8 oz/clump showed lowering of crown volume reduction during the second year and may have less than effective control.

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GLYPHOSATE AND IMAZAPYR COMBINATIONS FOR BIG LEAF MAPLE RESPROUT CONTROL IN PACIFIC NORTHWEST CONIFER PRODUCTION. R. P. Crockett and B. Alber, Product Development Associate, Monsanto, Vancouver, WA 98682, and Technical Representative Non-Crop Markets, Wilbur Ellis Co., Portland, OR 97208.

Abstract. A key element to successful conifer regeneration in the Pacific Northwest is the control of big leaf maple and other undesirable hardwoods. Big leaf maple resprouts can quickly grow and dominate conifer seedlings after logging. Recent studies have demonstrated that labeled tank mix combinations of glyphosate and imazapyr have been found to be highly effective in controlling a broad range of herbaceous weeds and woody brush, including big leaf maple.

This combination of herbicides is most effective when applied in the fall as a site preparation treatment after maple resprouts have established lateral branches. Glyphosate and imazapyr may be applied over Douglas fir with acceptable conifer safety if specific rate and timing requirements are satisfied based on elevation and conifer bud conditions.

Recommended use rates of the glyphosate and imazapyr mixture vary depending upon species present and the time interval between treatment and logging. Generally, the longer a site is allowed to grow prior to treatment, the lower the herbicide rates required, since leaf area index and spray droplet interception are directly related. Glyphosate rates fall within the range of 0.84 and 2.52 kg/ha, while imazapyr rates range between 0.07 and 0.28 kg/ha.

TOLERANCE OF ONE AND TWO YEAR OLD DOUGLAS-FIR SEEDLINGS TO TRICLOPYR APPLICATIONS. Vernon F. Fischer and Vanelle F. Carrithers, Collins Agricultural Consultants Inc., Hillsboro, OR 97123 and Senior Research Biologist, DowElanco, Mulino, OR 97042.

Abstract. An experiment was conducted to define the tolerance of Douglas-fir seedlings to triclopyr formulations during the first 2 yr after transplanting. Douglas-fir trees were planted near Marquam, OR on March 28, 1988 and March 16, 1989. Seedling trees, used at each planting date, were 2/0, 1000 to 1500 ft, from Vancouver Island. Applications of triclopyr ester and amine formulations were made at prebud break (March 23, 1990) and post bud set (September 25 and November 8, 1990) timings. Separate sets of trees were treated at the following growth stages: prebud break only, prebud break and again at post bud set, and at post bud set only.

The experiment was a randomized complete block design with three replications. Plots were 10 by 30 ft and contained 12 seedlings each. Carriers and spray volumes were water (with and without COC) at 10 gpa, diesel at 10 gpa, and a water/diesel thin invert emulsion at 12 gpa. Bivert TM, at 9.0 fl oz/A, was added to the water/diesel emulsion. A CO_2 backpack sprayer equipped with a six nozzle (8001 flatfan) boom was used to apply the treatments.

Evaluations of Douglas-fir injury was assessed at 1, 3, and 12 months after treatment (MAT). A 0 to 5 injury rating scale was used where: 0 = no injury, 1 = minor injury to foliage, 2 = injury to foliage and lateral buds, 3 = injury to foliage and terminal buds, 4 = major loss of foliage and death of terminal buds, 5 = seedling death.

Triclopyr amine did not cause significant damage to 1-yr-old trees at rates up to 1.5 lb/A during these application timings. Triclopyr ester with a water carrier did not injure trees at a 1 lb/A rate, but injury to terminal buds was seen after all application timings with 1.5 lb/A. The addition of COC at 3% v/v to the water mixture caused no injury differences. Triclopyr ester in a diesel carrier caused unacceptable injury, at the 1.0 and 1.5 lb/A rate, with damage to lateral and terminal buds. The water/diesel emulsion reduced injury to about the same level as triclopyr with a water only carrier at similar rates.

Two-yr-old fir seedlings tended to be more tolerant than 1-yr-old seedlings to triclopyr formulations. No injury was observed from the amine formulation at the timings and rates tested. The ester formulation, when applied in water, resulted in only slight needle injury to the 2-yr-old seedlings at all rates. No differences in injury were associated with the addition of COC to the ester formulation. Injury increased significantly when diesel was used as a carrier for triclopyr ester. Both terminal and lateral buds were damaged from prebud break and post bud set applications. The water/diesel emulsion again increased selectivity over the ester/diesel mixture. Some lateral bud injury was still seen, however, with the 1.5 lb/A triclopyr ester rate applied in the water/diesel emulsion. Multiple applications of triclopyr amine and ester formulations made to the same trees in the same yr did not cause significant injury except when applying triclopyr ester at 1.5 lb/A.

Triclopyr amine can be used at rates up to 1.5 lb/A for herbaceous weed control over 1 and 2 yr Douglas-fir seedlings. Triclopyr ester can also be used at rates up to 1 lb/A in water, or in a water/COC mixture, or in a water/diesel emulsion. Diesel must not be used as the sole diluent over young trees.

Table 1. Injury of 1- and 2-yr-old Douglas-fir trees after prebud break application of triclopyr ester and amine formulations made on March 23, 1990.

Treatment	Diluent[a]	Rate	1-yr-old			2-yr-old		
			1MAT	3MAT	12MAT	1MAT	3MAT	12MAT
		lb/A	Douglas fir injury[b]					
Control		0	0	0	0	0	0	0
Triclopyr ester	water	0.5	0	0	0.8	0.2	0	0
Triclopyr ester	water	1.0	0.5	0.3	0.7	0	0	0.5
Triclopyr ester	diesel	1.0	1	3.3	3.3	0	2	3.7
Triclopyr ester	water/diesel	1.0	0	1	0.7	0	0	0.5
Triclopyr ester[c]	water	1.0	0.7	0.3	0.7	0	0	0
Triclopyr ester	water	1.5	1.3	2.3	1.3	0	0	1
Triclopyr ester	diesel	1.5	2	3.3	4	0.7	2.3	4
Triclopyr ester	water/diesel	1.5	0.7	2.3	1.5	0.3	1.8	2.8
Triclopyr ester[c]	water	1.5	1.3	0.7	0.7	0	0	1.3
Triclopyr amine[d]	water	0.5	0	0	0	0	0	0.3
Triclopyr amine	water	1.0	0	0	0	0	0	0.7
Triclopyr amine	water	1.5	0	0.2	0	0	0	0.8
LSD(0.05)			0.8	0.6	1.2	0.4	0.3	0.7

[a]Water and diesel carrier at 10 gpa each, water/diesel emulsion at 12 gpa.
[b]0 = no effect, 5 = seedling death.
[c]COC added at 3% v/v.
[d]X-77 added at 0.25% v/v to the amine treatments.

Table 2. Injury of 1- and 2-yr-old Douglas-fir trees after prebud break followed by a post bud set applications of triclopyr ester and amine formulations made on March 23, 1990 and September 25, 1990. The indicated rate was applied to seedlings on each of the two dates.

Treatment	Diluent[a]	Rate	1-yr-old			2-yr-old		
			1MAT	3MAT	12MAT	1MAT	3MAT	12MAT
		lb/A	Douglas fir injury[b]					
Control		0	0	0	0	0	0	0
Triclopyr ester	water	0.5	0	0.5	0.2	0	0	0
Triclopyr ester	water	1.0	0.2	1	0.3	0.3	0	0
Triclopyr ester	water	1.5	1.8	1.5	0.8	0	0	0.2
Triclopyr amine[b]	water	0.5	0	0	0	0	0	0.2
Ttriclopyr amine	water	1.0	0	0.3	0.3	0	0.2	0.3
Triclopyr amine	water	1.5	0.2	0.2	0.2	0.2	0.2	0.3
LSD(0.05)			0.6	1.2	NS	NS	NS	NS

[a]X-77 added at 0.25% v/v to the amine treatments.
[b]0 = no effect, 5 = seedling death.

Table 3. Injury of 1- and 2-yr-old Douglas-fir trees after post bud set applications of triclopyr ester made on November 8, 1990 with a water carrier at 10 gpa.

Treatment	Rate	1-yr-old 1MAT	1-yr-old 3MAT	1-yr-old 12MAT	2-yr-old 1MAT	2-yr-old 3MAT	2-yr-old 12MAT
	lb/A	Douglas fir injury[a]					
Control	0	0	0	0	0	0	0
Triclopyr	0.5	0.3	0	0	0	0.3	0
Triclopyr	1.0	0.8	0.5	0	0.2	0	0
Triclopyr	1.5	1	0.5	0	0	0.3	0
(LSD 0.05)		NS	NS	NS	NS	NS	NS

[a]0 = no effect, 5 = seedling death.

INTRODUCING E-ZJECT™, A NOVEL WAY TO CONTROL SELECTED WOODY BRUSH. Ron P. Crockett, Product Development Associate, Monsanto Agricultural Co., Vancouver, WA 98682.

Abstract. Hand treatment of woody brush and trees with herbicides is often the only method possible when ground and aerial broadcast applications are not available. Effective hand treatments have included: cut stump, frill (hack-n-squirt), and various basal spray techniques. Although effective, these methods often require workers to use chain saws, hatchets, and other equipment in dangerous use sites.

E-Zject offers an efficient way to control woody brush by hand without many of the drawbacks of traditional methods. E-Zject is a lightweight, hand-held lance that injects glyphosate filled capsules through thin barked stems and into the cambium zone. Each lance has a 400 capsule holding capacity, while each capsule contains 0.15 g of glyphosate. The glyphosate herbicide diffuses out from the capsule into the cambium and adjacent phloem and xylem tissues, and is subsequently moved throughout the plant resulting in control.

Various studies since 1987 have evaluated species sensitivity, application timing and rate, and optimal capsule spacing patterns. Results demonstrate the efficacy of E-Zject on a wide range of woody brush and trees. The application method has a broad range of uses that include: forestry, roadsides, rights-of-way, industrial, residential, fencerows, railroads, and aquatic sites.

Best results are obtained when injections are made at even spacings around stems at rates of 1 capsule per 3 to 4 cm diameter on trees with diameters less than 20 cm. Species that have a heavy spring sap flow should be treated after full leaf expansion in the spring, or with conifer species, after the period of heavy sap flow. Species with multiple stems arising from a single plant base or stump should be treated as if they are individual plants.

E-Zject™ is a Registered Trademark of Monsanto Co., St. Louis, MO 63167.

LEAFY SPURGE RESPONSE TO RATE AND TIME OF APPLICATION OF IMIDAZOLINONE HERBICIDES. Robert N. Stougaard, Robert A. Masters, and Scott J. Nissen, Assistant Professor, Range Scientist, and Assistant Professor, Department of Agronomy, University of Nebraska, USDA-ARS, and Department of Agronomy, University of Nebraska, Lincoln, NE 68583.

Abstract. Leafy spurge is an aggressive perennial weed that reduces hay yields and livestock carrying capacity by competing with forage grasses and rendering infested areas undesirable to cattle. Currently herbicides offer the best solution for control. However, available herbicides either afford only short-term control, are uneconomical on a large acreage basis, injure desirable forbs and legumes, or present concerns from the stand point of potential ground water contamination. Cost-effective, environmentally sound herbicide alternatives are needed to manage this aggressive weed on rangeland and pastures. Preliminary investigations demonstrated that several members of the imidazolinone herbicide class have activity on leafy spurge. The objective of this research was to optimize imidazolinone herbicide timing and application rate for the control of leafy spurge.

Imazapyr, imazethapyr, and imazaquin were applied with a tractor-mounted sprayer at 0.07, 0.14, and 0.28 kg/ha in early June and September 1989 to a subirrigated meadow range site near Ainsworth, NE. Herbicides applied in the fall provided better control of leafy spurge than those applied in the spring. Averaged across herbicides, the fall application of 0.28 kg/ha provide 85% control of leafy spurge by late June 1990. Ten months after the fall application, leafy spurge yield was reduced to 338 kg/ha on plots treated with 0.28 kg/ha as compared to 2144 kg/ha from the nontreated controls. Grass yields in June 1990 were unaffected by treatment with imazethapyr and imazaquin, regardless of the rate or time of application. In contrast, grass yields were reduced 54 and 71% 10 months after fall application of imazapyr at rates of 0.14 and 0.28 kg/ha, respectively.

UPTAKE AND TRANSLOCATION OF IMAZETHAPYR AND IMAZAPYR BY LEAFY SPURGE. Robert A. Masters, Scott J. Nissen, and Robert N. Stougaard, Range Scientist, Assistant Professor, and Assistant Professor, USDA-ARS and Department of Agronomy, University of Nebraska, Lincoln, NE 68583-0915.

Abstract. The uptake and translocation of imazethapyr and imazapyr by leafy spurge was studied over an 8 day time period. Vegetatively propagated leafy spurge plants were grown in the greenhouse for 3 months. Top growth was removed and root systems were chilled for 14 days before being transplanted into cone-tainers. The rooting medium was a fine, washed-silica sand. Plants were maintained in a growth chamber with 16 h photoperiod, 50% relative humidity and PAR of 750 $\mu E\ m^{-2}\ sec^{-1}$. Plants were watered daily with 0.5 strength Hoagland's solution. Imazethapyr and imazapyr were applied to separate plants at a rate of 0.07 kg/ha in a 1% (v/v) solution of 28% liquid nitrogen fertilizer containing 0.25% non-ionic surfactant. Two alternate leaves, approximately 15 cm below the shoot apex, were protected from spray application by wax paper. Twenty-seven μCi per plant of radio-labeled imazethapyr or imazapyr were mixed with spray solution and applied to these leaves as 10, 1 μl droplets (5 μl per leaf). At harvest, plants were divided into 7 parts: (1) shoot above treated leaf, (2) treated leaf, (3) shoot below the treated leaf, (4) crown, (5) root, (6) elongated root buds and (7) dormant root buds. The treated leaves were vortexed for 30 sec in a 10% methanol solution containing 0.25% non-ionic surfactant. Radioactivity in the leaf wash solution was determined by liquid scintillation counting (LSC) and used to estimate herbicide uptake. Amount of radioactivity translocating to each plant part was determined by oxidizing the plant tissue followed by LSC.

Imazapyr was absorbed more readily by leafy spurge then imazethapyr. Based on the amount of herbicide applied, 93% of imazapyr and 18% of imazethapyr was absorbed by leafy spurge. Apoplastic translocation of imazapyr was greater than imazethapyr. Eight days after treatment, 19% of applied ^{14}C-imazapyr and 3% of applied ^{14}C-imazethapyr had translocated to the roots. The amount of radioactivity associated with elongated adventitious shoot buds along the roots was greater than that associated with

either the roots or dormant shoot buds, regardless of herbicide applied. Elongated buds appeared to be a strong sink to which the herbicides translocated. Imazapyr and imazethapyr symplastic translocation to the leafy spurge roots was very similar when compared as a percentage of absorbed material, with approximately 20% of the absorbed herbicide translocating to the root system 8 days after treatment.

METABOLISM OF IMAZETHAPYR AND IMAZAPYR BY LEAFY SPURGE. Scott J. Nissen, Robert A. Masters, and Robert N. Stougaard, Assistant Professor, Range Scientist and Assistant Professor, Department of Agronomy, USDA-ARS, Department of Agronomy, University of Nebraska, Lincoln, NE 68583-0915

Abstract. The metabolism of imazethapyr and imazapyr by leafy spurge was studied over an 8 day time period. Vegetatively propagated leafy spurge plants were grown in the greenhouse for 3 months. Top growth was removed and root systems were chilled for 14 days before being transplanted into cone-tainers. The rooting medium was a fine, washed-silica sand. Plants were maintained in an growth chamber with 16 h photoperiod, 50% relative humidity and PAR of 750 $\mu E\ m^{-2}\ sec^{-1}$. Plants were watered daily with 0.5 strength Hoagland's solution. Imazethapyr and imazapyr were applied to separate plants at a rate of 0.07 kg/ha in a 1% (v/v) solution of 28% liquid nitrogen fertilizer containing 0.25% non-ionic surfactant. Two alternate leaves, approximately 15 cm below the shoot apex, were protected from spray application by wax paper. Radio-labeled imazethapyr (0.75 μCi per plant) or imazapyr (1.0 μCi per plant) were mixed with spray solution and applied to these leaves as 10, 1 μl droplets (5 μl per leaf). At harvest, plants were divided into 7 parts: (1) shoot above treated leaf, (2) treated leaf, (3) shoot below the treated leaf, (4) crown, (5) root, (6) elongated root buds and (7) dormant root buds. Treated leaves, crowns, roots, and root buds were homogenized in 90% methanol and extracted for 12 hr at 22 C. The methanol/water extracts were evaporated to aqueous phase under vacuum. The amount of radioactivity present as the parent compounds and metabolites was determined by C_{18} HPLC and flow-through liquid scintillation counting (LSC). Remaining plant parts were oven dried and radioactivity determined by sample oxidation and LSC.

Both herbicides remained intact 2 days after treatment (DAT); however, 8 DAT imazethapyr metabolites were detected in all plant parts. Imazapyr metabolites were detected only in the treated leaf sample and not in other plant parts. The lower rate of imazapyr metabolism could explain why it provides better long-term control of leafy spurge than imazethapyr. Imazethapyr control tends to decrease 1 yr after application and this decrease in control could be a function of the rate at which imazethapyr is metabolized in crown and root tissue. Imazethapyr metabolism is slowest in root buds, which might explain some of its growth regulating properties. The primary imazethapyr metabolite had the same retention time as α-hydroxyethyl-imazethapyr. No attempts were made to identify other herbicide metabolites.

ECONOMICS OF WEED CONTROL IN BELL PEPPERS USING HAND WEEDING, NAPROPAMIDE OR COMBINATIONS.

W. T. Lanini and M. Le Strange, Extension Specialist and Farm Advisor, Department of Plant Biology, University of California, Davis, CA 95616.

Abstract. Napropamide is the only available preemergence herbicide for California bell pepper growers. Many growers have questioned whether bell peppers can be grown profitably if napropamide was also withdrawn. This study compared napropamide at 1.1 or 2.2 kg/ha, hand weeding for 0, 2, 4, 6, 8 or 14 weeks, or combinations of napropamide at 1.1 or 2.2 kg/ha plus hand weeding at 4 or 4 and 8 weeks, in transplanted bell peppers. Measurements were made on weed control, weed control cost, yield, crop quality, and harvest cost.

Field experiments were initiated in 1990 at Davis and Five Points, California. Bell pepper yields were 15% greater than the next highest treatment yields when weeds were excluded for the 14 weeks (full season). Napropamide at either 1.1 or 2.2 kg/ha was not effective at controlling broadleaf weeds, and yields were reduced by over 90%. Hand weeding at 4 and 8 weeks on the napropamide plots reduced weed competition and yield loss. Napropamide treatments at either rate reduced hand weeding time and cost by over 50% at the 4 week hand weeding, but only marginally reduced hand weeding cost at 8 weeks. Hand weeding at 2 week intervals was more efficient than 4 week intervals. Harvest cost was highest on plots with the highest yields ($r = 0.94^{***}$), with some slowing of the harvest crew associated with high weed cover ($r = -0.831^{***}$). Crop quality was better (lower percent of culls) on plots with greater weed cover. Profit was greatest when napropamide was used at either rate and hand weeding was done at both 4 and 8 weeks or when hand weeding was done for full season with no napropamide treatment.

MULTIPLE HERBICIDE TREATMENTS FOR THE RESTORATION OF KIKUYUGRASS INFESTED PERENNIAL RYE/KENTUCKY BLUEGRASS SWARDS.

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Abstract. Kikuyugrass is an extremely aggressive perennial weed of turf. In warm, temperate areas where it is well adapted (the coastal areas of southern and central California) it rapidly invades desirable turf swards, completely engulfing them with its thick, coarse thatch. Current control measures such as fumigation with methyl bromide require loss of use of the turf area, after fumigation, while new desirable species such as Kentucky bluegrass or perennial rye are reestablished and can cost as much as $1200/A. The purpose of these trials was to evaluate several postemergence herbicides, applied in sequential treatments to weaken and gradually reduce the kikuyugrass portion of a mixed population with a resultant increase in desirable cool-season species (Kentucky bluegrass and perennial ryegrass). This would allow a gradual conversion of kikuyugrass infested swards back to desirable species without loss of use of the area.

Two trials were established in the coastal region of southern California in the cities of Camarillo and Huntington Beach. Prior to treatment, both swards consisted of approximately 85% kikuyugrass and 15% mixed Kentucky bluegrass and perennial ryegrass. MSMA (2 lb/A), triclopyr (0.5 lb/A), quinclorac (0.5 lb/A), fenoxaprop (0.18 lb/A), and mixes of triclopyr plus MSMA, quinclorac plus MSMA, and triclopyr plus quinclorac were evaluated as single and multiple applications. The multiple applications were made at 4 week intervals (four applications were made for all but the fenoxaprop plots, which received only three treatments). Each treatment was replicated four times. Applications were initiated on July 15 in Camarillo and on August 15 in Huntington Beach. Kikuyugrass control and Kentucky bluegrass/perennial ryegrass phytotoxicity evaluations were made at 2 week intervals after the first treatment.

The effect of treatment was similar for both locations. One application of any of the herbicides or herbicide combinations did not effect kikuyugrass beyond initial, temporary phytotoxicity. After four applications, MSMA, triclopyr, and fenoxaprop had reduced kikuyugrass to less than 15% of the sward. Quinclorac and the combination treatments of triclopyr plus MSMA, quinclorac plus MSMA, and triclopyr plus quinclorac had reduced kikuyugrass to less than 3% of the sward. None of the treatments was significantly phytotoxic to the Kentucky bluegrass or the perennial rye. It is apparent from these trials that sequential applications of these herbicides were effective in reducing the density of kikuyugrass in mixed swards, while not injuring desirable cool season grass species, and that combinations of the herbicides increased this desirable effect.

MON-13200: A NEW BROAD SPECTRUM PREEMERGENCE HERBICIDE FOR TREES, NUTS, AND VINES. S. L. Kimball, E. E. Sieckert, W. B. Parker and S. S. Adams, Senior Development Associate, Product Development Associate II, Research Specialist and Development Associate, Monsanto Company, Fresno, CA 93710, Lodi, CA 95242, St. Louis, MO 63147, and Holtwood, PA 17532.

Abstract. MON-13200 is a broad spectrum preemergence herbicide under development by Monsanto Company for use in tree and vine crops. Field trials throughout the USA show that use rates of 0.56 to 2.24 kg/ha provide excellent activity on hard-to-control annual weed species without adverse effect to the crop. MON-13200 has low water solubility and does not move readily in the soil. It also has good tank-mix compatibility with other herbicides, and can remain on the soil surface for several weeks prior to activation by rainfall or irrigation. The efficacy and application flexibility provided by MON-13200 permits season-long broad spectrum control in tree and vine crops across different environmental conditions and cultural practices.

MON-12000: A NEW HERBICIDE FOR CONTROL OF PURPLE NUTSEDGE (*Cyperus rotundus*) AND YELLOW NUTSEDGE (*Cyperus esculentus*) IN TURFGRASS. Nelroy E. Jackson, Monsanto Agricultural Company, St. Louis, MO 63167.

Abstract. MON-12000 is a new herbicide being developed for control of purple and yellow nutsedge in turfgrass, as well as for control of broadleaf weeds in corn. Small plot trials were conducted in 1988, 1989, and 1990 in common bermudagrass turf. Some locations had been overseeded with perennial ryegrass. MON-12000 at rates of 0.0347, 0.0694 and 0.1378 kg/ha gave 85 to 99% control of purple and yellow nutsedge 4 to 8 weeks after treatment at the 3- to 8-leaf stage. The length of control was rate-responsive. When sequential applications were made after new germination of nutsedge had reached the 3- to 5-leaf stage of growth, both nutsedge species were controlled for an additional 4 to 8 weeks. Development of symptoms was faster in purple than in yellow nutsedge. Control of purple nutsedge with initial applications of MON-12000 in April/May was better than that of imazaquin at 0.42 kg/ha (with and without 1.12 kg/ha of MSMA). There was no growth reduction in either common bermudagrass or perennial ryegrass from MON-12000 at 0.0347, 0.0694 or 0.1378 kg/ha. However, imazaquin caused severe phytotoxicity to bermudagrass and perennial ryegrass turf, with the bermudagrass turf recovering in 3 to 4 weeks. Common bermudagrass was safely overseeded with perennial ryegrass in the fall, after spring or summer applications of MON-12000.

CHEMICAL CONTROL OF ALS RESISTANT AND SUSCEPTIBLE KOCHIA. Dennis Tonks and Philip Westra, Graduate Research Assistant and Associate Professor, Department of Plant Pathology and Weed Science, Colorado State University, Fort Collins, CO 80523.

Abstract. Chemical control of sulfonylurea (SU) resistant and susceptible kochia was evaluated in the greenhouse and field. A greenhouse study compared the response of two resistant and two susceptible kochia biotypes to five non-SU herbicides at three rates when applied at three growth stages. Results of this study concluded resistant and susceptible kochia biotypes responded similarly to the non-SU herbicides. In addition, kochia treated at earlier growth stages was more susceptible to control. A second greenhouse study evaluated the same non-SU herbicides in combination with three SU herbicides at three rates applied to the same four kochia accessions in a factorial arrangement of treatments. The response of kochia to the SU herbicides confirmed resistance or susceptibility in each accession. Response of resistant and susceptible kochia to broadleaf herbicides was similar and differed only by herbicide. Plant biomass reduction of resistant kochia ranged from 52 to 93% of the untreated checks when non-SU herbicides were combined with SU herbicides while SU treated kochia was nearly equal to the check.

A field study compared the response of 12 kochia accessions (six resistant and six susceptible) to combinations of SU and broadleaf herbicides. Kochia accessions were planted in 30.5 m rows and herbicides were applied perpendicular to the rows. Biomass production and control differed among kochia accessions due to herbicide treatments. Resistant kochia was not controlled by SU herbicides (control was less than 10%). SU resistant kochia was controlled when treated with SU herbicides combined with broadleaf herbicides. Broadleaf herbicides which controlled resistant kochia in combination with SU herbicides generally controlled both resistant and susceptible kochia equally well. This indicates that there is no negative-cross resistance for these herbicides. No synergistic effect was observed by the addition of an SU herbicide to a non-SU herbicide on resistant kochia. Kochia control in the field was lower than control observed in greenhouse studies.

INFLUENCE OF METOLACHLOR ON ROOT-KNOT NEMATODE (*MELOIDOGYNE INCOGNITA*) INTERACTION WITH *CYPERUS ESCULENTUS* AND *CAPSICUM ANNUUM*. M. J. Kenney, J. Schroeder, S. H. Thomas and L. W. Murray, Research Assistant, Assistant Professor and Associate Professor, Department of Entomology, Plant Pathology, and Weed Science, Associate Professor, Department of Experimental Statistics, New Mexico State University, Las Cruces, NM 88003.

Abstract. Yellow nutsedge and root-knot nematode (*Meloidogyne incognita* Koford and White, host race three) are serious pests of chile peppers. Previous research indicates that these species interact when grown together and that yellow nutsedge is a host of root-knot nematode. Metolachlor is registered for yellow nutsedge suppression in chile peppers grown in New Mexico. Therefore, greenhouse experiments were conducted in 1991 and 1992 to determine if the interaction between these pests and chile peppers is influenced by the application of metolachlor. The experimental design was a factorial arrangement of treatments in a randomized complete block with six replications. Treatments included all practical combinations of yellow nutsedge, chile peppers, root-knot nematodes, and metolachlor. A single chile pepper plant was established in 20 cm pots containing 3.8 L of sandy loam soil. A single germinated nutsedge tuber was planted in the pots when the chile pepper plants had two to four true leaves. When the chile pepper plants had four to six true leaves the pots were inoculated with approximately 5,000 root-knot nematode eggs and juveniles/pot. Two weeks following nematode inoculation, 2.24 kg/ha metolachlor was mixed with sandy loam soil and applied as a surface treatment to the pots. Every other week, chile pepper height, number of leaves, number of open flowers, and number of fruits as well as the number of

nutsedge shoots were recorded. Twelve weeks after nematode inoculation, plants were harvested and shoot and root weights were taken for both plant species as well as fruit weights for chile peppers. In addition, yellow nutsedge tubers were counted and tested for germination by storing the tubers at 2 C for 1 week, then placing the tubers in moist towels which were kept on a greenhouse bench for 1 week.

Metolachlor or chile reduced nutsedge shoot number when grown with yellow nutsedge. When root-knot nematode was introduced into pots containing either metolachlor or chile plus yellow nutsedge, yellow nutsedge shoot number was greater than when grown with metolachlor or chile alone. When metolachlor was present, adding either chile or root-knot nematode had no influence on nutsedge tuber number. When metolachlor was not present, chile lowered tuber number, whereas root-knot nematode increased tuber number. When metolachlor was not present, tuber germination was not changed. When metolachlor was present, adding chile increased tuber germination.

TERBUFOS INTERACTION WITH POSTEMERGENCE GRASS HERBICIDES IN CORN. T. Neider and S. D. Miller, Research Associate and Professor, Department of Plant, Soil, and Insect Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. The postemergence grass herbicides nicosulfuron and primisulfuron have the potential to cause corn injury under unfavorable environmental conditions. The level of tolerance is influenced by the rate corn metabolizes these herbicides. In addition, terbufos (a soil applied insecticide) has been reported to accentuate injury with nicosulfuron or primisulfuron. A field trial was established at the Research and Extension Center, Torrington, WY to evaluate the response of a resistant and susceptible corn isoline to terbufos placement and application timing of nicosulfuron and primisulfuron. Plots consisted of two rows of resistant and two rows of susceptible Pioneer 3180 corn. The treatments were replicated four times in a split-split plot factorial design. The main plots were terbufos placement, subplots corn isoline, and sub-subplots a factorial arrangement of herbicide and application timing. The trial was maintained weed-free during the growing season. The corn isolines differed markedly in their tolerance to postemergence applications of nicosulfuron or primisulfuron and the differences were most pronounced with applications 20 days after planting. Corn injury decreased when nicosulfuron or primisulfuron applications were delayed to 35 days after planting. Terbufos increased corn injury with these herbicides only slightly and corn injury was not influenced by terbufos placement. Corn yields related closely to crop injury and were lowest when nicosulfuron and primisulfuron were applied on the susceptible isoline 20 days after planting.

BIOLOGY AND CONTROL OF NORTH AMERICAN WILD-PROSO MILLET BIOTYPES. M. Callan and P. Westra, Graduate Research Assistant and Associate Professor, Department of Plant Pathology and Weed Science, Colorado State University, Ft. Collins, CO 80523.

Abstract. Researcher supplied seeds of 17 wild-proso millet biotypes from Canada, Michigan, Wisconsin, Minnesota, North Dakota, Nebraska, Wyoming, Colorado, Utah, and Idaho have been used to produce progeny grown for up to 3 successive yr under the same environmental conditions at Ft. Collins, CO. In addition, three domestic proso millet varieties have been grown in the same studies. Considerable variations in plant growth and architecture are found among the wild-proso millet biotypes. Some are tall growing (up to 45 inches), while others stay quite short (30 inches). Some shatter their seeds and mature earlier than others. All of the wild-proso millet biotypes, however, shatter their seed readily, and partition relatively less biomass into seed production than do the domestic varieties. Among the wild-proso millet biotypes, there is considerable variation in seed coat color, including tan, brown, black, and olive-green colored seed. Seeds from the domestic varieties display no post-harvest dormancy and do not shatter, while seeds from some wild-proso millet biotypes display considerable dormancy after harvest. The average seed

weight for domestic millets is from 1 to 2 mg higher than for wild-proso millet seed. Preliminary field screening of nicosulfuron at the rate of 1 oz/A for control of all 20 accessions in these studies showed that use of the additives crop oil concentrate plus 28% nitrogen, or the use of Scoil as an additive provided up to 95% season long control. Nicosulfuron applied alone or with crop oil concentrate or X-77 was not effective for season-long control. This research was conducted without the presence of corn competing with the proso millet accessions.

EFFECTS OF METSULFURON ON MEIOSIS, SEED SET, AND FORAGE PRODUCTION IN THE WHEATGRASSES, RUSSIAN WILDRYE, AND GREAT BASIN WILDRYE. Blair L. Waldron, J. O. Evans, K. H. Asay, and K. B. Jensen, Graduate Research Assistant and Professor, Plants, Soils, and Biometeorology Department, Utah State University, Logan, UT 84322-4820, and Research Plant Geneticists, USDA-ARS Forage and Range Research Lab, Logan UT 84322-6300.

Abstract. Metsulfuron is being tested extensively for control of weeds on rangelands and the Conservation Reserve Program. Metsulfuron is not registered for use on wheatgrass stands grown for seed. The effect of metsulfuron on the cytology and seed set of the wheatgrasses has not been documented. Studies were conducted at Utah State University to analyze the effects of field applied metsulfuron on the forage production, chromosome pairing, and seed set of common range grasses.

Metsulfuron was applied both pre- and postemergence to 11 grass entries. Preemergence application was accomplished using a logarithmic sprayer, which linearly increases the amount of active ingredient as it proceeds the length of the plot. Plant material was collected at six rates (0, 12.6, 25.2, 37.8, 50.4, and 63 g/ha). The postemergence application was applied at seven rates (0, 4.2, 12.6, 25.2, 37.8, 50.4, and 63 g/ha) with a bicycle sprayer.

Increasing rates in the preemergence application caused a decrease in forage production in all grass entries. Only Luna pubescent wheatgrass, Nordan crested wheatgrass, Pryor slender wheatgrass, and Secar snake river wheatgrass exhibited any tolerance with no significant reduction of dry matter at the 12.6 g/ha rate. Spike production was reduced by increasing preemergence rates. Luna pubescent wheatgrass and Pryor slender wheatgrass were the most tolerant of increasing rates, not showing significant spike production decrease until the 37.8 and 25.2 g/ha rates respectively. Secar snake river wheatgrass and Goldar bluebunch wheatgrass were analyzed for normal chromosome pairing and disjunction. Both grass entries exhibited normal chromosome pairing at the control and the highest herbicide dosage.

Increasing rates in the postemergence application did not affect forage production. Several of the grass entries showed a significant reduction in dry matter at the control (0 g/ha) level. This is best explained by the severity of the weed competition in the postemergence plots. Spike production was significantly reduced in T21076 thickspike wheatgrass at the 50.4 g/ha rate. Goldar bluebunch wheatgrass and Hycrest crested wheatgrass had significant decreases in spike production at the 63 g/ha level. Analysis of Secar snake river wheatgrass and Goldar bluebunch wheatgrass for normal chromosome pairing manifested no significant abnormalities at the highest herbicide rate.

MEASURING THE EFFECTS OF DENSITY AND PROPORTION ON THE COMPETITIVE ABILITY OF ALS RESISTANT AND SUSCEPTIBLE KOCHIA BIOTYPES. P. J. Christoffoleti and P. Westra, Colorado State University, Ft. Collins, CO 80523.

Abstract. Several weed species with biotypes resistant to triazine herbicides express reduced productivity when compared to the susceptible biotypes. Whether similar trends in lower biomass production and reproduction output is found in weeds resistant to acetolactate synthase (ALS) enzyme inhibitor herbicides remains to be examined.

Experiments were set up at Colorado State University to asses the influence of density and proportion on the competition between ALS resistant and susceptible kochia biotypes. In research, the competition effects are estimated on the basis of biomass and seed production between the two biotypes. A simple model is used to estimate the degree of intra-biotype competition, inter-biotype competition and niche differentiation from final biomass data of a set of population varying in biotype composition, and total density of resistant and susceptible kochia. To estimate competition effects, the model utilizes data from an addition series experiment.

Prediction of the shift in the kochia biomass production from a density dependent to density independent relationship is made. Several assumptions are made, since the equations are based on a rectangular hyperbola to describe the biomass density response. In field experiments carried out in Fort Collins in 1990 and 1991 treatments were set up to form a simple matrix of two biotypes. In the "monobiotype" density per plot ranged from 0 to 176, and 22 to 352 plants in the mixture. The multibiotype reciprocal yield models were used to graph the response of each biotype to its own density for varying densities of the competitor biotype. Biotype density had an influence on the response of resistant and susceptible kochia biotype.

SOIL TEMPERATURE EFFECTS ON DOWNY BROME AND WINTER WHEAT SEED COLONIZATION BY A PLANT-SUPPRESSIVE BACTERIUM. J. A. Doty and A. C. Kennedy, Research Assistant and Soil Microbiologist, Washington State University and USDA-ARS, Pullman, WA 99164-6421.

Abstract. Early seed colonization by plant-suppressive bacteria is essential to subsequent root colonization and maximum inhibition of downy brome growth for weed biocontrol. *Pseudomonas fluorescens* strain $D7^{rif}$, which inhibits downy brome seed germination and early plant growth, was tested for its ability to colonize winter wheat and downy brome seeds at three different soil moisture contents and four soil temperatures using spermosphere competence methods. Winter wheat supported greater numbers of bacteria than did downy brome on a per seed basis, however downy brome supported greater numbers of bacteria per cm^2 seed surface area. Bacterial populations on the seed increased with increasing soil moisture and temperature up to 25 C. Downy brome seed supported the introduced bacteria at the lower soil moisture content, while winter wheat did not. It is hypothesized that downy brome is more sensitive to environmental stimuli and is able to initiate the germination process at soil water potentials as low as -55.1 MPa. Winter wheat is bred for delayed and uniform germination and lacks this sensitivity. A critical time period for colonization by introduced bacteria occurs within 6 hr of seed imbibition.

INTERFERENCE OF BROADLEAF AND GRASSY WEEDS IN SUGARBEETS. A. Mesbah, S. D. Miller, K. J. Fornstorm and D. Legg. Research Associate, Professors, and Associate Professor. Department of Plant, Soil, and Insect Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Most of the studies dealing with weed competition in sugarbeet evaluated yield losses based on individual weed species. However, yield losses from more than one weed species may be less or more than the combined loss from each weed alone. Field experiments were conducted at Torrington, Wyoming in 1990 and 1991 to determine the influence of several densities and duration of competition of green foxtail and kochia, alone and in combination. Weed densities consisted of 3 and 6 green foxtail/m, 0.5 and 1.5 kochia/m, and all possible combinations. Sugarbeet root yield decreased as green foxtail and kochia densities, alone and in combination increased, while no significant effect was shown on sucrose content. Similarly yield decreased as the duration of competition from a mixed density of three green foxtail and 0.5 kochia increased, while no significant effect was shown on sucrose content. Based on regression analysis, the time required to control this mixed density before realizing appreciable yield loss was approximately 2 weeks.

DPX-66037 FOR WEED CONTROL IN SUGARBEETS. Don W. Morishita, Robert W. Downard, Charles E. Stanger, C. William Kral, Robert Leavitt, and Jeffery L. Pacheco, Assistant Professor, Research Associate, and Associate Professor of Weed Science, Development Representatives, University of Idaho, Oregon State University, and E.I. du Pont de Nemours and Co., Inc., Twin Falls, ID 83301.

Abstract. Field experiments were conducted in Idaho, Oregon, and California to evaluate DPX-66037 alone, and in tank mixture, with several registered herbicides for weed control in sugarbeet. Data from these experiments indicate that DPX-66037 has a high degree of crop safety on sugarbeets. DPX-66037 was applied postemergence to the sugarbeets at split application rates ranging from 0.25 to 1 oz/A. Highest injury ratings corresponded to the higher use rates, however the injury was not reflected in sugarbeet yield or quality. This herbicide also appears to very compatible in tank mixture with phenmedipham and desmedipham. Kochia, redroot pigweed, common lambsquarters, and hairy nightshade were all effectively controlled by DPX-66037 plus phenmedipham and desmedipham tank mixtures. Applications made at the 2-leaf stage controlled weeds as good or better than cotyledon stage applications. The use of DPX-66037 in combination with phenmedipham and desmedipham may provide an opportunity for better postemergence weed control as well as increase the period of herbicide application timing in sugarbeets.

A NEW SULFONYLUREA HERBICIDE FOR POSTEMERGENCE WEED CONTROL IN SUGARBEETS. C. William Kral, John L. Saladini, Walter C. Wilms, and Jeffrey L. Pacheco, Development Representative, Product Development Manager, Development Representative, and Development Representative, E. I. du Pont de Nemours & Company, Inc., Wilmington, DE 19880.

Abstract. DPX-66037 (previously released as DPX-JT478), is a new selective postemergence sulfonylurea herbicide for the control of many annual broadleaf weeds and suppression/control of several annual grass weeds in sugarbeet. Toxicology and environmental fate studies are very favorable, and consistent with other sulfonylurea herbicides. Two applications at 0.25 oz/A applied as a tank mix with desmedipham plus phenmedipham has provided control of wild mustard, redroot pigweed, kochia, hairy nightshade, common lambsquarters, common ragweed, nettleleaf goosefoot, annual sowthistle, little mallow, Pennsylvania smartweed, and suppression/control of green foxtail and yellow foxtail. Soil dissipation of DPX-66037 is rapid, allowing flexible crop rotations following the use of this herbicide.

Table. Sugarbeet response to fonofos incorporation methods or in combination with preplant herbicide treatments. (Fornstrom and Miller)

Comparison[1]	Injury	Stand Initial	Stand Harvest	Yield	Sucrose
	%	— 1000 pl/A —		T/A	%
Fonofos-incorporation					
No fonofos	7	27.0	25.0	29.7	15.3
Fonofos before disc	9	24.7	20.6	27.2	14.7
Fonofos before press	25	6.4	6.6	12.5	14.9
Fonofos after press	8	24.7	20.8	26.9	14.8
LSD (0.05)	4	6.0	9.8	7.4	NS
Herbicide					
Cycloate	11	21.3	19.2	26.3	14.9
Cycloate+ethofumesate	19	16.4	14.7	20.5	14.5
Ethofumesate+diethatyl	14	19.4	16.3	22.7	14.9
None	4	25.7	22.9	26.8	15.3
LSD (0.05)	2	3.9	2.6	4.8	NS
Fonofos-inc-herbicide					
No fonofos					
Cycloate	5	27.0	29.2	31.3	15.3
Cycl+etho	14	22.7	19.6	27.3	14.8
Etho+diet	9	24.8	20.5	30.1	14.9
None	0	33.5	30.9	30.1	16.1
Fonofos before disc					
Cycloate	8	27.0	19.6	29.0	14.3
Cycl+etho	16	20.9	15.7	22.1	15.2
Etho+diet	9	22.7	21.8	29.9	14.8
None	3	29.2	25.3	28.0	14.5
Fonofos before press					
Cycloate	25	8.3	6.5	13.9	15.5
Cycl+etho	33	2.6	5.2	9.1	13.7
Etho+diet	31	3.9	4.8	8.6	14.9
None	11	10.9	10.0	18.5	15.3
Fonofos after press					
Cycloate	8	24.0	21.3	31.2	14.7
Cycl+etho	15	19.6	18.3	23.7	14.3
Etho+diet	9	26.1	18.3	22.2	14.9
None	1	29.2	25.3	30.6	15.3
LSD (0.05)	5	NS	NS	NS	NS
Mean	12	20.7	18.3	24.1	14.9

[1]Treatment rates:
fonofos--5 oz/1000 ft of row
cycloate--2.5 lb/A
cycloate+ethofumesate--1.5+1.5 lb/A
ethofumesate+diethatyl--1.5+1.5 lb/A

FONOFOS INCORPORATION METHODS WITH PREPLANT HERBICIDES IN SUGARBEETS.
K. James Fornstrom and Stephen D. Miller, Professors, Department of Civil Engineering and Department of Plant, Soil, and Insect Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Optimum stands of weed free sugarbeets can be obtained by matching seed spacing with emergence rate and using complementary herbicide treatments; however emergence rates are sometimes sporadic. In some instances combination of insecticides with preplant herbicides have been blamed for poor sugarbeet stands. Three studies conducted in 1990 and 1991 comparing four insecticides in combination with six herbicide treatments did not show any interactive effects between insecticides and herbicides on sugarbeet stands. All treatments were power incorporated ahead of the planter. In 1991 a study was conducted to compare fonofos incorporation methods in combination with preplant incorporated herbicide treatments. Fonofos incorporation treatments included: power incorporation before the planter disc; placement immediately before the planter press wheel; and placement immediately after the planter press wheel.

Severe sugarbeet injuries and stand reductions were obtained when fonofos was placed immediately before the planter press wheel. Sugarbeet injury increased from approximately 8% to 25% and sugarbeet stand was reduced from approximately 25,000 plants/A to 6,000 plants/A when fonofos was placed in front of the press wheel rather than before the planter or after the press wheel (Table). Sugarbeet injury also indicated an interaction between fonofos placement and herbicide treatment. Sugarbeet stand reductions were accompanied by a reduction of yield to 12.5 T/A for the placement in front of the press wheel compared to 27.9 T/A average yield for the other treatments. (Published with the approval of the Wyoming Agricultural Experiment Station.)

IMPACT OF EXOTIC WEEDS IN THE UNITED STATES. Larry W. Mitich and Guy B. Kyser, Weed Scientist and Research Assistant, University of California, Davis, CA 95616.

INTRODUCTION

For the purposes of this report, we are using the terms 'non-native,' 'introduced,' and 'exotic' interchangeably in reference to any weed introduced by human activities from outside the borders of the United States. A 'weed,' of course, is a plant growing where it is not desirable. Many of our introduced weeds were imported intentionally, as ornamentals, herbs, or food plants. A great many more came as 'stowaways' in crop seed.

In most cases it is not possible to make a quantitative evaluation of a particular species' contribution to losses. What we have tried to do is create a picture juxtaposing the extent and type of weed losses in the United States, the relative proportion of exotic and native species in different regions, and the nature of introduced and native weed species.

In several places in this report, we have derived numerical values by compounding estimates; for example, valuing the importance of a weed by how many states list it as common in Table 6. Such secondary estimates provide useful relative information, but these numbers must not be treated as empirical and, of course, are not usable for statistics. All monetary values presented here are reported in 1990 dollars.

NATURE AND EXTENT OF LOSSES

United States crop losses. In 1982, U.S. losses due to weeds and weed control costs exceeded $26 billion; $17.1 billion (10%) in yield losses, quality reduction, and increased growing costs; $4.0 billion in herbicides; and $5.4 billion in tillage and hand labor (13). During 1986 to 1988, losses in six common field crops alone exceeded $2.2 billion/yr (Table 1).

From 1975 through 1979, the United States lost over $14 billion/yr to weeds - not counting losses in hay crops, pasture, and range (and therefore livestock) (Table 2) (6).

Projected losses in field crops in 1976 if growers did not have access to available herbicides were approximately double actual losses (Table 3).

Table 1. Estimated average annual losses due to weeds in six agronomic crops in the United States, by region, 1986-1988[a].

Region	Commodity	Value (x $1000)	Mean loss[b]	Loss value (x $1000)
			– % –	
Western	Corn	425,541	4.5	19,149
	Cotton	1,081,928	?	?
	Potatoes	786,834	3.5	27,539
	Rice	137,948	?	?
	Soybeans	---	---	---
	Wheat	1,633,882	7.7	125,809
Southern	Corn	1,174,369	10.0	117,437
	Cotton	3,704,244	7.0	259,297
	Potatoes	161,987	8.6	13,931
	Rice	576,056	4.3	24,770
	Soybeans	1,993,185	9.0	179,387
	Wheat	1,166,497	4.4	51,326
North central	Corn	10,841,388	5.4	585,435
	Cotton	77,278	20.0	15,456
	Potatoes	389,790	7.0	27,285
	Rice	19,334	15.0	2,900
	Soybeans	7,735,303	6.7	518,265
	Wheat	2,952,963	4.9	144,695
Northeast	Corn	465,520	10.5	48,880
	Cotton	---	---	---
	Potatoes	305,603	7.0	21,392
	Rice	---	---	---
	Soybeans	157,440	9.3	14,642
	Wheat	77,722	8.3	6,451
Total		35,864,812	6.42	2,204,0462

[a]Data based on most recent information available. Information is incomplete, but values are not expected to change significantly.
[b]Does not include loss values for western cotton and rice.
--- = insignificant acreage of this crop in this region.
? = information incomplete at this time.

Table 2. Estimated average annual losses due to weeds in several commodities in the United States, 1975-1979 (in 1990 dollars) (6).

Commodity group	Average annual loss: Monetary (x $106)	Percent of total weed losses
Field crops	10,716	85
Vegetables	1,035	8
Fruit and nut crops	738	6
Forage seed crops	62	<1

Table 3. 1976 projection of losses in U.S. field crops without available herbicides (1).

Crop	Percent loss	
Corn	25	
Cotton	40	
Peanuts	90	
Sorghum	35	
Soybeans	24	
Rice	70	
Small grains	20	
Total estimated loss	31	$26.98 billion

Nature of crop losses. In the Proceedings of the Southern Weed Science Society 1988 to 1990 (2, 3, 4), types of losses due to weeds are itemized and their costs estimated for many southern agricultural commodities. In Table 4, these loss types are listed along with percentages estimated for a few commodities.

Cost of herbicides and loss of crop yield and quality comprise 71% to 98% of the losses due to weeds in southern crops; cost of extra land preparation often plays an important part in weed losses. It seems safe to infer that these effects are responsible for most U.S. weed losses, though values must certainly differ in other regions and other crops.

Table 4. Weed losses in the southern states. Itemization in Proceedings of the Southern Weed Science Society 1988 to 1990, with percentages of total weed loss for example commodities (2, 3, 4).[a]

	Percent of total losses										
Cost	Fruits & nuts	Turf & ornamentals	Hay, pasture, alfalfa	Cotton	Soybeans	Tobacco	Peanuts	Corn	Grain sorghum	Rice	Small grains
Herbicides	51	31	9	48	40	29	54	45	56	49	18
Yield loss	25	17	55	16	33	42	28	33	16	19	44
Quality loss	22	45	27	8	13	7	3	<1	<1	6	9
Extra land preparation	1	4	6	21	9	17	8	9	14	10	16
Land value loss	<1	4	<1	3	4	2	<1	1	4	16	4
Increased cost of harvesting	1	2	2	4	2	4	3	5	4	2	7
Total value of loss (x 10^6)	838	230	347	337	530	27	108	264	164	139	229

[a]Values may not total 100% because of rounding and nonitemized losses.

Additionally, Shaw (12) notes that weeds increase costs of tillage, fertilizer, and crop processing; interfere with irrigation; require fuel and other energy expenditure for control; and host insects, nematodes, pathogens, and rodents.

Other weed-associated costs. Losses due to weeds resulting from crop interference and yield loss are the economic effects which come first to mind and which are most easily estimated. However, weeds have additional effects. Chandler (5) suggests less obvious costs associated with weeds.

Livestock. Losses from poisoning, off-flavors in dairy products, hindrance of reproduction or weight gain, damaged wool or hides. The introduced weed leafy spurge (*Euphorbia esula*) alone may have cost forage and livestock production $4.2 million in Montana in 1979, and $24 million in North Dakota in 1983 (8). In 1987, estimated losses in lamb and calf production due to poisonous plants in the 17 western states amounted to over $77 million; total cattle and sheep losses were over $262 million (11). Such estimates are almost certainly low, for a number of reasons; moreover, these figures do not include losses to horses, swine, goats, or big-game animals.

Weed control in non-crop areas. Losses from industrial sites, ditchbanks, highways, railroads, utility, parking lots, storage areas, recreational areas. In 1957, aquatic and ditchbank weeds cost U.S. agriculture $250 million in 1990 dollars, and in 1975, $388 million. Currently, aquatic weed control in the western states alone costs more than $50 million annually.

Water. Loss of 2 million acre-feet in the 17 western states, amounting to $215 million in 1977 (7).

Employee time. The loss and medical costs due to weed pollen allergies (native ragweed east of the Mississippi; native sage and sumpweed west of the Mississippi).

REGIONAL PROPORTIONS OF EXOTIC WEED SPECIES

United States noxious weeds. "Noxious," in reference to weeds, is a legal term rather than a botanic or qualitative term. Noxious weeds are defined in the United States as weeds whose growth and spread are regulated by law (at least in theory). These weeds are typically very difficult to control once they have become established.

In the United States, 40 weed species and weed groups are considered noxious in 10 or more of the 50 states (14). Of these, 33 (83%) are non-native, six are native, and one (*Cuscuta* spp.) has both native and exotic representatives. Of the 19 species or groups noxious in 20 or more states, 15 (79%) are non-native (Table 5).

Table 5. Weeds considered noxious in 20 or more states (14).

Scientific name	Nativity	Number of states
Agropyron repens	exotic	50
Agrostemma githago	exotic	25
Allium canadense	native	29
Allium vineale	exotic	32
Brassica kaber	exotic	33
Cardaria draba	exotic	24
Centaurea repens	exotic	31
Cirsium arvense	exotic	50
Convolvulus arvensis	exotic	50
Convolvulus sepium	native	22
Cuscuta spp.	native & exotic	49
Euphorbia esula	exotic	24
Plantago lanceolata	exotic	29
Rumex acetosella	exotic	23
Rumex crispus	exotic	25
Setaria faberi	exotic	22
Solanum carolinense	native	37
Sonchus arvensis	exotic	28
Sorghum halepense	exotic	31

The north central region, the most productive in the United States, finds a similar proportion of introduced weed species among its crops (Table 6).

Table 6. Proportion of exotic weeds listed among the most common or most troublesome weeds in at least three north central states (8).

Crop	Number of weeds reported in 3 or more states[a] [number of exotic weeds/total number of weeds]		Percentage of exotic weeds reflecting number of states reporting[b]	
	Most common weeds	Most troublesome weeds	Most common weeds	Most troublesome weeds
Corn	9 / 13	8 / 14	74	63
Soybeans	7 / 15	7 / 13	61	54
Wheat	13 / 15	11 / 11	90	100
Sorghum	9 / 12	8 / 10	78	78
Most costly weeds	42 / 55		80	

[a]Reported weed groups which include both native and exotic species are counted as native.
[b]Calculated by ranking each weed by the number of states reporting it.

In Table 7 are listed proportions of exotic to native weeds reported as most common or most troublesome in the west.

Table 7. Proportion of exotic weeds listed among the most common and most troublesome weeds in the western states (10).

Crop or category	Exotic weed proportion among major weeds (number of exotic weeds / total number of weeds)	
	Most common weeds	Most troublesome weeds
Alfalfa	9 / 10	9 / 10
Dry beans	8 / 10	8 / 10
Corn	8 / 10	8 / 10
Cotton	4 / 6	3 / 4
Small grains	9 / 10	8 / 10
Sugarbeets	7 / 9	7 / 9
Fruits	9 / 10	9 / 10
Vegetables	8 / 9	8 / 9
Ornamentals	5 / 6	7 / 8
Turf	8 / 10	9 / 10
Pasture	8 / 9	7 / 9
Most costly weeds	9 / 10	
Weeds of increasing importance	13 / 14	

Though exotic weed species most often comprise 70% to 90% (typically around 80%) of the problem species in most regions of the United States (and of noxious species in the United States as a whole), exotics comprise only 50% to 70% (typically around 60%) of the problem species in the southern United States (Table 8).

Of 18 weeds listed as major problems in the northeastern states, 14 (78%) are non-native.

Table 8. Proportion of exotic weeds listed among the most common or most troublesome weeds in at least three southern states (2, 3, 4).

Crop	Number of weeds reported in 3 or more states[a] [number of exotic weeds/total number of weeds]		Percentage of exotic weeds reflecting number of states reporting[b]	
	Most common weeds	Most troublesome weeds	Most common weeds	Most troublesome weeds
Corn	9 / 14	10 / 17	64	62
Grain sorghum	9 / 14	8 / 15	58	55
Rice	4 / 7	5 / 9	65	63
Small grains	11 / 16	11 / 14	83	87
Cotton	6 / 12	11 / 16	61	67
Soybeans	9 / 16	8 / 18	55	52
Peanuts	6 / 11	7 / 13	55	55
Tobacco	6 / 10	7 / 12	64	59
Fruit and nuts	7 / 11	4 / 10	63	48
Turf and ornamentals	13 / 17	10 / 16	83	75
Alfalfa, hay, pasture	11 / 19	16 / 20	67	74

[a]Reported weed groups which include both native and exotic species are counted as native.
[b]Calculated by ranking each weed by the number of states reporting it.

NATURE OF EXOTIC WEED REPRESENTATION

Similar native and exotic weeds. Many weed genera have both native and exotic representatives. In some cases, it is difficult to say whether the taxon would present a serious problem if only native forms were present. Often the lack of natural enemies - one of the things that helps a weedy species to behave as such - may tip the balance in favor of imported species. This appears to be the case with composites; non-native species such as Canada thistle (*Cirsium arvense*), sowthistles (*Sonchus* spp), and prickly lettuce (*Lactuca serriola*) are distinctly more troublesome than most native composites. (Obviously, validating this suggestion would require making comparisons of how American weed flora fare on other continents.)

On the other hand, spurges (*Euphorbia* spp.) seem to have laid claim to the U.S. in both native [prostrate (*E. humistrata*), flowering (*E. corollata*)] and exotic [leafy (*E. esula*), garden (*E. hirta*)] forms.

Table 9. Weed genera with both native and exotic representatives of importance.

Genus	Exotic species	Native species	Importance of exotic species relative to native species
Allium	*vineale*	*canadense*	more important
Convolvulus	*arvensis*	*sepium*	more important
Cuscuta	many	many	equivalent
Descurainia	*sophia*	*pinnata*	equivalent
Euphorbia	*esula, hirta,* others	*humistrata, corollata,* others	equivalent
Panicum	*miliaceum*	*dichotomiflorum, texanum, capillare*	less important
Polygonum	*convolvulus, aviculare,* others	*coccineum, pennsylvanicum,* others	equivalent
Solanum	*nigrum, sarrachoides,* others	*americanum, carolinense, triflorum,* others	less important
Xanthium	*spinosum*	*strumarium*	less important

Table 10. Additional important weeds native to the United States (excluding woody weeds of forests, range, and rights-of-way).

Taxonomic name	U.S. common name
Amaranthus	pigweeds
Ambrosia spp.	ragweeds
Ampelamus albidus	honeyvine milkweed
Amsinckia intermedia	coast fiddleneck
Cardiospermum halicacabum	balloonvine
Conyza canadensis	horseweed
Helianthus annuus	common sunflower
Helianthus ciliaris	blueweed
Sorghum bicolor	shattercane (sorghum)
Toxicodendron radicans	poison ivy
Veronica spp.	speedwells

Weeds of rangeland. Most weeds of rangeland - including poisonous weedy species such as *Delphinium* and *Astragalus* species - are native to the United States, as we would expect for such largely uncultivated areas. Some exotic weeds are a problem, particularly in heavily grazed areas.

A few exotic weeds are both noxious and poisonous to livestock. Poisonous noxious exotic weeds include leafy spurge, *Centaurea* species [including yellow starthistle (*C. solstitialis*), diffuse knapweed (*C. diffusa*), and spotted knapweed (*C. maculosa*); Russian knapweed (*Acroptilon repens*); kochia (*Kochia scoparia*); and black henbane (*Hyoscyamus niger*) (8).

Other exotic weeds poisonous to livestock include poison- hemlock (*Conium maculatum*), halogeton (*Halogeton glomeratus*), St. Johnswort (*Hypericum perforatum*), and several species of *Senecio* [including common groundsel (*Senecio vulgaris*) and tansy ragwort (*S. jacobaea*)].

Difficulties in determining provenance. Traditional literature is likely to underestimate the number of non-native species, because many immigrants became established so quickly and so thoroughly that they were described by botanists as natives.

A grey area in distinguishing immigrant species occurs with plants that originated in tropical America and spread north - including several *Amaranthus* species and many others. Such weeds must have spread north much like some native weeds have spread within the U.S.; some of these plants may well have begun to behave as weeds before the advent of European agriculture.

CONCLUSIONS

We would expect exotic species to make up an increasing proportion of our weeds in cultivated areas, because problem species continually shift as we learn control methods.

The very fact of a plant's being nonnative favor its becoming a weed. First, many such plants lack natural enemies in their new environment. Second, many introduced species developed in competitive Mediterranean or tropical environments; those that find our temperate regions suitable use their genetic competitiveness to initial advantage in disturbed areas. However, non- cropland which is left undisturbed after development often 'renaturalizes,' and exotic weeds decrease in importance.

The fact that an appreciably greater percentage of weeds in the southern states are native may be due to the fact that these weeds also evolved in a subtropical environment and are more comparable in competitiveness with introduced species.

The closer we approach to saturation of our agricultural resources, the greater an economic impact weeds and other pests have. We cannot, say, farm 10% more land to make up for a 10% yield shortfall due to weeds.

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MON-13200 PERFORMANCE IN WESTERN ALFALFA. E. E. Sieckert, W. B. Parker, S. L. Kimball, and S. Blank, Product Development Associate II, Research Specialist, Senior Development Associate, and Product Development Specialist, Monsanto Company, Lodi, CA 95242 and St. Louis, MO 63167.

Abstract. MON-13200 provides preemergence broadspectrum weed control in western alfalfa. Fall applications of 0.5 to 1.0 kg/ha of MON-13200 controls narrowleaf and broadleaf weeds including groundsel, chickweed, shepherdspurse, London rocket, yellow foxtail, barnyardgrass, and downy brome. Preliminary investigations have shown outstanding control of small seed alfalfa dodder with MON-13200. The physical properties of MON-13200 enable application flexibility. Established alfalfa is tolerant to granular or liquid formulations of MON-13200. Liquid applications are safer when applied to dormant alfalfa, than when applied to actively growing alfalfa. Unit activity and longevity are greater with granular applications under conditions where trash and alfalfa stubble may intercept liquid applications.

DODDER CONTROL IN ALFALFA WITH MON-13288 AND TRIFLURALIN. S. B. Orloff and D. W. Cudney, Farm Advisor and Weed Science Specialist, University of California Cooperative Extension, Lancaster, CA 93535 and University of California, Riverside, CA 92521.

Abstract. Dodder is a serious pest in the high desert alfalfa production region of Southern California. A preemergence treatment with trifluralin has done much to alleviate this problem. However, dodder control late in the season declines and the spectrum of weeds controlled with trifluralin is limited. Monsanto 13288 was compared with trifluralin in two field trials in Daggett and Newberry Springs, CA and in two greenhouse studies at the University of California, Riverside. Ten percent granules of trifluralin were applied at 2 lb/A and compared with 0.5% granules of MON-13288 applied at 0.5, 0.75, 1, and 1.5 lb/A.

Field applications were made to established alfalfa using a ground driven gravity flow applicator. Field trials were treated in January and February. The soil at both field sites was a sandy loam with less than 0.5% organic matter. In the first greenhouse study, herbicide applications were made by distributing preweighed quantities of granules to the surface of pots 0.1 m^2 in surface area. The pots were previously seeded with 5 g of dodder seed and covered with 1 cm of a sandy loam soil. The second greenhouse trial was conducted similarly to the first trial except that alfalfa had been planted and reached the 3-trifoliate-leaf stage prior to seeding with dodder and the herbicide application.

None of the herbicide treatments caused observable injury to the alfalfa in the field. All herbicide treatments controlled dodder relative to the untreated check. Application rates of 0.75 lb/A or higher were needed for acceptable dodder control with MON-13288.

Greenhouse studies indicated that herbicide treatments with trifluralin and MON-13288 had a significant effect on dodder growth, but emergence was only reduced in treatments containing MON-13288 at rates above 0.75 lb/A or the combination of MON-13288 and trifluralin. Dodder that emerged from plots treated with MON-13288 did not achieve a length greater than 3 cm and did not twine around seedling alfalfa. Dodder that emerged from trifluralin was also shortened in length, but not to the same degree as with MON-13288. Some of the trifluralin treated dodder seedlings did attach to the alfalfa but significantly less than in the control plots (a 49% and 89% reduction in twining for the 1 and 2 lb/A rates, respectively).

GRASS TOLERANCE TO IMAZETHAPYR. M. A. Ferrell, D. W. Koch, P. J. Ogg, and F. Hruby. Extension Pesticide Coordinator, Extension Agronomist, Senior Agronomist, and Research and Extension Center Superintendent, Department of Plant, Soil, and Insect Sciences, University of Wyoming, Laramie, WY 82071, American Cyanamid Company, Longmont, CO 80501, and Archer Research and Extension Center, University of Wyoming, Cheyenne, WY 82001.

Abstract. A field study was initiated at the Research and Extension Center, Archer, Wyoming in the spring of 1991 to evaluate the effects of postemergent imazethapyr plus surfactant, with or without liquid nitrogen, treatments on seedling grasses and weed control. Seeded grasses were wheatgrass, crested (Hycrest); wheatgrass, intermediate (Oahe); fescue, tall (Fawn); bluegrass, big (Sherman); wildrye, Russian (Bozoisky); and bromegrass, smooth (Manchar).

Visual grass stand ratings and visual grass injury ratings show imazethapyr, with or without liquid nitrogen, did not reduce grass stands and there were no visible signs of injury when applied to 2.5- to 5-leaf grasses. Grass stands were better in treated versus untreated plots. Oahe (72%) had very good establishment, followed by Manchar (65%). Fawn (50%) and Hycrest (47%) had equal stands with moderate establishment and Sherman (18%) and Bozoisky (8%) had poor establishment. Prostrate knotweed control was excellent for both rates of imazethapyr, with or without liquid nitrogen. Kochia control was between 75 and 79% for all treatments; however, imazethapyr with liquid nitrogen provided 3% better kochia control than imazethapyr without liquid nitrogen (Table 1).

Greenhouse experiments were initiated in 1991 to evaluate the effects of postemergence imazethapyr plus surfactant, with or without liquid nitrogen, treatments on seedling perennial grasses at the Plant, Soil, and Insect Science greenhouse, Laramie, Wyoming. Grasses were the same as in the field study.

One-leaf grass was injured by 1 and 2 oz/A rates of imazethapyr 1 month after treatment and continued to show injury 4 months after treatment. Grass injury was reflected in less plants/pot and reduced grass height when evaluated 1, 3 and 4 months after treatment. Grasses showing the greatest injury to 1 oz of imazethapyr 1 month after treatment were crested wheatgrass (74%), Russian wildrye (72%) and smooth brome (66%). Most tolerant to the 1 oz rate was big bluegrass (44%). Grasses least tolerant to the 2 oz rate 1 month after treatment were big bluegrass (81%), crested wheatgrass (79%) and smooth brome (77%). Intermediate wheatgrass (59%) and tall fescue (60%) were the most tolerant to the 2 oz rate. The 2 oz rate of imazethapyr caused an average of 8% more injury to grasses than the 1 oz rate 1 month after treatment (Table 2). Grass injury ranged between 10 and 56% 3 months after treatment for the 1 oz rate and between 38 and 98% for the 2 oz/A rate, depending on variety (Table 3). Four months after treatment grasses were still showing considerable injury with ranges between 5 and 41% for the 1 oz/A rate and 32 to 90% for the 2 oz rate, again dependent upon variety (Table 4).

The greenhouse experiment was repeated with grasses in the 2.5- to 4.5-leaf stage. Grass injury, number of plants/pot, and grass height ratings taken 1 month after treatment show imazethapyr did not reduce grass stands or grass height and there were no visible signs of injury (data not shown). (Published with the approval of the Wyoming Agricultural Experiment Station.)

Table 1. Grass tolerance to imazethapyr applied at the 2.5 to 4.5 leaf stage, in the field.

Treatment[1]	Rate	Perennial grass cultivar[2]						Average of all grasses	Weed species	
		Hycrest	Oahe	Fawn	Sherman	Bozoisky	Manchar		Knotweed, prostrate	Kochia
	oz/A	% grass stand[3]							% control[3]	
Imazethapyr + X-77[4]	1	51	75	53	16	8	65	44	97	75
Imazethapyr + N + X-77[4]	1	45	71	55	21	5	64	44	97	78
Imazethapyr + X-77[4]	2	50	75	53	23	11	65	46	96	76
Imazethapyr + N + X-77[4]	2	48	74	47	21	8	67	44	97	79
Check		43	63	40	8	5	65	37	0	0
LSD 0.05		NS	NS	NS	NS	NS	NS	4	2	2
CV		16	16	16	16	16	16	16	2	3

[1]Treatments applied June 6, 1991.
[2]Wheatgrass, crested (Hycrest); wheatgrass, intermediate (Oahe); fescue, tall (Fawn); bluegrass, big (Sherman); wildrye, Russian (Bozoisky); and bromegrass, smooth (Manchar). Grasses seeded March 6 and 7, 1991.
[3]Evaluations made September 3, 1991.
[4]Surfactant (X-77) added at 0.25% v/v. N = liquid nitrogen (28-0-0) added at 1 qt/A.

Table 2. Grass tolerance to imazethapyr applied at the one leaf stage, in the greenhouse, one month after treatment.

Treatment[1]	Rate	Perennial grass cultivar[2] Hycrest			Oahe			Fawn			Sherman			Bozoisky			Manchar			Average of all grasses		
	oz/A	IN[3]	GP[3]	GH[3]	IN[3]	GP[3]	GH[3]	IN[3]	GP[3]	GH[3]	IN[3]	GP[3]	GH[3]	IN[3]	GP[3]	GH[3]	IN[3]	GP[3]	GH[3]	IN[3]	GP[3]	GH[3]
Imazethapyr[4]	1	74	5.0	6.7	60	4.4	7.6	62	5.0	4.9	44	4.0	1.9	72	3.2	5.1	66	4.4	5.6	63	4.3	5.3
Imazethapyr[4]	2	79	4.0	7.9	59	4.6	7.8	60	4.6	4.1	81	2.6	2.1	72	4.0	4.6	77	3.6	5.4	71	3.9	5.3
Check		0	5.0	16.1	0	5.0	16.3	0	5.0	12.2	0	5.0	5.4	0	5.0	11.7	0	5.0	14.3	0	5.0	12.7
LSD 0.05		6	0.9	1.3	6	0.9	1.3	6	0.9	1.3	6	0.9	1.3	6	0.9	1.3	6	0.9	1.3	3	0.4	0.5
CV		11	16	13	11	16	13	11	16	13	11	16	13	11	16	13	11	16	13	11	16	13
Average[5]		51	4.7	10.4	40	4.7	10.6	41	4.9	7.1	42	3.9	3.1	48	4.1	7.2	48	4.3	8.4			

[1]Treatments applied April 22, 1991.
[2]Wheatgrass, crested (Hycrest); wheatgrass, intermediate (Oahe); fescue, tall (Fawn); bluegrass, big (Sherman); wildrye, Russian (Bozoisky); and bromegrass, smooth (Manchar). Grasses seeded April 12, 1991.
[3]Evaluations May 3, 1991 for grass height and May 13, for grass damage and number of plants per pot. IN = % grass injury; GP = number of plants per pot; GH = grass height in cm.
[4]Surfactant (X-77) added at 0.25% v/v. Liquid nitrogen (28-0-0) added at 1 qt/A.
[5]Average is for grasses without regard to rate. LSD (0.05) of 4 for grass damage; 0.5 for number of plants per plot; and 0.8 for grass height is valid within the row.

Table 3. Grass tolerance to imazethapyr applied at the one leaf stage, in the greenhouse, three months after treatment.

Treatment[1]	Rate	Perennial grass cultivar[2]																		Average of all grasses		
		Hycrest			Oahe			Fawn			Sherman			Bozoisky			Manchar					
	oz/A	IN[3]	GP[3]	GH[3]	IN[3]	GP[3]	GH[3]	IN[3]	GP[3]	GH[3]	IN[3]	GP[3]	GH[3]	IN[3]	GP[3]	GH[3]	IN[3]	GP[3]	GH[3]	IN[3]	GP[3]	GH[3]
Imazethapyr[4]	1	46	4.0	25.0	41	2.6	12.4	56	1.6	8.6	10	3.8	27.2	20	2.6	21.8	44	1.6	15.2	36	2.7	18.4
Imazethapyr[4]	2	57	3.0	15.2	66	1.4	6.0	98	0.2	1.2	72	0.8	10.8	38	2.2	14.8	98	0.2	0.8	72	1.3	8.1
Check		0	5.0	70.4	0	4.8	15.6	0	5.0	17.0	0	5.0	29.6	0	4.8	19.0	0	5.0	18.8	0	4.9	28.4
LSD 0.05		22	1.1	8.7	22	1.1	8.7	22	1.1	8.7	22	1.1	8.7	22	1.1	8.7	22	1.1	8.7	9	0.4	3.6
CV		49	29	38	49	29	38	49	29	38	49	29	38	49	29	38	49	29	38	49	29	38
Average[5]		34	4.0	36.9	36	2.9	11.3	51	2.3	8.9	27	3.2	22.5	19	3.2	18.5	47	2.3	11.6			

[1]Treatments applied April 22, 1991.

[2]Wheatgrass, crested (Hycrest); wheatgrass, intermediate (Oahe); fescue, tall (Fawn); bluegrass, big (Sherman); wildrye, Russian (Bozoisky); and bromegrass, smooth (Manchar). Grasses seeded April 12, 1991.

[3]Evaluations July 17, 1991. IN = % grass injury; GP = number of plants per pot; GH = grass height in cm.

[4]Surfactant (X-77) added at 0.25% v/v. Liquid nitrogen (28-0-0) added at 1 qt/A acre.

[5]Average is for grasses without regard to rate. LSD (0.05) of 22 for grass damage; 0.6 for number of plants per plot; and 5.0 for grass height is valid within the row.

Table 4. Grass tolerance to imazethapyr applied at the one leaf stage, in the greenhouse, four months after treatment.

Treatment[1]	Rate	Perennial grass cultivar[2]																		Average of all grasses		
		Hycrest			Oahe			Fawn			Sherman			Bozoisky			Manchar					
	oz/A	IN[3]	GP[3]	GH[3]	IN[3]	GP[3]	GH[3]	IN[3]	GP[3]	GH[3]	IN[3]	GP[3]	GH[3]	IN[3]	GP[3]	GH[3]	IN[3]	GP[3]	GH[3]	IN[3]	GP[3]	GH[3]
Imazethapyr[4]	1	41	4.0	26.4	12	2.6	12.0	36	1.6	9.0	5	3.8	27.4	8	2.8	22.0	32	1.6	17.4	22	2.7	19.0
Imazethapyr[4]	2	50	3.0	16.6	48	1.4	6.0	90	0.2	1.4	64	0.8	11.2	32	2.2	17.0	88	0.2	3.0	62	1.3	9.2
Check		0	5.0	70.8	0	4.8	19.0	0	5.0	18.8	0	5.0	31.8	0	4.8	19.8	0	6.4	22.2	0	5.2	30.4
LSD 0.05		29	1.1	9.2	29	1.1	9.2	29	1.1	9.2	29	1.1	9.2	29	1.1	9.2	29	1.1	9.2	12	0.4	3.7
CV		83	28	37	83	28	37	83	28	37	83	28	37	83	28	37	83	28	37	83	28	37
Average[5]		30	4.0	37.9	20	2.9	12.3	42	2.3	9.7	23	3.2	23.5	13	3.3	19.6	40	2.7	14.2			

[1]Treatments applied April 22, 1991.

[2]Wheatgrass, crested (Hycrest); wheatgrass, intermediate (Oahe); fescue, tall (Fawn); bluegrass, big (Sherman); wildrye, Russian (Bozoisky); and bromegrass, smooth (Manchar). Grasses seeded April 12, 1991.

[3]Evaluations August 6, 1991. IN = % grass injury; GP = number of plants per pot; GH = grass height in cm.

[4]Surfactant (X-77) added at 0.25% v/v. Liquid nitrogen (28-0-0) added at 1 qt/A.

[5]Average is for grasses without regard to rate. LSD (0.05) of 17 for grass damage; 0.6 for number of plants per plot; and 5.3 for grass height is valid within the row.

WEED CONTROL IN WINTER WHEAT, CHEMICAL FALLOW, AND OTHER CROPS WITH UCC-C4243. D. N. Joy and A. R. Bell, Product Development Representative, and New Product Research Manager, Uniroyal Chemical Company, Inc., Yakima, WA 98908 and Bethany, CT 06524.

Abstract. UCC-C4243, 1-methylethyl 2-chloro-5-[3,6-dihydro-3-methyl-4-trifluoromethyl-2,6-dioxo-1 (2H)-pyrimidinyl]-benzoate, is active preemergence and postemergence at application rates of 0.06 to 0.17 kg/ha for control of many annual broadleaf and small seeded grass weeds. The postemergence activity resembles that of paraquat; however, UCC-C4243 exhibits broad spectrum preemergence activity also. This combination of attributes is ideal for use in chemical fallow where there is a need to control existing weeds as well as preventing additional weeds from emerging. Typical use rates in winter wheat range from 0.06 to 0.11 kg/ha for control of many common annual weeds. Winter wheat has shown tolerance to preemergence applications of UCC-C4243 at rates up to 0.17 kg/ha. UCC-C4243 applied at 0.22 to 0.44 kg/ha has provided excellent preemergence and postemergence control of major non-crop and industrial site weeds such as kochia and Russian thistle. In addition, UCC-C4243 has shown utility in crops such as spring wheat, dormant alfalfa, peas, trees, and vines.

WEED CONTROL IN WINTER WHEAT WITH UBI-C4243. A.G. Ogg, Jr., D. C. Thill, and D. J. Rydrych. Plant Physiologist, USDA-ARS, Pullman, WA 99164; Professor, Dept. Plant, Soil and Entomological Sciences, Univ. of Idaho, Moscow, ID 83843; and Professor (retired) Oregon State University, Box 415 Helix, OR 97835.

Abstract. UBI-C4243 is an experimental herbicide from Uniroyal Chemical Company that in preliminary tests has controlled many broadleaf weeds in wheat. In the fall of 1990, UBI-C4243 was applied preplant incorporated (PPI), preplant surface (PPS), post plant, preemergence incorporated (POPI), and preemergence (PRE) to soft white winter wheat at 0.07, 0.1, and 0.14 kg/ha, at LaCrosse, WA, Moscow, ID, and Pendleton, OR. At LaCrosse, WA and Moscow, ID 'Hill 81' wheat was planted with standard double-disc drills. At Pendleton, OR, 'Stephens' wheat was planted with a 'Great Plains' drill. A spike-tooth harrow was used to incorporate the herbicide in the PPI and POPI treatments. At all three locations, UBI-C4243 at 0.07 kg/ha controlled broadleaf weeds (blue mustard, coast fiddleneck, common lambsquarters, field pennycress, henbit, mayweed chamomile, prickly lettuce, and volunteer rape) 80% or more and at 0.1 kg/ha controlled broadleaf weeds 95% or more, except when applied PPI where weed control was reduced. UBI-C4243 applied at 0.14 kg/ha controlled downy brome 90% when averaged over all timings, and was least effective when applied PRE. Slight visual injury symptoms were noted on wheat at Pendleton, OR where UBI-C4243 was applied POPI, and wheat populations were reduced up to 28% at Moscow, ID by 0.14 kg/ha of UBI-C4243 averaged across application times. The wheat recovered from these early season effects and yield of wheat treated with UBI-C4243 was equal to or greater than yield of wheat treated with commercially accepted herbicides [metribuzin plus bromoxynil at LaCrosse, WA; (trifensulfuron plus tribenuron) plus bromoxynil at Moscow, ID; chlorsulfuron at Pendleton, OR]. Based on these experiments, UBI-C4243 appears to have significant potential for broad spectrum weed control in winter wheat.

WEED CONTROL WITH UCC-C4243. Edward S. Davis, Peter K. Fay, and Arnold W. Walz, Assistant Professor, Professor, and Senior Associate of Product Development, Central Agricultural Research Center, Moccasin, MT 59462, Plant and Soil Science Department, Montana State University, Bozeman, MT 59717, Uniroyal Chemical Company Inc., West Des Moines, IA 50265.

INTRODUCTION

UCC-C4243 is a broad spectrum herbicide with postemergence and preemergence activity being developed by the Uniroyal Chemical Company. UCC-C4243 applied postemergence causes desiccation of plant tissue after exposure to sunlight and preemergence applications cause reduced seedling growth followed by similar desiccation. UCC-C4243 applied to a dry soil surface over a moist subsoil is relatively ineffective and requires at least 1.3 cm of moisture for activation. UCC-C4243 applied to roots or stem tissue translocates in an acropetal direction but does not translocate in a basipetal direction and therefore has potential as a crop desiccant. Field trials were conducted in Montana with UCC-C4243 in spring wheat, winter wheat, alfalfa, and fallow from 1988 through 1991.

MATERIALS AND METHODS

Field trials were arranged in a randomized complete plot design with three replications per treatment. Individual plot size was 7 by 25 ft in crop and 10 by 40 ft in fallow. Herbicides were applied using a CO_2 backpack sprayer delivering 14 gpa at 40 psi through 8002 flat fan nozzles. Herbicide treatments applied postplant incorporated were incorporated with a coil tine harrow 1 to 1.5 inches deep. Trials were conducted under typical Montana dryland cropping conditions. Visual crop injury and yield was measured and control of weedy species was evaluated.

RESULTS AND DISCUSSION

UCC-C4243 applied preemergence to spring wheat (Var. Pondera and Newana) at 0.09 and 0.125 lb/A resulted in very little crop injury while providing complete control of common lambsquarters, redroot pigweed, kochia, prostrate pigweed, and green foxtail and suppression of wild oats (Tables 1 and 2).

Preplant applications of UCC-C4243 to Newana spring wheat at 0.09 and 0.125 lb/A gave 97 and 99% control respectively of sulfonylurea resistant populations of Russian thistle evaluated 2 weeks after treatment (WAT) and 81 and 94% control evaluated 6 WAT. A few Russian thistle plants survived the UCC-C4243 treatments and appeared very healthy. The tankmix of metsulfuron 0.038 lb/A plus 2,4-D amine 0.25 lb/A was not effective on this population of Russian thistle (Table 3).

Postplant incorporated applications of UCC-C4243 to spring wheat at 0.125 and 0.188 lb/A gave greater than 95% control of green foxtail. UCC-C4243 at 0.125 lb/A tankmixed with 1 lb/A of triallate provided 90% control of wild oats compared to just 47% control when triallate was used alone at 1 lb/A. This tankmix also gave 100% control of green foxtail (Table 4).

UCC-C4243 was safe on winter wheat when applied preemergence at 0.063 to 0.188 lb/A but was not effective at controlling downy brome. Triallate was the most effective treatment with only 70% control (Table 5).

UCC-C4243 appears to have promise for broad spectrum weed control in established alfalfa but must be applied while the crop is dormant. This trial was treated when the alfalfa had resumed growth in the spring so substantial injury was observed due to desiccation of the leaf and stem tissue. No permanent damage occurred due to lack of basipetal translocation of the herbicide. Broad spectrum weed control was similar to that provided by imazethapyr at 0.06 lb/A (Table 5).

Short residual, broad spectrum herbicide treatments for weed control in fallow were tested in winter wheat stubble. UCC-C4243 has good activity on Russian thistle applied both pre and postemergence. UCC-C4243 is not effective on annual grass weeds, but excellent control of Russian thistle, volunteer wheat, wild oat, and downy brome was achieved when tankmixed with atrazine, clomazone, or UBI 2587 (Pantera) (Table 6 and 7). UCC-C4243 tankmixed with UBI-2587 reduced Russian thistle control, and UCC-C4243 seemed to antagonize grass control with glyphosate (Table 8).

Table 1. UCC-C4243 applied preemergence to spring wheat.

Treatment	Rate	TRIAE injury	Control			TRIAE yield
			CHEAL	AMARE	KCHSE	
	- lb/A -	%	%			Bu/A
UCC-C4243 pre	0.09	3	100	100	100	30
UCC-C4243 pre	0.125	1	100	100	100	34
UCC-C4243 pre +	0.09					
2,4-D amine	0.38	2	100	100	100	33
UCC-C4243 pre +	0.125					
2,4-D amine	0.38	7	100	100	100	31
Metsulfuron +	0.0038					
2,4-D amine	0.25	1	98	94	95	31
Control	0.25	0	0	0	0	30

Table 2. UCC-C4243 applied postemergence to spring wheat.

Treatment	Rate	TRIAE injury	Control					TRIAE yield
			AMARE	AMABL	CHEAL	AVEFA	SETVI	
	- lb/A -	%	%					Bu/A
UCC-C4243 pre	0.09	4	100	100	100	58	100	47
UCC-C4243 pre	0.125	10	100	100	100	70	100	48
UCC-C4243 pre +	0.09							
2,4-D amine	0.38	8	100	100	100	46	100	47
UCC-C4243 pre +	0.125							
2,4-D amine	0.38	9	100	100	100	61	100	47
Fenoxaprop +	0.78							
2,4-D + MCPA		8	76	96	100	71	94	49
Control		0	0	0	0	0	0	49

Table 3. UCC-C4243 applied postemergence to spring wheat for control of sulfonylurea resistant Russian thistle.

Treatment	Rate	TRIAE injury	Russian thistle control		
			2 WAT	4 WAT	6 WAT
	- lb/A -	%	%		
UCC-C4243 pre	0.09	0	97	92	81
UCC-C4243 pre	0.125	0	99	98	94
UCC-C4243 pre +	0.09				
2,4-D amine	0.38	0	98	91	86
UCC-C4243 pre +	0.125				
2,4-D amine	0.38	0	100	98	91
Metsulfuron +	0.0038				
2,4-D amine	0.25	0	33	37	8
Control	0.25	0	0	0	0

Table 4. UCC-C4243 applied postplant incorporated in spring wheat.

Treatment	Rate	TRIAE injury	Control							TRIAE yield
			SETVI	AMARE	SINAR	ANABL	THLAR	SETVI	AVEFA	
	-lb/A-	%	%							Bu/A
UCC-C4243 pre	0.063	0.7	85	100	93	100	100	83	47	50
UCC-C4243 pre	0.125	1.3	97	100	100	100	100	98	64	50
UCC-C4243 pre	0.188	2.7	100	100	100	100	100	96	48	43
Triallate	1.0	0.0	0	0	0	0	0	0	47	48
Triallate +	1.0									
UCC-C4243	0.125	1.3	95	100	100	100	100	100	90	47
Control		0.0	0	0	0	0	0	0	0	51

Table 5. UCC-C4243 in established alfalfa.

Treatment	Rate	MEDSA injury	Control							MEDSA yield
			THLAR	KCHSC	POLCO	SETVI	LACSE	CHEAL	AVEFA	
	-lb/A-	%	%							Ton/A
UCC-C4243	0.19	50	100	80	100	100	50	100	80	1.38
UCC-C4243 pre	0.25	47	100	87	100	97	47	100	87	1.29
Imazethapyr +										
Sunit II	0.06	11	97	94	93	90	11	97	94	1.80
Control		0	0	0	0	0	0	0	0	2.31

Table 6. UCC-C4243 in fallow.

Treatment	Rate	Control		
		SASKR	TRIAE	BROTE
	- lb/A -	%		
UCC-C4243	0.06	33	0	0
UCC-C4243	0.125	100	7	3
UCC-C4243 + atrazine	0.06 + 0.5	100	100	100
UCC-C4243 + clomazone	0.06 + 0.5	100	99	92
UCC-C4243 +	0.06			
UBI-2587+COC	0.06	100	80	88
UBI-2587+COC	0.06	0	92	93
Control		0	0	0

Table 7. UCC-C4243 in fallow.

Treatment	Rate	Control		
		SASKR	AVEFA	BROTE
	- lb/A -	%		
Clomazone + atrazine	0.75 + 0.5	96	99	100
UCC-C4243 + COC	0.06	40	10	0
UCC-C4243 + COC	0.125	66	38	0
UCC-C4243 + atrazine	0.06 + 0.5	98	98	100
Control		0	0	0

Table 8. UCC-C4243 in fallow.

Treatment	Rate	Control		
		SASKR	AFEVA	BROTE
	- lb/A -		%	
UCC-C4243 (pre)	0.09	75	0	0
UCC-C4243 (pre)	0.125	65	0	0
UCC-C4243	0.09	99	40	33
UCC-4243 + UBI-2587	0.09 + 0.06	25	100	100
UCC-C4243 + glyphosate	0.09 + 0.31	97	7	0
Glyphosate + 2,4-D	0.09	99	95	93
Control		0	0	0

SUMMARY

UCC-C4243 has promise as a broad spectrum herbicide for use in dryland wheat production. Confirmed sulfonylurea resistant populations of kochia and Russian thistle appear to be susceptible to UCC-C4243 treatment although further testing is necessary to evaluate "escapes" where > 98% control is achieved. UCC-C4243 has excellent activity on green foxtail and moderate activity on wild oat. The combination of UCC-C4243 with triallate has promise and should be tested further. Application of UCC-C4243 to established alfalfa prior to initiation of spring growth provided good broad spectrum weed control, however it is weak on downy brome. Tankmixes of UCC-C4243 with atrazine, clomazone, or UBI-2587 were effective in chemical fallow but dry years will reduce performance.

FIELD BINDWEED CONTROL IN A WHEAT-FALLOW ROTATION WITH BAS-514. T. D'Amato and P. Westra, Research Associate and Associate Professor, Department of Plant Pathology and Weed Science, Colorado State University, Ft. Collins, CO 80523.

Abstract. Field bindweed remains the most persistent, troublesome perennial weed for winter wheat producers in Colorado. Coordinated research in the Central Great Plains from 1988 to 1990 evaluated several herbicide combinations involving picloram, banvel, 2,4-D, and glyphosate plus 2,4-D premixes for effective field bindweed control. Control in excess of 90% 1 yr after treatment (YAT) was consistently achievable with several herbicide mixes evaluated, but by 2 YAT, significant new field bindweed regrowth had occurred in most plots.

Since 1988, we have evaluated potential field bindweed control with a new herbicide, BAS-514. In many instances, we have conducted the BAS-514 studies where its control of field bindweed could be compared with control provided by labeled herbicides commonly used to control field bindweed.

In the season of application, BAS-514 applied at 0.25 lb/A has provided good to excellent field bindweed control (95% +). The yr following application, however, control at this rate has dropped off beginning in June or early July. BAS-514 applied at 0.5 lb/A has provided in excess of 85% control 2 YAT, and the increased control 2 YAT from the 0.75 lb/A rate was small compared to the increase in herbicide rate. Under Colorado conditions, based on several years of research at several sites, it appears that the necessary BAS-514 rate for effective field bindweed control will lie between 0.25 and 0.5 lb/A.

Plantback research with BAS-514 suggests that under dryland conditions in Colorado, corn, sorghum, and proso millet have good crop tolerance to this new herbicide. Irrigated crop research will determine the response of several irrigated crops to BAS-514.

JOINTED GOATGRASS SURVEY AND RESEARCH RESULTS IN COLORADO. W. Stump and P. Westra, Research Assistant and Associate Professor, Department of Plant Pathology and Weed Science, Colorado State University, Ft. Collins, CO 80523.

Abstract. Surveys conducted in 1989 and 1991 assessed the acreages of jointed goatgrass, volunteer rye, and downy brome infestations in all 63 counties in Colorado. One or more of these weeds are found in 44 of the 63 counties, infesting 1.3 million A of crop land. These winter annual grasses currently constitute our most serious weed threats to sustainable wheat production in Colorado. As a result of this survey, a jointed goatgrass task force was assembled by the Colorado Department of Agriculture. A four point education and research strategy was developed by the task force to include: 1.) conduct prevention, education, and roadside management programs; 2.) promote weed control through crop rotation and cultural practices; 3.) develop new strategies for jointed goatgrass control in wheat; and 4.) develop effective biological control methods.

In 1991, a statewide survey of grain handlers (97 participants) revealed that of the 1991 winter wheat crop, 22.7% was contaminated with jointed goatgrass, 9.8% with downy brome, and 3.2% with volunteer rye. More than 50% of the respondents indicate that these three weeds, particularly jointed goatgrass, have increased in severity over the past 3 yr.

Studies on the effects of tillage, crop rotations, novel new control strategies, soil seed depletion studies, and chemical fallow on winter annual grasses have been established at Platner, Ft. Collins, and Platteville Colorado. At Platner a 5 yr rotation study has been established to determine the effect of rotation duration and cropping sequence on jointed goatgrass population dynamics and has completed the first cropping cycle. Results from a tillage study indicate that jointed goatgrass emergence was greatest with no or little soil disturbance. The undisturbed check plots had 23 plants/2 ft^2 compared to disking and plowing treatments which only had 4 and <1/2 ft^2 respectively. The seed bank depletion study has revealed little change in the goatgrass population after 1 yr.

Volunteer rye studies were conducted at the Ft. Collins site. A tillage study similar to the one conducted with jointed goatgrass has shown that volunteer rye emergence is increased with soil disturbance except with deep plowing. In the undisturbed check emergence was 14 plants/2 ft^2 yet disking and sweeping produced 53 and 42 plants/2 ft^2 respectively. Volunteer rye seed banks are ephemeral in nature with <1% seed viable after 3 yr in a burial study and plant populations reduced up to 90% in the seed bank depletion study after 3 yr.

A depth of emergence study was conducted in the greenhouse with the three grasses under optimal moisture conditions. All grasses emerged from all depths although emergence was drastically reduced at 15 cm the deepest depth. Downy brome had the least emergence over all depths when compared to volunteer rye and jointed goatgrass.

WEED CONTROL IN POTATOES WITH HERBICIDES APPLIED WITH A POSTEMERGENCE-DIRECTED SPRAY SYSTEM. Charlotte V. Eberlein, Mary J. Guttieri, and Felix N. Fletcher, Associate Professor, Research Associate, and Research Technician, University of Idaho Aberdeen Research and Extension Center, Aberdeen, ID 83210.

Abstract. A drop nozzle spray system for making directed applications of selective and non-selective herbicides in 'Russet Burbank' potatoes was developed. Bromoxynil, glufosinate, monocarbamide dihydrogensulfate, or a bentazon plus metribuzin mixture were applied mid- or late-postemergence with the drop nozzle sprayer. Experiments were conducted under weedy and weed-free conditions in order to evaluate weed control with and potato tolerance to the herbicides. Weed control was excellent with bromoxynil or bentazon plus metribuzin, good to excellent with monocarbamide dihydrogensulfate, and fair to good with glufosinate. Initial foliar injury was 12 to 21% with directed applications of glufosinate,

≤ 12% with bromoxynil, < 10% with monocarbamide dihydrogensulfate, and ≤ 5% with bentazon plus metribuzin. Yield of US No. 1 tubers was reduced 30% by glufosinate at 0.75 lb/A, the rate needed for good broadleaf weed control. In contrast, yield of US No. 1 tubers was not reduced by directed sprays of bromoxynil, monocarbamide dihydrogensulfate, or bentazon plus metribuzin. Directed sprays of bromoxynil, monocarbamide dihydrogensulfate, and bentazon plus metribuzin showed good potential for control of troublesome broadleaf weeds, such as hairy nightshade and kochia, in potatoes. When misapplied over the top of potato foliage, bentazon plus metribuzin caused much less potato injury than bromoxynil or monocarbamide dihydrogensulfate.

ERWINIA CAROTOVORA **SURVIVAL IN POTATO SOILS AS INFLUENCED BY WEED RHIZOSPHERES.** P. Westra, L. Harrison, and M. Harrison, Assistant Professor, Research Associate, and Professor, Department of Plant Pathology and Weed Science, Colorado State University, Ft. Collins, CO 80523.

Abstract. The population dynamics of known serogroups of *Erwinia carotovora* subsp. atroseptica Eca (SK1) and *Erwinia carotovora* subsp. *carotovora* Ecc (III,IV, and XXIX) applied to field plots in the presence and absence of weeds in 1989 was followed through the growing season of 1990. A faster decline in quantifiable populations was seen in Eca treatments compared to Ecc treatments. Eca was not recovered in 1990 but applied Ecc serogroups and unidentified Ecc serogroups were recovered from plots in 1990. Long term persistence of applied Ecc serogroups was found in the presence of barnyardgrass, green foxtail, and kochia, but in the presence of redroot pigweed, hairy nightshade, and lambsquarters persistence was short. The water used to irrigate the plots introduced unidentified serogroups which were recovered from plots in 1990. Unidentified Ecc serogroups were recovered more frequently in 1990 than the known serogroups applied to plots in 1989. Contaminated machinery may have been responsible for the cross-contamination which occurred between Ecc and Eca-infested plots. Known serogroups applied in 1989 and unidentified serogroups, probably introduced with irrigation water, were recovered more frequently in 1990 from plots planted with grassy weeds or kochia than plots planted with redroot pigweed or hairy nightshade. No strains of Ecc or Eca were recovered in 1990 from plots planted with lambsquarters. Initial fall 1991 assessment of the interaction of weed-enhanced *Erwinia* survival with disease expression in potatoes shows that no *Erwinia* carried over in sufficient numbers in yr 3 of the study to cause disease expression in tubers from any plots. Additional assessment of stored tubers will further evaluate potential disease expression in potatoes harvested from all plots. This research will determine the relative importance of controlling selected weed species in potato rotations where the threat of *Erwinia* potato contamination can pose serious problems. Assessment of post harvest tuber quality showed that less than 1% of the tubers from this study were contaminated with *Erwinia*. Further analysis will determine if the *Erwinia* encountered is from the original serogroups applied to the soil.

EXTENSION, EDUCATION AND REGULATORY

EXTENSION WEED MANAGEMENT PROGRAMS IN OREGON. L. C. Burrill and R. D. William, Extension Agronomist, Department of Crop and Soil Science and Extension Horticulturist, Department of Horticulture, Oregon State University, Corvallis, OR 97331.

Abstract. Weed control programs in the Oregon State University system are located in departments of Crop and Soil Science, Horticulture, and Forest Science as well as in county extension programs and at several branch stations. A separate program to monitor and control certain weeds classified as noxious is administered by the Oregon Department of Agriculture which also works closely with county noxious weed groups. The authors lead state-wide extension programs in close cooperation with County Extension Agents. A Pacific Northwest Weed Control Handbook is revised and published annually in collaboration with Extension specialists in Idaho and Washington. This publication serves as the major method of extending information on herbicide registrations for specific crops and selected weeds. Weed control or vegetation management research including living mulches and cover crops is done in cooperation with Extension Agents to generate information and to serve as focal points for extension programs in the counties.

A book, *Guide to Selected Weeds of Oregon* was published in cooperation with the Oregon Department of Agriculture and contains photographs of 144 of the most serious weeds in Oregon. A large collection of weed slides is available to county agents for weed identification programs in their counties. Recertification training on pesticide safety is coordinated by the Integrated Plant Protection Center. The extension weed control specialists work with county agents and others in planning and conducting several large training courses annually as part of the recertification effort.

A new bulletin series on the biology and identification of selected weeds is underway as a tri-state effort. Regular use is made of radio, video, and newsletters to spread information on weed management. A specially equipped 50 gallon pull-type sprayer and a Spray Check® spray table are available to county agents and specialists to aid in teaching sprayer calibration and the care and selection of spray nozzles. Another new effort involves use of systems approaches to improve complex and value-laden situations using non-judgmental techniques associated with the pesticide controversy and the future of agriculture.

WEED SCIENCE EXTENSION PROJECTS IN MONTANA. D. L. Zamora, Assistant Professor, Department of Plant and Soil Science, Montana State University, Bozeman, MT 59717.

Abstract. Weed science education and awareness projects for crop and noncrop weeds are conducted at Montana State University and at various other organizations in the state. Crop-weed extension activities include weed seedling identification, weed management demonstration plots, and herbicide weed control trials. Weed seedling identification is a popular program with agricultural producers and retailers. The *Montana Weed Seedling Guide*, a pocket-sized book, features line diagrams to illustrate seedling leaf shapes and other diagnostic features and color photographs of common weed seedlings. Dichotomous keys for common broadleaf and grass seedlings in Montana have also been prepared. The current emphasis of the weed seedling program is a workshop using live weed seedlings to teach the use of the dichotomous keys. A graduate student has been conducting these workshops throughout the state. The next phase in the weed seedling identification program is to teach others how to present the identification workshop. Interested people attend a training session where they are "certified" to teach weed seedling identification. The certified instructors can order live weed seedlings grown at Montana State University for workshop sessions. Eventually the methods for growing the seedlings and for presenting the workshop will be published to facilitate general use.

Extension activities at Montana State University in noncrop weeds include identification, management, biology, and a plant identification service. Training sessions are conducted for noxious weeds and other noncrop weeds; noxious weeds not yet established in the state are emphasized. Herbarium specimens, live plants, and slides are currently used as training tools; videos for identification, biology, and control are being planned for future training sessions. Extension bulletins are planned for management of noxious weeds and biology of specific noncrop weeds. The Extension Service also provides a plant identification service. This service is provided at no cost to all citizens in the state and is funded by grants. It is extremely valuable because it enables us to detect new invaders and monitor weed movement in the state.

Other extension activities for crop and noncrop weeds include demonstration plots and weed control guides. Field plots are used to demonstrate weed management using herbicides, grazing, and integrated treatments. Field plots also are established statewide to address current issues such as herbicide resistance and herbicide carryover injury and to provide information for herbicide recommendations. A paper and computer herbicide recommendation guide for crop and noncrop weeds in Montana is prepared by the Extension Service. The recommendations are based on the results of state and regional weed control trials. An expert system, WEEDPROB, makes weed control recommendations based on the crop, weed spectrum, crop and weed stage, weed density, and selected soil conditions. The expert system ranks recommendations by efficacy, cost, and probability of leaching.

There are weed educational projects in Montana that are not conducted by Montana State University. These projects include management demonstration projects, classroom educational programs, and weed awareness brochures. Cooperative projects organized by the county extension agents, county weed supervisors, and federal agencies are conducted to demonstrate weed management techniques such as sheep grazing and biological control of leafy spurge. A classroom oriented program called the "Montana Weed Project" was developed as part of the Resource Education Awareness Project. This program is an interdisciplinary curriculum for fifth through twelfth grades on the effect of weeds on the environment. For educating the general public, many weed identification and awareness brochures have been prepared by the state weed control association, federal agencies, the state department of agriculture, and individual counties.

EXTENSION WEED SCIENCE PROGRAMS AND EFFORTS AT THE UNIVERSITY OF IDAHO. Don W. Morishita, Charlotte Eberlein, and Robert H. Callihan, Assistant Professor, Associate Professor, and Professor of Weed Science, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83843.

Abstract. The University of Idaho currently has four weed scientists, three of whom have extension responsibilities. All three with extension appointments are located in different areas of the state. Those responsibilities have been divided more or less by commodity group rather than by geographical region. However, this does not preclude any of the weed scientist from addressing weed science related questions from their clientele. Activities of all extension weed scientists include active participation in presenting educational information related to weed science at workshops, seminars, and short-course schools, as well as the electronic news media. Additionally, popular press publications, extension publications, and technical journal publications have been prepared.

Specific extension programming activities has included some of the following: 1) short-course weed identification and herbicide mode and mechanism of action; 2) reduced-rate herbicide field demonstration plots; 3) herbicide injury demonstration plots; 4) identification and confirmation of triazine-resistant pigweed species; 5) development of an expert-systems computer weed identification program; 6) grower surveys to determine the extent of weed infestations and herbicide use for several weed species; and 7) weed diagnostic (identification) service.

University of Idaho weed scientists also are actively involved in local and state organizations concerned with statewide weed management efforts. All are members of the Idaho Weed Control Association and have been actively involved in the direction of this organization.

CALIFORNIA'S EXTENSION WEED SCIENCE PROGRAM. D. W. Cudney and C. L. Elmore, Extension Weed Scientists, University of California, Riverside, CA 92507 and Davis, CA 95616.

Abstract. California has undergone a severe reduction in Weed Science personnel the last 4 years. Two of the six Weed Science Specialists have retired. Three of the four full-time Weed Science Farm Advisors retired in 1991. There are no immediate plans to rehire Weed Scientists to fill these positions. This loss of county-based and campus-based Weed Scientists is not unique to Weed Science, but is part of an overall downsizing of Extension in California due to extreme budgetary constraints brought about by a declining economy. It is hoped that when the economy recovers, there will be some positive gains in extension Weed Science positions. However, until the economy improves, it is apparent that the Weed Science program in the state will have to attempt to do the job with fewer people. In addition to a reduction in the work force, there have also been cuts in support staff and the operating budgets of the Weed Scientists.

California Weed Scientists will be faced with a challenge of how to maintain a solid extension, research, and education program. In order to do this the following has been proposed as a temporary solution:

1. Prioritize major problems and work on the highest priorities first. This will mean that some of the projects of lower priority may not be accomplished.

2. Encourage some of the commodity Farm Advisors who have not been active in Weed Science projects to get involved. We will be facing competition from other pest management disciplines for these people's time.

3. Utilize the IPM Farm Advisors in the state to help fill in for the loss of county-based Weed Science Farm Advisors.

4. Utilize California's IPM publication system to deliver weed management manuals through a more efficient computer-based "on line" system.

5. Capitalize on the opportunity to work regionally on Weed Science projects and publication needs. There are many research and education projects that would benefit more than one state. There is much to be gained in quality and efficiency with collaborative projects (a good example is *Weeds of the West*).

Some of these measures have already been implemented, at least in part. It is evident that a more thorough implementation of these and other imaginative measures will have to be made to keep California's Weed Science program strong in the short term. However, in the long term the answer will have to come from restaffing the vital Weed Science positions that have been lost.

AN OVERVIEW OF EXTENSION WEED CONTROL PROGRAMS AND METHODS IN UTAH.

S. A. Dewey, Associate Professor and Extension Weed Specialist, Department of Plants, Soils, and Biometeorology, Utah State University, Logan, UT 84322-4820.

Abstract. There is only one state Extension weed specialist in Utah. His primary responsibility is to increase public awareness and concern about weeds, and to promote effective weed control practices. Greatest emphasis is placed on agronomic crops, range and pasture, and noxious weeds. However, he also is expected to provide Extension weed control support in areas of commercial and home horticulture (fruits, vegetables, and ornamentals), aquatics and irrigation canals, parks and recreation areas, and rights-of-way. Extension agents in Utah's 29 counties promote and conduct weed programs at the local level through educational efforts aimed at numerous and diverse clientele groups. Extension information delivery methods currently used at the state and/or county level include:

Publications. The Utah Weed Control Handbook (EC 306) is a 100- to 150-page summary of EPA-approved herbicide options for use on the various crops and non-crop categories in Utah. It is revised and published annually. EC 391 'Weed Control for the Homeowner' is a 20-page bulletin containing information on weed control options in lawns, vegetable gardens, shrubs, and other residential settings. It is updated and re-published regularly, as needed. The 'Weeders Digest' newsletter is published periodically to inform county Extension agents and weed supervisors of current issues, new products, seminars and meetings, and other items of interest. Newsletter recipients also include interested farmers, ranchers, USFS, BLM, SCS, and other government agency personnel. An annual 'Summary of USU Extension Weed Control Demonstration and Research Projects' is published and distributed exclusively to county Extension agents. It contains results of all state and county Extension weed control demonstrations and research studies conducted during the year. This publication is a means to inform all Extension agents of new products and weed control strategies, and demonstrates how specific products might be expected to perform under their local conditions. The publication also provides agents with a vehicle in which to publish results of their own weed control demonstrations. Looseleaf notebooks have been prepared containing all available Extension weed identification and/or weed control publications (bulletins, circulars, etc.) from Utah and other western states. One notebook is placed in each county Extension office, and updated as new bulletins become available. A copy of the book *Weeds of the West* has been placed in every county Extension office. Extension regularly publishes a multi-page insert in the Utah Farmer-Stockman magazine. Each insert addresses a specific agricultural topic of current interest. Weed control has been the main topic or a supportive element of several of these inserts. Individual weed awareness or weed control articles are published in other popular agricultural periodicals and newspapers.

Slide/Tapes and Videos. Two slide/tape sets have been prepared in recent yr to teach identification of the noxious and invading weeds of Utah. Both programs have been made available on videotape. A slide/tape presentation on dyers woad biology and control has been produced. Another slide/tape presentation was developed to help educate the general public about the many ways weeds impact Utah. A large file of weed control and weed identification slides is maintained on campus by the Extension weed specialist. Custom-made slide presentations (with computer-generated text slides or script) are prepared by the weed specialist at the request of individual agents for use in local meetings. County Extension agents are made aware of weed control videos and slide sets produced by industry or other universities, and arrangements are made for their use or purchase through Utah's Extension weed specialist.

Computer programs. A computerized information base program called *The Utah Fruit Pest Management Program* has been developed recently by Tony Hatch, state Extension fruit specialist, in cooperation with the Extension weed, insect, and plant pathology specialists. The program is designed to assist Utah fruit growers recognize important insect, disease, and weed pests, and to select the most effective control options. *Planetor* is a decision-making computer program developed by Larry Bond, Extension ag economist, in cooperation with other Extension specialists, to assist in whole-farm crop and chemical use planning. The program allows farmers to make 'best choices' for crop rotations, herbicides, insecticides, and fertilizers, maximizing economic returns and minimizing any risks to the environment.

Seminars and tours. Numerous individual county weed identification and weed control seminars are conducted each yr. The Extension weed specialist participates in as many of the seminars as possible (in person, or via teleconference communication). Others seminars are conducted solely by the county agents and or county weed supervisors. Specific weed topics vary widely, and address local needs and interests. Each yr a team of four to eight Extension specialists provides intensive day-long or half-day crop production seminars in each county within a designated Extension district (8 to 10 counties). New seminars are conducted in each district on a 3-yr rotation. Seminars normally focus on a single crop commodity. All major production aspects usually are addressed, including variety selection, fertilization, irrigation, insect and disease control, and marketing. Weed control is always a major part of the programs. Weed control field days and tours are conducted periodically to show local farmers and ranchers the results of herbicide demonstrations and research plots in various parts of the state. Other tours and seminars are conducted by Extension agents and/or the weed specialist specifically to provide weed identification training to local clientele. Weed identification tours may be day-long events with buses transporting groups to various weed infestations, or they may be short evening walking tours (referred to as twilight tours) in a few fields or a small area within a community. Some counties conduct what are termed 'BYOW' (bring your own weed) seminars. Participants are encouraged to bring as many weeds as possible to the meeting for identification. Weeds are displayed on tables, and the group is instructed on the correct identification of each weed. A weed identification service is provided for agents and others who send samples to the USU plant diagnostic lab or directly to the Extension weed specialist. Some counties have begun conducting a sprayer calibration field day on national 'earth day' to promote responsible application of pesticides. Local farmers are invited to bring their sprayers to a central location, where experts help check and calibrate the equipment. Extension is heavily involved in planning and presenting the program at the annual Utah Weed Control Association and Utah Weed Supervisors Association conferences. Extension representatives belong to numerous local weed control advisory and policy making organizations, including county weed boards, the Tri-State Weed Coordinating Association, the State Dyers Woad Task Force, and the State Weed Committee of Utah (an advisory group to commissioner of agriculture).

Field demonstrations. In cooperation with local Extension agents approximately 15 to 25 herbicide demonstration/research studies are established annually throughout the state. Their primary purpose is to allow agents to become familiar with new herbicides, comparing them with current products on local weed populations under local conditions. Ideally, these demonstrations let Extension agents gain experience with most new herbicides before local farmers become aware of the products. In many cases the county agent is responsible for spraying, evaluating, and harvesting the plots. Demonstrations usually are designed as replicated randomized plots to provide greater research value.

Radio and television. Radio and television are valuable tools in the dissemination of weed control information in Utah. The KSL Greenhouse show is an extremely popular, award winning, weekly, call-in radio program produced and hosted by area Extension agent, Larry Sagers. It is heard throughout Utah and in many parts of Idaho, Montana, and Wyoming, with an average estimated listening audience of over 50,000. Weed control is a frequent topic on the show. News-related weed issues usually result in two or three opportunities for network television interviews during the year. USU is currently expanding its 'distance education' communications capability to allow live 2-way audio/video satellite broadcasts between our campus and other universities, live 2-way audio/video microwave system (EDNET) broadcasts between campus and 22 county sites within Utah, and live 2-way audio 1-way video broadcasts from campus to most county Extension offices in the state. At least two weed control seminars are scheduled for this delivery method in 1992.

Agent training. Intensive 'inservice' workshops (2 to 4 days) are conducted in the summer for interested Extension agents and county weed supervisors, providing them with in-depth training on weed identification and/or weed control. Other workshops have been offered to train selected agents (at least two per Extension district) in herbicide field research and demonstration methods. Each Extension district has been provided with a research-quality CO_2 backpack sprayer for use by trained agents in establishing local herbicide studies. The Extension weed specialist works cooperatively with these agents in designing studies (providing PDMP or PRM computer print-outs and necessary herbicides). Agents locate, spray, evaluate, and harvest plots. The specialist usually participates in at least one evaluation of the plots during the season. Extension agents from surrounding counties are encouraged to attend at least one field evaluation session to become familiar with the work. The specialist also helps summarize data, and helps prepares the final report for entry in the annual Extension demonstration summary.

AN OVERVIEW OF WEED SCIENCE EXTENSION PROGRAMS AT THE UNIVERSITY OF WYOMING. T. D. Whitson, Extension Weed Specialist and Associate Professor, Department of Plants, Soil, and Insect Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Extension programs in Wyoming are divided into four categories: 1) agent training; 2) professional training; 3) grower meetings, workshops, demonstrations and tours; and 4) publications, slide-tape sets, and video tapes.

Agent training starts with a visit to the University extension agents office with an explanation of successful programs being conducted in weed science by other county agents. During that visit the agent can choose from some of the currently used programs or suggest some that they would like to see developed for the people in the county they serve. The more widely accepted programs usually include those that involve the agent and give them recognition in their own county and also allow them to be a full partner in research and demonstration work. The degree of involvement in demonstration/research differs from county agent to county agent. After helping them with the understanding of research principles and the techniques of establishing research and demonstration plots they are capable and often take the lead in weed control experiments. In the establishment of experiments that are replicated and duplicated and will be published, our responsibility includes the establishment of a protocol and prepackaging all herbicides in seal-a-meal plastic bags with plots number to be sprayed listed on each bag. The agents are provided the stakes, aluminum tags, 300 foot tapes, sprayers and grower and university recognition signs to allow a state-wide uniform system to be used.

With the use of grower and county recognition signs the agents are given credit for their work to people of their county. Another advantage is that plots are seldom destroyed accidently by the grower or his hired help because they know that research plots are behind the sign. Also, as a result of the sign agents are asked questions about the work and stay informed about the herbicides and their activity. This makes agent training easy because they are involved in the process. Nearly every yr tours are held to allow agents to discuss this work with other agents and county ranchers and farmers. In addition, nearly all reports either as state, regional or national refereed journal articles include county agents as co-authors of the research report. In Wyoming this type of research and extension report is an important part of the process for professional advancement. In addition to demonstration work county agents are updated continuously by telephone calls and letters.

Professional training in Wyoming is conducted for people who are commercial applicators. This training is done by University specialists at various times: a) during initial applicator certification, b) during the recertification process for renewal of licenses, c) by working with governmental and county agencies to update them, d) by hosting a herbicide workshop for professionals every other year, using company professionals as our primary training resource, e) symposiums are conducted, such as the regional leafy spurge symposium or noxious and poisonous plant symposiums, and f) telephone calls with individual questions are very frequent from this group of professional people.

Grower meetings, workshops, demonstrations and tours are very popular methods of providing Wyoming producers with information. Many of our extension agents are very effective educators and are providing weed control information at many of their schools. They should be encouraged to explain demonstrations and research work in which they have participated. This gives them more credibility in their counties and allows University specialists to be in support positions.

Publications include: the *Wyoming Weed Control Guide* (12 part series), *Weed Control in Lawn and Garden, Identification and Control of Wild Proso Millet, Jointed Goatgrass, Rangeland Research and Extension Demonstrations, Weeds and Poisonous Plants of Wyoming and Utah*, and *Weeds of the West*. Slide-tape sets include *Leafy Spurge a Rangeland Invader, Weeds in Wyoming that Cause Livestock Poisoning*, and *Cropland and Rangeland Weeds* and a video tape was done on sugarbeet weed management.

The concept of demonstrations was the basis for agricultural extension work in the early 1900's. Seaman A. Knapp the father of Extension said " Tell a farmer what to do and he will question it, show him information on what has been done and he will doubt it, but demonstrate principles on his own land and he must believe it". (Published with the approval of the Wyoming Agricultural Extension Service.)

WEED SCIENCE EXTENSION IN WASHINGTON STATE. R. Parker, Extension Weed Scientist, Washington State University, Prosser, WA 99350.

Abstract. When fully staffed, three scientists comprise the specialist component of the weed science extension program for Washington state. Even though each weed scientist has statewide responsibilities, the extension program is arbitrarily divided by type of agriculture. The agriculture fairly well divides Washington into three regions. One scientist is responsible for the dryland cereal/pea/lentil areas in eastern Washington, another is responsible for irrigated crops (the majority of which are located in central Washington), and the third is responsible for crops and programs in the high rainfall areas of western Washington. One specialist is located on the main campus at Pullman and the other two at branch stations located in their respective work areas. Since each specialist has statewide responsibilities, they frequently will find themselves doing programs in counties outside their normal geographic area.

The appointment for each weed specialist differs. The specialist located at Pullman has a 75% extension-25% teaching split, the western Washington position, when filled at Mount Vernon will have a 75% extension-25% research split. The other position is presently 100% extension and is located in the irrigated area at Prosser.

Until recently, an area agent had a full-time weed science extension position. He had responsibility for some of the weed programs in five northeast Washington counties. In addition, there are several other specialists doing bits and pieces of extension work in weed science. These include range, cranberries, forestry, turf, and so forth.

The primary role of the weed specialists, in the author's opinion, is to train county and area extension agents, back up these agents, and be a resource for their programs. In addition considerable time is spent in pesticide recertification, Master Gardener training, demonstration/research plots, herbicide screening, and so on along with the normal day to day activities.

In Washington we are closely allied with the neighboring states of Idaho and Oregon and to a lesser extent British Columbia. We periodically help with programs in those states and in turn utilize their expertise in Washington programs. For example, the irrigated agriculture found in Oregon's Columbia Basin similar to that found in Washington. The distance travelled to serve this segment of Oregon's agriculture is considerably less for the WSU specialist from Prosser to reach than for either of OSU's weed specialists located in Corvallis. However, Oregon State University's two specialists are considerably closer to the southwest Washington than any of WSU's. In addition to coordination of some extension programs, much of the research conducted by the three states is coordinated to prevent duplication. This type of cooperation between Oregon, Idaho, and Washington faculty has led to the *Pacific Northwest Weed Control Handbook* and a growing number of publications on individual weeds written for use by growers and others.

EXTENSION WEED SCIENCE PROGRAMS AT COLORADO STATE UNIVERSITY. K. George Beck, Associate Professor and Extension Weed Scientist, Department of Plant Pathology and Weed Science, Colorado State University, Fort Collins, CO 80523.

Abstract. Three weed scientists share Cooperative Extension responsibilities at Colorado State University. Bert Bohmont is the senior member and his position is 100% Cooperative Extension. Dr. Bohmont is the pesticide coordinator at CSU and is responsible for pesticide safety education, pesticide applicator training, pesticide impact assessment, and IR-4 programs. Bert organizes the annual Crop Protection Institute where regional pest management professionals gather to receive updates on pest management strategies. Phil Westra and George Beck share responsibilities for developing and disseminating information on weed management systems. Their appointments are 70% Cooperative Extension and 30% Agricultural Experiment Station. Dr. Westra's research and extension areas of activity include the numerous field and row crops raised in Colorado. The majority of his effort is directed toward herbicide resistance, winter annual grass management in small grains, and developing weed management systems in corn, onion, sugar beet, and potato production. Phil also is cooperating with Dr. Ed Schweizer, USDA/ARS, on developing a bioeconomic model and alternative weed control strategies for Colorado cropping systems. Dr. Beck's research and extension activity areas include pasture/rangeland, non-crop areas, and alfalfa/grass hay production. The majority of George's efforts are directed toward developing integrated weed management systems for leafy spurge, Russian knapweed, and Canada thistle and conducting leafy spurge and Russian knapweed ecology research.

The team is involved in research-based education programs for county extension clientele, the Colorado Weed Management Association, federal, state, and county agencies, master gardeners, and several public groups such as the Colorado Native Plant Society, the Nature Conservancy, and grower organizations. George has been actively involved on committees that wrote state and federal weed laws. The Colorado Undesirable Plant Management Act and the amendment to the Federal Noxious Weed Act of 1974, Section 15 the Management of Undesirable Plants on Federal Lands, were passed by the Colorado Legislature and Congress, respectively, in 1990. Our extension weed science team also conducts a weed identification service as part of the CSU Pest Clinic. The Pest Clinic is enhancing its service through a statewide computerized system. This data base also will facilitate weed mapping throughout Colorado.

WEEDS OF AQUATIC INDUSTRIAL AND NON-CROP AREAS

SMOOTH CORDGRASS CONTROL USING GLYPHOSATE. Ron P. Crockett, Product Development Associate, Monsanto Agricultural Co., Vancouver, WA 98782.

Abstract. Smooth cordgrass is a rhizome producing perennial grass that has invaded the intertidal salt marshes and mud flats of Willapa Bay in southwestern Washington state and other sites along the West Coast. The presence of smooth cordgrass threatens a $13 million oyster industry in Willapa Bay, reduces migratory and shore bird habitats, and reduces the residential property values and recreational access to marine waters wherever it is found. Smooth cordgrass has the ability to trap up to 15 cm of sediment each year and thereby increases the probability of channelization and flooding in the tidal areas, and may eventually lead to the loss of the entire mud flat area. To date, approximately 810 ha of Willapa Bay have been infested by smooth cordgrass. Projections indicate that within the next 20 yr some 12,140 ha of Willapa Bay may be overtaken by smooth cordgrass.

Small plot replicated studies using glyphosate (formulated as Rodeo Herbicide) were established to simulate broadcast aerial and hand held spray-to-wet applications. In addition, a small clone of smooth cordgrass was treated using a hand held wiper. Initial burndown of the smooth cordgrass with all rates and methods was complete at 2 months after treatment (MAT) with nearly 100% control. Only slight differences were evident in early summer (10 MAT) between the 1.8 and 3.6 kg/ha broadcast treatments and the 1% and 2% v/v spray-to-wet solutions. All treatments exhibited excellent overall control including control of rhizomes. Additional studies were initiated in 1991 by the U.S. Fish & Wildlife Service to evaluate timings of glyphosate applications, while the Washington State Department of Natural Resources established minimum application rate studies on the Bone and Niawakum Rivers which both empty into Willapa Bay.

MON-13200 - A NEW HERBICIDE FOR BROAD SPECTRUM PREEMERGENCE WEED CONTROL. T. B. Klevorn, E. M. Johnson, Y. L. Sing, and S. J. Auinbauh, Product Development Manager, Herbicides, Research Specialist, Senior Research Specialist, and Research Specialist, Monsanto Agricultural Company, A Unit of Monsanto Company, St. Louis, MO 63167.

Abstract. MON-13200 is a new preemergence herbicide discovered by Monsanto Company and currently under development worldwide. It has activity against a broad spectrum of weed species and selectivity in a number of tree, vegetable, and agronomic crops. With either PPI or PRE applications, MON-13200 is especially effective against annual grass weed species and provides excellent long-term control at rates of 140-1120 g/ha. MON-13200 also controls several small-seeded broadleaf weeds at these rates of application. Toxicology and environmental fate studies conducted so far show favorable results for this new herbicide.

SUPPRESSION OF WEED VEGETATIVE GROWTH IN NON-CROP SITES WITH ASC-66746 AND ASC-65258. R. W. Gunnell, L. C. Haderlie, W. J. Rich, and W. R. Slabaugh, Research Agronomist, Agraserv, Incorporated, Weston, ID 83286, Weed Scientist, Agraserv, Incorporated, American Falls, ID 83211, Research Agronomist, Agraserv, Incorporated, Ashton, ID 83420, and Product Development Supervisor, ISK Biotech Corporation, Boise, ID 83709.

INTRODUCTION

Suppressing vegetative growth of weeds and/or desirable plant species with plant growth regulators is an alternative to other plant growth regulation methods which may be more costly and negatively impact the treatment site. The objectives of this study were to determine the level of weed growth suppression with ASC-66746 and ASC-65258 (experimental plant growth regulators of ISK Biotech Corporation), and to evaluate the effect of these plant growth regulators on weed seed viability.

MATERIALS AND METHODS

Two plant growth regulators (ASC-66746 and ASC-65258) were broadcast applied to actively growing weeds in the late seedling/pre-flower growth stage in a non-crop site near Dayton, Idaho June 28, 1991. Predominant weed species were Russian thistle (12 inches dia., 7 to 8 inches tall), yellow sweetclover (5 to 7 inches tall), green foxtail (6- to 8-leaf, 4 to 5 inches tall) and tumble mustard (2 to 6 inches tall, 6 to 14 inches dia. rosette). Individual prickly lettuce (6 inches tall) and kochia (10 inches tall) plants were noted, but populations were too low for evaluation. Plots were 10 by 20 ft with five replications in a randomized complete block design. Treatments were applied with a two l bottle sprayer calibrated to deliver 20 gpa at 25 psi. Soil type was sandy loam with 1.1% OM and a pH of 8.3.

RESULTS AND DISCUSSION

Weed growth suppression was first evaluated July 20, 1991. Russian thistle growth was reduced by all treatments, but ASC-65258 treatments were more effective than ASC-66746 treatments (Table 1). Yellow sweetclover growth was inhibited equally well by all chemical treatments. Growth regulator treatments reduced green foxtail growth less than other species tested, but ASC-65258 treatments were more effective than ASC-66746 treatments. Tumble mustard growth inhibition was influenced by growth stage at time of treatment. Tumble mustard plants in the rosette growth stage did not continue growing while mustard plants which were bolting at time of treatment continued growth and flowered. Growth of bolted tumble mustard plants was reduced by all treatments, but ASC-65258 treatments caused the greatest growth reduction.

In addition to growth suppression, the treatments caused a variety of plant injury symptoms. Russian thistle injury symptoms included epinasty, malformed (enlarged) flower parts and overall stunting. Yellow sweetclover was not changed in appearance except for stunting. Green foxtail was changed least of the species evaluated. Foxtail plants were only slightly stunted and older leaves were chlorotic at the leaf tip. Injury to tumble mustard plants depended on mustard growth stage at time of growth regulator application. Mustard plants that were in the small rosette stage at application did not grow beyond the rosette stage and lower (older) leaves became necrotic and dry. Mustard plants that were beginning to bolt at application continued to grow and flowered. Lower plant leaves were necrotic, but new growth was not as affected.

The experiment was reevaluated for weed growth suppression August 17, 1991. Weed growth measurements showed that Russian thistle growth continued, but was suppressed by all chemical treatments (Table 2). Growth responses of green foxtail and tumble mustard were similar to Russian thistle. As in the July 20 evaluation ASC-65258 treatments inhibited Russian thistle, green foxtail and tumble mustard growth best, but yellow sweetclover growth reduction was uniform among treatments. Yellow sweetclover did not continue to grow. Except for reduced growth, sweetclover plants appeared normal and healthy. Growth response of individual prickly lettuce and kochia plants was noted in some treatments. A prickly lettuce plant found in treatment no. 4 (ASC-65258 0.5) appeared to have been mechanically mowed at an earlier growth stage. Growth from the main stem was completely stopped, but new growth occurred from lower branches on the main stem. Height of the treated plant was 25 inches compared to 39 inches for a prickly lettuce plant found in the untreated control. Two kochia plants, one in treatment no. 1 (ASC-66746 1.0) and the other in treatment no. 3 (ASC-66746 2.0) were evaluated for growth reduction and injury. Height of the plants was 9 and 7 inches, respectively, compared to a 41 inch tall kochia plant in the untreated control. In addition to growth reduction, leaf tissue on the treated kochia plants was necrotic.

After the August 17 evaluation there was no measurable change in growth for the species evaluated. Growth reduction in treated plots demonstrated the manner in which plant populations may be manipulated by chemical treatments. In this study Russian thistle was the dominant species in the untreated control. In treated plots Russian thistle growth reduction caused the release of green foxtail and, to a lesser extent, yellow sweetclover. This shift to a predominant grass population was directly proportional to the growth reduction of Russian thistle.

On September 6, 1991 green foxtail and tumble mustard seed were harvested separately by hand. Individual replications were randomly sampled and seed was placed in small paper bags for storage. Russian thistle seed was not mature on this date and yellow sweetclover had not produced seed. Russian thistle seed was harvested November 11, 1991. Harvested seed for the three species was stored at room temperature (70 F) until November 25, 1991. Seed was transferred to the freezer (-10 F) for cold treatment prior to germination and was removed from cold storage December 23, 1991. On December 26 20 seeds/species/replication (100 seeds/treatment) were placed on blotter paper in individual petri dishes to test germination. Five milliliters of water were added to each dish and afterward on an as needed basis.

Percent germination was evaluated January 2 and 9, 1992 (7 and 14 days after adding water). Tumble mustard germinated earliest followed by green foxtail and Russian thistle. After 14 days there was no visual or statistical difference in seed viability among treatments (Table 3).

Table 1. Suppression of weed vegetative growth with ASC-66746 and ASC-65258 (22 days after treatment).

		Average plant height			
Treatment	Rate	Russian thistle	Green foxtail	Yellow sweetclover	Tumble mustard
	(lb/A)	inches			
ASC-66746	1.0	11.6 b	15.6 ab	6.6 b	22.2 b
ASC-66746	1.5	10.4 bc	15.2 ab	6.2 b	22.2 b
ASC-66746	2.0	10.8 bc	16.4 ab	6.8 b	22.2 b
ASC-65258	0.5	9.4 cd	13.6 b	6.8 b	15.2 c
ASC-65258	1.0	8.2 de	15.4 ab	6.6 b	13.6 c
ASC-65258	1.5	7.2 e	14.2 b	5.8 b	10.4 d
Untreated	---	21.4 a	18.0 a	13.8 a	26.6 a

Means followed by the same letter do not significantly differ (Duncan's MRT, P=.05).

Table 2. Suppression of weed vegetative growth with ASC-66746 and ASC-65258 (50 days after treatment).

Treatment	Rate	Average plant height			
		Russian thistle	Green foxtail	Yellow sweetclover	Tumble mustard
	(lb/A)	inches			
ASC-66746	1.0	13.8 b	18.0 bc	6.4 b	23.4 a
ASC-66746	1.5	15.0 b	20.2 b	7.0 b	23.2 a
ASC-66746	2.0	13.2 bc	18.8 bc	6.4 b	24.0 a
ASC-65258	0.5	11.2 cd	16.6 c	8.4 b	17.2 b
ASC-65258	1.0	11.2 cd	17.0 bc	7.2 b	18.4 b
ASC-65258	1.5	9.8 d	16.6 c	6.0 b	17.8 b
Untreated	---	26.6 a	24.0 a	15.6 a	25.4 a

Means followed by the same letter do not significantly differ (Duncan's MRT, P=.05).

Table 3. Percent weed seed germination after application with ASC-66746 and ASC-65258.

Treatment	Rate	Germination			
		Russian thistle	Green foxtail	Yellow[a] sweetclover	Tumble mustard
	(lb/A)	%			
ASC-66746	1.0	49 a	66 a	----	21 a
ASC-66746	1.5	42 a	74 a	----	40 a
ASC-66746	2.0	37 a	82 a	----	27 a
ASC-65258	0.5	35 a	75 a	----	18 a
ASC-65258	1.0	43 a	66 a	----	31 a
ASC-65258	1.5	37 a	88 a	----	17 a
Untreated	---	35 a	80 a	----	35 a

Means followed by the same letter do not significantly differ (Duncan's MRT, P=.05).
[a]Yellow sweetclover did not produce seed in either treated or untreated plots.

SUMMARY

ASC-66746 and ASC-65258 inhibited growth of the weed species investigated. ASC-65258 limited Russian thistle, green foxtail and tumble mustard growth better than ASC-66746. Growth reduction of yellow sweetclover was comparable for both compounds. The degree of stunting and severity of injury were species dependant. Green foxtail was changed least by growth regulator treatments. Overall growth was reduced by chemical treatments and leaf tips were chlorotic, but foxtail appearance was not altered. Russian thistle plants were both stunted and malformed by treatments. Tumble mustard plants treated in the rosette stage did not continue to grow and leaf tissue became necrotic. However, bolted mustard plants continued to grow and flower. Yellow sweetclover growth was uniformly controlled for the growing season by all growth regulator treatments. No other injury symptoms were noted. Limited observations of prickly lettuce and kochia indicated that some of the treatments halted primary stem growth of prickly lettuce and caused severe injury and growth reduction of kochia. Plant population shifts favored the grass species in treated plots. ASC-66746 and ASC-65258 treatments did not reduce seed viability of treated plants, but overall number of plants flowering and producing seed was reduced by chemical treatments.

BASIC SCIENCES

RATE OF METRIBUZIN AND PENDIMETHALIN DEGRADATION IN SOIL. Robert L. Zimdahl, Brian K. Cranmer, Professor and Research Associate, Department of Plant Pathology and Weed Science, Fort Collins, CO 80523, and Walter W. Stroup, Professor, Department of Biometry, University of Nebraska, Lincoln NE 68583.

Abstract. The first-order kinetic model historically has been used to describe herbicide degradation for three reasons: it has been assumed correct, it is mathematically simple, and it works well most of the time. However, detailed observation of herbicide degradation phenomena shows that first-order kinetics frequently overestimate initial and underestimate later herbicide residues. This research investigated alternative empirical descriptions of metribuzin and pendimethalin degradation at two field sites and in two soils under laboratory conditions using combinations of five moisture levels and three temperatures.

First-order and biexponential models were compared in this study. The biexponential equation has the form

$$C = aC_o/[(a + bC_o)e^{at} - bC_o]$$

where C = concentration, C_o = initial concentration, a and b are parameters determined through regression and t = time. Residual analysis was accomplished via the *runs* test that compares the degree of randomness of residuals by examining the number of sign changes in the time series of the residuals for each model fit. Random distribution of residuals is a crucial assumption of regression analysis. In our analyses, the first-order and biexponential models were acceptable for 9 and 16 data sets, respectively. Furthermore, cases where the first-order model passed, it did so only marginally, reinforcing the validity of the biexponential model.

We also introduce a third alternative, the Hoerl model, which takes the form

$$Y = ae^{bX}(X^c)$$

where Y = concentration, X = time after herbicide application and a, b, and c are parameters determined through regression. This equation may prove promising for herbicide degradation description.

LOW TEMPERATURE SEED GERMINATION CHARACTERISTICS OF SULFONYLUREA HERBICIDE-RESISTANT *KOCHIA SCOPARIA* L. ACCESSIONS. William E. Dyer, Peng W. Chee, and Peter K. Fay, Assistant Professor, Undergraduate Student, and Professor, Plant and Soil Science Department, Montana State University, Bozeman, MT 59717.

Abstract. Anecdotal information and field observations suggest that sulfonylurea (SU) resistant kochia may germinate at lower soil temperatures and/or grow more rapidly than susceptible kochia. To investigate this possibility, seeds were collected from three resistant and two susceptible kochia populations in Montana in October, 1990. Seeds were germinated at temperatures ranging from 4.6 C to 16.8 C on thermal gradient bars and germination was recorded every 12 hr for 72 hr. There were three replications of each kochia accession and the experiment was repeated twice. At 4.6 C, germination rates of all resistant accessions were more rapid than susceptible accessions. At 7.2 C, percent germination of one resistant accession was higher than all others after 12 hr, but overall rates were not different from 24 hr to 48 hr. Germination rate differences between resistant and susceptible accessions were not observed at temperatures above 10.5 C.

To determine if altered levels of branched chain amino acids in resistant accessions may be correlated with the rapid germination phenotype, free amino acid contents of dry seeds were quantified by HPLC analysis of OPA-derivatized extracts. Two replicate analyses were conducted on each of two separate seed samples from each accession, and results were normalized based on free phenylalanine content. In all cases, concentrations of free isoleucine, leucine, and valine in resistant accessions were significantly higher than in susceptible accessions. The results indicate that, in these kochia accessions, mutations in genes encoding acetolactate synthase that confer resistance to SU herbicides may concomitantly reduce or abolish sensitivity of the enzyme to normal feedback inhibition patterns. More rapid germination of resistant accessions at low temperatures may be possible because elevated pools of branched chain amino acids compensate for normally limiting concentrations found in susceptible accessions. If the rapid germination phenotype proves to be widespread among SU-resistant weeds, agronomic practices that exploit this trait may be useful as management strategies.

DNA SEQUENCE VARIATION IN ACETOLACTATE SYNTHASE GENES FROM HERBICIDE RESISTANT AND SUSCEPTIBLE WEED BIOTYPES. M. J. Guttieri, C. V. Eberlein, D. L. Hoffman, C. Smith, and D. C. Thill, Research Associate and Associate Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho Aberdeen Research and Extension Center, Aberdeen, ID 83210, Research Geneticist, USDA-ARS National Small Grains Germplasm Research Facility, Aberdeen, ID 83210, Postdoctoral Associate and Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83843.

Abstract. Resistance of weed biotypes to inhibitors of acetolactate synthase (ALS) is an increasingly widespread problem. Previous work with resistant crop plants indicates a particular protein domain, known as Domain A, in which point mutation in the codon for the proline residue confers resistance to ALS inhibitors. The nucleotide sequence of a 234 bp region encompassing Domain A of the ALS gene was determined for resistant (R) and susceptible (S) biotypes of prickly lettuce, kochia, and Russian thistle by pairing polymerase chain reaction (PCR) amplification and DNA sequence analysis. In both prickly lettuce and kochia, the R biotypes have a single point mutation in the codon for the proline residue in Domain A. In prickly lettuce, the mutation confers substitution of a histidine for the native proline; in kochia, the mutation confers substitution of a threonine residue for the native proline. Two different ALS-homologous amplification products have been cloned and sequenced from plants grown from seed of a resistant Russian thistle isolate. One sequence, designated ALS-1, has 100% homology to the S kochia nucleotide sequence in Domain A, while the other sequence, designated ALS-2, has only 72% homology to the S kochia sequence. Although the DNA sequence homology in Domain A between weed and crop species is generally moderate, the amino acid sequence in Domain A is completely conserved across herbicide-susceptible weed and crop species sequenced to date. The S kochia sequence has a restriction enzyme recognition site spanning the proline and arginine codons in Domain A. Point mutation to the R genotype results in loss of this restriction site. PCR amplification and electrophoresis of restriction digests is diagnostic for resistance to ALS inhibitors in kochia collections evaluated.

PHENOTYPIC VARIATION IN YELLOW NUTSEDGE. Jodie S. Holt, Associate Professor, Department of Botany and Plant Sciences, University of California, Riverside, CA 92521.

Abstract. Phenotypic variation within and among populations of yellow nutsedge was investigated and correlated with genetic variation previously reported. Analyses were conducted on 20 individuals collected from each of 10 widely separated populations in California. Replicate plants were started by clonal tubers collected from each of the 200 individuals, and grown in pots buried outdoors in sandbeds. During the period from planting to flowering, plants were measured for vegetative and reproductive characteristics.

These included days to sprouting, days to flowering, height, rachis number, rachis length, aboveground biomass, tuber weight, number of rays, ray length, number of spikelets/ray, and spikelet length and width. Analysis of variance was used to evaluate the importance of collection location and genotype to phenotypic characteristics. Results showed that genotypic variation as described by isozyme analysis was not a significant determinant of phenotypic variation. For example, within a genotype, variation occurred for presence/absence of flowering and size and number of reproductive parts. Collection location, expressed in terms of latitude in California, was a greater source of variation in phenotypic expression. Thus, quantitative traits in yellow nutsedge show evidence of selection that results in a large amount of variation not detectable by analysis of discrete enzyme characters. As a consequence, responses of yellow nutsedge to control measures varies widely across environments.

EXPRESSION OF A SPECIFIC TRANSCRIPT UP-REGULATED IN HYDRATED DORMANT SEEDS OF CHEAT. Peter J. Goldmark and M. K. Walker-Simmons, Project Director, DJR Research, Star Route 69, Okanogan, WA 98840; and Research Plant Physiologist, USDA-ARS, Washington State University, 209 Johnson Hall, Pullman, WA 99164-6420.

Abstract. Weed seed dormancy is an important survival and competitive trait of grass weeds that infest winter cereal crops. An understanding of weed seed dormancy mechanisms may provide new methods for weed control. A model system using seeds of cheat was chosen to study gene expression in dormant hydrated embryos. An embryonic cDNA library was prepared from dormant seeds and transcripts specific for dormant embryos hydrated for 10 hr were selected by differential screening. One selected clone, pBS128, is strongly up-regulated in hydrated dormant seed embryos. The transcript is present in both dormant and nondormant mature dry seed embryos. Upon hydration transcript levels are strongly up-regulated in dormant embryos and maintained at elevated levels for at least 6 days. In contrast, transcript levels decline rapidly when nondormant embryos are hydrated and disappear by 6 hr post-imbibition.

Transcript levels of pBS128 are affected by plant hormone application. Treatment of dormant seeds with gibberellic acid breaks dormancy and causes a dramatic drop in pBS128 transcript levels prior to visible germination. Abscisic acid (ABA) application to nondormant cheat embryos blocks germination and increases steady state levels of the pBS128 transcript. ABA also enhances pBS128 transcript levels in dormant embryos. The transcript is only expressed in seed embryos. pBS128 transcript has not been detected in seedling leaf or root tissue, including water-stressed seedling tissue with high ABA levels.

The pBS128 transcript is present in dry mature seed embryos of all grass weeds species examined. These include jointed goatgrass, wild oat, common rye, downy brome and cheat. This transcript is also present in crested wheatgrass seeds.

These studies suggest that weed seed dormancy is an active process involving transcription of certain genes that are required for the maintenance of embryonic dormancy. The gene specifying the pBS128 transcript is probably one of the genes involved in this active process and expression of this transcript may be modulated by tissue localization and ABA.

JOINTED GOATGRASS SEED DORMANCY VARIES BY REGION ON THE SPIKE. Ted L. Carpenter and Donald C. Thill, Scientific Aide II and Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow ID 83843.

Abstract. Jointed goatgrass (designated a noxious weed in eight states) is increasingly troublesome in Idaho and Washington winter wheat fields, especially in winter wheat seed production fields. Jointed goatgrass spikelets cannot be separated from wheat seed efficiently, due to the similar size of jointed goatgrass spikelets and wheat grain. Because it is related closely to wheat, no currently available herbicide selectively controls this weed in wheat. Seed dormancy allows a small percentage of buried jointed goatgrass seed to remain viable for at least 5 yr in dry areas of the Pacific Northwest. The conditions that produce extended dormancy in some jointed goatgrass seed are unknown. Experiments were initiated to determine relationships between dormancy and seed development factors such as, environment influencing the mother plant, spikelet region on the spike, and seed position within the spikelet. Seed from a single accession were planted near Pullman, WA and Lind, WA in 1989. Entire spikes were hand-harvested in 1990, separated by spikelet position (1 through 15), and stored at -18 C. Spikelet positions one through three were grouped as lower region, four through six as middle region, and seven through terminal as upper region. Individual seed (from spikelets containing exactly two seed in the lowermost positions only) were removed and stored. The basal and second position seed were subjected to 30-day germination tests. Seed were placed in petri dishes in a germination chamber maintained at 15 C and 24 hr darkness. Germinated seed were counted and removed daily. The experiment was arranged as a randomized complete block split-plot design (repeated) with four replications, two sites, three regions on the spike, and two seed positions within the spikelet.

Mean percent viability was 99.75%. Seed that did not germinate within the 30-day tests were subjected to a tetrazolium chloride test for viability. Dormancy results of basal seed data are reported, because all second position seed germinated within 14 days. Data were subjected to analysis of variance (ANOVA) which showed that experiments could be combined for analyses of dormancy as a dependent variable. Differences by region on the spike were highly significant ($p=.001$). Site by region interactions also were significant ($p = .001$). Seed from the middle of the spikelet were the most dormant in spikes from both sites. Dormancy percentages for Lind-grown seed were 17.5%, 40.5%, and 38.9% for lower,middle, and upper spike regions, respectively. Dormancy percentages for Pullman-grown seed were 33.2%, 43%, and 32% for lower, middle, and upper spike regions respectively.

PICLORAM MOVEMENT AND DISSIPATION IN A NORTHERN RANGELAND ENVIRONMENT.
S. A. Cryer, J. R. Peterson, C. A. Lacey, G. Kennett, M. B. McKone, Senior Research Engineer and Senior Scientist, Dow Elanco, Midland, MI 48640, Consultant, Helena, MT 59604, Consultant, Missoula, MT 59807, and Technical Service and Development, Billings, MT 59102.

Abstract. A field study was established near Missoula, Montana to evaluate the dissipation and movement of picloram (Tordon 22K formulation) in a northern rangeland environment. Picloram was applied on June 16, 1988 at the rate of 1 lb/A to a highly permeable fine sandy loam to loamy sand soil. The treated area was subsequently divided into four equal area subplots. Supplemental irrigation was applied to maintain 125% of the average annual precipitation. Soil and groundwater samples were collected at predetermined intervals for 846 days following application. Individual half-lifes were determined from each subplot.

Analytical results for various soil horizons indicate picloram residues were generally limited to the top 36 inches of the soil profile (Table). An average of 9.7% of applied remained in the soil 846 days after the initial application. Degradation data averaged over the four subplots indicated an average half-life of 251 $\pm$64 days in this northern rangeland environment. No quantities of picloram above instrument quantitation limits (0.1 ppb) were detected in down-gradient groundwater wells.

Table 1. Spatial and temporal locations of picloram in the soil profile. Values were averaged between the four subplots. The values are on a percent applied basis, where 1 lb/A picloram was applied.

Days	Soil depth (inches)							
	0-6	6-12	12-18	18-24	24-36	36-48	48-60	60-72
	ppm							
0	10.73	1.69	NS	NS	NS	NS	NS	NS
5	42.62	4.41	NS	NS	NS	NS	NS	NS
55	63.34	2.08	0.56	0.18	ND	Trace[a]	NS	NS
110	56.86	2.36	0.47	4.25	ND	ND	NS	NS
354	25.61	19.77	2.66	0.36	ND	ND	ND	ND
481	4.71	10.19	4.25	1.23	0.36	ND	ND	ND
715	4.35	3.65	2.00	2.23	2.00	Trace[a]	ND	ND
846	2.36	1.28	2.10	1.54	2.25	Trace[a]	ND	ND

[a]This indicates that one or more of the subplots had a value of <0.005 ppm.

ISOZYME VARIATION AMONG AND WITHIN POPULATIONS OF BROOM SNAKEWEED. Y. Hou and T. M. Sterling, Graduate Assistant and Assistant Professor, Department of Entomology, Plant Pathology and Weed Science, New Mexico State University, Las Cruces, NM 88003.

Abstract. Broom snakeweed is distributed widely in the western United States. It reduces rangeland productivity and is toxic to livestock. In New Mexico, broom snakeweed infests about 60% of rangeland. This weed is highly variable and can grow under a variety of environmental conditions. It is unknown whether this variability will have an impact on the success of biological control of this weed in rangeland. The objective of this study was to evaluate and characterize genetic variability among and within different New Mexico populations using isozyme analysis with starch gel electrophoresis. Plants collected from eight locations in New Mexico were maintained and propagated as cuttings in the greenhouse. Enzymes were extracted from young leaf tissue with buffer containing 0.1 M tris (pH 8.5) plus 1% reduced glutathione. Enzymes included phosphoglucomutase, phosphoglucoisomerase, 6-phosphogluconate dehydrogenase, malate dehydrogenase, aconitase, shikimate dehydrogenase, esterase, malic enzyme and aspartate aminotransferase. Various gel and electrode buffer systems were used for isozyme separation. Isozyme detection was made using appropriate staining buffer and substrates. Several isozyme polymorphisms were detected among and within the eight populations. These results suggest there are genetic differences among and within different broom snakeweed populations in New Mexico.

AUXIN BINDING IN PICLORAM SUSCEPTIBLE AND RESISTANT YELLOW STARTHISTLE.
M. K. Pedersen, T. M. Sterling, N. K. Lownds, E. P. Fuerst, Graduate Assistant, Assistant Professor, Department of Entomology, Plant Pathology, and Weed Science, Assistant Professor, Department of Agronomy and Horticulture, New Mexico State University, Las Cruces, N. M. 88003, Professor, Washington State University, Pullman, WA 99164.

Abstract. Picloram resistance in yellow starthistle is of great concern in the western United States because of the weed's noxious characteristic. Picloram susceptible (S) and resistant (R) accessions of yellow starthistle do not differ in picloram absorption, translocation, or metabolism suggesting that picloram resistance is due to an altered site of action. Picloram-induced ethylene production in S increased with increasing picloram concentrations whereas picloram production in R was not altered. Picloram is an auxin type growth regulator, and because auxin induces ethylene synthesis, it is hypothesized that auxin may

bind differently in the two accessions. To study auxin binding, cell cultures were established in modified Murashige and Skoog medium. Higher levels of auxin may be found in meristematic tissue. The response of S and R cell cultures to picloram was similar as shown in whole plants. Protein was extracted from S and R cells in citrate buffer pH 5.5 and centrifuged at 1400 x *g* to obtain a crude extract containing both soluble and membrane bound auxin binding protein. Ultracentrifugation at 100,000 x *g* for an hr separated soluble and membrane bound protein. The three protein sources were incubated at 4 C for an hr with ^{14}C-IAA 33μM (3.4 mCi/mmole). Binding was terminated using cellulose nitrate/acetate (0.45μm) and the filter and filtrate counted using a scintillation counter. The results showed no significant binding in the crude extract nor in the soluble fraction for S and R, but some binding was detected in the membrane bound protein fraction. No differences in auxin binding was detected between S and R.

PROMOTION OF WEED SEED GERMINATION BY LIGHT DURING SOIL TILLAGE. THE IMPORTANCE OF THE VERY-LOW-FLUENCE RESPONSE. Ana L. Scopel, Carlos L. Ballare, and Steven R. Radosevich., Dpto. de Ecologia, Fac. de Agronomia, Univ. de Buenos Aires, Av. San Martin 4453, 1417 Buenos Aires, Argentina, and Dept. of Forest Science, Oregon State University, Corvallis, OR 97331.

Abstract. Recent studies demonstrated that weed seeds undergo a dramatic increase in light sensitivity during burial, and this has been interpreted as a natural shift to the Very-Low-Fluence (VLF) mode of phytochrome action. Field experiments showed that sensitized seeds can be induced to germinate by light pulses that establish less than 0.01% Pfr. These pulse-like irradiations are thought to be key light signals perceived by the seeds during events of soil cultivation. To assess the relative importance of the VLF response in the detection of soil cultivation by weed seeds a series of experiments were carried out in the Willamette Valley (OR) in which tillages were performed: a) during daytime, b) during daytime with the implements covered to prevent light from reaching the soil during the cultivation episode, c) during the night and, d) during the night with a lighting system on the implement. Cultivating the soil at night resulted in a 50 to 70% reduction in seedling emergence compared to the daytime cultivation. The treatment in which light was added during the night cultivation was not effective in increasing seedling emergence over the night controls. However, preventing sunlight from reaching the soil surface only during the cultivation itself resulted in an about 40% reduction in the emergence of dicotyledonous weeds relative to the daytime treatment. These results support the hypothesis that the VLF response plays an important role in the mechanisms whereby light requiring weed seeds detect cultivation events. Our observations also indicate that either controlling the amount of light received during the tillage operation or performing the cultivations at night may be rewarding management strategies for reducing weed seedling emergence.

THE ROLES OF CRYPTOCHROME AND PHYTOCHROME IN MEDIATING DODDER PARASITIC GROWTH UNDER BLUE LIGHT. M. A. Haidar, P. Westra, and G. Orr, Graduate Research Assistant and Associate Professors, Department of Plant Pathology and Weed Science, Colorado State University, Fort Collins, CO 80523.

Abstract. Dodder is an obligate stem parasite which must detect and attack a potential host for survival. An array of sequential environmental cues mediate dodder development and modify their growth from a higher plant to a parasitic mode of growth. Emergence of the seedling from the soil surface into light stimulates hook opening. Hook opening is controlled by phytochrome (photmorphogenesis). Sensing of neighboring plants (i.e., potential hosts) by de-etiolated dodder seedling is detected initially by changes in light quality. Within the sphere of influence of a neighboring plant, an environment enriched in blue and far-red light potentiates a change in state of the dodder thread-like organ to that of its parasitic mode of

growth. Our work implicates two photoreceptors; phytochrome and a specific UV-A/Blue light photoreceptor (cryptochrome) are involved. Prolonged exposure to blue light stimulate coiling and prehaustoria (an early stage of infection structure) development in dodder-like threads. Cryptochrome is the main photoreceptor mediating blue light responses, but potentiation is affected by the presence of Pfr. Pfr opposes the action of cryptochrome. Based on chemical and photostationary state (Pfr/Ptot) studies, our results indicate that blue does not act via phytochrome, but through a specific UV-A/B photoreceptor. However, the state of phytochrome is the principal limiting factor.

FENOXAPROP TOLERANCE AMONG ITALIAN RYEGRASS CULTIVARS IS DUE IN PART TO DIFFERENCES IN ACCase. Gul Hassan, George W. Mueller-Warrant, and Stephen M. Griffith, Plant Physiologist, Crop and Soil Science Department, Oregon State University and National Forage Seed Production Research Center, USDA-ARS, Corvallis, OR 97331.

INTRODUCTION

Diclofop, fenoxaprop, fluazifop, haloxyfop, and quizalofop are classified as aryloxyphenoxypropanoic acid herbicides. These herbicides have emerged as important tools for the control of *poaceous* weeds in dicotyledonous crops and have shown their worth in cereals and grass seed crops (1, 15). The herbicidal properties of aryloxyphenoxypropionates are similar to those of cyclohexane-1,3-diones like sethoxydim and clethodim. Both groups of compounds have been reported as the potent inhibitors (7, 10, 17, 18) of the enzyme acetyl-CoA carboxylase (ACCase), a biotin-containing high molecular weight multifunctional protein catalyzing the ATP-dependent carboxylation of acetyl-CoA to malonyl-CoA in various pathways including fatty acid synthesis pathway (23). ACCase catalyzes two partial reactions, viz. the carboxylation of the biotin prosthetic group and a transcarboxylase reaction which transfers the carboxyl group from biotin to acetyl-CoA to form malonyl-CoA. The mechanism is described as a two site "ping pong" reaction (5, 6, 18). This enzyme has been reported to be the target site of the two groups of herbicides described above, which of course have diverse chemistries (17, 20, 25). The inhibition of this pathway causes an inhibition of thylakoid membrane formation, chloroplast multiplication and biogenesis, and finally cell division and membrane lipid biosynthesis (13, 14).

Our greenhouse studies have shown about 6-fold differences in tolerance to fenoxaprop between the least and the most tolerant cultivars of Italian ryegrass at the whole plant level. Tolerance was also observed to increase with plant age. The present studies were carried out to determine whether the differential whole plant tolerance of Italian ryegrass to fenoxaprop is the result of the behavior of ACCase.

MATERIALS AND METHODS

Chemicals. Acetyl-CoA, and adenosine 5-tripsphate (ATP) were obtained from Sigma Chemical Co. [^{14}C]Na_2CO_3 was obtained from NEN-Dupont. Analytical grade parent acid racemate fenoxaprop was obtained from Hoechst. To obtain desired concentrations in 1 M Tricine (pH 8.0), fenoxaprop was first dissolved in HPLC grade methanol (1.6% final concentration in reaction mixture). Equal concentrations of methanol were maintained in all treatments including the check.

Plant material. Seed was sown in flats filled with pasteurized potting mixture of sand, peat, loam, and pumice in a ratio of 1:1:1:3 by volume and pH corrected to 6.5. Each of the 11 cultivars at the respective growth stages were planted in individual flats, and the flats were randomized on the greenhouse benches. Temperatures of 20 C day/15 C night were maintained throughout the growing period. No artificial light was provided in the greenhouse.

Extract preparation. At the 2-leaf stage whole plants were harvested, whereas at the 4-leaf and the tillering stage the youngest two leaves were taken for extraction. The tissues were collected from the greenhouse in an ice box. The plant material was thoroughly washed with distilled water, wiped dry, and then ground in liquid nitrogen using a mortar and pestle. When the tissue was in a powdered form, buffer was added in a w/v ratio of 1:2.5 (fresh weight to buffer). The extraction buffer was comprised of 100 mM Tricine (pH 8.0, HCl), containing 15% ethylene glycol and 0.2% 2-ß-mercaptoethanol (v/v/v). The macerate was filtered through a single layer of miracloth (Calbiochem). The filtrate was centrifuged at 14,000 g for 30 min. The pellet was discarded and the supernatant was either used immediately or stored at -20 C until use.

Protein determination. The protein content (mg/ml) of the enzyme supernatants were assayed using Bio-Rad method and BSA as a standard (4). For assay the supernatants were diluted 15-fold.

Acetyl-CoA carboxylase assay. ACCase activity was assayed as described by Stoltenberg et al., (24) with minor modifications. The activity was assayed in reaction volumes of 250 μl in a fume hood by the acetyl-CoA dependent incorporation of $[^{14}C]HCO_3$ in 7 ml mini vials. The reaction mixtures (final volume) contained 100 mM Tricine (pH 8.0, HCl), 0.5 mM dithiothreitol [DTT], 2 mM $MgCl_2$, 2 mM ATP, 50 mM MKCl, 3 mM acetyl-CoA, 15 mM $NaH^{14}CO_3$ (375 dpm/nmol) and 0.1 ml of crude enzyme extract. The reaction was started with the addition of enzyme and the cocktail was incubated at 35±2 C (17, 20, 23) for 15 min. The reaction was terminated by the addition of 25 μl 12 M HCl. All the steps of the enzyme assay, from addition of enzyme onwards, were carried out in a fume hood. The reaction mixtures were subsequently dried in an evaporation rack to allow vaporization of unreacted $^{14}CO_2$. After evaporation the solids were redissolved in 2 ml boiling double distilled water. Radioactivity incorporated into the acid and heat stable fraction was estimated by liquid scintillation spectroscopy after adding 5 ml of scintillation cocktail into the above solution. The readings from the scintillation counter were corrected for background, counting efficiency, and acetyl-CoA and ATP-independent incorporation of radioactivity.

Statistical analyses. The specific activity in untreated check of individual cultivars in terms of g fresh weight and mg of protein in both tillering stage alone and the growth stage experiments was subjected to GLM technique (19) and means were separated by Duncan's multiple range test. For the inhibition, the specific activity/mg/min at three fenoxaprop regimes was converted to % of check and subsequently subjected to linear regression analysis after averaging each treatment across replications. I_{50} (mmol fenoxaprop required to retard $[^{14}C]HCO_3$ incorporation by 50% as compared to an untreated check) was computed by interpolation for each cultivar.

RESULTS AND DISCUSSION

ACCase sensitivity at tillering stage. The whole plant tolerance among the Italian ryegrass cultivars was ranked on mean growth relative to checks and GR_{50} (fenoxaprop rate required to reduce the fresh-weight by 50%). The cultivars Marshall, Torero, and Gulf were ranked as the most tolerant, and the cultivars Ace and Futaharu as the least tolerant, to fenoxaprop (Table 1). The ACCase assay revealed differences among the cultivars for specific activity and inhibition of acetyl-Co A carboxylase at tillering stage. The activity of ACCase expressed per g fresh weight and per mg protein was significantly (P=0.0001) different among the cultivars. Similarly, the ACCase from the 11 cultivars exhibited a differential tolerance (P=0.0001) to fenoxaprop. The ACCase activity expressed per g fresh weight was the highest in Biliken (Table 2). When expressed per mg protein, ACCase activity was highest in Biliken and Ace, although statistically at par with all other cultivars except Futaharu, Sakurawase, Marshall, and Ellire (Table 2). Our whole plant studies have revealed the tolerance of Marshall, Gulf, and Ellire, whereas Waseyutaka was among the susceptible cultivars (Table 1). So, unlike the findings of Parker et al., (16) and Shah et al., (21) enhanced expression of the target site alone does not explain the tolerance at the whole plant level and indeed, frequently contradicted it.

The sensitivity to fenoxaprop of the ACCase from the cultivars, as estimated by I_{50}, describes a tolerance of Marshall over all other cultivars included in the tests (Table 2). There existed a 4-fold difference between the most and the least tolerant ACCase to fenoxaprop. For the cultivars Marshall, Ace, and Tetrone, the relative inhibition of their Accase by fenoxaprop (Table 2) conforms to their whole plant tolerance (Table 1). The tolerance of ACCase in Futaharu does not correspond with the whole plant sensitivity to fenoxaprop. However, when activity of ACCase (g fresh weight^{-1}) and inhibition (I_{50}) (Table 2) are viewed simultaneously, the whole plant tolerance can generally be explained with these studies at the enzyme level. Futaharu is apparently sensitive to fenoxaprop at the whole plant level because of the low expression of the tolerant form of the enzyme. The previous work showed an increased tolerance to graminicides at the whole plant level due to a tolerant ACCase among different species (3, 11, 12, 14, 24). At the intraspecific level, the differential tolerance among biotypes has been evaluated in the cases of acquired resistance to herbicides. A tolerant biotype of Italian ryegrass from Oregon has been evaluated to differ from the wild type due to a different isozyme (9), whereas the tolerance in rigid ryegrass was attributed either to differential metabolism (8) or faster regaining of membrane potential (22). We did not study the absorption, translocation, or the metabolism of fenoxaprop, nor did we evaluate the biophysics of the membranes, any of which could be possible explanations of the differential tolerance to fenoxaprop at the whole plant level in addition to our target site findings.

Table 1. Tolerance of 10 Italian ryegrass cultivars in several whole plant tests under greenhouse conditions, based on fresh weight relative to check in individual tests.

Cultivar	Summer 1988	Spring 1989	Winter 1990	Summer 1990	Mean	Rank[a]
	% of check[b]					
Marshall	74.4a	56.6abcd	65.4a	115.0a	77.9	1
Torero	64.9ab	71.5a	63.4ab	100.3abc	75.0	2
Gulf	67.4ab	47.5cde	68.9a	100.6abc	71.1	3
Aubade	60.7abcde	62.3abc	52.1c	80.9de	64.0	4
Barmultra	60.0abcde	67.7a	54.2bc	82.1d	61.6	5
Tetrone	42.5efg	69.8a	47.8c	101.9ab	61.0	6
Sakurawase	63.9abc	39.0e	51.4c	88.1bcd	60.6	7
Waseyutaka	30.7g	69.8a	54.0bc	83.9cd	55.1	8
Ace	37.7fg	46.8b	45.2c	73.0de	47.6	9
Futaharu	35.8g	49.2b	35.2d	65.1e	43.1	10

[a]Ranking is in the descending order of tolerance.
[b]Means sharing the same letter in common do not differ statistically in the same column at 0.05 probability level.

Table 2. Activity of ACCase with and without fenoxaprop as nmol $H^{14}CO_3$ incorporated min^{-1} and I_{50} in 11 Italian ryegrass cultivars at tillering stage.

Cultivar	ACCase activity[a] Fresh wt.	Protein	I_{50}
	— g —	— mg —	mmol
Marshall	102.41b	6.71bcd	2.74a
Gulf	101.37b	7.36abc	1.50bcd
Ellire	65.11c	5.70cde	1.86b
Aubade	96.27b	8.39ab	0.77d
Barmultra	66.66c	7.58ab	1.49bcd
Tetrone	101.76b	8.31ab	1.52bcd
Sakurawase	84.99bc	4.78e	1.92b
Biliken	128.54ab	8.84a	1.13bcd
Waseyutaka	104.80b	8.15ab	1.66bc
Ace	91.09b	9.00a	0.85cd
Futaharu	70.68c	5.52de	1.65c

[a]Mean of six determinations.

ACCase tolerance at different growth stages. A serious problem in terms of loss of the activity of ACCase was noticed during storage. A recent report shows a drastic deterioration of ACCase activity during storage even at -20 C (2). Despite this difficulty, growth stages significantly affected ACCase activity (P=0.0001). Irrespective of the cultivar, three-times higher activity of ACCase at the tillering stage was observed (Table 3) as compared to the 2- and 4-leaf growth stages. We also observed an elevated activity of ACCase in our studies on rice (data not reported). Our work shows that not only can plants at older stages be used for such studies, but also the activity is greater when expanding leaves at advanced growth stages are used for extraction. This could minimize the number of plants that must be raised for extraction which is crucial in tests such as biochemical genetic studies. Although our studies of Italian ryegrass cultivars at various growth stages were not definitive due to the loss of activity of ACCase in storage, the enhanced activity of ACCase in advanced growth stages may account for the increased tolerance to ACCase inhibitors in older grass plants at whole plant level.

Table 3. Main effect of growth stage on ACCase activity with and without fenoxaprop nmol $H^{14}CO_3$ incorporated min^{-1} g fresh $weight^{-1}$ and mg $protein^{-1}$, and I_{50}.

Growth stage[a]	ACCase activity[a] Fresh wt.	Protein	I_{50}
	— g —	— mg —	mmol
2-Leaf	20.4b	1.71b	2.38a
4-Leaf	11.8b	1.63b	2.03a
Tillering	70.8a	5.08a	1.85a

[a]Mean of 20 determinations.

CONCLUSIONS

ACCase activity expressed as nmol $[^{14}C]HCO_3$ incorporated min^{-1} mg $protein^{-1}$ and g fresh $weight^{-1}$ increased with plant age. However, at any given growth stage, the specific activity alone was not related to the whole plant tolerance. At the tillering stage, when the activity of ACCase was the highest, there existed about a 4-fold difference in I_{50} between the most tolerant cultivar, Marshall, and the least tolerant cultivars, Aubade and Ace. These differences approximately agreed with the whole plant tolerance. The tolerance and sensitivity of Gulf and Futaharu at the whole plant level, however, did not correspond to their sensitive and the tolerant ACCase. But, when I_{50} and ACCase activity in untreated check, are considered simultaneously, the target site sensitivity correlates well with the tolerance at the whole plant level.

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CHARACTERIZATION OF PICLORAM UPTAKE, TRANSLOCATION, AND PICLORAM-INDUCED ETHYLENE PRODUCTION IN RUSSIAN KNAPWEED. R. G. Morrison, N. K. Lownds and T. M. Sterling, Graduate Assistant, Assistant Professor, Department of Agronomy and Horticulture and Assistant Professor, Department of Entomology, Plant Pathology and Weed Science, New Mexico State University, Las Cruces, NM 88003.

Abstract. Russian knapweed is an aggressive, perennial weed widely distributed in western Canada and the United States. Control is achieved using picloram, a restricted-use herbicide, whose potential for off-site movement and effects on nontarget species points to the need to reduce picloram use rates. Increasing picloram uptake should allow reduced use rates. Therefore, studies were conducted to characterize picloram uptake, translocation and an associated response, ethylene production.

Knapweed seedlings were grown in the greenhouse from seed obtained from a single native population. Picloram uptake was determined using radiolabelled, analytical grade picloram applied as the potassium salt (pH 6.1) in individual droplets (0.24 μl, equivalent to 770 μm in-flight diameter) to the adaxial surface of each leaf. Total volume was 2.5 to 5.0 μl. Concentrations ranged from 6.21 to 74.5 mM depending upon the experiment. At selected times after treatment, treated leaves were excised from the plant and herbicide residues removed by rinsing with 2 ml of 1:1 v/v MeOH:H_2O. Radiolabel rinsate was quantified using liquid scintillation spectroscopy. Immediately after rinsing, leaves were placed in 10 ml test tubes, capped and incubated at 30 C for 2 hr. Ethylene production was determined after injection of a 1 ml headspace sample by gas chromatography. Following ethylene determination, leaves were weighed and dried at 62 C for 48 hr. In translocation studies, plants were separated into the tissue above the treated leaf, leaves and stem below the treated leaf, roots and rhizomes. All tissues were oxidized and ^{14}C determined as above. Total ^{14}C recovery was 95% or greater. Uptake was expressed as % of applied and ethylene as the rate of production (nl/hr/g fwt).

Picloram uptake increased rapidly between 0 and 30 min after application and remained constant through 72 hr. In general, uptake was less than 10% of applied, clearly suggesting most of the herbicide remained on the leaf surface. Uptake was constant (about 6% of applied) over concentrations of 6.21 to 74.5 mM. Only 9% of the picloram absorbed was translocated after 96 hr. Of the picloram translocated, 58% was recovered from the leaves above the treated leaf and 29% from leaves and stem below the treated leaf. Thirteen percent was translocated to the roots and rhizomes.

Picloram-induced ethylene production was observed 24 hr after treatment. Peak ethylene production occurred between 24 and 48 hr and remained elevated through at least 72 hr. Ethylene production also increased in non-treated leaves although the response was highly variable. Picloram-induced ethylene production was observed at picloram concentrations above 12.42 mM and was constant for concentrations from 24.83 to 74.5 mM.

CHARACTERISTICS OF DIFFERENTIAL HERBICIDE RESPONSE IN SULFONYLUREA-RESISTANT *KOCHIA SCOPARIA* L. ACCESSIONS. Kailayapillai Sivakumaran, Dawit Mulugeta, Peter K. Fay and William E. Dyer, Graduate Research Assistants, Professor, Assistant Professor, Department of Plant and Soil Science, Montana State University, Bozeman, MT 59717.

Abstract. As a result of repeated use of chlorsulfuron to control broadleaf weeds, resistant kochia populations have arisen independently in geographically widespread areas. To investigate the mechanism of resistance to chlorsulfuron and other acetolactate synthase (ALS) inhibiting herbicides, seeds were collected from a susceptible population in Bozeman, and resistant populations in Power and Chester MT, and Minot ND. At the whole plant level, Minot and Chester accessions were highly and equally tolerant to chlorsulfuron, but differed in their resistance to other sulfonylurea herbicides. The Bozeman accession was equally susceptible to all herbicides tested. ALS enzyme assays were carried out to correlate greenhouse

data with sensitivity of the enzyme *in vitro*. I_{50} levels for the Bozeman accession ranged from 20 to 45 nM for all the herbicides tested. Resistant accessions showed a very high but similar level of tolerance to chlorsulfuron (200X), but varied in their response to triasulfuron, metsulfuron, thibenuron chlorimuron and sulfometuron. ALS from the Chester accession was 2X more tolerant to these herbicides compared to Minot. We are presently studying the molecular mechanisms for these differences in cross-resistance. We have isolated putative genomic clones encoding ALS from susceptible (Bozeman) and resistant (Chester) accessions, and DNA sequencing is underway.

LEAFY SPURGE AND VESICULAR-ARBUSCULAR MYCORRHIZAE FUNGI INTERACTIONS. James D. Harbour, Stephen D. Miller, and Stephen E. Williams, Research Associate and Professors, Department of Plant, Soil, and Insect Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Leafy spurge is a noxious perennial weed which infests millions of acres of rangeland in the northern and western United States. Leafy spurge is infected with vesicular-arbuscular mycorrhizae (VAM) fungi. VAM fungi are widely accepted as beneficial organisms in the majority of plant families. The objectives of this research were to determine how VAM fungi impact the growth and development of leafy spurge. Leafy spurge was inoculated with nine VAM fungi endophytes. Nine inoculated and nine control plants were analyzed for total nonstructural carbohydrates (TNC) and total phosphorus (TOTP) at 28, 56, 84, 112, and 140 d after inoculation. The experiment was replicated in time. No differences in leafy spurge TNC content were observed between any endophyte; however, inoculated plants tended to have lower TNC content than non-inoculated plants at all sampling dates. This reduction ranged from 1 to 12%. VAM endophytes increased TOTP in leafy spurge from 1 to 164%. *Glomus mosseae* Ocean isolate was the least efficient and *G. macrocarpum* the most efficient in mobilizing phosphorus. Sampling dates generally did not influence TOTP in leafy spurge. TOTP contents were 18 to 55% higher in inoculated plants than non-inoculated plants.

ALTERNATIVE METHODS OF WEED CONTROL

NONCHEMICAL WEED CONTROL IN DRY PEAS AND LENTILS. Chris M. Boerboom, Extension Weed Specialist, Department of Crop and Soil Sciences, Washington State University, Pullman, WA 99164-6420.

Abstract. Broadleaf weeds are difficult to control in dry pea and lentil production in the Palouse. Increased crop density, rotary hoeing, and harrowing were evaluated in 1990 and 1991 as possible alternatives or supplements to chemical control in peas and lentils. To evaluate crop density, peas and lentils were seeded in main plots at 0.5X, 1X, and 1.5X of normal seeding rates where 1X equals 224 kg ha^{-1} of peas and 67 kg ha^{-1} of lentils. Subplots were either nontreated for broadleaf weeds or metribuzin was applied preemergence at 0.21 kg ha^{-1}. The metribuzin rate was lower than standard rates of 0.28 to 0.42 kg ha^{-1} so that additive effects of crop competition and metribuzin could be observed if present. To evaluate mechanical weed control, peas and lentils were either untilled, rotary hoed, or harrowed with subplot treatments of nontreated or 0.21 kg ha^{-1} of metribuzin applied preemergence. Mechanical treatments were made at either 12 or 24 days after planting (DAP) in 1990 and 16 or 27 DAP in 1991. In these experiments, grass weeds were controlled with herbicides.

Fusarium root rot and pea enation mosaic virus stressed both crops in 1990 and as a result, pea and lentil yields increased with increasing crop density. However, no yield response was observed under the favorable conditions of 1991 as expected. In 1990, the low and high densities of nontreated peas reduced weed biomass by 27 and 53% compared with the weed biomass produced on noncropped areas, respectively. Low and high densities of nontreated lentils only reduced weed biomass by 14 and 23% in 1990. In 1991, low and high densities of nontreated peas reduced weed biomass by 82 and 99% and low and high lentil densities reduced weed biomass by 33 and 70%, respectively. However, while high seeding rates of peas and lentils reduced weed biomass by an average of 72 and 43%, the addition of metribuzin reduced weed biomass by an average of 99 and 96%, respectively.

Tillage treatments did not cause significant crop injury, reduce final crop density, or reduce pea or lentil yields. However, the treatments failed to improve weed control, either alone or in combination with metribuzin. Frequent spring rains and subsequent weed germination may have replaced weeds killed by the tillage operations. Of nonchemical weed control options evaluated in peas and lentils, rotary hoeing or harrowing were not effective and increased crop density appeared to only have limited potential for suppressing broadleaf weeds. Although current herbicides are less effective than desired, nonchemical weed management options appear to have limited potential to effectively replace or supplement herbicides.

HAWAII DEPARTMENT OF AGRICULTURE'S PLANT PATHOLOGY QUARANTINE FACILITY TO STUDY EXOTIC PLANT PATHOGENS AS BIOCONTROL AGENTS FOR WEEDS. M. O. Isherwood, Jr., and E. M. Killgore, Agricultural Pest Control Manager and Plant Pathologist, Plant Pest Control Branch, Hawaii Department of Agriculture, Honolulu, HI 96814.

INTRODUCTION

The first successful biological weed control project in the State of Hawaii utilizing a plant pathogen was the use of a naturally occurring fungus, *Fusarium oxysporum*, in controlling prickly pear cactus (1). In 1976, the fungal pathogen *Entyloma ageratinae*, which was imported from Jamaica, dramatically controlled Hamakua pamakani, *Ageratina riparia* (2, 3), a serious weed pest of Hawaiian forests. More recently, Trujillo et al (4) reported success with the fungal pathogen *Colletotrichum gloeosporioides* f.sp. *clidemiae* as a biological control agent for the weed Koster's curse, *Clidemia hirta*.

These historical successes became the impetus for the Hawaii State Department of Agriculture (HDOA) to initiate plans to develop a plant pathology program in order to study and conduct research on plant pathogens as possible biological control agents. To go hand in hand with such a program, the Department began construction of its own pathogen containment facility so that research on exotic plant pathogens could be performed in the State of Hawaii. This was a dream that began in 1986 and became a reality in 1991. In July, 1991, the United States Department of Agriculture-Animal Plant Health Inspection Service-Plant Protection and Quarantine (USDA-APHIS-PPQ) granted HDOA the certificate to operate its Plant Pathology Quarantine Facility (PPQF). This certification marked the culmination of years of planning and subsequent redesigning to meet certification standards. The PPQF is certified to operate as a Level 4 facility, so that research involving highly airborne exotic fungal plant pathogens such as the rust and downy mildew fungi is possible.

THE PLANT PATHOLOGY QUARANTINE FACILITY (PPQF)

The PPQF occupies 630 ft^2 of the Plant Pathology Laboratory and Greenhouse Facility (PPLGF) building which is located in Honolulu, Hawaii. The remaining non-quarantine General Research Facility (GRF) totals 1620 ft^2 and consists of three greenhouses, two office/laboratories, autoclave room, etc. The PPQF or containment section consists of seven maze-like rooms: locker room no. 1, the shower, locker room no. 2, the filter compartment, the vestibule, the quarantine laboratory, and the quarantine greenhouse. Research on local and approved-for-release pathogens is conducted in the GRF. Entry into the GRF is not restricted whereas entry into the PPQF is highly restricted.

The PPQF was designed to permit the importation and research of exotic plant pathogens in a secure or contained area. Containment is primarily achieved by the following:

1. Negative pressure gradient. A differential negative pressure gradient is maintained in a series of rooms throughout the building (PPLGF). Atmospheric pressure in the building decreases gradually from the entrance of the building to the rear of the Facility, where the most contaminated rooms are situated. These rooms, the quarantine laboratory and greenhouse have the lowest pressure readings (-0.10 inch of water). As a result, there is always an inward flow of air towards the most contaminated rooms, thereby keeping airborne pathogens contained.

This negative pressure gradient is established by maintaining the quarantine laboratory and greenhouse under negative pressure, then regulating air movement throughout the rest of the building. Negative pressure in the quarantine laboratory and greenhouse is achieved by the interaction of exhaust fans, supply fans and air handling units. More air is exhausted than supplied, creating a negative pressure situation. Room air pressure control systems, strategically located throughout the PPLGF, regulate the air flow throughout the building and maintain the negative pressure gradient. The room pressure control system consists of a room pressure gauge and air ducts with dampers.

The negative pressure gradient is the most significant feature of the containment facility; hence, negative pressure in the quarantine greenhouse and laboratory is constantly monitored by two differential pressure monitoring devices. In the event of negative pressure failure, an alarm system is activated, alerting PPQF staff members to the situation. In addition, a propane, emergency generator powers the room pressure control systems and the exhaust air fans in case of an electrical power failure.

2. HEPA filters. Air that is exhausted from the PPQF passes through two High Efficiency Particulate (HEPA) filters which are arranged in series and which are rated at 99.7% efficient for particles 0.3 μm or larger. These filters are 24 by 24 by 12 inches and are constructed with a plywood frame with fluid seals. The "in series" arrangement allows the PPQF staff to change the upstream filter without losing containment integrity. Changing the downstream exhaust filter requires facility decontamination. These HEPA filters are preceded by pleated prefilters which trap most of the particulate airborne matter. There are also HEPA filters in the supply air system in a similar set up as the exhaust air system. It was necessary to install these filters in

the supply air system as a precaution against any backflow of air that might occur in case of a breakdown in the ventilation system.

3. Construction features. The entire building was constructed with special consideration for air tightness. Features such as caulking, taping, seals and paint sealants, minimize air leakage through walls, cracks, and seams. There are no windows in the building, and the quarantine greenhouse is enclosed in polycarbonate (bullet proof) glass as a precaution against breakage.

4. Waste materials and effluent. All discarded materials as well as objects exiting the PPQF are steam-sterilized in an autoclave prior to release. The autoclave has two access doors: one from the quarantine side and the other from the noncontainment side. Solid objects such as eyeglasses and tools can be removed after a thorough scrubbing in the shower. All effluent from the PPQF drains into one of two retention tanks (550 gallons each). Sodium hypochlorite (5.25% ai) is added as the sterilant for the contaminated effluent. Treatment procedures require a minimum concentration of 3000 ppm chlorine for not less than 2 hr contact time before discharging into the city's sewer system.

5. Personnel shower upon exiting. All personnel exiting the facility must shower completely from head to toe. Showering is not necessary upon entry, but complete disrobing is imperative. Laboratory apparel which includes scrubs or overalls, headgear, and footwear, is provided in the locker room on the contaminated side of the shower.

6. Approved protocol in place. A Protocol written specifically for the PPQF governs every action/procedure in the PPQF. This Protocol was an important consideration in the certification process, for it addresses entry/exit requirements, maintenance procedures for all ventilation filters, emergencies, the negative pressure system, research procedures, the alarm system, the use of the autoclave, the responsibilities and duties of the PPQF staff, decontamination procedures, etc.

CONCLUSION

The responsibility of maintaining a containment facility is a tremendous one. The certification of the PPQF is granted for 1 yr only, after which recertification is necessary. The Facility is also subject to inspection by USDA-APHIS-PPQ as well as State Plant Quarantine Inspectors for compliance with the Protocol.

The PPQF staff members are well aware of the potential irreparable damage an exotic plant pathogen can do to the agriculture industry as well as to the native ecosystem of the Hawaiian Islands. At the same time, the HDOA projects involving the use of plant pathogens as biological control agents for weeds, may someday help the industry in lowering weed control costs as well as to help to preserve and protect the natural flora of the Hawaiian Islands. Current HDOA projects include: gorse, which is a noxious weed pest in pasture lands; firebush and highbush blackberry, which are weed pests in the forests and parks in the State; and ivy gourd, an invasive weed pest of lowland areas.

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NITROGEN UPTAKE BY WEEDS AND CROPS AS AFFECTED BY WEED MANAGEMENT LEVEL, TILLAGE PRACTICE, AND CROP ROTATION IN AN INTEGRATED PEST MANAGEMENT PROJECT.

David R. Gealy, Frank L. Young, Alex G. Ogg, Jr., and Robert I. Papendick, Plant Physiologist, Agronomist, Plant Physiologist, and Soil Scientist, respectively, USDA-ARS, Department of Crop and Soil Sciences, Washington State University, Pullman, WA 99164.

Abstract. Nitrogen is the nutrient most utilized from soil and often is the nutrient most limiting to crop production. The interactions of tillage, crop rotation, and weed management level on uptake of nitrogen by weeds and crops were evaluated in a long-term integrated pest management research project at Pullman, WA. Crop rotations were continuous wheat and a 3-yr rotation of winter wheat, spring barley, and spring dry peas. Tillage systems within each rotation were conventional and conservation. Conservation tillage was a combination of reduced-and no-till. Weed management levels were based primarily on herbicides and were minimum, moderate (currently recommended practice), and maximum. Crops and weeds were sampled about 1 week after crop anthesis during the first 3 yr (1986 to 1988) of a 6 yr study. Total biomass and nitrogen content (ug g^{-1} and kg ha^{-1}) were determined for each sample. In both crops and weeds, total biomass was highly, positively correlated with total N uptake, because concentration of N in plant tissues tended to be generally consistent within a crop species or weed type. Over all treatments, the proportion of N/ha^{-1} taken up by weeds ranged from less than 1% in the continuous wheat rotation, under conventional tillage and maximum weed management level to 20% in the 3-yr rotation, under conservation tillage and minimum weed management level. Grass weeds accounted for 1.6 to 6.4 times more N/ha^{-1} uptake than did broadleaved weeds. The proportion of N/ha^{-1} taken up by weeds in the 3-yr rotation was about twice that in the continuous wheat rotation. The proportion of N/ha^{-1} utilized by weeds was greater in the 3-yr rotation because peas tended to be substantially weedier than other crops. The proportion of N taken up by weeds was 55% greater in conservation than in conventional tillage plots. Weed management level generally was inversely correlated with proportion of N/ha^{-1} taken up by weeds, indicating the agronomic benefit to weed control. These results indicate that crop rotation, weed management level, and tillage affect competition for nitrogen between crops and weeds. Economic analysis will be essential to integrate this information into meaningful recommendations.

PROJECT 1: WEEDS OF RANGE AND FORESTS
Chairman: Mike Ralphs

Subject: Training Livestock to Graze Weeds: A Control and Management Tool

1. Principles of Diet Training. Beth Burritt, Utah State University, Logan, Utah.

A key to understanding the use of sheep as bio-control agents is to understand that diet training is a dynamic process and diet training is not genetically fixed. Diet experience in the early life of sheep has the greatest influence of life-time eating habits. Diet training is possible but several major obstacles have to be overcome. First, sheep are neophobic, being afraid to try new things. Second, sheep don't like aversive compounds. And third, sheep continually sample the food in their environment that can cause them to begin feeding on plants they have been trained to avoid. Diet training works best with young animals. One of the best methods for diet training is to use the mother as a role model. Use of young peers is also effective but not as effective as using the mother. Getting sheep to accept aversive plants can be improved by selecting animals that show greater tolerance to aversive compounds.

2. Training Sheep to Graze Leafy Spurge. John Walker, USDA, ARS, Dubois, ID.

A key reason to develop animals as biocontrol agents for weed control is to add other options to our control bank other than herbicides. The initial problem is how to convert weed species into a high quality forage. A goal is to place the weed species in a position to be at a competitive disadvantage to our crop species. Controlling weeds using livestock can be handled by grazing management and behavior management. Some historical grazing management has consisted of grazing until desirable forage was gone, then weeds were grazed. However, with proper grazing distributions, frequency, intensity, and seasonal rotation, grazing management is an effective tool for weed control. Exposing animals to targeted weed species has shown to be effective modifying the behavior of animals. Significantly greater quantities of weeds were consumed by animals exposed to weeds in their diets than those without being exposed.

3. Training Sheep to Graze Larkspur. Mike Ralphs, USDA, ARS, Logan, UT.

Larkspur is the largest killer of cattle on mountain rangeland. Early studies had shown sheep to be up to six times more resistant to larkspur than cattle. A goal has been to develop sheep to pre-graze cattle rangelands to reduce the risks of larkspur poisoning in cattle. There have been several successes getting sheep to graze larkspur, but consistency of control has been a problem. Also, the level of sheep grazing has not been sufficient to become a dependable biocontrol. Part of the problem of integrating sheep and cattle has been a reluctance of administrators to have to deal with separate lessees on the same range. Studies have shown sheep are more prone to graze larkspur early in the season when it is more palatable. Positive conditioning of sheep to gain preferential browse acceptance is possible. This has been tested by dosing and pre-conditioning the animal before going to the field, changing their social eating training, and mothers teaching their young. Overall, it has not been totally successful. The results have been encouraging to conclude additional work should continue.

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PROJECT 2: WEEDS OF HORTICULTURAL CROPS
Chairperson: Bob Mullen

Subject: Minor Crop Use Registration-Current Status and Future Direction

A series of presentations were made by five speakers representing the IR-4 program, minor crop use registration at EPA, the chemical industry, the food processing perspective, third party minor crop registration, and the role of the University researcher in minor crop registration. Short question and answer sessions followed each presentation and a lively 20-minute period of audience participation in discussion of minor crop use registration issues followed.

In brief modified outline form, highlights of each speaker's presentation are given:

Dr. Jerry Bacon, National Research Coordinator of Inter-Regional Research Project No. 4, gave an excellent overview of the IR-4 Program-how it operates and the present status of the program.

I. The IR-4 Program is involved with SAES, EPA, FDA, USDA-ARS, USDA-CSRS, and pesticide and animal drug manufacturers in a cooperative effort for registrations of minor use pesticides and drugs.
   A. Objectives:
      1. Food Use.
         a. Pesticides and Biologicals.
      2. Ornamentals.
      3. Animal Drugs.

II. IR-4, working with individual crops or crop groups, is concerned with:
   A. FIFRA Data Requirements on Products including:
      1. Product Chemistry.
      2. Wildlife Effects.
      3. Toxicology.
      4. Environmental Fate.
   B. Pesticide re-registration, which greatly compounds the problem of minor crop use registration, and requires strong support efforts including:
      1. Direct Development of Data.
      2. Manufacturer's Notification.
      3. Phase 3 Response.
      4. Assistance from NAPIAP and Grower Groups.

III. IR-4 organization-a grass roots structure:
   A. Regional Offices/Laboratories.
   B. State Liaison Representatives.
   C. USDA-ARS Minor Use Program.
   D. IR-4 Headquarters.
   E. Technical Committee.
   F. Administrative Advisors.
   G. EPA Minor Use Officer.

Margaret Reiff, Manager of the Western Regional Coordinator's Office, University of California, Davis, gave a brief orientation of her office's function and relationship to National IR-4 and local university and private researchers in the Western Region.

Jay Holmdal, Product Development Manager - Herbicides for Rohm and Haas Company, presented his vision of the Role of Industry in Minor Crop Use Registration.

I. To justify product development initially, registration must be achieved first with a major crop (corn, rice, cotton, soybeans, etc.) use.

II. Mechanisms for obtaining minor crop use registration would include:
   A. IR-4.
   B. 24(c).
   C. Third party registrants.
   D. Crop groupings to facilitate the registration process.
   E. Philosophical and monetary support from food processors and grower organizations.
   F. SECTION 18.

There are some limitation with registration, re-registration, and the Special Reviews process that the manufacturer's must face, but industry might be able to provide funds for analytical costs or laboratory support. It is critical for industry to be involved and support the whole minor crop use registration process.

Dr. Steve Balling, Manager of Pest Management Programs for Del Monte Foods, presented information on Processor Concerns in Maintaining Registration for Pesticides Used in Minor Crops.

I. Re-authorization of FIFRA is a Congressional issue and proposed federal legislation will define minor crops as those with less than 300,000 A or where the expected use of a product will be on less than 300,000 A.
   A. The limited market potential for the minor use registration of a product and the high costs associated with product development initially create serious concerns for the registrant.

II. Future concerns in minor crop pesticide use include:
   A. Need to look at non-chemical alternatives.
   B. The current "status quo" is unstable.
   C. There is a major feeling that the United States will lose its competitive edge in the world market because of the loss of minor crop use registrations.
   D. The alternative is for agriculture to become more knowledge-based and maintain a technological edge.

It is important to support IR-4 project funding and future directions include expanding the vision of agriculture, and improving scientific credibility and input.

In lieu of repealing the Delaney Clause, there is a very real concern that tolerances will be required on processed food products, not just raw product. Processors are caught in the middle because of consumer's perception that there is a pesticide problem on food and don't want pesticides used even though science has shown they have the safest food supply in the world.

Because of the NAS report on pesticide use, grower's organizations and processors have provided accurate data on percentage of crop treated and actual product use in the hopes these figures will be used in risk/benefit assessment.

Dr. Ray William, Extension Horticulture Specialist and Professor at Oregon State University, gave a status report on Third Party Registrations and particularly the whole issue of liability. Currently, grower or other organizational groups or individuals interested in obtaining a third party registration submit a petition to the State Department of Agriculture. The petitioner would be the liable party and responsible for the petitioning process. The State Department of Agriculture will require field efficacy and crop safety data as will as crop residue information. The manufacturer must authorize and acknowledge the proposed product use. Required data would be University reviewed and the label would be distributed by the third party petitioner.

The whole process of indemnificaton was then discussed. In an effort to reduce manufacturer and third party petitioner liability, a signature by the user releasing liability would be required. There is concern that this liability release would hold up in court were a claim to be filed for non-performance or damage. There is a need to separate liability from the personal assets of the petitioner(s). In a recently concluded case in Idaho, a grower who brought suit against a third party registrant was told he or she had no right to sue and the claim was dismissed.

It was the general expression of the Project 2 audience that the whole issue of Third Party Registration and indemnification is so complex and important that it should be expanded and covered in a workshop format by WSSA or WSWS at a future meeting.

Harry Agamalian, Extension Weed Science Farm Advisor from the University of California, covered the role of University researchers in minor crop registration, particularly as it relates to the localized situation.

A number of cases were cited that demonstrated success for minor crops or crop groupings from participating in the IR-4 program, resulting in critically needed product registrations.

I. For the local University researcher the objectives in minor crop registration are:
   A. Solving weed problems.
   B. Responding to community needs.
   C. Evaluation of existing and new herbicides.
   D. Developing agro-chemical awareness.
   E. Initiating IR-4 research requests.

II. Coordination is critical with:
   A. Fellow colleagues within a state or region.
   B. Helping with needs in similar commodities in other states even though the product may not gain registration in your state.
   C. Liaison to manufacturer's representatives.
   D. Re-registration efforts.

Third party registration involves cooperation with the local industry, manufacturers of the desired product(s), consultants, university researchers, and IR-4.

Improved funding may stimulate interest in pursuing projects. Up to now the major problem with minor use registrations has been the lack of financial support.

III. Priorities are needed for projects:
   A. Team approach to set goals and timeframe.
   B. Identification of critical needs.
   C. Greater input from the user.

The creation of Regional Field Research Centers could be very beneficial for expediting the process for the whole IR-4 program.

1993 Officers of Project 2:

Chairperson: Jill Schroeder
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Dept. 3BE
Las Cruces, NM 88003-0003
(505)646-2328

Chairperson-elect: Mark Sybouts
Product Development
BASF Corporation
6650 E. Olive Ave.
Fresno, CA 93727
(209)255-5301

PROJECT 3: WEEDS OF AGRONOMIC CROPS
Chairperson: Rick Arnold

Subject: Groundwater Protection, 2,4-D Reregistration, and Bromoxynil Exposure.

Robert J. Lamoreaux presented a talk entitled, Herbicide evaluation with emphasis on the protection of groundwater: A Sandoz perspective. He discussed laboratory and field studies that are conducted as part of the herbicide development process and presented a computer model called PREAP, pesticide registration and environmental assessment program. Several questions were raised concerning model parameters and if Sandoz would actually base its decisions on model predictions of whether or not a new herbicide poses a groundwater quality threat. Lamoreaux had some reservations with using the model to unequivocally predict groundwater contamination because the potential for preferential flow is not part of the model. An example of an actual field study was used to illustrate this point. There also were several comments on the use and validity of suction and other types of lysimeters. Apparently suction lysimeters have not worked in all situations, but no conclusion was reached on the reason for the problem. Lamoreaux concluded that even though a herbicide candidate may control many economically important weeds in many major crops, it cannot be developed if its "environmental profile" indicates that the compound has potential for groundwater contamination.

Donald L. Page discussed issues surrounding 2,4-D reregistration and some recent studies that concern the link between 2,4-D and cancer. There were numerous questions. He explained that the present toxicology package contains nothing to raise safety concerns about 2,4-D, even though recent epidemiological studies (the NCL Kansas and Nebraska Farm Worker studies) have suggested a link between herbicides (including 2,4-D) and non-Hodgkins lymphoma. A more recent NCL study which was widely reported by the news media suggested a link between canine lymphoma and dogs exposed to lawns treated with 2,4-D. He indicated that in these three studies excessive exposure was required to reach the conclusions that farm workers who reportedly applied herbicides more than 20 days a year or dogs reportedly exposed to lawns treated four times a year or more, would develop non-Hodgkins lymphoma. These conclusions were not statistically significant or only marginally so. Page explained that at least seven other epidemiological studies, including studies involving phenoxy plant workers, have shown no link between 2,4-D and non-Hodgkins lymphoma or any other type of cancer. The predicted date of reregistration completion of the 2,4-D package is late 1995 or 1996. Related to task force activities on public relations, Page commented that a newsletter is published by the group and that they have funded a University of Minnesota study and a Harvard symposium examining the 2,4-D cancer issue. Reprints from these or other studies may be available upon request. Page stated that a 2,4-D library exists and contacts also could be made via the 2,4-D Hotline.

James A. Barron reviewed the results from a bromoxynil worker exposure study. This study re-enforced the significant impact of protective clothing to reduce pesticide exposure for mixer/loader or applicators. Other factors that reduced exposure were the use of non-glug jugs, larger sprayers, and sprayers with closed cabs. A question was raised on whether there was a linear response between actual exposure to bromoxynil and the amount handled. Barron did not know if relative exposure would decrease with the handling of larger quantities since the study was not designed to answer this question. A question also was raised if this study would apply to other herbicides. Many felt that this study would be representative of other herbicides, especially because EPA accepted the study. Less extensive testing may still be required on other products. The results of this study will be published, and slide sets will be available through Rhone-Poulenc, upon request.

1993 Officers of Project 3:

Chairperson: Chris Boerboom
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Washington State Univ.
Pullman, WA 99164-6420
(509)335-2961

Chairperson-elect: Neal Hageman
Product Development
Monsanto Company
9348 Crosspointe Dr.
Highlands Ranch, CO 80126
(303)791-9371

PROJECT 4: EXTENSION, EDUCATION, AND REGULATORY

Chairperson: Don W. Morishita

Subject: Pesticide Safety Program and Human Food Exposure

1. STEALTH (Safety Team For Environmental Accountability In And Long Term Health)

Nelroy Jackson, Monsanto Agricultural Products Company, presented a paper on Monsanto's pesticide safety program. The objective of this program is to promote an environmental awareness through the identification of safety, health, and environmental issues and to develop situations to identify problems. This program designed by Monsanto is to be used by their own field personnel and for University and other field researchers. The key components of the program are to be field friendly, to personalize safety, and to show care for personal safety rather than the safety record. It also is designed to be nonthreatening and to have the support of management.

The goals of the program are to develop a safety mentality through the use of "toolbox talks" that discuss processes that focus on safety and to create an injury free workplace and maintain safety mentality. Accomplishments of this program have shown that field personnel have taken on a greater responsibility for personal and environmental safety and they have become more aware of safe storage and transport of chemicals and chemical containers. This program has developed the use of chemical spill kits and provided information on the disposal of excess experimental chemicals. Personal protective equipment also has been provided for field personnel. Other accomplishments include the training of personnel in standard operating procedures for the handling and maintenance of chemicals and equipment along with training for temporary help and driver's safety training. The final accomplishment includes an academic outreach program which has provided safety seminars, safety kits, and safety equipment for university researchers. Discussion that followed Nelroy Jackson's presentation included the emphasis by Nelroy that the length of employment of personnel should not exclude safety training. Job safety analysis should be included with standard operating procedures. Supervisors should set the example for the personnel and Monsanto include safety and health guidelines with all research protocols.

2. Human Exposure Studies

Bob Krieger, Technical Assessment Systems, Inc., presented a paper on human exposure studies. He first discussed risk assessment. Failure to get human data for exposure assessments is a key issue in risk assessment. Relying on animal data can lead to erroneous conclusions. There needs to be a human exposure database to adequately challenge the risk assessment data generated from animal testing.

Any pesticide use results in exposure. It is possible to get human exposure data by monitoring work task. This should be done routinely according to Krieger. Risk assessments have changed from quantitative LD_{50} data to threshold and no effect level (NOEL) data. This soft data measurement has added great uncertainty into risk assessments. Exposure data developed from human patch tests has been used. Patch tests use a default assumption that all material that contacts skin is absorbed. Absorption data based on animal tests indicate that this may not be a valid assumption. Exposure to chemicals should be divided into work tasks such as mixing, loading, applying, etc. Solutions to exposure problems should then be based on the work tasks. Data developed for these work tasks could be based on known compounds.

3. Pesticide Residues in Food

Bob Stovicek, Primus Group Research, Inc., presented information on pesticide residue testing in food. He expressed a concern that the science of the analytical chemist was getting ahead of the toxicologist. The analytical chemist can detect levels of pesticide residues that the toxicologist at this point is unable to assess the risks or effects in animals or humans. Primus Group Research helps growers by testing food products for pesticide residues. This group deals with activist groups by using science to measure pesticide residues. In general, Primus Group Research finds that most growers comply with pesticide residue regulations. Some of the problems with pesticide residues are caused by off target movement of pesticides onto crops. Another reason for produce or food crops exceeding pesticide residue levels is due to problems with the preharvest intervals on certain pesticides. For instance, a pesticide that has a preharvest interval of thirty days may have pesticide residues exceeding the thirty day interval. This results in the food crop that exceeds a pesticide tolerance. Work must be done by the chemical industry and regulatory agencies to eliminate some of these problems.

1993 Officers of Project 4:

Chairperson:	Stott Howard ICI Americas, Inc. 1200 S. 47th Street Box 4023 Richmond, CA 94804 1-800-544-0273	Chairperson-elect:	Phil Peterson Cenex Land O'Lakes Rt. 13879-6 NW Ephrata, WA 98823 (509)787-2518

PROJECT 5: WEEDS OF AQUATIC, INDUSTRIAL AND NON-CROP AREAS
Chairperson: Vanelle Carrithers

Subject: Purple Loosestrife and Salt Cedar

1. Purple Loosestrife Control Update. Hugh McEachen

I. Methods of Control.
   A. Biological. Three insects may be ready for release in 1993. This includes 2 beetles and 1 weevil. Gary Piper of Washington State University is coordinating the effort.
   B. Cultural. Hand pulling, clipping of seedheads, and plant coverings with black plastic have shown limited and temporary success.
   C. Chemical. Effective control of mature purple loosestrife has been obtained with applications of glyphosate. Triclopyr has been recently tested under a federal EUP for mature plants and seedlings. 2,4-D has been used on a limited basis to successfully control seedlings. A variety of application methods have been used to fit specific sites. Regulatory and public resistance to aerial applications of herbicides to control loosestrife may be mollified as new aerial application techniques are adopted utilizing 'slow-fly' or spot treatment capabilities.

II. Regulatory Issues.
   A. Washington State. Nearly $500K was appropriated in 1991 for purple loosestrife control by the Washington legislature. Forty percent of the money was allocated to education, while the remainder went directly for control efforts. A state wide omnibus Environmental Impact Statement is currently being prepared that includes provisions for purple loosestrife control.
   B. Montana. Barbra Mullin discussed a state-wide embargo on the import and sale of ornamental purple loosestrife in Montana. Control efforts are being coordinated and supported through the State Noxious Weed Trust Fund. Difficulties in reaching consensus on control methods resides in philosophical differences among landowners that includesthe Kootenai and Salish Tribes and other private landowners. There are currently 200 infested acres of purple loosestrife in Montana.

III. Emerging Issues.
   A. Competitive Vegetation. There is a need to identify if any desirable plant can be found to displace purple loosestrife. Dept. of Wildlife has proposed to look at poplars and willows because of their ability to grow taller than purple loosestrife.
   B. Management Strategies. Effective control of emerged plants seems achievable, but follow-up efforts for seedling control must be considered for long-term management.

C. Containment. Efforts should be made first to prevent growth of current infestations, while watching carefully that new infestations are not allowed to become established. The small seed size and distribution by water and water fowl makes the containment of purple loosestrife all the more difficult.

2. Tamarisk (Salt Cedar) Control. Bill Neill and Keith Duncan

I. Issues. Salt cedar is a perennial deep rooted high salinity tolerant brush that was introduced in the 20's and 30's and currently infests huge tracts of ground in the desert southwest of the United States. Salt cedar mines two to three times the amount of water compared to other woody brush. It will completely dominate an area and effectively lowers the water table preventing other species from becoming established. Salt cedar has directly affected the water flow of the Pecos River in New Mexico resulting in severe fines levied by Texas for shortfalls in stream flow coming into Texas.

II. Control Options. Flooding and mechanical treatments have largely been ineffective as methods of control for salt cedar. Plants are able to tolerate flooding for long periods of time, and are able to quickly resprout after mechanically cutting. Burning has been only partially effective since plants will resprout from below ground. Researchers are working on biological agents, but feel that they are 15 years away from release of organisms to control salt cedar. Cut stump and foliar herbicide sprays have been effective. Imazapyr, triclopyr, picloram, and silvex have all been effective. Combinations of imazapyr and glyphosate have been shown to provide excellent control of salt cedar in Arizona and New Mexico. Coverage of all meristematic points (ends of branches) has been an effective method for some applications rather than trying to cover the entire plant using a spray to wet technique.

III. Benefits of Salt Cedar Control. Lakes and streams previously thought to be completely dry, have again become productive, once salt cedar is controlled.

Inter-agency committees and cooperation among interested and affected parties seems to be important in developing control strategies for both purple loose-strife and salt cedar. State legislatures need to be educated on the economic and ecological benefits of controlling these and other exotic weeds that displace native habitats. As can be seen in Washington State, once those benefits are understood, funds can be earmarked and control efforts successfully implemented.

1993 Officers of Project 5:

Chairperson: Ron P. Crockett
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Vancouver, WA 98682
(206)892-9884

Chairperson-elect: Scott M. Stenquist
U.S. Fish and Wildlife, (ARW-DBS)
911 N.E. 11th Ave.
Portland, OR 97232-4181
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PROJECT 6: BASIC SCIENCES

Chairperson: Tracy Sterling

Subject: <u>Weed Seed Biology and Ecology</u>

The Project 6 meeting was conducted from 3:00 to 4:30 p.m. on Wednesday, March 11 with 31 people in attendance. Bill McCloskey was nominated and voted in as chairperson-elect for 1992. The topic of the 1992 project was weed and seed biology and ecology as they relate to weed management. Claudio Ghersa, Crop Science Department, Oregon State University, Corvallis, led the discussion.

Managing weed seeds in agroecosystems is possible by understanding dormancy characteristics of the weed seed and the weed seed bank. Mechanisms of dormancy were not discussed; however, the importance of dormant seeds as they relate to the seed bank was emphasized. Dormancy is quantitative. Highly dormant seeds will germinate over a wide range of environments. It is important that we understand these characteristics when trying to manage a particular seed bank. Only a portion of any seed bank is the 'active' seed bank or the seeds able to germinate at a certain point in time, resulting in weed stands; therefore, these are the seeds we need to manage.

There are a variety of methods which may be used to manage weed seeds. First, seed inputs to the seed bank can be reduced by controlling the source plants, harvesting their weed seeds or reducing seed immigration. Secondly, outputs from the seed bank can be increased by increasing seed death (by deep plowing of the seeds). More specifically, the active seed bank can be reduced by several methods including, timing of soil tillage, type of soil tillage, type of soil cover or mulch, or the cropping season.

We have domesticated our weeds because they are specifically adapted to our current cropping practices. If we change our cropping practices, we should be able to manipulate the weeds until they have adapted to the new practices. Most weed seeds germinate from 0 to 10 cm soil depth. Moldboard plowing can bury up to 80% of the seeds to a depth in the soil profile where temperatures are suboptimal for germination. In addition, seedbed preparation without planting would enhance weed seeds to germinate. Addition of a mulch to the soil surface can also reduce germination. Predation of seeds may be encouraged if tillage were timed so as not to disturb potential predators such as mice or birds. Timing of crop harvest can have a major effect on quality (reduce dormancy by harvesting earlier) and quantity (less shattering by harvesting earlier) of weed seeds. Dormancy could be exploited by keeping these seeds dormant and away from signals that break dormancy. These seeds if left undisturbed may eventually be lost. It should be kept in mind that manipulation of a particular weed species may result in selection of a new species. For example, using practices which reduce soil temperature may shift the weed spectrum from C-4 grasses to C-3 broadleaves.

Several methods were discussed in terms of conducting seed bank studies. Sampling techniques should be designed around where active zones of germination exist for a particular weed species in the soil being studied. For example, seeds should be overestimated. Patchiness of weed stands should be kept in mind when sampling using soil cores. Seeds can be extracted from dry soil by grinding the soil and then using sieves and blowers to extract the desired seeds. Control seeds should be added to check extraction efficiency.

1993 Officers of Project 6:

Chairperson:	Bill Dyer Dept. Plant & Soil Sci. Montana State University Bozeman, MT 59717 (406)994-5063	Chairperson-elect:	Bill McCloskey Dept. of Plant Sci. Univ. of Arizona Tucson, AZ 85721 (602)621-7613

PROJECT 7: ALTERNATIVE METHODS OF WEED CONTROL

Chairperson: Bob Callihan

Subject: Microbials, Grazing Animals, Interplanting & Integrated Weed Management

Over 70 members attended and participated in the meeting. The five principal topics of discussion were:

Microbials. A. Ogg, USDA-ARS, Pullman, WA
Grazing Animals. P. Fay, Montana State University
Interplanting. R. Williams, Oregon State University
Integrated Weed Management on Arable Land Rainfed.
F. Young, USDA-ARS, Pullman, WA
Irrigated. P. Westra, Colorado State University

Classical, enhancement, and augmentation approaches were discussed, with emphasis on augmentation. Several mycoherbicides are registered for commercial use. The limitation of microbials is that they have a narrow range of specificity. What's needed to advance this technology is a major commercial success. An excellent article on "Biocontrol of Weeds" was published in Scientific American in 1991.

Grazing animals are a solution for a few people and for specific niches. Most research has been conducted with sheep, but goats are also used. Goats complement sheep in that they often graze weed species that sheep will not eat. Other topics discussed were the availability of sheep, timeliness of grazing, overgrazing, bonding of lambs to goats, and economics of selling goat meat.

Interplanting is becoming more popular all the time. Farmers tend to experiment more with interplanting methods than do weed scientists. Examples mentioned where interplanting is successful are: seeding grasses into alfalfa and planting oats with canola.

The integration of tillage with other weed management practices has been successful on both rainfed and irrigated arable land. However, in some areas, such as the Palouse, conventional tillage needs to be avoided to minimize soil erosion. In Colorado, in conventional corn studies, weed management practices that include pre-cultivation tillage (rotary hoe or flex harrow) and an in-row cultivator have controlled weeds satisfactorily.

1993 Officers of Project 7:

Chairperson: Ed Schweizer
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Fort Collins, CO 80526
(303)498-4238

Chairperson-elect: Dan Ball
Columbia Basin Ag. Res. Center
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1992-93 WESTERN SOCIETY OF WEED SCIENCE OFFICERS AND EXECUTIVE COMMITTEE. Seated (L to R): Jesse Richardson, Secretary; Doug Ryerson, President-elect; Steve Miller, President; Paul Ogg, Immediate Past President; Wanda Graves, Treasurer/Business Manager. Standing (L to R): Phil Westra, Member-At-Large; Rodney Lym, WSSA Representative; Don Morishita, Education and Regulatory Section Chairman; and Charlotte Eberlein, Research Section Chairman. (Not pictured: Gary Lee, CAST Representative)

MINUTES OF THE BUSINESS MEETING
WESTERN SOCIETY OF WEED SCIENCE
45TH ANNUAL BUSINESS MEETING
SALT LAKE HILTON, SALT LAKE CITY, UTAH
MARCH 12, 1992

The meeting was called to order by President Paul Ogg at 7:35 a.m. Minutes of the 1991 business meeting were approved as published on pages 132 to 135 in the Proceedings of the 1991 annual meeting in Seattle, Washington. M/S/C.

Local Arrangement Committee. Steve Dewey thanked the Salt Lake City Hilton for the excellent facility and hospitality.

Program Committee. Steve Miller
a. The facilities were excellent.
b. The deadlines for papers need to be kept. There should be no exceptions.
c. Breakdown of papers:
Totaled volunteered papers: 86
Graduate student contest: 16 (should have been 20)
Poster session: 22
d. Preregistration deadline: No exceptions. Should return form to registrant with note that full registration fee is needed.
e. Paper submission deadline: Need to get papers to editor prior to the deadline. This predetermined deadline is based on postmark date.

Research Section and Research Progress Report. Ed Schweizer
a. The 1992 WSWS Research Progress Report has 366 printed pages and includes 171 separate reports.
b. 300 copies were ordered from the printer at a cost of $11.32 per copy.
c. Contributions to each project:

	Papers
Project 1: Weeds of Range and Forest	44
Project 2: Weeds of Horticultural Crops	10
Project 3: Weeds of Agronomic Crops	101
Project 4: Extension, Education, and Regulatory	3
Project 5: Weeds of Aquatic, Industrial, and Noncrop Areas	6
Project 6: Basic Sciences - Ecology, Biology, Physiology, Genetics, and Chemistry	4
Project 7: Alternative Methods of Weed Management	3

Extension, Education, and Regulatory Section Report. Tom Whitson
a. This is the first time "Extension" papers have been presented.
b. Seven presentations were made at this meeting.
c. Purpose for these presentations is to provide us better methods of transferring information about weed control to commercial people and growers.

Business Manager/Treasurer Report. Wanda Graves
a. Total 357 registered for Salt Lake City WSWS Meeting.
b. 245 preregistered.
c. 45 graduate students.
d. 9 spouses registered.

Finance Committee Report. Robert Callihan
a. Records in order as submitted.

Member-At-Large Report. Don Colbert (Not present)

a. Don coordinated the effort to update the WSWS Operating Guide which had not been revised since 1986. These changes included duties of WSWS officers and existing committees; and added the duties of 5 committees (Necrology, Student Paper Judging, Poster, Awards, and Sustaining Membership).

Past President's Report. Peter Fay

a. Certificates of Deposit rates are falling.
b. WSWS cash reserves: $54,000 currently in CDs.
c. New investments: Will be putting 4 of 5 Cds into two different mutual funds as they mature. Leave Acct. #115-006-866436 in a CD for security.

WSSA Representative Report. Rod Lym

a. The WSSA met on February 12 to 14, 1992 in Orlando Florida.
b. New officers elected were Alex Ogg, Vice President; Donn Thill, Secretary; and Peter Fay, Member-At-Large.
c. Approximately 890 people attended the conference.
d. WSSA will continue to support two Congressional Science Fellows.
e. WSSA agreed to begin participation in the American Registry Of Certified Professionals In Agronomy, Crop, and Soils (ARCPACS).
f. WSSA is seeking to increase the number of grants received by weed scientists from the CSRS competitive grants program.
g. Membership dues to WSSA were raised in 1992 to $60 for regular members, $20 for students, and $100 for institutions.

CAST Report. Gary Lee

a. In 1992, the Council for Agricultural Science and Technology celebrates 20 years of service as an unbiased scientific resource for information on food and agricultural issues.
b. Dr. Lowell Jordan is President of CAST and Dr. Gale Buchanon is President-Elect for 1992.
c. Suggestions for topics which can be developed into publications are welcome.

Nominations Committee Report. LaMar Anderson

a. Election results:
   President-Elect: Doug Ryerson
   Secretary: Jesse Richardson
   Educ. & Reg. Section Chair-Elect: Vanelle Carrithers
   Research Section Chair-Elect: Bill Dyer

Fellows and Honorary Members Committee Report. Jack Evans

a. Nomination forms will be in the Summer WSWS Newsletter.
b. Please submit names for Honorary Members and Fellows.

Awards Committee Report. Alex Ogg

a. Nominations for WSWS Outstanding Weed Scientist need more significant information from those who are nominating candidates.

Poster Committee Report. Jill Schroeder

a. 22 abstracts were submitted for presentation as posters at the 1992 WSWS Salt Lake City meeting.
b. The operating guidelines for the Poster Committee indicates that a "call for posters" will be coordinated with the "call for papers". The committee would like clarification on this guideline.

Student Paper Judging Committee Report. Bill Brewster

a. For 1992, there were 15 student papers submitted. Due to the large number of papers, 2 sessions and 2 separate contests were implemented from basic science (8) and agronomy (7).

b. Student paper monetary awards will be $100 for 1st place, $75 for 2nd, and $50 for 3rd. First place winners will also receive a $25 WSSA book certificate.
c. 1992 WSWS Student Paper Winners:
   1- Agronomy:
      1st Place - Jean A. Doty, Washington State University
      2nd Place - Abdelouhab Mesbah, University of Wyoming
      3rd Place - Blair L. Waldron, Utah State University
   2- Basic Science:
      1st Place - K. Sivakumaran, Montana State University
      2nd Place - James D. Harbour, University of Wyoming
      3rd Place - Mostapha A. Haidar, Colorado State University

Necrology Committee Report. LaMar Anderson
a. Deaths during the past year: Dr. Harold Alley and Robert Beatty.

Placement Committee Report. Mike King
a. The Placement Service was under-utilized at the 1991 WSWS meeting in Seattle. People did review the WSSA notebooks, but apparently did not fill out the "Positions Available/ Desired" forms.
b. Reminders were made during various times at this year's meeting.
c. The Placement Committee will see about placing an announcement in the WSSA Newsletter regarding our placement service prior to next year's meeting.

Site Selection Committee Report. Ann Henson
a. A contract has been signed with the Albuquerque Hilton Hotel for March 9 to 15, 1996 (Saturday/Friday nights).
b. The committee's operating guide update was completed for the summer meeting.

Sustaining Membership Committee Report. Joan Lish
a. There are 15 Sustaining Memberships for 1992.
b. These sustaining members contributed $4800 (6 @ $200 each and 9 @ $400 each).

Resolutions Committee Report. Don Morishita
a. 1 Resolution: "...Be it resolved that the Western Society of Weed Science expresses it's appreciation to the members of the 1992 WSWS Program Committee and to the management and staff of the Salt Lake City Hilton Hotel." *Motion was made to accept resolution. M/S/C

Legislative Committee (Ad Hoc) Report. George Beck
a. The WSWS Legislative Committee activities remain centers within the Intermountain Noxious Weed Advisory Council (INWAC). Three position papers were developed by INWAC concerning the proposed Plant Protection Act, the proposed National Biological Diversity Act (H.R. 585), and an evaluation of the Federal Noxious Weed Act:
   1. <u>Plant Protection Act</u>: The primary objection was the inclusion of the Federal Noxious Weed Act of 1974 as one to be repealed and consolidated under the proposed PPA.
   2. <u>National Biological Diversity Act (H.R. 585)</u>: INWAC neither endorsed or opposed the bill. However, the committee offered comments and suggestions to the bill's authors concerning their omission of the impact that exotic and native weed species have on biological diversity.
   3. <u>Evaluation of the Federal Noxious Weed Act</u>: The committee believes the Federal Noxious Weed Act of 1974 needs to be amended to provide for more effective noxious weed regulation in the U.S.

Publications Committee (Ad Hoc) Report. Tom Whitson
a. WSWS net profit from *Weeds of the West* totals $41,793.43.
b. 2nd printing: Advance orders are currently underway.
c. The WSWS has invested only $121 for *Weeds of the West*.

Editorial Committee (Ad Hoc) Report. Rod Lym

a. The 1991 WSWS Proceedings (Vol. 44) included 80 papers printed on 163 pages including text, indexes, and membership list. Secretarial cost was $570.
b. The total length allowed for papers to be published in the 1992 Proceedings is 8 pages including figures and tables except in special cases approved by the editor.
c. Most disks for 1992 papers were submitted during meeting.

Herbicide Resistant Weeds Committee (Ad Hoc) Report. Charlotte Eberlein

a. The most important activity associated with this committee in 1991 was a "Weed Resistance Workshop" sponsored by Pete Fay, Bill Dyer, and Charlotte Eberlein. Subjects covered consisted of current resistance problems in the areas of research, extension, and industry.
b. The committee held an open workshop on Wednesday night (March 11) to continue working on its goals.

Weed Management Short Course Committee (Ad Hoc) Report. Barbra Mullin

a. Purpose of the committee is to make recommendations to the WSWS Executive Board on the development and implementation of a noxious weed management short course for federal land managers.
b. Goals of the course: To provide a quality, on-going noxious weed management course. Three types of courses are proposed:
   1. Introductory Course: Provides basic weed science and weed management training to federal and state land management agency employees with little or no background in weed management.
   2. Intermediate Course: To provide update training to federal and state land management agency personnel with weed management responsibilities and with a working knowledge of weed management.
   3. Correspondence Course: For the future; a supplement to course, and expand on Bert Bohmont's weed course.

New Business

a. Three new States joined the WSWS during 1991 (North Dakota, Nebraska, and Kansas).
b. The WSWS will be providing $2000 to the WSSA to help support a Congressional Science Fellow.
c. The 1992 WSWS Proceedings will be dedicated to Dr. Harold P. Alley.
d. History Of Western Society Of Weed Science to be written by Dr. Arnold Appleby.
e. Larry Burrill announced a "Retirement Party" for Dr. Arnold Appleby to be held in Corvallis, OR, on July 18, 1992.
f. Galen Schroeder: Announced a new book available; *The North Central Weed Control Conference: Origin And Evolution*, by Robert N. Anderson.
g. Graduate student reimbursements: One letter from each university for their graduate students.
h. Vince Lange (Monsanto Safety And Health Booth): Loal Vance, Weed Control Coordinator, Department Of Agriculture, Idaho, was the winner of the spill kit.
i. Special thanks to these contributors: Mobay Chemical Corp.: Graduate Student Breakfast March 10, Ciba-Geigy: Graduate Student Breakfast March 11, DowElanco: WSWS Business Meeting Breakfast March 12.
j. Phil Westra: Need more graduate student posters.
k. Incoming WSWS President Steve Miller presented a plaque of appreciation to Paul Ogg, for his year as President of the WSWS.

The meeting was adjourned by President Steve Miller at 8:41 a.m.

Submitted by:

Jack Schlesselman, Secretary
Western Society Of Weed Science

WESTERN SOCIETY OF WEED SCIENCE
FINANCIAL REPORT
MARCH 1, 1991 THROUGH FEBRUARY 29, 1992

Income		
Weeds of the West Book	$122,060.00	
Registrations	17,111.50	
Spouse Registrations	360.00	
Membership Dues	860.00	
Sustaining Membership	5,100.00	
1991 Research Progress Reports	2,594.50	
1991 Proceedings	2,923.50	
Tour	37.00	
Bank Interest	6,825.74	
1992 Proceedings	1,973.50	
1992 Research Progress Reports	1,957.00	
		$161,802.74
Expenses		
1991 Meeting		
Audio Visual	$ 1,025.69	
Spouse Breakfast	161.02	
Luncheon	5,918.27	
Coffee Breaks	1,037.86	
Guest Speakers	454.50	
Grad Student Awards	640.14	
Grad Student Room Subsidy	750.00	
Tour	533.10	
Clerical - Registration Desk	128.25	
Conference Supplies/Bus.Mgr. Lodging & Meals	517.82	
Refunds	126.50	
Postage	1,017.50	
Phone	162.53	
Office Supplies	79.68	
Office Equipment	144.89	
Annual State Filing Fee	15.00	
Tax Accountant	130.00	
CAST Dues	585.00	
Business Manager Salary	3,150.00	
Weeds of the West Book	97,800.85	
1992 Planning Meetings	278.35	
Printing		
1991 Research Progress Reports	3,775.60	
1991 Proceedings	4,380.49	
Typist for Proceedings	570.38	
Newsletters, Programs	1,275.17	
Stationery	643.70	
Miscellaneous (bulk mail handling, etc)	98.17	
1992 Conference Registration Refunds	270.00	
Award Plaques	148.57	
		$125,819.03
CAPITAL		
1990-91 Balance Forward	$ 81,622.05	
Current Earnings	35,983.71	
		$117,605.76
DISTRIBUTION OF CAPITAL		
Certificate of Deposits	$ 50,970.63	
Money Market Savings	48,473.68	
Checking Account Balance	18,161.45	
		$117,605.76

1992 FELLOW AWARD
WESTERN SOCIETY OF WEED SCIENCE

Donald C. Thill

Donald (Donn) C. Thill is Professor of Weed Science in the Department of Plant, Soil, and Entomological Science at the University of Idaho. He received a BS and MS in Agronomy at Washington State University and a PhD in Crop Science, with specialization in Weed Science, at Oregon State University. He joined the faculty at the University of Idaho in 1980. He previously had ben employed by USDA-ARS and PPG Industries. Thill's research is focused on four major areas; weed-crop interference in spring barley, sulfonylurea herbicide-resistant weeds and crops, common crupina biology and eradication, and weed control in small grain cereals. Thirteen MS and thirteen PhD students have completed degrees or are currently under his supervision. Thill has authored or co-authored 30 refereed journal articles on various aspects of weed science and has written three book chapters. He teaches undergraduate and graduate courses in weed biology, pesticides in the environment, and herbicide fate and mode of action.

Thill has served as President, Program Chair, Secretary, and Chair of many committees of the Western Society of Weed Science. He is currently serving as Secretary to the Weed Science Society of America. He has served as President and held many other offices of the Idaho weed control Association. He is a past Secretary of the inland Empire Agricultural Chemical Association. He is an Associate Editor of *Weed Technology*. Thill has received the WSSA award for Outstanding Young Weed Scientist and the University of Idaho award for Research Excellence.

1992 FELLOW AWARD
WESTERN SOCIETY OF WEED SCIENCE

Harold M. Kempen

Harold Kempen has been a Farm Advisor with the University of California Cooperative Extension Service since 1961. He recently retired as Farm Advisor in Kern County, CA, where he served for most of his professional career. Harold received his BS degree in Agronomy with honors from the University of Wisconsin and his MS degree in Plant Physiology from the University of California in Davis. In 1987 Harold authored a detailed guide for growers and advisors entitled, *Growers Weed Management Guide*, now being revised for the 3rd Edition. It provides specific details of herbicide and non-herbicidal methods for managing weeds in 22 commodity crops. Weed susceptibility charts and pictures of equipment make this publication one of the most popular weed publications in the western United States. Harold has been a champion at using the popular agricultural media to teach producer and non-producer groups as well as to help save the critical technologies so valuable to American agriculture. He is certainly a spokesman for agriculture and has played a major role as a public figure on controversial issues involving agricultural technologies and is a member of the California Production Consultants Association. In 1987, he was the recipient of the Kern County/CAPCA Outstanding Contribution to Agriculture Award in recognition of his numerous accomplishments.

Harold has had a long and major commitment to the activities and goals of the Western Society of Weed Science. He first joined WSWS in 1958 and has served many assignments and committees including Education and Regulatory Session Chairman, Resolutions Committee Chairman and led many panels and workshops.

Harold has served as President of the California Weed Conference an eleven hundred member organization that also paid special recognition of his contributions to weed management by selecting him as Honorary Member in 1988. He is a charter life member of the International Weed Science Society and a member the European Weed Society, WSSA and CAST.

1992 HONORARY MEMBER AWARD
WESTERN SOCIETY OF WEED SCIENCE

Bruce Ames

It is with great pride that the members of the Western Society of Weed Science have selected as their 1992 Honorary Member, Dr. Bruce Ames. Dr. Ames has made numerous contributions throughout his career that have had positive impacts upon human health and agriculture. He was born in New York City and completed his B.S. degree in biology at Cornell University and his Ph.D. in chemistry and genetics at the California Institute of Technology. For little more than a decade in the early years of his professional life, he served as biochemist at the National Institute Health. He spent one year in the laboratories of F.H.C. Crick and F. Jacob in Cambridge and Paris.

In 1968, he became Professor of Biochemistry and Molecular Biology at the University of California Berkeley where he is presently affiliated. In 1979 he became Director, National Institute of Environmental Health Science Center in Berkeley, a position he currently holds. Dr. Ames was formerly on the Board of Directors of the National Cancer Institute (National Cancer Advisory Board). He was a recipient of the most prestigious award for cancer research, the General Motors Cancer Research Foundation Prize (1983), and of the highest award in environmental achievement, the Tyler Prize (1985). He has been elected to the Royal Swedish Academy of Sciences and the Japan Cancer Association. His 300 scientific publications have resulted in his being the 23rd most-cited scientist (in all fields) (1973 to 1984).

Professor Ames has been the international leader in the field of mutagenesis and genetic toxicology for over 20 years. His work has had a major impact on, and changed the direction of, basic and applied research on mutation, cancer and aging. The development of Ames' mutagenicity test as a practical tool for the detection of potential carcinogens had led to its use in over 3000 laboratories and in all of the major drug and chemical companies, where it has had a major influence in weeding out mutagenic chemicals while it is cheap to do so and before they are introduced in commerce.

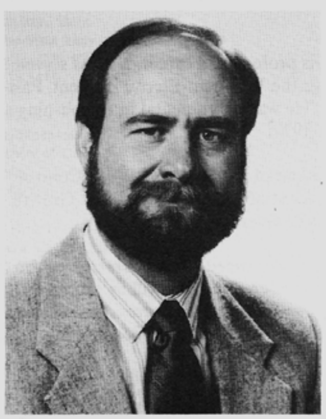
1992 OUTSTANDING WEED SCIENTIST AWARD
PUBLIC SECTOR

ALEX G. OGG, JR.

Alex G. Ogg, Jr. was born in 1941 and was raised on a diversified irrigated farm in Wyoming. He attended the University of Wyoming and graduated with honors in agriculture in 1963. Alex worked from 1963 to 1966 as an agricultural research technician in aquatic and non-crop weed control for ARS/USDA at Prosser, Washington. During this same period, he attended Oregon State University and received an M.S. in Weed Science in 1966. From 1966 through 1969, Alex worked as a plant physiologist for the Pesticide Regulation Division, USDA, at Corvallis, Oregon. He received his Ph.D. in Plant Physiology in 1970. In 1969, Dr. Ogg accepted a position with ARS/USDA at Prosser, Washington. His responsibilities included weed control research in horticultural and specialty crops. His research included studies on biology and control of nightshade and the application of herbicides through sprinklers. In 1984, Alex was chosen to be research leader of the newly formed non-irrigated agriculture weed science research unit at Pullman, Washington. The mission of the research unit is to reduce crop losses from weeds in conservation crop production systems. His personal research emphasizes the control of downy brome and jointed goatgrass in winter wheat. He has authored or co-authored over 100 papers on weeds and their control.

Dr. Ogg has served the Weed Science Society of America as a reviewer of WEED SCIENCE, as Associate Editor of WEED TECHNOLOGY, and as a member or chairman of numerous committees. In 1984, he was chosen to represent ARS/USDA on the WSSA delegation to China. In 1986, Alex was elected Member-at-Large and has served on the Board of Directors for 4 years. In 1992, he was elected as Vice President of WSSA, which will automatically take him to the presidency of the Society in 2 years.

1992 WESTERN SOCIETY OF WEED SCIENCE OUTSTANDING WEED SCIENTISTS AND FELLOW (L to R): Alex Ogg (OWS - Public Sector), Ken Dunster (OWS - Private Sector), and Harold Kempen (Fellow).



1992 WSWS FELLOW
Don Thill

1992 WSWS HONORARY MEMBER
Bruce Ames

Alex has long been a leader in the western states and in WSWS. He has served as Secretary, Vice President, and President and was awarded the Fellow of WSWS in 1987.

Dr. Ogg's skill as an astute researcher, his energy and persistence in his work, his leadership in working with colleagues and students, and his continuing commitment and service to the weed science discipline make him a most worthy recipient of the 1992 Outstanding Weed Scientist Award--Public Sector.

1992 OUTSTANDING WEED SCIENTIST AWARD
PRIVATE SECTOR

KENNETH W. DUNSTER

Kenneth W. Dunster began his professional career in weed science in July, 1960, as a Field Development Representative for AmChem Products, working in the intermountain western region. He has been a guiding and steadying influence in WSWS since that time. He presently is a Rhone-Poulenc Senior Field Research and Technical Development Representative in Byron, California.

In 1966, Ken moved to Loveland, Colorado, and assumed field development responsibilities in the mountain states district. He was promoted to Senior Area Research Representative in 1971 and assumed responsibilities for coordinating R & D activities in California, Arizona, and Nevada from a California location. He became the Manager for Western Regional Field Development for Union Carbide in 1978. In 1987, after the merger of Union Carbide and Rhone-Poulenc Ag Company, Ken assumed responsibilities for field development in Hawaii and the coast area of California as a Senior Field Development Representative.

Ken Dunster has been at the forefront of research and development of crop protectants since he first joined the agrichemical industry in 1960. His work has led to the registration and success of numerous products on a large diversity of crops over a wide geographical area. Among these are the successful development of bromoxynil on small grains, additional development of several phenoxy formulations for perennial weed and brush control under rangeland conditions, the development of pyramin herbicide in sugarbeets, and bromoxynil for weed control in seedling alfalfa. In recent years, his emphasis has shifted more toward plant growth regulators, including the development of ethophon programs on tomatoes, grapes, walnuts, peppers, pineapple, sugarcane, and cotton.

Ken has been a mainstay in WSWS since the beginning of his professional career. He has served on numerous committees and various offices, and advanced through the President-Elect, President, Past-President steps. He received the WSWS Fellow Award in 1978. He was instrumental in establishing a firm financial foundation for WSWS during his term as president in 1970.

Besides his contributions to WSWS, Ken has served as President of the Montana Weed Control Association, President of the California Weed Conference, President of the California Plant Growth Regulator Conference, and in a large number of other positions in several organizations.

Ken Dunster serves as an excellent example of what a good, private weed scientist should be. He has been not only highly competent in his professional career, but has been unusually willing to share his time and knowledge with others and be a strong contributor to many societies. He has earned our respect and gratitude, and clearly deserves the 1992 Outstanding Weed Scientist Award--Private Sector.

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