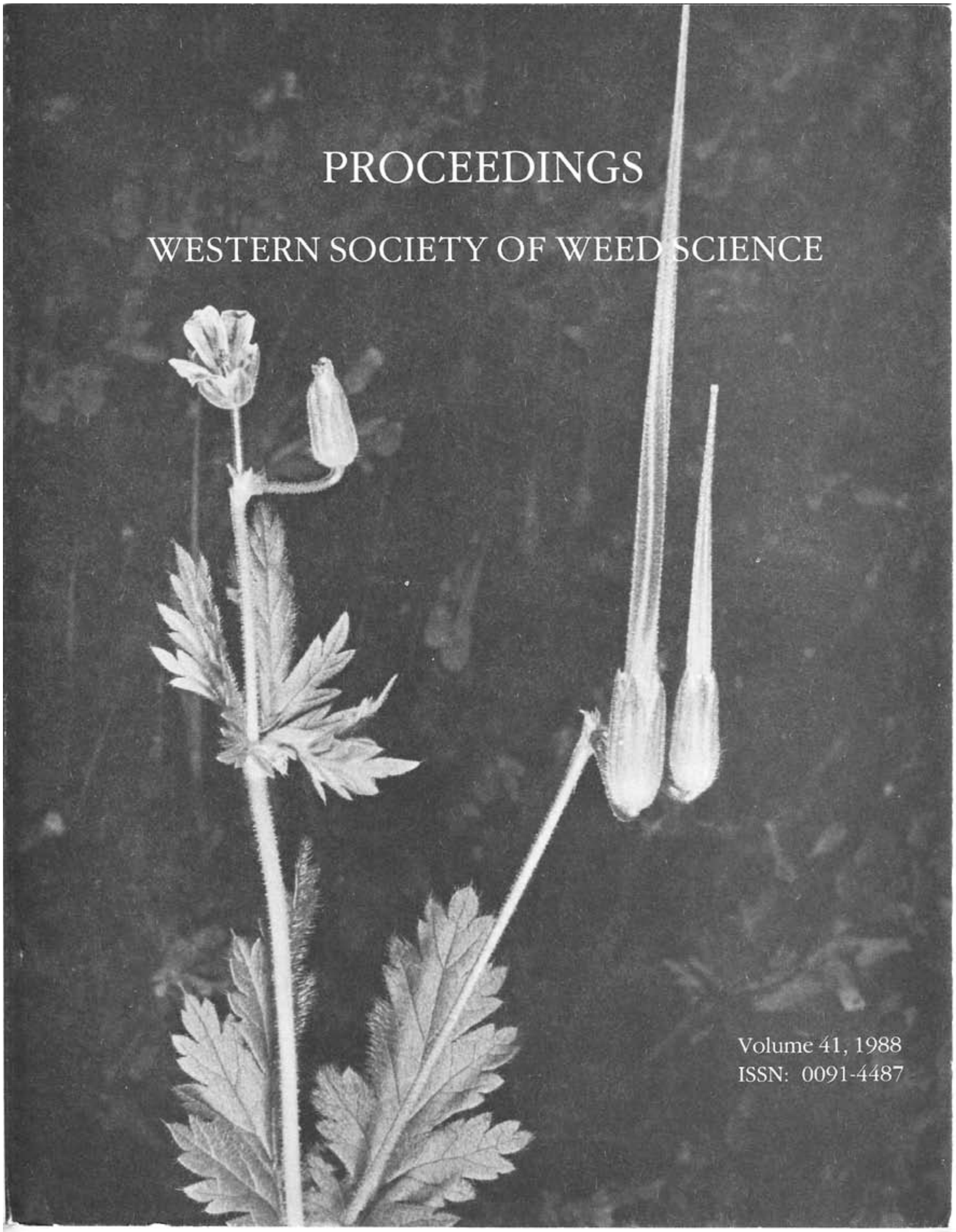
PROCEEDINGS

WESTERN SOCIETY OF WEED SCIENCE



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PRESIDENTIAL ADDRESS

Larry W. Mitich[1]

The annual Western Society of Weed Science conference has a tremendous influence on our careers in weed science and related fields. Each year it provides an opportunity to reminisce and renew friendships, to measure our progress and to chart our course for the future.

This is the 41st annual meeting of our society. What dramatic changes have occurred in weed science since the society was founded in June 1936, and its first conference was held in Denver in 1938. In no other career during that time period could one have participated in a more dynamic and challenging profession or in one that has contributed more to mankind's well-being.

Our annual meetings have always provided an excellent opportunity to share information and experiences with a broad-based audience from the 13 states comprising the society.

The Western Society of Weed Science was the first of the regional societies to organize formally, and it predates the Weed Science Society of America by 20 years. Our conference has grown in influence through the years because it links representatives from industry, research, teaching, extension, merchandising and regulation into an effective team.

Why were regional weed science societies initiated? There are many reasons for existing, of course. The major reason is to facilitate the exchange of ideas, experiences, opinions and information. We are challenged to plan ways of obtaining better weed control through coordinated weed research and educational efforts. The ultimate objective of our society is simply the control of weeds by federal, state and private agencies. The Western Society of Weed Science is and will remain a scientific and educational organization dealing with rural and urban weed science activities without financial gain.

Like many of you, I have seen the science of weed control unfold in my lifetime. My father's Wyoming farm had its share of weeds--field bindweed, wild mustard, wild oats and downy brome, among others. What drudgery it was to pull mustard from the wheat or to make the repeated cultivations that were necessary to produce a row crop. But chemical weed control changed all that. How exciting it was in the 1940's to see wild mustard die and the wheat gain new vigor after it was treated with a wondrous new chemical called 2,4-D. Truly the modern age of weed control had begun!

Robert Dunlap and his local arrangements committee have done an outstanding job in organizing facilities for this meeting. They have worked long and hard to provide everything necessary for a successful conference. Thanks, Bob, for the efficient manner in which you have handled this demanding task.

Dr. Donn Thill and his program committee have developed a quality program which fulfills the purpose of our society, and we are indebted to him. The program is filled with scientific merit and innovative approaches. The Poster Session is becoming increasingly popular and deservedly so; it provides an effective, alternate way of presenting and discussing new information.

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[1]Extension Weed Scientist, Dept. of Botany, University of California, Davis

Seventy-eight papers will be presented at this meeting, including 14 graduate student papers and the 16 posters you saw this morning in the Poster Session. In addition, seven research project meetings are scheduled. We thank the authors for their contribution to the program; only through your efforts is this meeting possible. The fine speakers that Dr. Thill has scheduled for this General Session have agreed to participate in discussions during this afternoon's sessions. Thanks, Donn, for your hard work and creativity in putting all of this together.

The Western Society of Weed Science remains a viable organization, and we are grateful to Dr. LaMar Anderson, our dedicated business manager, for another year of sound management. Now to highlight a few of the society's activities and administrative affairs.

Membership. We have 475 active members in the Western Society of Weed Science and membership has remained fairly constant for the past several years. About 40% of those attending one meeting do not attend the following one. Many members become inactive. There is about a 25% turnover in membership each year, due to attrition, graduate students moving to different areas and persons who only attend the annual meeting when it is in their immediate area and who do not continue their membership. However, there are many potential new members among dealers, applicators, PCA's and the like. We should strive to broaden our membership and keep members active.

Finances. Our total assets are $48,328, an increase of $3,319 over 1987. The society has $39,448 in saving certificates which is equal to about a 2 1/2-year reserve, a reserve we strive to maintain. The total interest income from our savings in 1987 was $4,169. That interest income is very important to us. If it were not for the interest, we would be $851 in the red, and this is the second consecutive year that expenditures have exceeded income. This short-fall will likely necessitate revaluating the cost of our publications. The "Research Progress Report" has increased in size and is costing more than previously to publish. It seems only logical that we will have to increase the price of one or both of our publications next year.

Our total expenses for 1987-1988 have been $19,161, a figure that varies from year to year, but which is about par for the course, depending on the meeting site. Our conference in Hawaii next year will be an expensive one, despite the fact we will be staying at the Ala Moana, which offers the best room rates on the islands. In order to avoid a serious deficit at the Hawaii meeting, we must have a large attendance with everyone staying at the Ala Moana, and we must patronize the hotel's food services. If we fail to meet these requirements, we will be billed for use of the meeting rooms, which would be a sizeable expense. A slight increase in the registration fee may be necessary for the Hawaii meeting to avoid a deficit.

Interesting and exciting things are happening in weed science at the regional and national levels. The Weed Science Society of America and the regional weed science societies are enhancing their image, extending their influence and reaping the benefits in important ways. For the past two years, the Western Society of Weed Science President has participated in a spring meeting in Washington, D.C., under the auspices of the Weed Science Society of America. Senior WSSA officers and regional society presidents meet with national policy makers and present position papers on subjects of primary concern to our members.

Topics discussed during the 1987 meeting included the IR-4 programs for minor crops, weed science in competitive grants, USDA/ARS groundwater protection policies, the Noxious Weed Act, and implementation of the Endangered Species Act. In addition, seven priority items were discussed in a four-hour session with members of trade and commodity groups including the National Association of Wheat Growers and the National Cotton Council.

During the next two days, we met with Congressman Jamie L. Whitten (D-Miss.), Chairman of House Appropriations; Congressman Glenn English (D-Okla.), a member of the House Agriculture Committee; Dr. John A. Moore, Assistant Administrator of the EPA Office of Pesticides & Toxic Substances; Stan Krogman, of the U.S. Forestry Service; William Helms, Deputy Administrator in Plant Protection and Quarantine; Peter Myers, Deputy Secretary of Agriculture; and Congressman Pat Roberts (R-Kan.). We were received warmly, had an excellent opportunity to exchange information and ideas and were encouraged to continue making ourselves heard in Washington. The group is scheduled to meet again in May with Dr. Donn Thill representing our society.

To serve the growing and changing needs of the Western Society of Weed Science, two new ad hoc committees were formed during the year. Celestine Lacey chairs the Legislative Committee, organized to assist in the passage of legislation favorable to weed science interests. She works closely with George Beck who heads the Intermountain Noxious Weed Ad Hoc Committee (INWAC), which coordinates educational and legislative efforts to combat noxious weeds on rangelands. These two committees are working together to develop a comprehensive national noxious weed law. We welcome these new committees and wish them every success in accomplishing their mission and becoming an integral part of our society.

Weed scientists are always being confronted with new problems. About 25 years ago, we witnessed the development of public concern regarding the safety of food and feed as a result of pesticide use. At that time, pesticide manufacturers employed toxicologists to help determine and recommend acceptable pesticide levels in food and feed. The Environmental Protection Agency (EPA) used these and other data in setting legal tolerances.

Now we are witnessing the beginning of another era of concern, but this time dealing with water quality. Concern with water quality issues is increasing at local, state and national levels. The number one concern is pesticides in ground and surface water with a close second concern being fertilizers, especially nitrates. Dr. Doug Mackay, one of the General Session speakers, will address the issue of ground water contamination by organic chemicals.

We have no pesticide tolerances for water to guide our deliberations. We need to establish such tolerances for our various pesticides, rather than relying on health advisors to do it for us. It seems logical that industry is in the best possible position to petition EPA for water tolerances. Industry also has the financial resources to undertake a program of establishing pesticide tolerances in water because that expense will become part of the pesticide cost. Without pesticide tolerances for water, agriculturalists will be at a distinct disadvantage in defending the continued use of many pesticides. Public opinion is going to play a dominant role in pesticide use. We can only hope that those opinions are always based on critical analysis of the facts, rather than on unfounded fears. The best way to assure that reason prevails, it seems to me, is to set national standards for water tolerances now, before many ill-conceived, ineffective and complex guidelines evolve.

New technologies and concepts are bringing agriculture to the threshold of a new era. Compared with preceding mechanical and chemical agricultural eras, some of the changes may be difficult to comprehend. One thing we can be assured of--the new age will be greatly different from today's agriculture and some early signs are here already.

The biggest impact on agriculture in the 21st century can be summarized in one word: biotechnology. Two techniques involving molecular genetics have received the most attention: cell fusion and recombinant deoxyribonucleic acid (rDNA). Using these techniques, researchers have isolated and cloned genes to produce new plants. We can look forward to the development of plant species that can tolerate stress from salinity, drought, cold and herbicides, among other things. Wondrous creations are likely in the 21st century. What about corn plants that fix nitrogen directly from the air, kill adjacent weeds, survive freezing temperatures and have remarkable tolerance to herbicides, diseases and insects? But some major advances will be available within the next decade and have Corn Belt farmers excited: atrazine-resistant soybeans and glyphosate- and imazaquin-resistant corn. No doubt, by the year 2000 we will be laughing at what's in use today.

Computers are being programmed to detect weeds, permitting researchers to shed new light on weed control. An agricultural engineer at Purdue has given computers the power of vision to perform tasks involving visual judgement. A camera is used to send a digital image to a computer. A sensor locates weed plants growing in corn and bean fields. It distinguishes weeds from crop plants by measuring the thickness, length and area of the leaves. In laboratory tests, computer vision systems recorded and identified corn, soybeans, johnsongrass, jimsonweed, velvetleaf, giant foxtail and lambsquarters.

Researchers are just beginning to study image technology, and much work lies ahead. Eventually it may be possible to combine the weed identification system with a sprayer. Weeds could be sprayed selectively, replacing the broadcast application practice. Such a system could save farmers millions of dollars on herbicides. While the price of a computerized sprayer at the onset might be high, the equipment would pay for itself when used by minimum-till farmers who now spend several thousand dollars per year on weed control. Much remains to be accomplished, but this is the direction technology is headed.

The age of conservation tillage dawned a generation ago, and use of its various forms--minimum tillage, low tillage, no-till, ridge tillage and others--will become the standard practice of the future. How will conservation tillage affect herbicide use? In the future, less herbicide will be used than at present, thanks to improved application technology and improved products that will be more effective at lower rates. Products will become environmentally safer because of lower rates, lower toxicity and a more specific mode of action.

Western Society of Weed Science members will meet the future with the same enthusiasm and flexibility that they did in the past. Our society is over half a century old, but a feeling of optimism prevails within it. The cooperative spirit among our members is one of the principal reasons why the Western Society of Weed Science is such an energetic and vibrant professional organization. We have a rich tradition. We have the energy and technical expertise. We have the right stuff to make all systems go!

PERENNIAL WEED CONTROL

Donald L. Wyse[1]

Introduction

Perennial weeds continue to create problems in many cropping systems because they are very resilient to most commonly employed weed control practices. Current tillage practices and herbicide treatments have failed to successfully destroy the underground reproductive structures of perennial weeds. Most tillage systems that are currently in vogue or are being developed for the future utilize tillage practices that are less vigorous than those of the past. This has, and will continue to provide less disturbance of the underground reproductive structure of perennial weeds, making it more likely that future tillage practices will provide even less control of perennial weeds than in the past. Although several major advances have been made in the development of herbicides that control perennial weeds, these weeds still remain as major problems in most crop and non-crop environments. There are several reasons that can be given to explain why perennial weeds remain as a problem. In this paper I will discuss some of the factors that contribute to the high cost and difficulty of controlling perennial weeds with herbicides.

Lack of selective herbicides. Many perennial weeds cannot be selectively controlled in the growing crop because the crop lacks tolerance to the herbicide. This is the case for quackgrass [*Agropyron repens* (L.) Beauv.] infestations in small grains. Since these crops cannot tolerate glyphosate {*N*-(phosphonomethyl)glycine}, sethoxydim {2-[1-(ethoxyimino)butyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one}, or fluazifop {(±)-2-[4[[5-(trifluoromethyl)-2-pyridinyl]oxy]phenoxy]propanoic acid}, which have phytotoxicity on quackgrass, these herbicides must be used in crops grown on the land previously or applied prior to emergence of small grains. This type of treatment is in many cases more expensive and less consistent than selective treatments. Since planting of the crop follows the herbicide treatment by some extended period of time the weed has a chance to recover and becomes competitive by the time of crop emergence. To avoid this possibility high rates of the herbicide must be used to provide a level of control so that the weed is adequately controlled at the time of crop emergence. This non-selective system is more costly and less consistent than a selective herbicide system which could be used after planting the crop. Thus, effort should be given to the development of small grain varieties that have tolerance to herbicides that are phytotoxic to perennial weeds.

Why do single herbicide treatments fail to give complete control? Effective control of perennial weeds requires that the underground reproductive buds be killed. To accomplish this the herbicide must be absorbed and translocated in sufficient quantities to be phototoxic to a large number of the underground reproductive structures. There are only a few chemicals that can be absorbed by leaf tissue and translocated in the phloem to shoot buds on roots or rhizomes of perennial weeds. In many cases herbicides are not absorbed by leaf tissue at levels sufficient to develop lethal concentrations in the vegetative reproductive tissue. In other cases the herbicide is

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[1]Professor, Dept. Agron. and Plant Genetics, Univ. Minnesota, St. Paul, MN

absorbed at high levels but is not translocated because of rapid phloem toxicity, which limits transport to root sinks. In other cases large amounts of the herbicide are absorbed and translocated, however it is not translocated to enough of the buds to provide effective control. This lack of control is due to bud dormancy. Most perennial weeds produce massive numbers of buds that develop rapidly then stop developing or go into a stage of very slow development. As bud growth slows the sink strength is decreased and herbicide uptake is greatly reduced. The result is inadequate control of the dormant buds and subsequent regrowth and establishment of the weed population. Thus, it is evident to me that bud dormancy will remain one of the major limiting factors to effective perennial weed control in the future.

Detached rhizomes. Reports of insect effects on weeds are numerous, but relate primarily to the biological control of weeds. An evaluation of quackgrass rhizomes from glyphosate treated fields in Minnesota suggest that some quackgrass regrowth is due to insect feeding damage which interferes with the translocation of glyphosate through the rhizome system. Research indicated that the insect was providing the reverse of biological control, i.e. "biological protection." Other factors such as freezing and thawing, and tillage can detach the roots and rhizome of perennial weeds, preventing the translocation of herbicides to the reproductive structures of perennial weeds.

Perennial weed biotypes. Quackgrass is a highly variable species due to its self-sterility and very low frequency of inbreeding in nature. The high degree of heterozygosity present within this species has resulted in the description of a large number of varieties, forms and biotypes of quackgrass. Some researchers have reported the differential control of quackgrass biotypes with herbicides. Crown bud, tiller and rhizome development were studied in ten Minnesota quackgrass biotypes at two stages of development to determine if differential development of these structures influenced control with sethoxydim and haloxyfop {2-[4-[[3-chloro-S-(trifluoromethyl)-2-pyridinyl]oxy]phenoxy]propanoic acid}. There was a differential response among the ten biotypes to both herbicides at both stages of development. The biotypes differed in the number of crown buds, tillers and rhizomes that formed at both stages of development. In the three- to four-leaf stage the biotypes with the greatest number of crown buds were the most difficult to control. This suggests that in the susceptible stage (three- to four-leaf) the quackgrass biotypes with the least number of dormant crown buds will be the easiest to control; however, by the time all the biotypes reach the seven- to eight-leaf stage even the biotypes with the lowest number of dormant crown buds have produced enough crown buds that they become difficult to control with either sethoxydim or haloxyfop.

Stage of development. Haloxyfop and sethoxydim are less effective when applied to quackgrass in the five- to seven-leaf stage as compared to the one- to two-leaf stage. The reduced control of quackgrass in the eight-leaf stage, compared to the four-leaf stage, is not due to reduced herbicide retention on leaves or to changes in residual herbicide activity in the soil following postemergence applications. The efficacy of both herbicides on rhizome bud kill does not change between the four- and eight-leaf stages following applications to the foliage. However, the efficacy of both herbicides on crown tissue bud viability is less at the eight-leaf stage. Regrowth from dormant crown buds, following application of haloxyfop or sethoxydim to quackgrass in later stages of development can contribute substantially to reinfestation of quackgrass.

Summary

In this presentation I highlighted several of the major factors limiting the efficacy of herbicides on perennial weeds. This summary suggests that many factors interact in a very complex manner to limit the efficacy of herbicides on perennial weeds. The key to improved perennial weed control with herbicides is to develop a better understanding of herbicide uptake and translocation in perennial weeds. Currently, our lack of understanding of the relationship between sink strength and herbicide uptake limits the development of new technology that could increase herbicide efficacy. One of the key areas for future research is bud dormancy. When we develop the capability to increase the sink strength of dormant buds, we will be able to increase the efficacy of many herbicides used for perennial weed control.

GROUNDWATER CONTAMINATION BY ORGANIC CHEMICALS: OVERVIEW AND CONSIDERATION OF THE POTENTIAL IMPORTANCE OF PESTICIDE INERT INGREDIENTS

Douglas M. Mackay[1]

Abstract. Although still underway, state-sponsored monitoring of supply wells in California indicates that groundwater has been contaminated by a wide variety of organic chemicals in various areas throughout the state. The chemicals that are most frequently observed, certain industrial solvents and pesticide active ingredients, would, on the basis of current understanding of subsurface fate and transport, be expected to have a relatively high likelihood of contaminating groundwater provided they are released in sufficient quantities. Apparently no monitoring has specifically investigated the possibility of groundwater contamination by the inert ingredients of pesticide formulations. However, consideration of the types of chemicals often used as inerts and their likely subsurface behavior suggests that they are as likely to contaminate groundwater as some of the active ingredients which have been detected. Thus, if significant quantities of the more toxic inerts are actually used in California and elsewhere, monitoring of groundwater for their presence would appear to be advisable.

Groundwater Monitoring in California. The collection of data on ground water quality in California has occurred, is still occurring or is planned by a wide variety of programs conducted by a variety of government and private organizations. The following brief discussion, which is limited to the consideration of groundwater contamination by organic chemicals, is a condensation of a more detailed review of the topic by Mackay et al. (12).

Because concern about groundwater pollution generally centers around the quality of water extracted for use, much of the governmental attention has focused on monitoring of supply wells. Monitoring of supply wells in California for organic pollutants has been conducted by various organizations for over 10 years and has resulted in a number of publications summarizing the results (2, 3, 6, 7). One of the goals of these programs has been to determine where the extracted ground water exceeds governmental standards for

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[1]Assistant Professor, UCLA School of Public Health, Los Angeles, CA 90024

one or more pollutants, particularly the California State "action levels" (ALs), which are health-based advisory (i.e. nonenforceable) standards. Also of concern are the enforceable "maximum contaminant levels" (MCLs) set by the Environmental Protection Agency, but few MCLs have been promulgated.

Table 1 presents a summary of the results of three of the governmental efforts: 1) the monitoring of wells in large supply systems (>200 connections) by the California Department of Health Services in response to Assembly Bill 1803 (AB 1803), 2) the compilation of monitoring data for pesticides in supply wells in agricultural areas by the California Department of Food and Agriculture prior to and later in response to Assembly Bill 2021 (AB 2021), and 3) the monitoring of wells in small supply systems (<200 connections) by the California Department of Health Services in the second phase of the AB 1803 program. As the table shows, over 8000 supply wells have been monitored in California for "pesticides" or "organic chemicals." Here the term "pesticides" refers to a selected group of active ingredients (2, 3), while the term "organic chemicals" refers to a subset of selected solvents, fuel components, pesticide active ingredients, etc. (7). Table 1 shows that in over 2000 of the wells, one or more of the target organic pollutants was detected. In the AB 1803 work, approximately 200 wells were found to exceed one or more action levels. It is generally thought that this is an underestimate of the problem since 1) prior to these programs, many other wells were found to exceed ALs and were removed from service, and 2) the DHS is considering lowering the AL for DBCP (dibromochloropropane) to 0.01 ppb, which will greatly increase the number of wells exceeding ALs.

Table 1. Monitoring of supply wells in California: summary of results.

	A 1803- Large Supply Systems	AB 2021- Various Wells	AB 1803 Small Supply Systems
	DHS (1986)	DFA (1986)	DHA (1987)*
ANALYTES	ORGANICS	PESTICIDES	ORGANICS
WELLS SAMPLED	2970	8376**	2278
WELLS POSITIVE	538	2303**	162
WELLS OVER AL#	165	NA	38

NA Data not available
* Preliminary results of program in progress
** Includes data from California Dept. Health Sciences (4, 5) monitoring
\# AL = action limit

For each of the three programs discussed above, Table 2 lists the ten most frequently identified pollutants. In the AB 1803 program both industrial solvents and pesticide active ingredients were found. Through the AB 2021 effort, the listed pesticide active ingredients were found in groundwater beneath agricultural areas. DFA (1986) attempted to determine the likely source of the various pesticides and related products found in groundwater beneath agricultural areas and concluded that only 9 of the 16 detected probably arose from nonpoint agricultural use of the pesticides aldicarb, aldicarb sulfone, atrizine, DBCP, 1,2D (1,2 dichloropropane), diuron, EDB (ethylene dibromide), prometon and simazine. The rest presumably derived from spills, storage or other releases of the chemicals. Thus, the eight most frequently detected pesticide active ingredients are, according to DFA, reaching groundwater as a result of nonpoint agricultural use.

Subsurface Transport and Fate of Organic Chemicals. Numerous publications address the processes that control subsurface transport of organic chemicals at a variety of levels of detail (10, 11, 13, 14, 16). It is sufficient, for the purposes of this paper, to note that pesticides are generally assumed to be transported through the unsaturated zone dissolved in water, although transport in the vapor phase may be important in some cases, particularly for the more volatile chemicals (9, 10, 11). The potential for significant pollution of underlying groundwater is then a function of the rate of transport (i.e. mobility) through the unsaturated zone and the rate of the processes that degrade or transform the applied chemical in the subsurface.

Table 2. Ten most frequently observed pollutants in monitoring of supply wells, listed in descending order of frequency. Abbreviations are explained in the note following the table.

AB 1803- Large supply Systems	AB 2021- Various Wells	AB 1803- Small Supply Systems
PCE	DBCP*	DBCP
TCE	Atrazine*	PCE
DBCP	1,2 D*	TCE
Chloroform	Simazine*	Chloroform
1,1 DCE	Aldicarb*	1,2 D
1,1,1 TCA	EDB*	1,1 DCA
Carbon Tet.	Diuron*	1,1,1 TCA
Atrazine	Prometon*	Phthalates
1,2 DCE	Bromacil	Atrizine
Simazine	Molinate	TCFmethane

*Groundwater pollution by these pesticides was judged by California Dept. of Food and Agriculture (3) to be the result of nonpoint agricultural use.

Note: PCE (tetrachloroethylene), TCE (trichloroethylene), DBCP (dibromochloropropane), 1,1 DCE (1,1 dichloroethylene), 1,1,1 TCE (1,1,1 trichloroethane), Carbon tet (carbon tetrachloride), 1,2 DCE (1,2 dichloroethylene), 1,2 D (1,2, dichloropropane), EDB (ethylene dibromide), 1,1 DCA (1,1 dichloroethane), TCFmethane (trichloromethane)

Jury et al. (9) have proposed a simple model for assessing the groundwater pollution potential for organic chemicals. In essence, they assume an idealized subsurface environment in which 1) water flow is steady, 2) the mobility of organic contaminants relative to that of the water can be adequately represented by the organic-carbon based sorption distribution coefficient (K_{oc}), and 3) the biochemical transformations follow exponential rate laws (with a characteristic half-life, $t_{1/2}$) and the biotransformation potential decreases exponentially below the active soil zone. Under these and other simplifying assumptions, they show that the equations predicting the fraction of mass remaining after flow and degradation of the organic chemical through the unsaturated zone to a specified depth can be simplified considerably. They then define an organic chemical as having a low or insignificant risk of contaminating groundwater if the residual undegraded mass of the chemical is less than 1/10,000th of the mass applied as a pulse to the ground surface. Finally, they show that this criterion of insignificant pollution potential is met when:

$$K_{oc} > a\ t_{1/2} - b$$

where a and b are constants that depend on soil properties, microbial populations, water flow rate, etc. See Jury et al. (9) for full development of this screening model.

Figure 1(a) is a graphical representation of the screening model of Jury et al. (9), in which a log-log plot of K_{oc} versus $t_{1/2}$ is made. In the graphical form, the solid line ($K_{oc} = a\ t_{1/2} - b$) represents the boundary between the upper region in which organic chemicals with relatively insignificant potential of contaminating groundwater will plot (LOW RISK CHEMICALS) and the lower region in which those with relatively significant ground water pollution potential will plot (HIGH RISK CHEMICALS). In Figures 1(a) and 1(b) we will plot (HIGH RISK CHEMICALS). In Figures 1(a) and 1(b) we have used the boundary line corresponding to subsurface and environmental conditions that Jury et al. (9) deem representative of a worse case scenario from the standpoint of groundwater pollution potential (shallow water table), sandy soil, high infiltration rate, etc.).

Various active ingredients of pesticides are plotted in Figure 1(a), using the K_{oc} and $t_{1/2}$ values summarized in Table 4 and/or taken from Jury et al. (9). In Figure 1(a), the underlined active ingredients are those that have been found in California's groundwater (Table 2); the others were not listed by the California Department of Food and Agriculture (3) as detected in groundwater. It would seem that the screening model is reasonably well calibrated in that it correctly identifies all of the pesticide active ingredients observed in groundwater as "high risk chemicals." Jury et al. (9) present similar evidence of the usefulness of the screening model.

<u>An Unexplored Issue: Pesticide Inert Ingredients</u>. It is important to realize when considering summaries of detected groundwater contaminants such as in Tables 1 and 2, that available data may be incomplete or misleading. Mackay et al. (12) discuss three potential reasons: 1) poor quality data, containing false positives and false negatives, 2) failure to monitor for contaminants that are in fact present, and 3) inability to detect contaminants that are present (no available analytical techniques). Here we focus on a potentially important example of the second problem: "inert ingredients" present in some pesticide products or formulations.

A pesticide formulation may consist of one or more "active" ingredients which possess the pesticidal power required for the product. In addition,

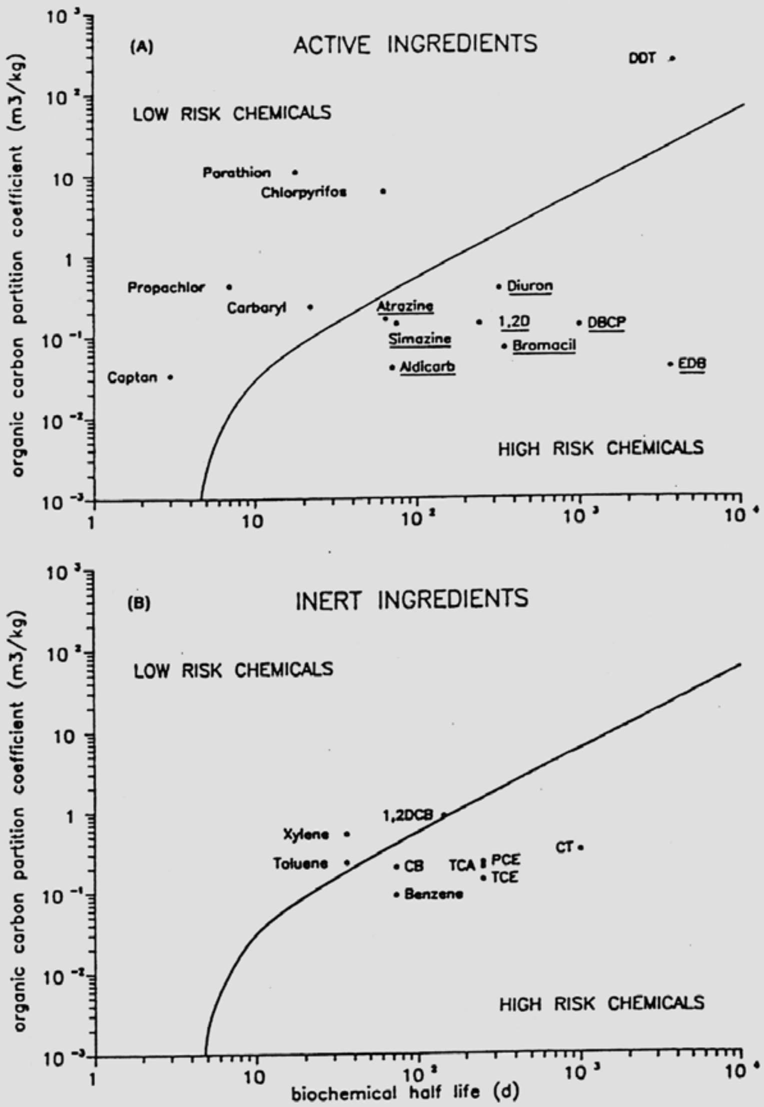

Figure 1. Screening model of Jury et al. (9), a log-log plot of the organic carbon partition coefficient (K_{OC}) versus the biochemical half life ($t_{\frac{1}{2}}$): (a) applied to selected pesticide active ingredients; (b) applied to selected inert ingredients of pesticides. See text for discussion.

the formulation may contain inert ingredients, sometimes as a relatively large fraction of the total mass, which are not specifically pesticidally active, at least for the target pest. However, of the 1200 or so substances used as inert ingredients in pesticide products nationwide, EPA has determined that approximately 50 are of "significant toxicological concern" from a human standpoint on the basis of the following criteria: carcinogenicity, adverse reproductive effects, neurotoxicity or other chronic effects or developmental toxicity (8). Another 60 substances were identified as "potentially toxic."

Table 4 lists examples of inert ingredients which EPA placed in these two categories. Of the remainder, about 300 were thought to be innocuous (water, etc.) and 800 could not be assigned to any of the other categories with confidence. A comparison of Table 4 (or the EPA lists) with the AB 1803 results in Table 2 indicates that many of the toxic or potentially toxic inert ingredients used in pesticide products nationwide are identical to many of the urban industry-related chemicals that are frequently found to pollute ground water in California.

Data on usage of inert ingredients are difficult to come by in the public domain, since the details of pesticide formulations are considered proprietary. One source estimates that approximately 200 million pounds of inert ingredients were used in California from 1971-1981 (6). Data are not available on the specific chemicals included in this total. In the absence of such data or other evidence to the contrary, it seems prudent to assume that at least some of the inerts of known or potential toxicological concern are and have been used in California.

Table 3. Examples of "inert ingredients" used in some pesticide formulations (8)

LEVEL OF TOXICOLOGICAL CONCERN	
"KNOWN"	"POTENTIAL"
Benzene	1,2 Dichlorobenzene
Carbon Tetrachloride	Toluene
Chlorobenzene	Chloroethane
Chloroform	Ethyl benzene
1,4 Dichlorobenzene	Methyl bromide
Dichloroethylene	Petroleum hydrocarbons
Formaldehyde	Xylene
Pentachlorophenol	p-Nitrophenol
Tetrachloroethylene (PCE)	1,1,1 Trichloroethane (TCA)
Trichloroethylene (TCE)	Trichlorofluoromethane

In Figure 1(b), the screening model of Jury et al. (9) is applied to inert ingredients from Table 3 for which environmental fate data could be located (Table 4). It is evident that some of the inert ingredients fall within the region of the "high risk chemicals" while others do not. This implies that at least some of the inert ingredients may be as likely to contaminate groundwater in agricultural areas as the active ingredients that have already been observed to do so.

This is certainly a crude analysis, ignoring processes that could prevent the inert ingredients from reaching the soil so that subsequent migration to groundwater would not be possible. However, the same processes would presumably affect the active ingredients to some extent, yet some of them have been found to reach groundwater. Clearly a more detailed analysis should include consideration of all processes that affect the transport and fate of agricultural chemicals after their release. In the absence of that more detailed analysis, however, the evidence at hand suggests that at least some of the inert ingredients may present a currently unquantifiable hazard to groundwater.

Table 4. Environmental fate parameters for selected pesticide ingredients (abbreviations explained in Table 2).

Pesticide Active Ingredients	K_{oc}	$t_{1/2}$
(Ten most frequently observed by the California Dept. of Health Services - see Table 2)	(m^3/g)	(d)
DBCP	0.13[1]	1000[1]
Atrazine	0.16[1]	64[1]
1,2 D	0.14[2,3]	> 247[2]
Simazine	0.14[1]	75[1]
Aldicarb	0.04[1]	70[1]
EDB	0.04[1]	3650[1]
Diuron	0.38[1]	328[1]
Prometon	---	---
Bromacil	0.07[1]	350[1]
Molinate	---	---
Selected Pesticide Inert Ingredients		
Benzene	0.09[3]	73[4]
Carbon Tetrachloride (CT)	0.32[3]	>>1000[4]
Chlorobenzene (CB)	0.20[3]	73[4]
Tetrachloroethylene (PCE)	0.23[3]	256[4]
Trichloroethylene (TCE)	0.14[3]	256[4]
1,2 Dichlorobenzene (1,2 DCB)	0.87[3]	146[4]
Toluene	0.23[3]	36[4]
Xylene	0.53[3]	36[4]
1,1,1 Trichloroethane (TCA)	0.20[3]	256[4]

--- Data could not be located.
1 Data from Jury et al. (9).
2 K_{ow} and approximate half life from enrichment cultures taken from Cohen et al. (6).
3 K_{oc} calculated from octanol-water partition coefficient (K_{ow}, taken from various summaries including Jury et al. (9) and Mackay and Vogel (13) using the method of Schwarzenbach and Westall (15).
4 Data from various sources summarized by Mackay and Vogel (13).

Conclusions

Overall, the results of monitoring of supply wells suggest that ground water pollution is relatively widespread in California. Although observed concentrations are often low (i.e. measured in parts per billion), they have exceeded levels of presumed health significance (i.e. action levels) in at least several hundred wells. Furthermore, as described by Mackay et al. (12), a detailed examination of these monitoring programs suggests that it is inappropriate to conclude that they have necessarily detected all of the pollutants that currently impact supply wells in California.

In this paper, an example of a class of potential but as-yet uninvestigated groundwater pollutants was addressed: inert ingredients of pesticide formulations. As early as 1984, the SWRCB emphasized the necessity to consider pesticide inert ingredients in ground water monitoring programs, as well as pesticide breakdown products and compounds appearing as contaminants in pesticide formulations (6). Since then, however, this issue seems to remain largely unexplored.

Many of the inert ingredients are identical to the industrial solvents which electronics and manufacturing industries have inadvertently released to the subsurface. These industries and our regulatory agencies are spending millions of dollars and vast amounts of time attempting to define and remediate the resulting subsurface contamination, which often results from the release of only a few tens of gallons of chemical. Yet little attention is paid to the possibility that the same chemicals are intentionally released to the environment by agricultural activities, perhaps in quantities that would be deemed relatively large in another context.

It would seem prudent for some attention to be directed to this matter, perhaps initially through a study by the California Department of Food and Agriculture to identify types and approximate amounts of chemicals used as inert ingredients in pesticides in California. If such a study were conducted, data would be available to assess whether a potential problem exists and an efficient exploratory monitoring program could be designed to elucidate the significance, if any, of the impacts on groundwater. In the absence of such a study, however, exploratory monitoring would still seem warranted.

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EPA'S NATIONAL PESTICIDE SURVEY: AN OVERVIEW

G.F. Kotas[1]

The Environmental Protection Agency (EPA) is conducting the National Pesticide Survey, a nationwide survey of pesticides in drinking water wells. This project summary explains the reasons for conducting the survey, the goals of the survey and how the survey will be designed and implemented.

Why is a Survey Needed?

Pesticides present in drinking water may pose dangers to human health. Since 1975, urban water systems have been required to monitor for six pesticides: endrin, lindane, methoxychlor, toxaphene, 2,4-D and 2-4,5-T. Recent evidence, however, indicates a larger problem of pesticides in ground water. At least 17 pesticides used in agricultural practices have been found in ground water in 23 states (1, 2). More recent estimates, currently being verified by EPA, show over 60 pesticides have been found in over 30 states. Studies of pesticides in ground water have been undertaken in recent years by the states of California, Florida, Maryland, Minnesota, New York, Washington and Wisconsin, among others. However, most of these studies have been limited to a small number of pesticides and specific geographic areas; no comprehensive nationwide study has yet been conducted.

The National Pesticide Survey (NPS) is a major component of EPA's overall effort to understand and characterize the problem of agricultural chemicals in ground water. With adequate survey information on the concentrations of different pesticides in wells around the country and the number of wells likely to be affected, EPA will be able to better design its regulatory programs to target pesticides of concern and to develop further regulatory initiatives. The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) gives the agency authority to regulate the marketing and use of pesticides. Pesticides that are shown to pose potential hazards by their ability to leach into ground water could be subject to further registrant monitoring requirements and a range of regulatory actions, including changes in label directions, use restrictions, or suspension or cancellation of a pesticide's registration. EPA will also use information from the survey to implement requirements of the Safe Drinking Water Act (SDWA). New maximum contaminant levels and monitoring requirements may be proposed for pesticides shown to pose a hazard in public drinking water.

Goals of the Survey

EPA has designed the National Pesticide Survey to meet two major objectives: (1) to determine the degree to which the drinking water wells of the nation are contaminated by pesticides; and (2) to better understand how pesticide concentrations in drinking water wells are associated with patterns of pesticide usage and the vulnerability of ground water to pollution.

The focus of the survey is on the quality of drinking water in wells rather than on the quality of ground water, surface water or drinking water at the tap. The survey is not designed to estimate the risk to human health

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[1]U.S. Environmental Protection Agency, Washington, D.C.

resulting from pesticides in drinking water. A different type of survey and research design would be needed to estimate human exposure to, and the risk posed by, pesticide-contaminated drinking water. However, the study will provide substantial data to develop inferences about populations potentially at risk from exposure to pesticides in drinking water wells, and it will yield valuable information on the pesticides present in private domestic and community drinking water wells.

Finally, the National Pesticide Survey is designed primarily to provide nationwide estimates of pesticide contamination. It is not intended to provide a statistically valid assessment of pesticide contamination of wells at the local, county or state level. Only when the sampling across the country is considered as a whole will the results be statistically meaningful.

Preparing for the Survey

In preparation for the survey, EPA has developed (1) a statistical design to select a set of wells that is representative of drinking water wells in the nation; (2) analytic methods to determine which pesticides may be present in water samples and at what levels; and (3) health advisories that establish the levels at which pesticide concentrations may pose a health problem.

Statistical Design. The National Pesticide Survey has been designed to yield results that are statistically representative of over 13 million domestic wells and the wells at some 51,000 community water systems. EPA expects to sample approximately 1500 drinking water wells in the course of the survey. Sampling will run from early 1988 through 1990.

To test public drinking water wells for pesticide contamination, EPA will select about 750 wells from community water systems listed on the Federal Reporting Data System. Wells in counties that are more vulnerable to ground-water pollution will be over represented in the sample in order to yield better, more precise estimates.

The statistical design of the domestic wells side of the survey is more complex, primarily because there is no comprehensive tabulation of private (rural domestic) drinking water wells in the United States. The process of identifying and selecting representative domestic wells for sampling is organized into three stages, as follows:

Stage 1: EPA classified all U.S. counties using specified measures of ground-water vulnerability (obtained from the DRASTIC model) and pesticide usage. From this classification scheme, EPA selected 90 counties, with some oversampling of counties that have high pesticide use and high vulnerability to ground-water pollution to ensure their adequate representation in the sample.

Stage 2: From each of the 90 counties, EPA selects a sample of sub-county areas, using more detailed information on cropping patterns and ground-water vulnerability. Within these subcounty areas, EPA identifies and statistically selects a sample of "household clusters." Each cluster consists of about 25 households that use private wells.

<u>Stage 3</u>: In the final step of the selection process, EPA screens the households in each cluster to develop a list of private wells. Using this list, a sample of about 750 domestic wells is selected for pesticide sampling.

<u>NPS Analytic Methods</u>. Each sample taken in the survey will be tested with eight different laboratory procedures, six of which were developed specifically for the NPS. Five of the procedures are "multi-residue" methods, capable of detecting 10 or more pesticides. These methods are expected to provide a more efficient way for EPA, states and other government and industry laboratories to analyze water samples in the future for the presence of numerous pesticides.

Five laboratories have also been chosen to analyze the water samples. Each lab has been assigned one or more of the eight analytic methods being used in the NPS.

The five labs are:

James M. Montgomery, Consulting Engineers Inc. of Pasadena, California (Methods 1, 3 and 8).

Alliance Technology Inc. of Bedford, Massachusetts (Method 2);

Radian, Inc. of Austin, Texas (Method 4);

Environmental Science and Engineering, Inc. of Gainesville, Florida (Methods 5 and 7); and

Battelle Columbus Division of Columbus, OH (Method 6).

Quality assurance will be the responsibility of two EPA laboratories--the Office of Drinking Water (ODW) lab in Cincinnati, Ohio, and the Office of Pesticide Programs (OPP) laboratory in Bay St. Louis, Mississippi. Both will act as "referee labs," with the OPP lab being responsible for analytic methods 1, 3 and 6, and ODW's lab overseeing the other methods.

<u>Health Advisories</u>. EPA has developed Health Advisories for 62 priority pesticides, using information collected on physiochemical properties, uses, chemical fate, health effects, treatment and existing criteria and guidelines. EPA has also developed one-page non-technical health advisories to explain the health effects of exposure to pesticides. These one-page health advisories will be distributed to the owners and operators of sampled wells where contamination is found.

Health advisories are available for review and comment for 50 NPS priority pesticides. Comments should be submitted to Jennifer Orme, Office of Drinking Water (WH-550D), U.S. EPA, 401 M St., S.W., Washington, D.C. 20460.

Individual copies of the health advisories may be obtained by calling the hotline (see below for number). Complete sets are available through the National Technical Information Service, 1-800-336-4700. Ordering information for the 50 health advisories, as well as for health advisories issued earlier this year, is shown below.

Health Advisories	Document No.	Cost
HAs for 50 NPS pesticides	PB88-113543/AS	$62.95
HAs for 16 pesticides (incl. 12 NPS pesticies)	PB87-200176/AS	$24.95
HAs for 25 organics	PB87-235578/AS	$30.95
HAs for 7 inorganics and legionella	PB87-235586/AS	$18.95

Pilot Study. Prior to implementing the full national survey, EPA conducted a pilot study in three states (California, Minnesota and Mississippi) to field test and refine the major components of the survey. Forty-eight (48) wells were sampled in the pilot study between March and August 1987. The sampling was equally divided between domestic rural wells and community water system wells. An evaluation of the pilot study is available on request from EPA.

How the Survey Will be Conducted

At each selected well, water samples will be taken and information collected on the use and construction of the well, as well as on physical characteristics and land use that could affect contamination in the vicinity of the well.

Water Sampling. Water sampling at the wells will be conducted in accordance with protocols established in the NPS Sampling Manual and the NPS Quality Assurance Plan (both available from EPA). Stringent quality control procedures will be followed to ensure that the sampling is conducted carefully and that the laboratory analyses produce high-quality results.

Each sample taken in the National Pesticide Survey will be analyzed for over 70 pesticides. EPA selected the pesticides to be analyzed on the basis of expected leaching potential, occurrence, production volume and other considerations. Five contract laboratories will analyze the survey samples. EPA's laboratories will provide oversight and will analyze samples as part of the laboratory quality control program.

Questionnaires. Questionnaires have been designed to gather information from both community water system operators and domestic well owners and to collect data on characteristics of the area surrounding the well. The major categories of information to be collected are: the location of wells, well use and construction characteristics, pesticide use in relation to the well, hydrogeologic characteristics and potential sources and routes of pesticide contamination.

Implementation. EPA's Office of Pesticide Programs and the Office of Drinking Water are jointly sponsoring the survey. Successful completion of the project depends on the continued support and cooperation of EPA's Regional Offices, laboratories and the participation and cooperation of many other organizations. In particular, the cooperation of state water supply agencies and departments of agriculture will be an essential factor in implementing the survey.

Sampling and data collection at domestic wells will be conducted by EPA's implementation contractor. EPA is requesting the state agencies with primary responsibility for water supply to conduct the water sampling and other data collection at community wells and to notify both domestic well owners and community water system owners/operators of the results of the well sampling. These agencies and the state agencies with FIFRA enforcement responsibilities are also being asked to serve as points of contact for communications with interested parties and to provide follow-up and expert advice on technical and health-related issues. Both state agencies will receive the well sampling results from the survey, as well as relevant technical and health-related information pertaining to the results.

EPA will continue the extensive communications efforts begun during the pilot study. These efforts include biweekly conference calls with state and regional contacts during the sampling period, convening of a state/EPA NPS workgroup and distribution of monthly project updates.

To be included on the NPS mailing list, or for further information on the National Pesticide Survey, contact EPA's toll-free Safe Drinking Water Hotline, Monday thru Friday, 8:30 a.m. to 4:30 p.m., E.S.T., at 1-800-426-4791. (In Washington D.C., call 382-5533). Written inquires may be directed to:

Gerald F. Kotas, Director
National Pesticide Survey
U.S. Environmental Protection Agency
401 M Street S.W. (WH-550)
Washington, D.C. 20460

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A 2,4-D TOXICOLOGICAL UPDATE

Wendell R. Mullison[1]

There have been a number of recent developments regarding the toxicity of 2,4-D that will be reviewed here. These will be divided into the following four categories which are: recent 2,4-D toxicological research, human exposure to 2,4-D, comments on the Kansas Farm Worker Study and comments on the Greenhill, Texas 2,4-D case.

RECENT 2,4-D TOXICOLOGICAL RESEARCH

The results of the toxicological research studies conducted for the Industry Task Force on 2,4-D Research Data have been published (6) and most of the following information has been taken from that paper.

[1]Dow Chemical Company, Midland, Michigan

Acute Dermal Toxicity. The acute dermal LD_{50} using rabbits was more than 2,000 mg/kg for 2,4-D acid, its sodium salt, dimethylamine salt, isobutyl ester, butyl ester, butoxyethanol ester and isooctyl ester. According to EPA guidelines, when compounds have such low dermal toxicity as 2,000 mg/kg or more, further investigations of dermal toxicity are unnecessary. The low dermal toxicity of 2,4-D is very important as this is the most usual route of human exposure during application.

Acute Oral Toxicity. These results show that 2,4-D acid and its derivatives have moderate to low acute oral toxicity. The acute oral LD_{50} values using rats for various derivatives of 2,4-D are given in Table I.

Table I

Acute Oral LD_{50}'s for Several 2,4-D Compounds with Fischer 344 Rats

Compound	LD_{50} (mg/kg)*
2,4-Dichlorophenoxyacetic acid (technical)	699
Sodium Salt of 2,4-Dichlorophenoxyacetic acid	997
Butyl ester of 2,4-Dichlorophenoxyacetic acid	695
Dimethylamine salt of 2,4-Dichlorophenoxyacetic acid	949
Isooctyl ester of 2,4-dichlorophenoxyacetic acid	896
Isobutyl ester of 2,4-dichlorophenoxyacetic acid	618
Butoxyethanol ester of 2,4-dichlorophenoxyacetic acid	850

*Milligrams of test substances per kilogram of body weight of the test animal.

Acute Inhalation. The acute inhalation LC_{50} for rats (Sprague-Dawley) after a four-hour exposure was determined to be greater than 1.79 mg 2,4-D acid per liter of air. This amount was the maximum obtainable concentration of 2,4-D in air. Since no deaths occurred at this dosage and a higher concentration cannot be obtained, an LC_{50} cannot be calculated. Nonetheless, the results show that 2,4-D has a low inhalation toxicity.

Dermal Sensitization. In preparation for the sensitization test, 0.5 ml of a 0.5% solution of 2,4-D acid in acetone was applied once a week to a clipped area on the back of guinea pigs for three weeks. Two weeks following administration of these dosages, a challenge dose of 0.5 ml of the same solution was applied the same way. Observations were taken 24 and 48 hours after the test application to assess the effects of this treatment. No redness, swelling or other dermal effects were noted. On the basis of these results, 2,4-D acid would be classified as being a non-sensitizer in guinea pigs. When the results of this test are negative, EPA requires no further tests of this type.

Sub-chronic Toxicity. A 90-day feeding study was conducted with rats (Fischer 344 strain) using technical 2,4-D acid at dose level of 0 (controls), 15, 60, 100 and 150 mg/kg of body weight/day. Various parameters, such as food intake, body weight changes, blood studies and urine analysis, were measured during the in-life phase of the study. At the conclusion of the experiment, both gross and microscopic examinations were made of all tissue and body organs of the animals. At the highest dosage of 150 mg/kg/day, the toxic symptoms were: decreased intake of food, lower body weight gains than untreated animals and evidence of slight effects on the liver and kidney. These effects were reduced at lower dose levels; however, it was concluded that dose levels of 60 mg/kg/day and above exceeded the Maximum Tolerated Dose (MTD) for rats. At the lowest dosage of 15 mg/kg/day, no adverse effects were noted in female rats, but in male rats this dose level produced a slight increase in relative kidney weight with no microscopic changes.

Since most dose levels exceeded the MTD and the lowest dose still produced a slight effect, another 90-day rat feeding study was conducted using lower dose levels. The diets contained levels of 2,4-D acid which amounted to dietary intakes of 0, 1, 5, 15 and 45 mg/kg of body weight/day and the same parameters were evaluated as in the previous study. The results showed slight compound-related increases in the weights of the kidney and thyroid accompanied by slight visual differences on microscopic examination of the kidney at the 5 mg/kg/day and higher doses. Possible compound-related decreases in enzyme levels in the blood serum were also observed. No compound-related effects were observed with regard to survival, clinical signs, body weights, growth rates, food consumption and eye effects. These results confirmed the effects found in the first study.

Highly purified 2,4-D acid (reported as 100%) was also evaluated at 0, 15, 60, 100 and 150 mg/kg/day in a 90-day feeding study in rats (Fischer 344 strain). The responses were essentially the same as those found when using the technical grade of 2,4-D acid (97.3%). These results showed there was little if any difference in toxicity between the technical grade and the highly purified 2,4-D acid. This is an important point as it shows no more observable toxic effects were observed from the impurities in the technical 2,4-D acid beyond those noted when using the highly purified 2,4-D acid. Thus, the impurities present in the technical 2,4-D acid were not causing any observable toxic effects.

A 90-day feeding study was also conducted in mice ($B_6C_3F_1$ strain) using technical 2,4-D acid. The dose levels were: 0, 5, 15, 45 and 90 mg/kg/day. The same parameters were evaluated as in the above subchronic rat studies. Microscopic examination revealed slight compound-induced changes in the kidneys. These were most frequent at the highest dosage and decreased as the dosage was lowered, with minimal effects at the lower concentrations. Increases in organ weights were observed in the pituitary, adrenals and kidneys (females only). No compound-related effects were observed in terms of survival, clinical signs, body weights, growth rates, food consumption, eye effects or gross and microscopic pathology.

Teratology. Technical 2,4-D was administered by gavage (stomach tube) daily for 10 days in pregnant rats during the period of most rapid organogenesis (development of organs and main body structures). The dosage levels were 0, 8, 25 and 75 mg/kg/day. Some slight maternal toxicity was shown by inhibition of body weight gain at the 75 mg/kg/day level but no other maternal and no embryo-toxic effects were observed. The conclusion was 2,4-D is not teratogenic in rats even at dosages that caused toxic symptoms in the dams.

Metabolism. The metabolic behavior of 2,4-D acid was studied in rats after oral administration of the sodium salt of ring-labeled ^{14}C-2,4-D. It was found that 90% of the 2,4-D was excreted in the urine within 12 hours and 95% within 24 hours after administration of a single oral dose. These results suggest that 2,4-D would not accumulate in rats even after repeated oral ingestion.

The isooctyl ester of 2,4-D was administered to rats to see if the metabolic pathway would be the same as for the acid. The results showed that the isooctyl ester of 2,4-D is quickly converted to 2,4-D acid which is then rapidly excreted in the urine. These results demonstrated that the isooctyl ester of 2,4-D was metabolically equivalent to 2,4-D acid which would also be true for other esters of 2,4-D.

Similarly, the metabolic behavior of 2,4-D was studied after dermal application to rats of ring-labeled ^{14}C-2,4-D as the propylene glycol butyl ether ester. The results showed that the ester was absorbed slowly through the skin and was converted rapidly to the acid in the body. The 2,4-D was excreted in the urine as the acid, with a half-life of 20 hours. Thus, the rate of absorption of 2,4-D ester through the skin was slower than its rate of hydrolysis to 2,4-D acid and its subsequent excretion in the urine. These results suggest that 2,4-D would not accumulate in rats even after repeated dermal exposure to esters.

The metabolic pathway of 2,4-D in the mouse was similar to that in the rat. The 2,4-D was excreted mainly by the kidney in the urine, but at high dosage levels, some elimination of 2,4-D also occurred in the feces.

Neuropathology. There have been a few human case reports that have linked circumstantially the farm and garden use of 2,4-D to polyneuropathy syndrome. Such effects in the peripheral nervous system are usually manifested by a tingling or numbness of the fingers and toes. Therefore, some animal experiments were designed to study this question. In a study in rats, 12% solution of a 2,4-D amine in water was applied dermally to rats for three weeks. Measurements were made of responses of the nerves in the rat's tail and hind legs. Observations were also made of the rat's behavior in a rod rolling test which is similar to a lumberjack's log rolling contest. All measurements were found to be within the normal range. Microscopic examination of the brain, spinal cord and peripheral nervous tissue showed no adverse effects. These data showed that 2,4-D did not cause neuropathic adverse effects in rats.

Multigeneration Reproduction. A multigeneration reproduction study with rats was conducted at dose levels of 0, 5, 20 and 80 mg/kg/day. Parameters evaluated included effects on mating, gestation, lactation, body weights of parental animals and offspring, as well as gross and microscopic pathological examination of body tissues and organs. During gestation and lactation periods in the F_0 generation (original parents), the dams in the 80 mg/kg of body weight/day group actually received a dosage of about 120 mg/kg/day. Adverse effects on the F_0 generation and the F_{1b} pups were excessive, prompting termination of the animals on the 120 mg/kg of body weight/day dosage level. The complete reproduction study, therefore, was conducted only at the 0, 5 and 20 mg/kg/day dosage levels. A slight decrease in pup weights was seen throughout lactation at the 20 mg/kg dose level. No reduction in reproduction indices was observed at either level. The NOEL* was 5 mg/kg/day in this rat reproduction study.

Chronic Feeding Studies. A chronic two-year feeding study in rats (Fischer 344 strain) has been completed. This covered most of the lifetime of these rats. The dose levels were 0, 1, 5, 15 and 45 mg/kg/day. The NOEL was considered to be 1 mg/kg/day, because minor effects were detected on microscopic examination of kidneys of rats in 5 mg/kg/day group and at higher dosage levels. These effects were not surprising since the kidney is the major route of elimination for 2,4-D. A slight, but statistically significant, increase in astrocytomas (brain tumors) was observed in the male rats in the highest dosage group (45 mg/kg/day). Astrocytomas are the most common type of brain tumors found in rats and occur spontaneously. Similar results have been obtained in studies with other chemicals, suggesting that this apparent increased incidence in the high dose males may have been simply due to biological variability among the animals used in this study. Therefore, further clarification was necessary to determine if the tumors in this study were caused by 2,4-D or were due to random variability in the groups of the test animals.

A recognized expert in this field, Dr. Adalbert Koestner, Professor and Chairman of the Department of Pathology, Colleges of Human Medicine, Veterinary Medicine and Osteopathic Medicine at Michigan State University, East Lansing, Michigan, conducted a thorough biological evaluation and analysis of the study results. To demonstrate a cause and effect for astrocytomas, the data must satisfy about 11 known criteria to be classified as a neurocarcinogenic agent. In this case 2,4-D did not meet any of these criteria. After careful examination of the rat brain tissue slides and data, Dr. Koestner's conclusion was that 2,4-D was not the cause of these astrocytomas, and therefore, it is not a neurocarcinogenic agent. Dr. Koestner's report, as well as the complete report of this rat study, is currently under review by the U.S. Environmental Protection Agency and Canada's Ministry of Health and Welfare.

A chronic two-year feeding study with 2,4-D on mice, popularly called a lifetime feeding study, showed no increase in tumors in any tissue or any organ. The dosages were 0, 1, 15 and 45 mg/kg/day. Microscopic examination showed no treatment-related structural changes in the brain and spinal cord and no astrocytomas were found. This experiment showed 2,4-D was not carcinogenic in mice.

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*A NOEL is based on laboratory experimental data which is the highest dosage in the most sensitive species that has had no observed effects on the experimental animals in a long-term feeding study, usually two years in rats and mice.

COMMENTS ON THE KANSAS FARM WORKER STUDY

The following information has been taken from a review by Mullison (7) of the Kansas Farm Worker Study (KFWS) (5) conducted by the National Cancer Institute. A more detailed discussion of this KFWS is given by Bond et al. (4). The KFWS was based on telephone interviews, which apparently did not give an accurate picture regarding the use of herbicides in Kansas. For instance, according to their study, approximately 75% of the Kansas farmers reported they had never used any herbicide.

There are several criticisms of this study. First, the accuracy of exposure data based on memory is open to question, particularly when it goes back many years. The accuracy of such exposure data is made even more doubtful when obtained from next of kin as occurred in approximately 50% of the cases in this study. Furthermore, with the small number of people in the various subgroups, errors in memory recall in only a few individuals could change statistically significant findings to non-statistically significant numbers. Second, the key specific question regarding the frequency of using 2,4-D was never asked. Thus, the numbers reported apply only to herbicides in general, not to 2,4-D in particular nor to any other specific type of herbicide. Third, the conclusion that non-Hodgkin's lymphoma (NHL) was associated with the use of 2,4-D is not consistent with several other epidemiological studies (4). Therefore, it does not seem appropriate to conclude from this study that there is an increased risk of getting NHL from exposure to 2,4-D.

Human Exposure to 2,4-D

The following comments on human exposure to 2,4-D have been taken from the paper by Mullison, Sweet and Davis (8) which gives a more detailed review of this subject and citations to references which have not been included in this review.

Forestry Exposure. An excellent study by Frank et al., measured exposure in forestry workers engaged in helicopter application of 2,4-D at the rate of 1.4 lb/A. This is of particular interest because the application of herbicides in forests has been a major concern to some public groups and has generated some of the greatest attention from the media.

There are two extremely noteworthy and interesting points in Frank's report. First the highest daily excretion of 2,4-D in the urine from any worker was 0.022 mg/kg of body weight per day. Since 2,4-D is excreted so rapidly in the urine, this would be approximately the highest daily dosage. One very conservative method of judging the risk from 2,4-D exposure to humans is to compare the resulting dosage with the acceptable daily intake* (ADI) in our diet. Expert panels appointed by the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) of the United Nations in 1971 established an ADI for 2,4-D at 0.3 mg/kg of body weight (1). Thus, comparing 0.022 mg/kg/day from the highest worker exposure to the ADI of 0.3 mg/kg/day, it is clear that a large additional amount of 2,4-D (approximately 14 times) would have to be absorbed by the worker before even reaching the

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*An acceptable daily intake (ADI) is the amount of a material that could be eaten every day of one's life without harmful effects and includes a 100-fold safety factor above the no-observed-effect-level (NOEL) in a two-year rat feeding study.

level scientists have concluded is an acceptable daily intake that could be ingested every day of your life without causing any adverse effects, and this includes 100-fold safety factors above the NOEL in a two-year chronic feeding study (popularly called a lifetime feeding study).

Second, a human volunteer stood directly under the spray swath for one exposure which was applied at a rate of 1.4 lb of 2,4-D per acre and from a height of 36.6 feet. This is approximately twice the rate that would be applied to a lawn. Subsequently, the spray was allowed to dry, and the volunteer did not shower or change clothing, a worst-case situation. The amount absorbed was 0.44% of the total amount of 2,4-D deposited on the skin and clothing (shorts, T-shirt and sneakers). The highest amount of 2,4-D excreted was 0.0045 mg/kg of body weight. Thus even in this exaggerated exposure case, there was a large safety factor of approximately 70 times, before the 1971 acceptable daily intake of 2,4-D was reached. Another method of estimating the risk would be to use the latest (1986) no-observed-effect-level (NOEL) of 1 mg/kg/day for 2,4-D. This method of estimating risk results in a safety factor more than 200 times below the dose to which rats have been exposed in a chronic two-year rat feeding study (often called a lifetime) without showing any adverse health effects.

Studies on metabolism and excretion of 2,4-D in humans have been reported by Kohli, et al. and Sauerhoff, et al. Single oral dosages of 5 mg/kg of 2,4-D by human volunteers did not cause any observed ill effects. 2,4-D is rapidly excreted unchanged from the body of mammals, primarily in the urine, and does not accumulate in the body. Nash, et al, have stated that a 50- or 60-year-old 176-pound farm or forestry worker with 30 years exposure to 2,4-D for 30 days each year could have absorbed and excreted as much as 0.9 g of 2,4-D in their lifetime. The Nash et al. paper also reported that the lieftime worker excretion of 2,4-D is about double the single ingested experimental dosage reported by Kohli and Sauerhoff that had no harmful effects. While it was not an experiment, Dr. E. J. Kraus, Head of the Botany Department at the University of Chicago, made the interesting observation in 1945 at a scientific weed control meeting that he had ingested 500 mg of 2,4-D a day for 21 days with no apparent ill effects. From the data reported in the Canadian Expert Panel paper, it can be calculated that an airplane mixer loader working 60 days per year for 20 years would have a total 2,4-D lifetime intake of 180 mg. With the exception of the supervisor classification, this was the lowest exposure reported. Performing the same type calculation, this paper cited the highest total lifetime intake of 2,4-D was 5890 mg for mist blower operators. Using a NOEL of 1 mg/kg/day, an 80 kg worker (176 lb) working 60 days a year for 20 years could absorb a total lifetime amount of 96,000 mg 2,4-D before reaching the no-observed-effect-level in rats by ingestion. In any case, these calculated figures would not be reached in these types of workers because 2,4-D is excreted so rapidly from the body.

Lawn Care Exposure

One area of 2,4-D use that has been attracting public attention is the application of 2,4-D to control weeds in turf, particularly home lawns. There have been some data collected from experiments designed to measure the actual human exposure to 2,4-D from an application to a lawn. A commercial lawn care company conducted a study on 45 of its employees to determine the amount of 2,4-D absorbed after applying this herbicide for three weeks. The 45 workers were stationed at five different locations. The daily amount of

2,4-D that entered their bodies as estimated from urinary excretion measurements varied from 0.0035 mg/kg to 0.0025 mg/kg of body weight. After comparing these values with the ADI figure of 0.3 mg/kg of body weights, it was concluded that workers engaged in lawn care spraying had very adequate safety margins. By inspection it can be seen that this safety factor would be approximately 100 before the ADI would be reached. On the other hand, using the recent NOEL of 1 mg/kg/day for 2,4-D the safety factor would be 286. Thus there is a good margin of safety for lawn care operators when applying 2,4-D regardless of which method of calculating risk is used.

A question sometimes asked about the use of 2,4-D on lawns is what is the extent of human exposure for freshly sprayed lawns. A very good paper on this subject of dislodgeable residues from turf grass sprayed with 2,4-D was written by Thompson, et al. A lawn was treated with 2,4-D applied at the rate of 0.892 lb/A. In this field study less than 0.4 mg of 2,4-D per square foot could be dislodged on the day of application after the spray had dried.

Based on their results, a commonly used application of 0.75 lb/A would give a dislodgeable residue of 0.35 mg of 2,4-D/sq ft on the day of application. From human absorption data, it is known that about 6% of the amount of 2,4-D directly applied to the skin is absorbed. Taking these data and assuming a small naked child, weighing 10 kg (22 lb), rolled back and forth on 10 sq ft of treated grass the day of the spray application after the grass had dried and dislodged all the 2,4-D available, the child could absorb a total amount of 0.02 mg/kg of 2,4-D. Using this unlikely scenario and the most recent NOEL level of 1 mg/kg/day would mean there is a safety factor of 50 for this 10 kg child before the exposure would reach the dosage given to animals for a lifetime without causing any adverse effects. Another method of comparison would be that the baby would receive 7% of the ADI value. Actually these safety factors are much greater because both the NOEL (1 mg/kg/day) and the ADI are based on lifetime exposures, and this example is based on a single day's exposure. This example also assumes a complete dislodgement and absorption of the 2,4-D which are most unrealistic assumptions in this worst case analysis. Babies usually are clothed when put out on lawns and are put on blankets. In any case they do not, by their movement, dislodge all the potentially dislodgeable 2,4-D or absorb all that is dislodged.

COMMENTS ON THE 2,4-D GREENHILL, TX CASE

A jury verdict on a legal case involving 2,4-D was handed down in Marshall, Texas, in December 1987. This case is now under appeal. Of course, the legal outcome of any trial regardless of the merits of the case is always uncertain until the case is closed. However, a brief review of the scientific facts about 2,4-D particularly in regard to whether it is or is not a human carcinogen should be noted.

Recently, three prestigious independent groups of scientific experts have surveyed the toxicological literature on 2,4-D. One of these groups, the Canadian Expert Panel on Carcinogenicity of 2,4-D, found after reviewing all of the relevant science that existing uses of 2,4-D in their province are unlikely to pose a significant human health risk. This report was reviewed by Dr. John Doull, immediate past president of the Society of Toxicology and delivered to the Ontario Pesticide Advisory Committee of the Ontario Ministry of the Environment. The panel specifically noted that its review did not find 2,4-D to be a human carcinogen and further noted that even from a theoretical standpoint any risk posed by the product would be less than that associated with a number of activities which the public generally regards as safe.

The second group, the U.S. Council for Agricultural Science and Technology also reviewed the scientific literature on 2,4-D and reached similar conclusions. The report further noted that even herbicide applicators working with the product on a routine basis would not achieve exposures equal to a level set by the World Health Organization as acceptable for daily dietary intake.

The third group was the Science Advisory Panel of the Environmental Protection Agency which reviewed the scientific literature on 2,4-D in June 1987, and did not find the product to be a human carcinogen.

Thus, three independent groups of recognized scientific experts after reviewing the literature have not found 2,4-D to be a human carcinogen.

It is shown by his own handwritten work record that Mr. Greenhill's primary job with the U.S. Forest Service at Oregon was not application of herbicides but fire fighting. According to these records, Mr. Greenhill worked seasonally as a fire fighter. His exposure to 2,4-D was from minimal "hack and squirt" applications. The actual time he spent in this operation could not have amounted to more than six weeks throughout his entire two-year period of employment with the Forest Service at Oregon from 1975 - 1977.

None of the physicians who examined or treated Mr. Greenhill during the course of his illness claimed that his condition was the result of herbicide exposure.

The sole medical witness for the plaintiff was Dr. Daniel Teitelbaum who stated that while he thought 2,4-D was the probable cause of Mr. Greenhill's cancer, myriad other exposures could potentially have caused or contributed to his condition.

In discussing the cancer question, Dr. Teitelbaum readily admitted that all the studies he examined for this case had already been considered by the Environmental Protection Agency, which has not concluded that 2,4-D is a human carcinogen. Thus the opinions of Dr. Teitelbaum, who by his own admission, is neither a pathologist, epidemiologist or oncologist, are his personal conclusions on existing literature which have been reviewed by many scientific experts who do not agree with his conclusions on this subject.

Dr. Teitelbaum stated at the trial that in establishing his diagnosis he had never examined, treated or spoken with Mr. Greenhill himself, nor had he spoken to the examining or treating physicians or even with members of Mr. Greenhill's family. He also stated that he had never examined the records kept of the herbicides Mr. Greenhill used and that he had no idea how much exposure to 2,4-D Mr. Greenhill had experienced.

After the trial, it was determined that Dr. Teitelbaum had based his conclusions about the cause of Mr. Greenhill's illness at least in part on his review of wrong medical records. That is, some of the medical documents he reviewed as Mr. Greenhill's were another man's records who had retained Dr. Teitelbaum to testify in a suit over benzene exposure that had nothing to do with Mr. Greenhill's case.

Mr. Greenhill died of Hodgkin's disease. This is a form of cancer specifically stated by the NCI or the Kansas Farm Worker study as <u>not</u> being linked to 2,4-D. In fact, the plaintiff's medical witness, Dr. Teitelbaum, testified that 95 percent of all cases of Hodgkin's disease is of unknown origin. Present evidence about the cause of Hodgkin's disease suggests a viral origin for the disease, with exposure to the virus stemming from infection in childhood or early adolescence.

In this trial it was alleged that a highly toxic compound is present as an impurity in the manufacture of 2,4-D. In the original development back in 1977 of the present Dow production process making 2,4-D, some complex organic impurities present in small quantities belonging to the family of chlorinated xanthones caused some manufacturing problems when the 2,4-D was formulated. This problem was solved by making process changes which lowered the amounts of the chlorinated xanthones present to trace quantities which then no longer caused production problems. Four points should be noted regarding this manufacturing process:

1. This was a process production problem not a toxicological problem.

2. Mr. Greenhill was never exposed to any product from that process.

3. Even Mr. Greenhill's medical expert knew of no scientific paper that stated chlorinated xanthones caused human carcinogenicity.

4. Chlorinated xanthones have such low animal toxicity that they are allowed to be used in dental bonding material.

Thus to conclude my comments upon the Greenhill, Texas 2,4-D Case, I am very sorry that Mr. Greenhill had cancer, and it is understandable that a jury might be sympathetic. However, in my opinion, the scientific evidence available does not show that his disease was caused by exposure to 2,4-D.

CONCLUSIONS

The toxicological studies commissioned by the 2,4-D Industrial Task Force support the conclusions of the earlier studies done on 2,4-D. Results from neuropathological experiments showed that 2,4-D did not cause adverse neuropathic effects and available evidence suggests 2,4-D does not adversely affect the immune system.

There are human exposure data for the farmer, forester, aerial and ground applicator, commercial lawn applicator and the bystander that shows they are not exposed to hazardous amounts of 2,4-D when label recommendations and prescribed methods of applications are used.

The Kansas Farm Worker Study is not in accord with the majority of 2,4-D epidemiological studies on Non Hodgkins Lymphoma and the adverse conclusions that some have drawn from it regarding 2,4-D are inappropriate since the key specific question regarding the frequency of 2,4-D use was never asked. Therefore, the preponderance of scientific evidence from toxicological and epidemiological studies shows that 2,4-D does not cause cancer.

Considering the short life of 2,4-D in the environment; its rapid excretion unmetabolized in mammals including humans; its moderate toxicity; and except for occasional traces its virtual absence from the food we eat, the water we drink, the air we breathe and the land we walk on; it seems reasonable to conclude that people are not exposed to hazardous amounts of 2,4-D resulting from its approved uses. In fact, the World Health organization (3) in their Environmental Health Criteria 29 review on 2,4-D stated "as far as the general population is concerned, 2,4-D intake from any source is negligible."

The jury decision in the 2,4-D Texas Greenhill trial has been appealed. While the scientific evidence in the Greenhill case seems quite clear, the outcome of any trial regardless of the merits of the case is always in doubt until the case is closed.

The herbicide 2,4-D has been in commerce and a subject for research since 1944. In our modern society 2,4-D has played an indispensable role in the production of food and fiber, in maintenance of our utility supply lines, highway and railroad systems, as well as being a useful tool in creating desirable wildlife habitats.

After considering the tremendous amount of research published on 2,4-D as well as its safety record after more than 40 years of use in the real world, it seems reasonable to conclude that 2,4-D can be used according to label directions without causing a health hazard to humans, domestic animals or wildlife and without causing unreasonable adverse effects to our environment. These facts should be very comforting to the public and allay concern regarding the use of 2,4-D.

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WEEDS AND POISONOUS PLANTS OF WYOMING AND UTAH

T.D. Whitson[1], Roy Rechenbach, M.A. Ferell[1], S.D. Miller[1], S.A. Dewey[2], J.O. Evans[2] and R.J. Shaw[2]

Abstract. Herbicide specificity has made proper weed identification much more important. A 284-page book has been produced in color as a cooperative effort between Wyoming and Utah weed scientists. The book includes 400 colored pictures of immature plants, flowers and flowering plants of over 140 species. The book describes many common species found in the Western U.S. In addition to color photographs descriptions include taxonomic, origin and habitat information of each of the species. Copies of the publication are available for $13.50 from The University of Wyoming Bulletin Room, P.O. Box 3313 University Station, Laramie, WY 82071.

[1]University of Wyoming, Laramie, WY
[2]Utah State University, Logan, UT

AN INTRODUCTION TO CLETHODIM, A POSTEMERGENCE HERBICIDE

M.J. Ansolabehere and L.L. Kvasnicka[1]

Abstract. Clethodim {(E,E)-(±)-2-[1-[[(3-chloro-2-propenyl)oxy]imino]-propyl]-5-[2-ethylthio)propyl]-3-hydroxy-2-cyclohenen-1-one} is a selective postemergence grass herbicide under development by Chevron Chemical Company, Agricultural Chemicals Division. In the herbicidal class, cyclohexanedione-oxime, clethodim has shown to be effective against a wide range of annual and perennial grasses, with little or no activity against broadleaf weeds and sedges. All broadleaf crops tested, including soybeans, cotton, peanuts, sugar beets, potatoes, alfalfa and most vegetable crops, have shown excellent crop tolerance. Preemergence activity for annual grass control has been observed from application rates of from 0.125 to 0.50 lb. active per acre when applied preemergence or preplant incorporated to many broadleaf crops. Best results from clethodim applications have been obtained when grass species are actively growing and are 2 to 8 inches in height. An oil concentrate at 1.0 qt. per acre is recommended with all postemergence applications.

[1]Chevron Chemical Company, Fresno, CA

JOINTED GOATGRASS LONGEVITY AND DORMANCY IN SOIL

Joan List, Donald Thill, Ted Carpenter and Frank Young[1]

Abstract. Jointed goatgrass (*Aegilops cylindrica* Host.) spikelets were inhumed at Moscow, ID and Lind, WA in August 1985, to determine seed dormancy and longevity. A packet of 50 spikelets was exhumed from 0, 5, 10, 15, 20, and 30 cm four times per year. The basal and subterminal seed was extracted from the spikelets, and viability and dormancy were determined by germination and tetrazolium viability tests. Seed stored in the laboratory and at each field site were the controls. Dormancy was cyclic in dry stored seed from the field sites, but total viability did not change from September 1985, to March 1987. Dormancy was cyclic in buried seed also; however, total viability decreased steadily from September 1985, to November 1987. Soil depth had little influence on dormancy and total viability. The decline in viability over time fits a typical log-linear response (R^2 = 0.8 at both Lind and Moscow). The predicted length of time for 99% of the original viable seedlot to lose viability is 2.8 years at Moscow and 5.4 years at Lind. Viability of laboratory-stored seed remained above 95% for 2 years. Viability of basal seed (95%) was slightly less than subterminal seed (97%). Dormancy of basal seed exhibited endogenous cycling over time. Subterminal seed was not dormant. Total viability at Moscow (26%) was lower than at Lind (38%), which may be attributed to the arid environment at Lind. Proper rotation to control jointed goatgrass must eliminate winter small grains for at least three years near Moscow and possibly five years near Lind.

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[1]Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID and USDA-ARS, Pullman, WA

PLANT PHOTOGRAPHY TECHNIQUES

Dean G. Swan[1] and Larry C. Burrill[2]

Most amateur photographers can photograph a plant. However, the ability to capture a plant on film accurately enough, so that the person viewing the photograph can identify that plant, requires special photographic techniques. These techniques are usually acquired only after many years of trial and error.

Because we believe that correct identification of weeds is such an important part of Weed Science, we want to share our photographic techniques. These were learned from other photographers, and many years of experience, and should enable you to improve your own plant photography. However, we want to emphasize that, although we have learned much, we continue working to improve our techniques.

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[1]Washington State University, Pullman, WA
[2]Oregon State University, Corvallis, OR

Weed photography is especially important because an accurate photograph goes beyond descriptive words. A good photograph, plus a descriptive botanical key, results in greater accuracy in plant identification than just a botanical key. An accurate identification of the problem is the first step in weed control.

Equipment

Cameras

For the photographer intent on taking good pictures of weeds, we suggest a single-lens-reflex (SLR) camera. These cameras have a through-the-lens viewing system that enables one to accurately frame and focus.

Most SLR cameras have built-in light meters. The fully automatic models may increase accuracy by reducing the chance for error, but even simple, inexpensive cameras enable one to make correct adjustments based on light readings.

Lenses

Most SLR cameras have 50mm lenses. The focal length of the 50mm lens comes closest to approximating one's eyesight and gives a realistic view of a scene. It shows the correct size relationship between subjects at different distances and between subjects and their surroundings. The 50mm lens is adequate for photographing weeds down to about two feet but cannot be used for macro photography without attachments. The preferred lens for close-up work is an f2.8 50mm macro.

Zoom lens

A zoom lens is a useful addition to a photographer's kit and may be the only lens needed. The advantage of a zoom lens is the infinite range of focal lengths, enabling variations of the same picture to be composed. A zoom with a macro lens will allow close-up pictures.

Extension tubes or bellows

For most macro work extension tubes or bellows must be used. Extension tubes come in three fixed lengths and can be added together to increase magnification. A bellows is infinitely variable, essential for the serious close-up enthusiast.

Tripods

A tripod is an essential part of a photographer's equipment. Although the photographer can hand-hold a camera, a tripod increases precision in composition. This enables the photographer to leave the camera in position while moving around. The biggest problem for the close-up photographer is having enough light to get the desired depth of field and stop plant movement. A slow shutter speed lets in more light and allows a smaller aperture which increases depth of field. Because cameras cannot be hand-held slower than 1/60 of a second (preferably 1/125 of a second) a tripod or some other type of holder is essential for close-up photography.

The ideal tripod should be heavy enough to be sturdy and still be portable. Extended legs should not flex under pressure, nor should leg locks slip. If the head wobbles when a camera is mounted, the tripod is useless. A tripod can be steadied in the field by hanging a camera bag or other weight between the legs.

Film

Although there are several types of color film on the market, the major differences are color tones and film speed. Films in the United States have an ASA rating which indicates their sensitivity to light. The higher the ASA rating the less light is required to expose correctly. This characteristic of film is referred to as "film speed". Film in Europe has a DIN rating to indicate the same thing. Today film is sold with an ISO designation, which is a combination of both numbers previously used. For instance, Kodachrome 64 film now carries a ISO 64/19 rating.

Slide film is commonly available with ASA ratings from 25 to 400. The faster films are coarse grained, thus less sharp when enlarged. This is rarely a problem when just using slides, but important if large prints are made from slides. When photographing for publications, slide films are better than negative films because color separations are usually better.

Each major slide film accentuates certain colors, which a photographer can often use to improve results. The color band on the film box usually indicates the colors accentuated by that film. For instance, Kodachrome film, which has a red band on the box, will bring out the warmer reds, browns and yellows. Ektachrome film favors the blues. Fujichrome enhances different shades of green and Agfachrome shades of orange.

Kodachrome 25: is the sharpest and least grainy, but is slow.

Kodachrome 64: is similar to Kodachrome 25 but faster. Most outdoor photographers agree that the Kodachrome films produce the most accurate colors in plant photographs.

Kodachrome 200: is a new film. If the quality proves similar to other Kodachrome films this will be a useful film.

Ektachrome 100, 200, 400: are versatile films because of the range of speeds. Blue tones are often strong enough to create an unrealistic image. For unusual situations these films can be exposed at double the ASA rating. (Be sure to tell the developing lab if you do this). Another advantage to Ektachrome film is one day developing service compared to 3 to 10 days required for Kodachrome film.

Fujichrome 50D, 100D, 400D: are also versatile films with good color separation.

How to take the photographs

A camera is a light-tight box with a lens at one end and a film holder at the other. When the shutter is released, light travels through the lens to the film and exposes it. For results to be successful the film must be exposed correctly. That is, it must receive the correct amount of light. Exposure is controlled by two adjustments on the camera: the shutter speed, which controls the duration of the exposure, and the aperture, which controls the intensity of the exposure.

The shutter

The shutter speed is calibrated in fractions of a second with higher shutter speeds letting in less light. Each speed higher halves the light and changing the shutter speed one interval slower doubles the light. The shutter speed also controls the appearance of movement on the final image. With slower speeds moving objects blur on the film, while faster shutter speeds "freeze" movement. Because no one can hand-hold a camera perfectly steady, a high enough shutter speed is needed to stop the effects of movement. The minimum speed usually recommended for hand-held cameras is equal to the focal length of the lens you are using, for example, 1/60 of a second for a 50mm lens. However, we recommend a minimum of 1/125 of a second. Use a tripod or other type of holder for slower speeds.

The aperture

The aperture is a diaphragm inside the lens that can reduce or enlarge the opening through the lens. When fully open, a maximum of light reaches the film; when closed down, less light reaches the film. The aperture scale on the lens is a series of ratios indicating the cross-sectional area of the light path. Changing the aperture a full interval, i.e. from f4 to f5.6, halves the cross sectional area and half as much light passes through the lens. Since the numbers are actually fractions, lower numbers indicate larger light path areas and higher numbers indicate smaller areas. The lower the number the more light gets through.

Depth of field

Technically speaking, a lens focuses sharply only across a given plane; yet to the eye, objects just in front of and just behind this plane are in focus. This zone in which everything seems to be in focus is called the depth of field. The depth of field is greatest at a moderate or infinite distance from the camera. The closer the subject is to the lens, the shallower the depth of field becomes. In close-up photography the depth of field ranges from a few to less than one millimeter. Therefore, in taking pictures at extremely close range, the thickness or roundness of an object has a great deal to do with how sharply it will be reproduced in the photograph. Flat objects, such as leaves, present few problems, but a flower, a grass panicle or a series of flowers located different distances from the camera are more difficult to get in focus. In these situations there are two ways to increase depth of field. The first method is to settle for a smaller image by moving the camera farther away from the subject and refocusing. This method is least desirable because the film surface is not fully utilized. The other method is to stop the aperture down as far as possible (to f16 or f22). Because this smaller aperture reduces the amount of light reaching the film, the picture must be taken with a slower speed or additional light.

Movement

Perhaps the toughest challenge in plant photography is plant movement. Plants are not the docile subjects they seem. They sway and twitch incessantly, often for no perceptible reason. The wind that you didn't notice becomes a relentless source of frustration.

The slightest movement, moreover, is exaggerated by the magnifying effect of close-up equipment. The best motion stopper is a fast shutter speed. If a low light level does not permit a fast shutter speed, the photographer must find a way to keep the plants from moving. A windbreak can help but is often not practical for field photography. For close-up photography the plants or plant parts can often be moved to a more favorable location. We frequently face our vehicle toward the sun and place the clamped camera and close-up holder on the front seat where adequate light comes through the windshield. With doors and windows closed and using the timer or cable release one can make long exposures with no plant movement. If the subject is limp or slightly wilted, turn the clamp over and photograph it upside down. Masking tape can be used to hold together, in the desired arrangement, small plant parts, such as tiny flowers and pods or berries. Moreover, the masking tape helps to hold the subject in the clamp.

Shadows

By looking at colored photographs of weeds, one can quickly spot examples of distracting shadows in otherwise good photographs. Although shadows help highlight the texture of a leaf surface and give a more accurate image, shadows of weeds on the soil or on another background distract from the subject. Shadows can be reduced in several ways. Correct use of one or more flash units will fill in the shaded areas effectively. Although flash photography can be complicated and more unpredictable than most people want, it can help the serious photographer. However, an unshaded flash may give too much light or create glare. Reflective umbrellas or a "soft box" help diffuse and soften the light. An inexpensive diffuser can be made from skylight Fiberglas which is placed between the sun and subject. One sheet thickness gives a soft shadow and three sheets thickness eliminates the shadows. Diffusers are seldom needed during bright overcast days.

Backgrounds

There is no single best background for photographing weeds. Color tones of the weeds, potential use of the photographs, portability requirements of the photographers equipment and time available for photography may influence the choice of backgrounds.

Blue sky

Blue sky is probably the most common background used by photographers of weeds. A soft blue background is suitable for both slides and for eventual publication of colored photographs. However, it is not always easy to position a plant so that only the sky appears in the background. If the photographer is alone, this may require holding the weed in one hand and manipulating the camera with the other hand. An option is to use a clamp mounted on a tripod or some other stable object to raise the weed high enough to allow a sky background. Scattered clouds, overcast days or fog severely restrict use of a blue sky background.

Poster board

A large poster board placed behind a weed offers a fairly flexible and effective background. The poster board may be supported with an easel or held by an assistant. Unless the photographer is lying on the ground and directing the camera up, the weed will have a split background of poster board and soil. This may or may not be desirable. One method we use is placing the poster board on the easel trough. The weed is then harvested, placed in a clamp, then set on a TV tray in front of the poster board. This allows an excellent camera angle. Since the wind constantly threatens to blow the easel and poster board over on top of the weed, use a sand bag suspended between the legs of the easel to add stability. By moving the poster board and subject in relation to the sun, shadows will not be a problem. Although you may wish to carry several colors of poster board we prefer the Kodak gray or black poster boards.

Because a poster board is frequently not large enough for the subject, we have built a triple-fold backboard of 3/8 inch plywood. When open it is 53 inches by 81 inches. "Studio-gray" roll paper is cut to size and held to the plywood with narrow strips of molding fastened with large, spring loaded paper clamps. This can be leaned against the sandbagged easel (if the wind is reasonably calm). To keep the "billows" of the paper from showing, place the backboard so the paper is shaded from the sun. This shading, essential for the studio paper, is in contrast to the poster board which works best when exposed to the sun.

Soil background

Prostrate weeds and seedlings present a special challenge to a photographer because there is often not enough contrast between weed and soil. Maximum contrast usually follows irrigation or rainfall which darkens the soil. However, a spray bottle of water can be used to wet the soil around the weed when conditions are dry. Use the Fiberglas to soften or eliminate the shadows.

Moist soil is also desirable for photographing seedlings. Seedling plants can be photographed in place or removed and placed on moist soil in a tray at a more convenient location. If the sun is bright, use the Fiberglas. For a steady, versatile mount, place the camera on one or more bean bags.

Natural background

The ideal weed picture would be one taken in the normal setting without an introduced background. The photographer intent on getting good weed pictures should be constantly looking for that rare situation where a weed is growing in a setting that provides enough contrast for a good photograph. Because weeds are usually surrounded by other weeds or crops a total commitment to a natural setting may not be productive. However, in moderately close-up or macro photography a wide open aperture will allow you to blur the background.

Cloth background

A carefully selected sky-blue cloth will often provide a suitable background and in some cases will match that of the sky. Test a variety of fabrics before making a final selection. A cloth may be placed on the ground as a background for prostrate weeds or upright weeds that have been pulled. A more natural appearing weed will result if the cloth is draped behind the growing weed. A major problem with cloth is the wind. Even if you try to stretch the cloth, it will move in the wind and "billows" will appear on the photograph.

Field studio inventory

Camera	Lenses
Extension tubes or bellows	Tripod
Easel with sandbag	Kodak gray card
Poster board with storage holder	Triple-fold board
One dozen large paper clamps	Molding for board

Rolls of studio gray paper
TV tray
Scissors
Pruning shears
Masking tape
Rubber bands
Shovel
Record book
(3) sheets Fiberglas
(2) wooden clamps
(2) bean bags
Leather gloves
Plastic bags
Water spray bottle
Weed ID book

ADSORPTION AND TRANSLOCATION OF METSULFURON IN FIELD BINDWEED (CONVOLVULUS ARVENSIS L.)

Mashhadi, H.R. and J.O. Evans[1]

Introduction

Metsulfuron {2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]-carbonyl]amino]-sulfonyl]benzoic acid} is a newly registered herbicide for selective broadleaf weed control in wheat and barley. It belongs to the sulfonylurea family of herbicides and its characteristics are similar to chlorsulfuron {2-chloro-N-[[(4-methoxy,6-methyl-1,3,5-triazin-2-yl)amino]car-bonyl]benzenesulfonamide} which has been extensively researched during the past few years. Uptake of chlorsulfuron and metsulfuron is via the roots and foliage of plants and once absorbed they are readily translocated (4,5). Reduction of the number of cell divisions is found to be mainly responsible for plant growth inhibition. Ray (4) showed 87 percent reduction of mitotic index of *Vicia faba* roots in one ppm chlorsulfuron. Sweetser et al. (5) showed that metabolism of chlorsulfuron by tolerant plants was the basis for its selectivity. Tolerant plants such as wheat, oats and barley rapidly metabolized chlorsulfuron to a polar inactive product. Hutchison et al. (2) reported that tolerant broadleaf plants like flax and black nightshade, as well as tolerant grasses, metabolize chlorsulfuron. Although low rates (4 g/ha) of metsulfuron is not active on perennial broadleaf weeds, higher rates (> 50 g/ha) of this herbicide may control many of these weeds.

The objective of this study was 1) to quantify the absorption and translocation pattern of metsulfuron in field bindweed and 2) to investigate if pretreatments of metsulfuron or other herbicides effect the absorption of metsulfuron in this plant.

Materials and Methods

Field bindweed seeds were collected at North Logan in 1985. The seeds were scarified in concentrated sulfuric acid for 1 hour and water rinsed for 15 minutes. The seeds were planted in vermiculite under greenhouse condi-tions with 25/18°C ($\pm$ 4) day/night temperature and 16 h photoperiod received

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[1]Utah State University, Logan, UT

from sunlight supplemented with high pressure sodium lights. Seedlings were irrigated with 1/2 strength modified Hoagland solution as needed. Three-week-old bindweed seedlings were transplanted to one liter nutrient solution bottles containing 1/2 strength modified Hoagland solution. MES buffer (2-(N-Morpholino)ethanesulfonic acid) pH 5.7, to final concentration of 1 mmolar was added to the nutrient solutions to stabilize pH (1). Metsulfuron labelled uniformly with ^{14}C in the phenyl ring (specific activity 8.6u ci/mg) was used for the study. The labelled metsulfuron was dissolved in a 1:3 acetone:water solution containing 25% V/V WK surfactant to obtain desired activity.

Plants were treated with ^{14}C labelled metsulfuron 2 weeks after transplanting. Treatments were made with a microsyringe with ten ul of radio-labelled metsulfuron applied in small droplets uniformly to the abaxial side of the third oldest and fully developed leaf on the longest runner. Immediately prior to ^{14}C metsulfuron treatments, bindweed plants were sprayed with metsulfuron (4 g/ha), picloram (140 g/ha), dicamba (560 g/ha), 2,4-D (1,120) g/ha) glyphosate (840 g/ha) and MCPA (1,120 g/ha). Metsulfuron (4 g/ha) was also sprayed on field bindweed 1, 2, 4, and 6 days before a single leaf treatment of ^{14}C metsulfuron was applied. Control plants where only the single leaf ^{14}C metsulfuron treatment was conducted were also established.

Treated plants were harvested 192 hours after ^{14}C metsulfuron treatment. The harvested plants were sectioned into 5 parts: treated leaf, foliage above treated leaf, foliage below treated leaf, rest of shoots and roots. Treated leaves were soaked in 10 ml acetone for 30 seconds, then rinsed with an additional 4-5 ml acetone to remove all unabsorbed herbicide. Plant materials were then oven dried at 70^{o}C for 48 hours and dry weights measured. The samples were oxidized in a Packard model 306 auto oxidizer set to deliver 5 ml Carbosorb and 10 ml Permafluor. Acetone in treated leaf wash was evaporated under the hood, and the same proportion of Carbosorb to Permafluor was added to each vial containing leaf wash. The activity of each oxidized sample was measured by a Beckman Model 8000 Scintillation Counter. The experimental design was a complete randomized block design with three replications.

One plant from each treatment of the latter experiment was mounted, pressed and exposed to Kodak 35 by 43 cm XAR-5 film for 4 weeks for auto-radiographs. The autoradiographs were developed in accordance with film instructions.

Results and Discussion

Percent recovery of the ^{14}C applied to a single leaf of field bindweed ranged from 81 to 97 percent. Eighty to ninety percent of the total ^{14}C metsulfuron recovered was in the leaf wash and the rest absorbed into the plant. No differences were was observed among treated plants with regard to percent ^{14}C recovered or percent absorbed.

Field bindweed treatments with any of the six systemic herbicides immediately before applying labelled metsulfuron to a fully expanded leaf appeared to slightly increase absorption in most instances but dicamba and metsulfuron may be exceptions (Figure 1). Metsulfuron applied as a foliage spray two days prior to administering the labelled herbicide significantly increased ^{14}C absorption into the plant (Figure 2).

More of the absorbed labelled metsulfuron translocated acropetally from the treated leaf than to other plant segments. The results are presented in Figure 3 and 4 as total C^{14} recovered per segment and C^{14} metsulfuron per

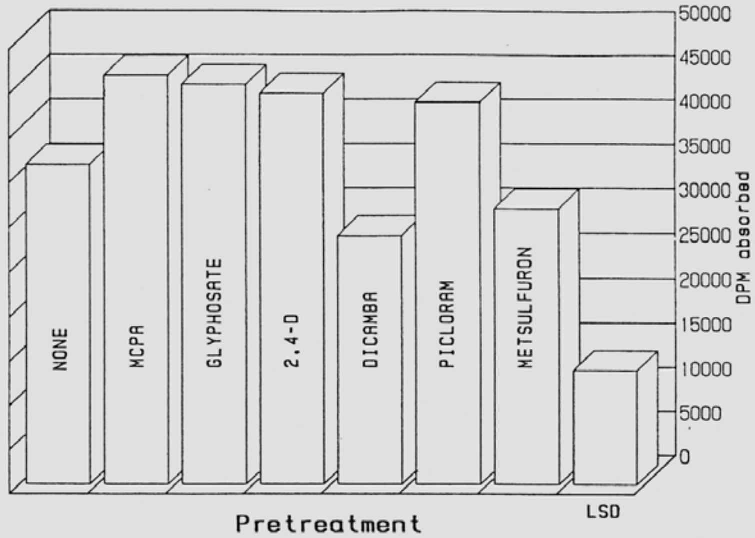

Figure 1. Total ^{14}C metsulfuron absorbed by field bindweed following pretreatment with different herbicides immediately prior to ^{14}C application.

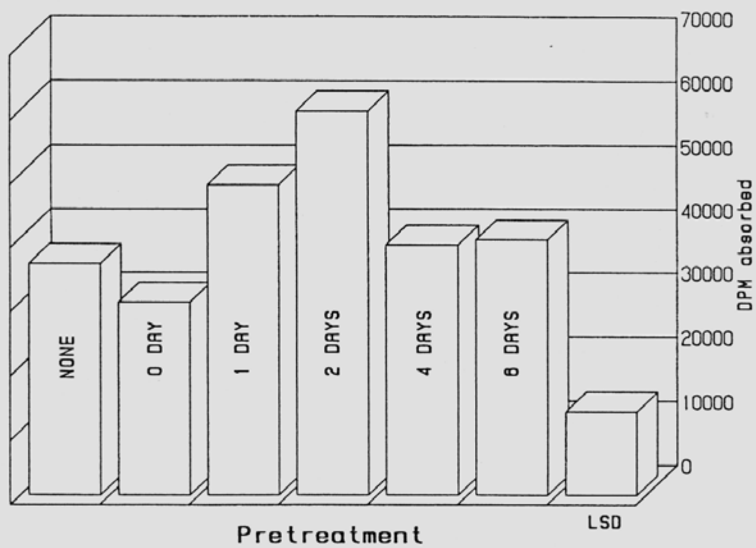

Figure 2. Total ^{14}C metsulfuron absorbed by field bindweed following pretreatment with non-labelled metsulfuron at various time intervals prior to ^{14}C application.

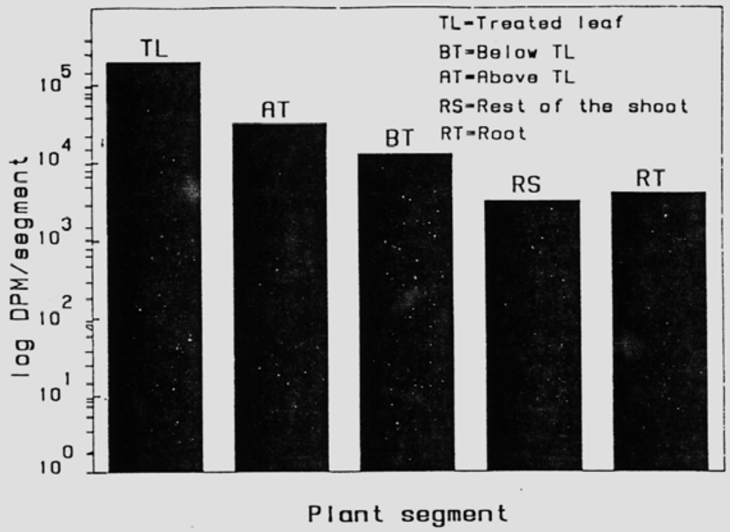

Figure 3. Total ^{14}C metsulfuron recovered in each segment of field bindweed 192 hours after labelled metsulfuron application.

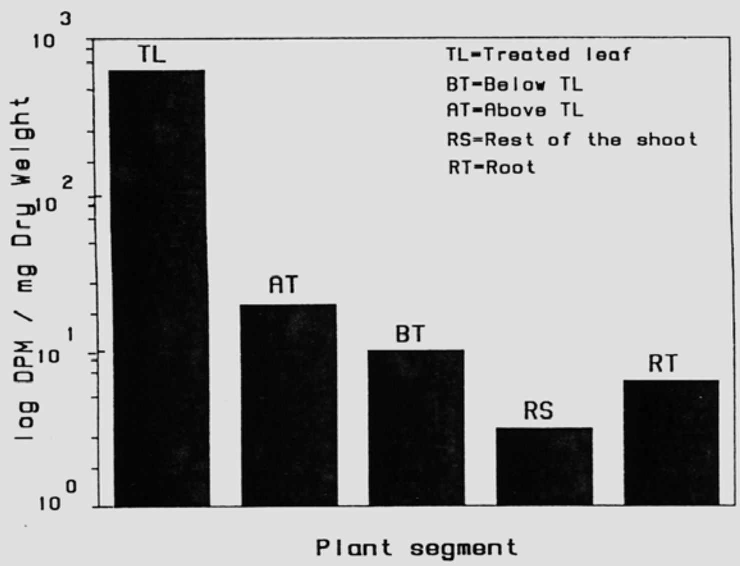

Figure 4. ^{14}C metsulfuron recovered and expressed per mg of dry weight of field bindweed plants 192 hours after labelled metsulfuron application.

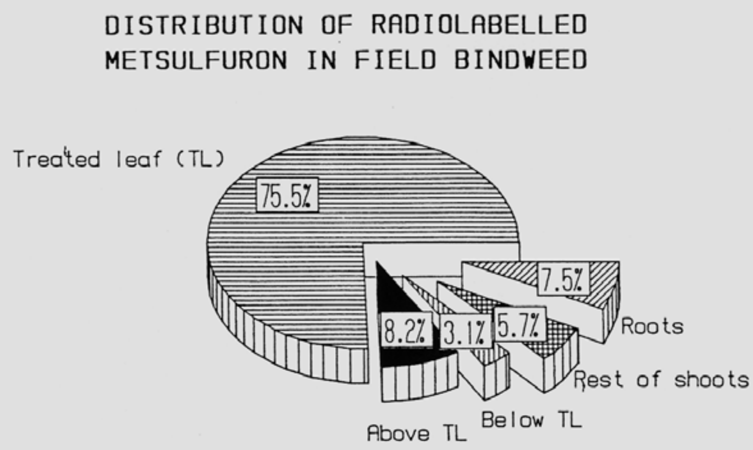

Figure 5. Percent distribution of total ^{14}C metsulfuron in field bindweed.

milligram dry weight of each segment respectively. The quantity of labelled metsulfuron translocated to the below treated leaf segment was higher than the rest of the shoot or root segments when expressed in total DPM per segment. Lower dry weights of below treated segments were responsible for this difference. The percent distribution of absorbed labelled metsulfuron in each segment of field bindweed indicated that about 75 percent of the total quantity of labelled metsulfuron was recovered in the treated leaf and the rest translocated from the treated leaf (Figure 5). Higher proportions of labelled metsulfuron were translocated above the treated leaf than to roots, lower stems or other runners on the bindweed plant.

Visual differences were not observed among the autoradiographs from plants receiving various treaments. The tendency of acropetal translocation, however, could easily be recognized and metsulfuron was also shown to be accumulated in the shoot meristems.

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EVALUATION OF CHEMICALS FOR SUPPRESSION OF PRIMOCANES IN EVERGREEN BLACKBERRIES AND RED RASPBERRIES, 1987

W.S. Braunworth, Jr.[1], E. Nelson[2] and G. Crabtree[1]

The use of dinoseb {2-(1-methylpropyl)-4,6-dinitrophenol} is critical for the suppression of primocanes in caneberries since there are no registered alternatives. Various herbicides were evaluated for primocane suppression in red raspberries (cv. Willamette) and blackberries (cv. Thornless Evergreen) in Sandy, Oregon.

[1]Oregon State University, Corvallis, OR 97331
[2]North Willamette Exp. Stn., Oregon State University, Aurora, OR

Red raspberries:

The experimental treatments and application rates for red raspberries are listed in Table 1. The experimental design was a randomized complete block with three replications. Plot size was 3 by 15 feet with 2.5 feet between berry plants. Chemical suppressions applications were made on 31 March and 15 April, 1987. Harvest was 6 June 1987. The paraquat (Gramoxone Super) {1,1'-dimethyl-4,4'bipyridinium ion} plus oxyfluorfen (Goal) {2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene} treatment (no. 5) was an exception to this with only one application on 31 March. Regrowth on 15 April did not warrant a second application of the paraquat plus oxyfluorfen treatment.

The volume of carrier used was based on those rates expected to be ideal for the herbicide being evaluated and the amount of foliage present. Volume of water as a carrier was 30 gal/a for treatments 1-6 and 9-12. Treatments 7, 8 and 13-15 had 60 and 100 gal/a of water as the carrier for the first and second application dates respectively. The diesel application (no. 16) was without water, and at 60 and 100 gal/a for the two application dates. A hollow cone nozzle, size D3-25, was directed at the lower 16 inches of the plants. Ratings were based on a visual assessment of the degree of control of the primocanes and lateral buds. These ratings were made five times during the season. On October 27, 1987, the number of canes per plant, based on the middle three plants, cane diameter (two feet above ground) and length, based on 12 canes of the middle hill were measured (Table 1).

Of the 19 treatments studied, only the standard, dinoseb, and paraquat plus oxyfluorfen provided adequate chemical suppression of the primocanes. The mechanical treatment, hand pruning, also had excellent suppression ratings, but this treatment was not economically reasonable on a commercial basis. Enquik (monocarbamide dihydrogensulfate) provided less suppression than the commercially acceptable treatments of paraquat plus oxyfluorfen and dinoseb.

Table 1 shows cane number, length, and diameter at the end of the season. Cane suppression as rated earlier in the season, was no longer evident when these cane measurements were made. In comparison to the untreated control (no. 19), the Enquik treatments (nos. 7, 8), paraquat plus oxyfluorfen (no. 12) and the dinoseb treatment (no. 13) resulted in similar cane numbers and diameters. Cane length was the same among treatments, except for the dinoseb treatment which was significantly shorter than the untreated control. However, this did not present a problem in training the canes. Based on the cane parameters, there appears to be no serious limitation for the use of paraquat plus oxyfluorfen as an alternative to dinoseb. Further evaluations of the effect of these treatments on yield will be useful in identifying a suitable replacement for dinoseb.

Evergreen blackberries

Based on the results from the red raspberry test a revised set of treatments was selected for the Evergreen blackberries (Table 2). Experimental design was a randomized complete block with three replications. Plot size was 3 by 24 feet, with 8 feet between berry plants. Application dates for all treatments were 24 April, 13 May, 11 June, 1 July, 1987. Water carrier rates were 30 gal/a for treatments 1 and 3-10, and 100 gal/a for the others. Cane suppression ratings were made 10 times from 30 April to 24 July, 1987 (Table 2).

Two herbicides, oxyfluorfen and lactofen (Cobra) {($\pm$)-2-ethoxy-1-methyl-2-oxoethyl 5-[2-chloro-4-(trifluoromethyl)phenoxy]-2-nitrobenzoate}, both at

Table 1. Suppression of primocanes of red raspberries, cv. Willamette, 1987.

Treatment No.	Name	Application rate	Rating (0-10) of Cane Suppression 4/07	4/15	4/21	4/24	4/30	Canes / plant 4/07	Canes / plant 10/27	Cane diameter 10/27	Cane length 10/27
		(lb ai or gal/a)								(cm)	(m)
01	PARAQUAT	0.5	2.2	1.0	.7	0	1.0	15.0	23	.85	2.39
	X-77	.25%									
02	PARAQUAT	1.00	3.5	2.4	2.0	1.3	2.3	15.3	21	.86	2.50
	X-77	.25%									
03	DIQUAT	0.50	4.8	3.5	3.7	3.3	3.3	14.7	20	.87	2.48
	X-77	.25%									
04	DIQUAT	1.00	5.3	4.2	5.0	3.7	4.3	16.7	19	.86	2.40
	X-77	.25%									
05	PARAQUAT	0.25	5.2	3.5	3.7	2.3	3.0	15.0	22	.88	2.50
	DIQUAT	0.50									
	X-77	.25%									
06	PARAQUAT	0.50	3.4	3.2	4.0	1.7	3.0	16.0	17	.88	2.42
	DIQUAT	1.00									
	X-77	.25%									
07	ENQUIK	*20.00	6.2	5.6	6.2	4.7	5.3	15.0	25	.89	2.47
	#OIL	* 1.00									
08	ENQUIK	*20.00	5.2	4.6	6.7	5.3	6.0	16.0	24	.92	2.58
	X-77	0.25									
09	ENDOTHALL	0.50	5.0	4.5	5.8	5.5	6.3	15.0	21	.87	2.55
	OIL	* 1.00									
10	ENDOTHALL	1.00	5.6	3.8	5.0	4.7	6.7	16.0	21	.82	2.29
	OIL	* 1.00									
11	ENDOTHALL	2.00	6.2	6.3	7.8	7.7	6.7	17.0	21	.86	2.23
	OIL	* 1.00									
12	PARAQUAT	0.40	8.8	9.6	8.3	8.3	7.3	15.3	21	.91	2.43
	OXYFLUORFEN	.5									
	X-77	.25%									
13	DINOSEB	2.50	8.0	7.9	9.2	9.7	7.7	16.3	22	.86	2.33
	OIL	* 1.00									
14**	PHOSACID	15.00	6.0	3.6	5.0	2.3	5.0	16.0	23	.88	2.57
	OIL	* 1.00									
15	PHOSACID	30.00	6.1	4.9	6.0	4.3	5.7	14.3	21	.88	2.45
	OIL	* 1.00									
16	DIESEL	100.00	6.1	6.1	5.8	5.0	7.0	14.7	20	.91	2.36
	X-77	.25%									
17	FLAME (butane torch)		6.6	3.6	4.2	1.0	2.0	14.7	22	.85	2.16
18	MECHANICAL (by hand)		9.8	9.4	10.0	9.5	7.3	15.0	26	.79	2.11
19	CONTROL		0	.2	0	0	0	16.7	25	.86	2.58
	LSD(0.05) =		2.0	2.2	1.9	2.5	1.7	1.8	5	.09	.23
	STANDARD DEVIATION =		1.2	1.3	1.1	1.5	1.0	1.1	3	.05	.13
	COEFF. OF VARIABILITY =		21.5	28.1	21.8	35.5	21.3	7.1	14	5.98	5.57

* = Rate is in gal/a; Spray volume was 60 gal/a and 100 gal/a for first and second applications, respectively. All other treatments were 30 gal/a.
** = PHOSACID is phosphoric acid; # = The oil used was Volk's Supreme.
Scale is from 0 (no cane suppression) to 10 (complete suppression)

rates of .5-1.0 lb ai/a, in addition to dinoseb showed commercially acceptable levels of cane control. The higher 2 lb ai/a rate of oxyfluorfen did not provide significantly greater control than the 1.0 lb rate. The paraquat plus oxyfluorfen treatment was also commercially acceptable but the data from plots with oxyfluorfen applied alone indicated that paraquat was not necessary.

<u>Summary and Recommendations</u>:

Both lactofen and oxyfluorfen (.5 to 1.0 lb ai/A) are possible replacements for dinoseb in Evergreen blackberries. Paraquat plus oxyfluorfen (0.4 + 0.5 lb ai/A) is a possible alternative to dinoseb in red raspberries. However, further testing is required to determine if paraquat is necessary in this combination treatment. Enquick may be registered in the near future for can suppression. Enquick provided less control than dinoseb of primocanes in both Evergreen blackberries and red raspberries. If registered and used by growers, Enquick, when used in commercial operations may not be as satisfactory as dinoseb.

No damage to the fruiting canes of the fruit was observed in the raspberries or the blackberries. It is important to study the effects of these herbicides for several seasons to be certain no crop injury occurs with repeated applications.

Table 2. Suppression of primocanes of blackberries, cv. Thornless Evergreen, 1987.

Treatment No.	Name	Application rate (lb ai or gal/a)	Rating of (0-10) for cane suppression 4/30	5/07	5/13	5/21	6/02	6/11	6/22	6/29	7/08
01	DIQUAT	2.00	4.0	4.0	4.7	6.0	4.7	4.0	6.8	6.0	6.7
	X-77	.25%									
02	ENQUIK	**20.00	4.0	4.3	4.0	5.8	3.7	3.0	6.7	5.2	6.7
	#OIL	* 1.00									
03	ENDOTHAL	2.00	1.3	.7	1.7	3.0	2.0	3.0	3.3	2.7	3.0
	OIL	* 1.00									
04	ENDOTHAL	3.00	3.3	2.7	3.0	4.3	1.3	2.0	4.5	4.0	4.7
	OIL	* 1.00									
05	PARAQUAT	0.40	6.7	5.8	5.0	7.4	6.8	6.0	7.2	6.3	7.5
	OXYFLUORFEN	0.50									
	X-77	.25%									
06	OXYFLUORFEN	0.50	6.0	7.0	6.0	8.4	7.3	7.0	8.2	7.0	7.0
	X-77	.25%									
07	OXYFLUORFEN	1.00	6.3	8.3	6.3	8.8	7.7	7.0	8.8	7.8	8.2
	X-77	.25%									
08	OXYFLUORFEN	2.00	6.3	8.7	6.0	9.0	8.3	8.0	9.3	8.2	8.7
	X-77	.25%									
09	LACTOFEN	0.50	7.7	7.7	6.3	9.1	8.0	8.0	9.0	7.0	8.7
	OIL	* 1.00									
10	LACTOFEN	1.00	7.2	7.7	5.7	9.2	8.2	8.0	9.3	7.8	9.0
	OIL	* 1.00									
11	NH4NO3	**30.00	3.0	2.0	3.0	2.8	3.3	3.0	4.5	2.2	3.7
	KCL	30.00									
	SOLUBOR	5.00									
	OIL	* 1.00									
12	DINOSEB	** 2.50	6.7	7.0	5.0	7.9	6.7	7.0	9.2	7.8	8.3
	OIL	* 1.00									
13	CONTROL		0	0	0	0	0	0	0	0	0
LSD (0.05) -			2.0	2.2	1.8	1.9	1.7	NA	1.8	1.7	1.4
STANDARD DIVATION -			1.2	1.3	1.1	1.1	1.0	NA	1.1	1.0	.8
COEFF. OF VARIABILITY -			24.5	26.4	24.7	18.2	19.3	NA	15.8	18.3	12.9

* - Rate is in gal/a.
** - Total spray volume was 100 gal/a; all other treatments were 30 gal/a.
# - The oil used was Volk's Supreme.
Scale is 0 (no cane suppression) to 10 (complete suppression).

WEED CONTROL IN WINTER WHEAT WITH OVER-SNOW APPLICATION OF SELECTED HERBICIDES IN A GRAPHITE-NITROGEN SUSPENSION

J. Asghari, S.A. Dewey and T.A. Tindall[1]

Abstract. Over-snow application of surface darkening agents, such as flyash or graphite, to accelerate snow melt is becoming a common practice in many parts of the intermountain west where snow mold (*Fusarium nivale* or *Typhula incarnata*) is a serious problem in winter wheat. Early snow removal disrupts mold development; greatly reducing yield losses normally caused by this disease.

Combining snow removal, weed control, and nitrogen fertilizer top-dressing into a single over-snow operation was investigated in field studies conducted in Utah and Idaho in 1986 and 1987. Metsulfuron {2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl]benzoic acid} at 0.004 lb ai/A, and chlorsulfuron {2-chloro-N-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]benzenesulfonamide} at 0.016 lb ai/A applied over 8 to 15 inches of snow in February or March effectively controlled a variety of weed species, including snow speedwell (*Veronica campylopoda*), blue-eyed mary (*Collinsia parviflora*), field pennycress (*Thlaspi arvense*) and common lambsquarters (*Chenopodium album*) when applied alone or in combination with graphite (18 lbs/A) and/or a 32% solution of urea ammonium nitrate fertilizer (25 lbs N/A). Tank mix combinations of 1.0 lb ae/A 2,4-D {2,4-dichlorophenoxy)acetic acid} + 0.25 lb ae/A dicamba {3,6-dichloro-2-methoxybenzoic acid} applied over the snow provided little or no control of weeds. No herbicide, alone or in combination with graphite and/or UAN caused visible injury symptoms to winter wheat.

Possible down-slope movement of herbicides in snowmelt runoff was not studied, but will be monitored in future experiments.

[1]Utah State University, Logan, UT

PERFORMANCE OF LACTOFEN ALONE AND IN COMBINATION WITH POST-EMERGENCE HERBICIDES IN CALIFORNIA PERENNIAL CROPS

T.C. DeWitt and W.D. Edson

Abstract. Several hard-to-control winter annual weed species are on the increase in California orchards. The most important of these species are cheeseweed and filaree. Glyphosate and paraquat have been found to be only partially effective in the control of these weed species. Oxyfluorfen provides effective control of these species; however, label restrictions allow its use only during the dormant period.

Lactofen {($\pm$)-2-ethoxy-1-methyl-2-oxoethyl-5-[2-chloro-4-(trifluoromethyl)phenoxy]-2-nitrobenzoate} has been tested on California perennial

[1]PPG Industries, Inc., Pittsburgh, PA

crops since 1985 at rate of 0.125 to 1.0 lb ai/a. The majority of the work with lactofen has been done at rates of 0.25 and 0.5 lb ai/a. The activity of lactofen on winter annual broadleaf weeds is excellent. Most species are controlled with 0.25 lb ai/a; however, 0.5 lb ai/a is required for filaree species and cheeseweed.

A postemergence grass control herbicide must be added to lactofen to control annual grass species. In general, the activity of the tankmix (either paraquat or glyphosate) is generally better than the activity of the individaul products alone. The combination of glyphosate and lactofen appears to be synergistic on species not controlled by single rates of the individual herbicides.

Lactofen has been found to be an effective herbicide for postemergence control of most herbaceous weeds in orchards in California. The addition of a postemergence grass herbicide is necessary to provide the broadest spectrum of weed control. Residual preemergence herbicides such as oryzalin, simazine or prodiamine may be tankmixed with lactofen for season-long weed control.

THE INFLUENCE OF IRRIGATION METHODS ON WEED CONTROL IN PROCESSING TOMATOES

N.L. Smith, W.T. Lanini, S. Grattan and L. Schwankl[1]

Abstract. A drip irrigation system, buried 8 inches below the soil surface was compared to conventional furrow and sprinkler systems for weed control efficacy in processing tomatoes. In theory the buried drip system would reduce weed infestation as long as the surface soil remained dry. In addition, yield comparisons between the systems were made. One half of each plot was treated with 2 lb/A napropamide {N,N-diethyl-2-(1-naphthalenyloxy) propanamide} and 6 lb/A pebulate {S-propyl butylethylcarbamothioate} following direct seeding of tomatoes. Initial germination was obtained by sprinkler irrigation over the entire plot area. When the crop was 6 inches in height, the plants were switched to their respective irrigation treatments. Tomatoes were thinned and all weeds removed at this time. Throughout the growing season measurements of weed density and crop growth were made. Plots were harvested and tomatoes were graded at maturity. Results indicate a weed reduction of over 80% and tomato yield increase of 15 tons/A from the buried drip system, as compared to the furrow or sprinkler treatments, all without herbicide application. The addition of the herbicide treatment reduced the weed biomass differences; however, the yields were still 7 tons 1A higher on the buried drip plots as compared to the other irrigation systems.

[1]University of California, Department of Botany, Davis, CA

EFFECTS OF TEMPERATURE AND FLAMING ON GERMINABILITY OF JOINTED GOATGRASS (AEGILOPS CYLINDRICA HOST) SEED

B.D. Willis, J.O. Evans and S.A. Dewey[1]

Introduction

Jointed goatgrass (Figure 1) is a winter annual that is rapidly spreading throughout Utah and the winter wheat producing areas of western states. It was introduced from Asia in grain shipments to the midwest probably as early as 1890. It presently exists in most major wheat producing states of the nation. The weed commonly infests roadsides, fencerows and wastelands first and then migrates to cropland and ranges. Seeds remain in the soil up to 5 years with nearly 100 percent germinability. Germination occurs on the soil surface and to a depth of 13 cm but seedlings only emerge from a depth of about 6 cm. It can rob crops of water and nutrients reducing wheat (grain) yields 30 to 50 percent with infestations of 90 goatgrass plants per square meter. In a 1980 survey jointed goatgrass was found in 16 Utah counties and over 6,000 acres infested (Figure 2). In a more recent survey in 1988, jointed goatgrass was found in 21 counties with at least 9,000 acres infested (Figure 3).

The objectives of this study were: 1) to test germinability of jointed goatgrass seed after flaming and several oven temperatures and 2) to correlate, if possible, seed heat treatments with field burning of grain stubble for control of jointed goatgrass.

This paper will emphasize flaming and oven temperatures while heat treatments with burning of grain stubble will be discussed in a separate report.

Materials and Methods

Jointed goatgrass seeds were counted into lots of 10 seeds and placed in envelopes. Envelops were randomly selected and assigned treatments. A bunsen burner flame was used to administer the treatments. Ten seeds (one treatment) were placed on a wire mesh screen and held 7 cm above the flame for 0, 1, 3, 5, 10, 30, and 60 seconds, representing treatments 1 through 7 respectively. Each treatment was replicated 4 times. Seeds were immediately removed from the screen after treatment and returned to the envelopes until all treatments were completed. Seeds were placed in petri dishes with moist blotter paper. Seed germinability was recorded 4, 5, 6, and 14 days after treatment (DAT). Moisture was added to the dishes when needed.

Jointed goatgrass seeds were selected as outlined above and subjected to heat treatments in a forced air electric oven. Seeds were placed on a wire mesh screen and held in the oven for 5, 10, 15, 20, 30, 60, 120, and 300 seconds at 25°C which served as controls for the experiment. These treatments were repeated at temperatures of 45, 65, 85, 105, 150, 200, and 275°C each replicated 4 times.

Seeds were immediately removed from the screen and placed in the envelopes. Ten (10) seeds of each replication for each treatment were placed in petri dishes with moist blotter paper.

Seed germinability was recorded 3, 4, 5, 6, 7, 8, 9, and 14 DAT.

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[1]Utah State University, Logan, UT

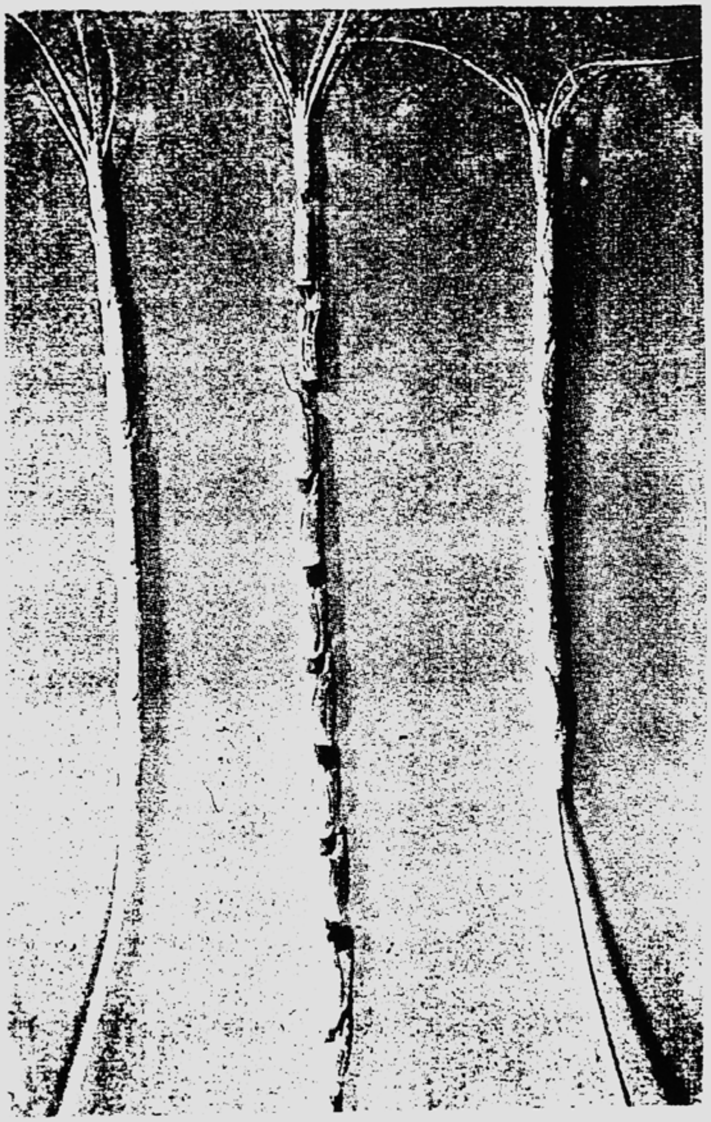

Figure 1. Three jointed goatgrass spikes. The center spike has been expanded to demonstrate the "jointed" character of the head.

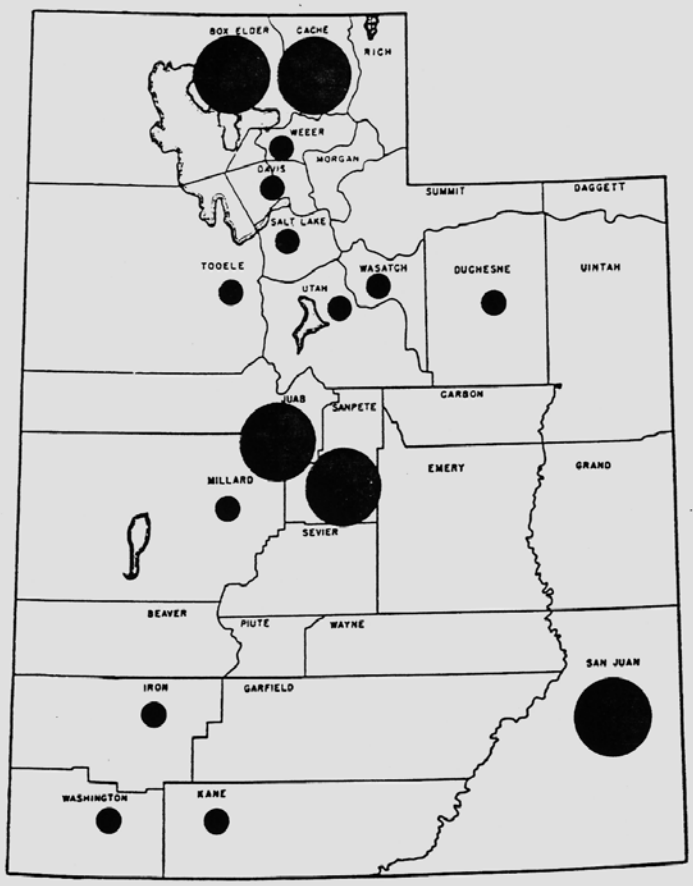

Figure 2. Map showing distribution of jointed goatgrass in Utah in 1980.

 - 1000 acres or more.

 - 100 acres or less.

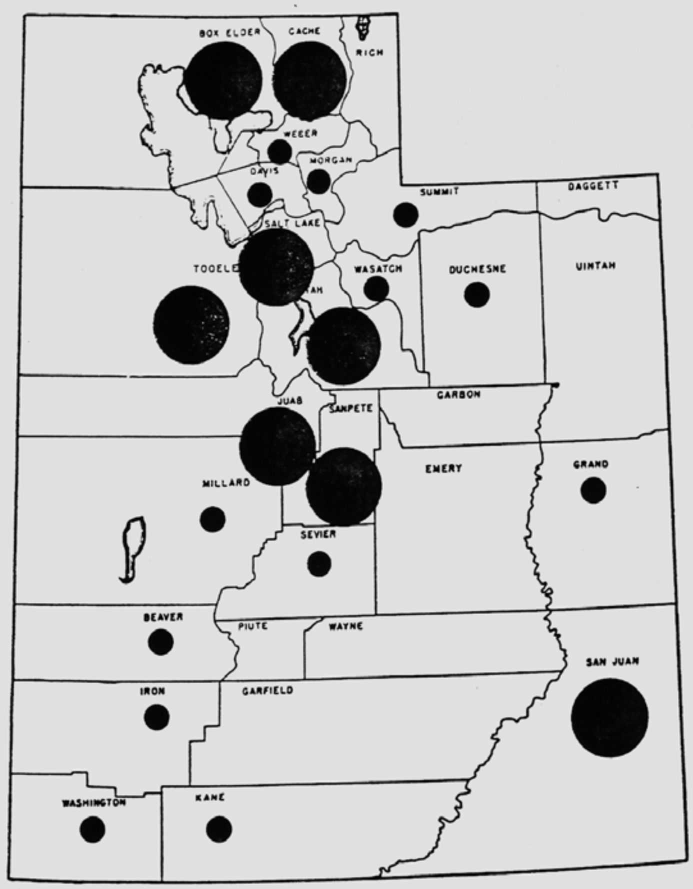

Figure 3. Map showing distribution of jointed goatgrass in Utah in 1988.

 - 1000 acres or more.

 - 100 acres or less.

Jointed goatgrass has spread to five (5) additional counties with infestations increasing in existing counties.

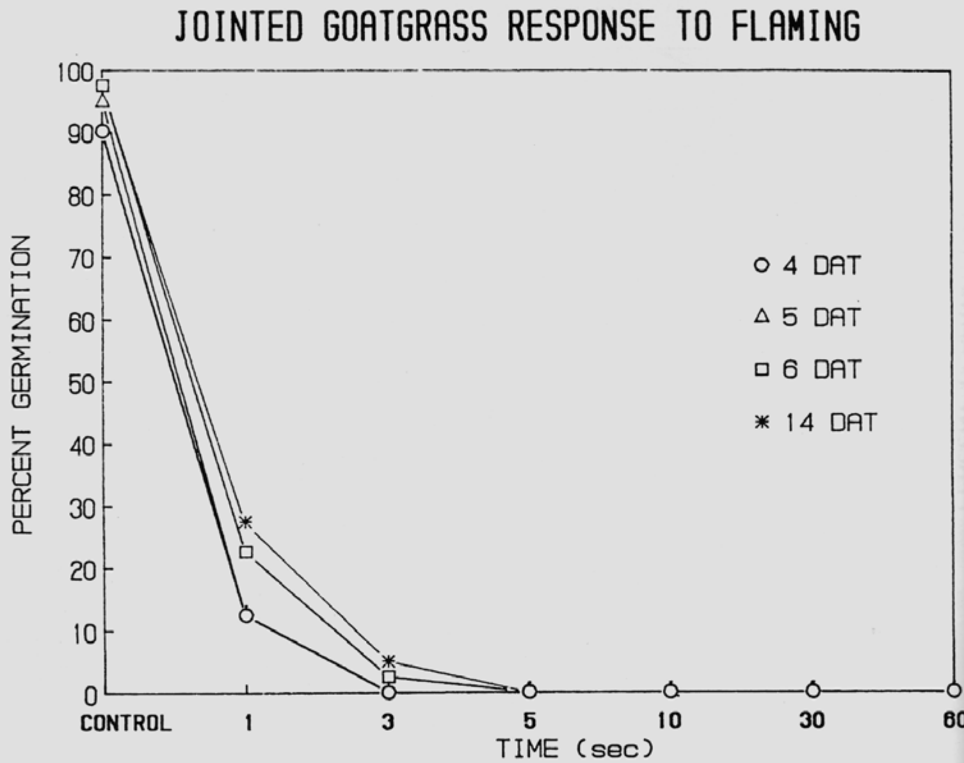

Figure 4. Germinability of jointed goatgrass seed exposed to flaming for 1, 3, 5, 10, 30, and 60 seconds.

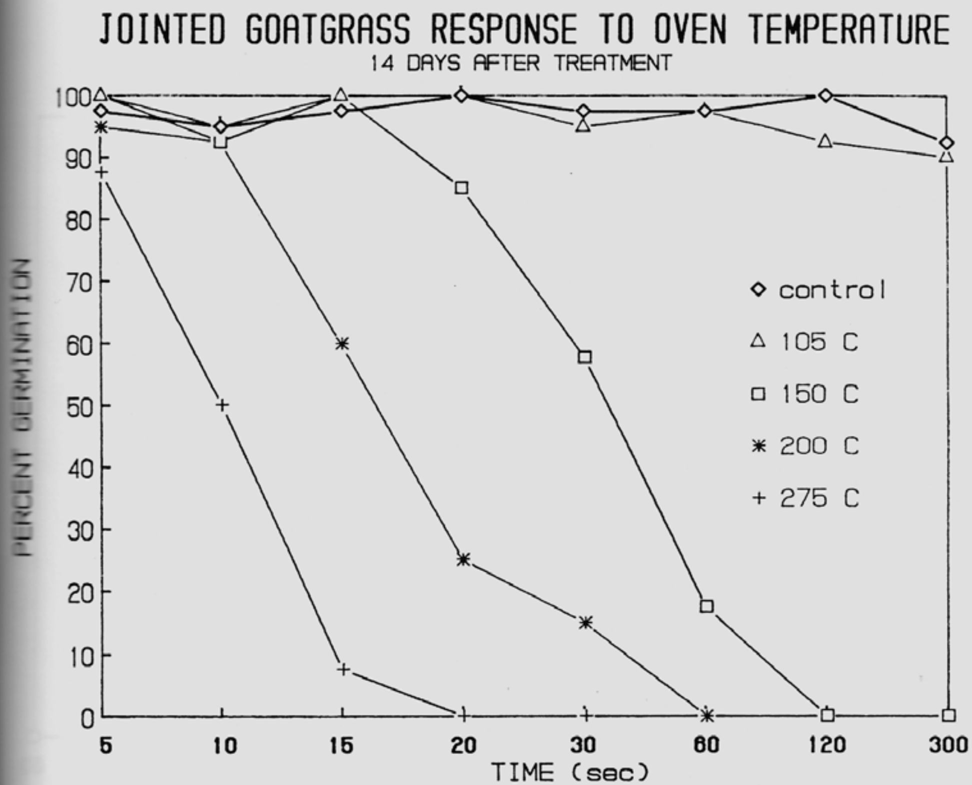

Figure 5. Germinability of jointed goatgrass seed exposed to different oven temperatures for five (5) minutes.

Results and Discussion

Germination of jointed goatgrass seed used in this study and not exposed to the bunsen burner flame was 97.5 percent. A one second exposure to the flame dropped germination to 27.5 percent. This represents a 72 percent drop in germinability of the seed tested and exposed to a flame for one second. Exposing goatgrass seed for 3 seconds to the open flame reduced germinability further to 5 percent. Jointed goatgrass seed exposed to the bunsen burner flame more than 3 seconds failed to germinate.

When jointed goatgrass seeds were exposed to heat via forced air oven exposure for differing time lengths they expressed no difference in germinability for temperatures ranging from 25°C to 105°C. Even seeds exposed to these temperatures for extended intervals (300 seconds) germinated from 90 to 100 percent. An oven temperature of 150°C dropped germinability to 85, 57.5, 17.5, 0, and 0 % for 20, 30, 60, 120, and 300 seconds respectively. At 200°C germinability dropped to 60, 25, 15, 0, 0, and 0 % for 15, 20, 30, 60, 120, and 300 seconds respectively. At 275°C germinability dropped to 87.5, 50, 7.5, 0, 0, 0, 0, and 0 % for 5, 10, 15, 20, 30, 60, 120, and 300 seconds respectively.

Jointed goatgrass germinability can be reduced by flaming for 1 second or more (Figure 4) and by oven temperatures of 150°C or more (Figure 5).

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PUCCINIA THLASPEOS A POSSIBLE BIOCONTROL AGENT FOR DYERS WOAD

B.R. Lovic, S.A. Dewey, S.V. Thomson, and J.O. Evans[1]

Introduction

Dyers woad (Isatis tinctoria) has become a serious weed problem on rangeland and cultivated crops in parts of Utah, Idaho and Wyoming. Distribution and density of the weed have increased dramatically since its introduction to the region in the early 1900's; and economic impact is currently estimated in millions of dollars.

[1]Utah State University, Logan, UT

How this species invades and dominates other vegetation types is not yet well understood, but is partly attributed to prolific seed production, and possible allelopathy. Dyers woad has now spread into many rugged and remote areas where chemical control is extremely difficult or impractical, and where biocontrol agents may be the only hope for effective control.

In May of 1978 a rust pathogen was observed by J.W. Thompson, Caribou county weed supervisor, on a few dyers woad plants in an isolated foothill canyon near Niter, Idaho. Plants infected with the rust were stunted, severely malformed, and failed to produce seed. The rust was identified as *Puccinia thlaspeos* Schubert by Dr. G.B. Cummins of the University of Arizona; and later confirmed by Dr. J.F. Hennen of the Arthur Herbarium at Purdue.

Distribution and Spread

Puccinia thlaspeos is reported as a naturally occurring rust throughout Europe and much of North America. Host species include Thlaspi, Arabis, and certain other genera within the Brassicaceae plant family. The 1978 discovery of *Puccinia thlaspeos* on dyers woad was the first reported occurrence on this host species; even though the weed occurs throughout much of the normal rust distribution range on both continents. The only known infections of *Puccinia thlaspeos* on dyers woad are within the geographical region described in this report.

Rust incidence at the original Niter location has increased from less than 1 infected plant per 100 in 1978, to an average of 44 per 100 in the spring of 1987. Rust distribution has also expanded during the past 10 years; and now diseased dyers woad plants have been found at all survey sites within a 1125 square mile area in southeastern Idaho and western Wyoming. Dyers woad was first introduced and is widely distributed in Utah, but natural infections of rust have not yet been observed there on the weed.

Dyers woad rosettes grown from Utah seed were successfully infected in a field study at Logan in 1987, after exposure to rusted plants transplanted from Idaho. The high incidence of rosette infection suggests that heterogeneity within the regional dyers woad population is not a cause for limited spread of the rust, or its absence on dyers woad in Utah.

Life Cycle

Puccinia thlaspeos is currently regarded as a collective rust species made up of several forms or races of the presently described type; ie, microcyclic (aecia and uredinia lacking), autoecious, and having systemic mycelia. The disease cycle on dyers woad includes spermogonial and telial stages which develop on infected plants either simultaneously or at irregular time intervals. Spermogonia were observed on dyers woad plants in the field, and on infected transplants grown in the greenhouse. Teliosori developed mostly on the abaxial side of leaflets, frequently completely covering the leaf surface. Mature teliosori produce numerous oblong or clavate 2-celled teliospores. Fresh teliospores germinate and produce basidiospores without dormancy at a rate of 30-40% after only 8 hours of incubation on water agar; whereas, only 10% of the teliospores collected and stored at room temperature for 12 months germinated.

Infection of meristematic plant tissues probably occurs by direct penetration of basidiospore germlings through cuticle and epidermis. The actual process and conditions required for infection still remain unknown since numerous attempts to inoculate dyers woad seedlings in the greenhouse or growth chamber have been unsuccessful. It is possible that a certain specific morphological plant growth stage is a prerequisite for infection, as reported for another rust (*Uromyces scutellatus*) with a similar life cycle (Defago, et al, Weed Sci. 33:857-860, 1985).

Symptoms and Effects

Rust symptoms typically appear first on young dyers woad rosettes in the fall or spring. Rosettes appear stunted, and central leaves are yellow and covered with emerging spermogonia and teliosori. Leaves on stems of newly bolted plants are typically small, thickened, chlorotic, and epinastic. Stems are often twisted or otherwise deformed, and stem internodes are shortened.

As plant development continues in the spring, rust sori and associated symptoms can be regularly observed on all new tissues at subsequent phases of plant growth; ie, on stems, leaves, sepals, petals, and fruits. This is a consequence of the systemic character of the disease, rather than due to secondary infections. Systemic rust diseases are uncommon; and the systemic effect of *Puccinia thlaspeos* on dyers woad is expected to greatly enhance the potential of this rust as an effective biocontrol agent.

Fruit and seed production has been completely prevented on all infected plants observed in spring and summer at the original infestation site in Idaho. This fact could be key to the potential effectiveness of the rust pathogen, since prolific seed production is the primary means of dyers woad reproduction and spread.

Summary

1- *Puccinia thlaspeos*, first discovered in Idaho on a single isolated infestation of dyers woad in 1978, has now spread naturally over approximately 1125 square miles.

2- Incidence at the original Idaho location has increased from less than 1% of dyers woad plants infected in 1978, to 44% in 1987.

3- Infected rosettes typically appear chlorotic. Bolted plants are covered with rust sori, are severely stunted, and often epinastic. Silicle development and/or seed production is normally prevented.

4- Infection of Utah dyers woad seedlings by infected Idaho transplants in field studies at USU indicates that absence of the rust in Utah is not due to environmental differences or genetic variability between woad populations.

5- Based on observations and studies conducted up to this point, we remain optimistic regarding the potential of *Puccinia thlaspeos* as an effective biocontrol agent for dyers woad.

WILD OAT AND SPRING BARLEY PLANT DENSITY AFFECTS SPRING BARLEY GROWTH AND DEVELOPMENT

L.S. Tapia, D.C. Thill, R.M. Evans and C.A. Mallory[1]

Abstract. The effect of five wild oat (*Avena fatua* L.) and five spring barley (*Hordeum vulgare* L.) plant densities on intra- and interspecific competition of both species was studied in a 1987 field experiment. Both species were seeded using an addition (Spitters) series design. The experiment was designed as a split block, split plot with four replications. Above ground plant samples were collected from a 0.25 m^2 area for growth analysis determination beginning 14 days after emergence and continued at 14-day intervals until physiological maturity of the barley. Analysis of variance and regression analysis were used to describe the relationship between dependent (growth analysis parameters) and independent (species density, species proportion, and sample times) variables. Pooled over plant density and sample times, barley plant density ranged from 0 to 427 plants/m^2. However, barley plant density was affected by wild oat plant density. Monoculture barley density was 262 plants/m^2 and averaged 225 plants/m^2 in mixture with wild oat. Barley biomass/m^2 was affected by the interaction of barley density and sample time. Barley biomass/m^2 increased with increasing barley density for the first three sample times, but not at the later sample times. Averaged over sample times increasing wild oat density decreased barley biomass. Wild oat plant density ranged from 0 to 177 plants/m^2 and was affected by barley density and by sample times. Pooled over time and density, wild oat biomass/m^2 was inversely related to barley density. Unlike barley, wild oat biomass at each sample time increased with increasing plant density.

[1]University of Idaho, Moscow, ID

GROWTH STAGING OF WHEAT, BARLEY AND WILD OAT; A STRATEGIC STEP TO TIMING OF FIELD OPERATIONS

J.E. Nelson[1], K.D. Kephart[2], A. Bauer[3] and J.F. Connor[1]

Abstract. Profitable small grain production requires that growers have a thorough knowledge of crop growth and development, and how cultural and environmental factors can influence crop development. Both crops and weeds respond to inputs, such as fertilizers, pesticides, plant growth regulators, and supplemental irrigation depending on the stage of growth. Improving application timing may reduce chemical or fertilizer effectiveness, and, in some cases, result in crop injury and yield loss.

[1]Montana State University, Bozeman, MT
[2]University of Idaho, Moscow, ID
[3]USDA/ARS Northern Great Plains Research Lab, Mandan, ND

A publication was developed to help growers understand wheat, barley, and wild oat development and growth. The primary target audience for the publication is growers, agri-chemical dealers, agri-chemical company salesmen, crop consultants and extension personnel. A field staging procedure and detailed descriptions and color photographs of small grain and wild oat development stages are included in the publication. The staging procedure includes sections on how to select, handle and stage plants using an easy-to-use field staging form. Standard development stage scales (Feekes, Zadoks, Haun) and recommendations for pesticide and growth regulator application timing can be applied to this staging method.

Special thanks is extended to American Cyanamid Company for assistance and support in the production of this publication.

EFFECT ON NUT SET OF PRE-BLOOM APPLICATIONS OF PPG-1721 ON SOFT- AND HARD-SHELL ALMOND VARIETIES

T.C. DeWitt and W.D. Edson[1]

Abstract. Soft-shell (Nonpariel) Almonds: PPG-1721-03 {3,6-dichloro-2-methoxy,2-ethoxy-1-methyl-2-oxoethyl ester} was evaluated at several rates for enhancement of nut set and yield on Nonpariel almonds. Treatment timing occurred during pre-bloom on February 10, 1987. Treatment rates were 0 (water control), 25, 50, 100 and 200 ppm and were applied with a handgun at 400 gallons per acre.

Final nut set data was taken on June 2, 1987 from 400 blossoms per tree. Statistical differences in nut set were observed between rates. The most efficacious treatment for enhanced nut set was 100 ppm. Nut set was increased by 26.3% over the untreated control. Harvest data was taken on August 8, 1987 by collecting a 100 nut sample from each single tree replicate. Analysis of the data for nut weight, kernel weight, blanks and shellout indicated that there were no statistical differences between treatments.

Hard-shell (Peerless) Almonds: PPG-1721-03 was evaluated at several rates for enhancement of nut set and yield of Peerless almonds. Treatment applications were timed to coincide with pre-bloom (February 20, 1987). All treatments were applied with a handgun sprayer at 400 gallons per acre. Treatment rates were 0 (water control), 25, 50, 100 and 200 ppm.

Nut set evaluations were taken on May 13, 1987 by scoring the number of set nuts per 100 blossoms in each quadrant of the tree. Analysis of data for PPG-1721-03 indicated that there were significant differences in nut set from the 100 and 200 ppm rates. When compared to the control, there was a 19% to 23% increase in set. Harvest of this trial was completed on September 20, 1987 by evaluating a 100 nut sample for kernel size, blanks and crackout for each single tree replicate. Analysis of the harvest data indicated that there were no differences between treatments and the control.

In summary, nut set data taken after the completion of "June drop" resulted in significant increases in set in both trials. The rate response for the soft-shell variety appeared to be lower than the response curve of the hard-shell variety. The range of rate response for the soft-shell

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[1]PPG Industries, Inc., Pittsburgh, PA

variety was 50 to 100 ppm (21% to 26% increase), while the hard-shell variety was 100 to 200 ppm (19% to 23% increase). Evaluation of nut and kernel size indicated that there was not a reduction in kernel size in either trial.

The information from these trials indicates that PPG-1721 is effective in enhancing nut set and subsequent yield in almonds. Nut and kernel size were not reduced regardless of rate of application or almond variety. Total per acre yield data was not taken in either trial due to an insufficient number of replicates.

THE EFFECT OF MINERAL NUTRITION AND THE RESPONSE OF TREES AND VINES TO SOIL APPLIED HERBICIDES

A.H. Lange[1]

Abstract. In general very safe herbicides have only occasionally been observed to be phytotoxic to commercial crops. However, unseen phytotoxicity may occur because commercial application rarely have untreated checks. Furthermore, even in field experiments weedy check and sometimes hand weeded check causes more growth reduction than the phytotoxicity from the herbicides. Occasionally in commercial usage, however, the phytotoxicity has been unexpectedly excessive. Sometimes these unexpected reactions are due to unusual environmental effects like excess rainfall, low or high temperatures, disease, nematodes, etc. Not infrequently, exceptionally low organic matter has proven to be the problem. In a few documented instances mineral imbalance has appeared to be the predominant factor.

In a large number of uniform trials done over a number of years evaluating the effect of simazine on trees and vines in California soils there appeared to be a definite relationship between high salt levels in the soil and phytotoxicity from simazine. There also appeared to be some definite variety responses both to salt, simazine and the interaction.

It is likewise reasonable to assume that mineral deficiency could cause an interaction with an herbicide normally safe in a soil with balanced nutrition. This nutrient deficiency could be incipient and only became apparent when a root-affecting herbicide is added to the soil environment. Some of the experiences with herbicides and mineral imbalances are discussed in this exhibit. The whole area of mineral nutrition and tree response is worthy of considerable future research.

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[1]University of California, Kearney Agricultural Center, Parlier, CA

HERICIDAL CONTROL OF TALL LARKSPUR (*Delphinium occidentale* (S. Wats.) S. Wats.)

L.V. Mickelsen and M.H. Ralphs[1]

Abstract. Field studies were conducted at two different mountain sites to determine the efficacy of several herbicides to control tall larkspur (*Delphinium occidentale* (S. Wats.) S. Wats.). The herbicides included picloram {4-amino-3,5,6-trichloro-2-pyridinecaboxylic acid}, clopyralid {3,6-dichloro-2-pyridinecarboxylic acid}, triclopyr {3,5,6-trichloro-2-pyridinyl)oxy]acetic acid}, glyphosate {N-(phosphonomethyl)glycine}, metsulfuron {2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl]benzoic acid}. The herbicides were applied at three different rates in a randomized block design, and replicated three times at each site. Measurements taken included foliar cover, density, stem numbers and root mortality. Density results indicated that clopyralid at 1.1, 2.2 and 4.5 kg ae/ha reduced larkspur by 0, 28 and 39% respectively. Picloram at 1.1, 2.2 and 4.5 kg ae/ha reduced larkspur by 0, 51 and 80% respectively. Triclopyr at 2.2, 4.5 and 9.0 kg ae/ha reduced larkspur by 31, 64 and 89% respectively. Metsulfuron at 3.5, 8.6 and 13.8 g ai/ha reduced larkspur by 41, 65 and 82% respectively. Metsulfuron at 3.5, 8.6 and 13.8 g ai/ha reduced larkspur by 41, 65 and 82% respectively. Glyphosate at 2.2, 4.5 and 6.7 kg ae/ha reduced larkspur by 97, 97 and 100% respectively. Grass production increased under all treatments with the exception of the glyphosate plots and the picloram plots at 4.5 kg ae/ha. Forbs and shrubs decreased in all treatments. Further research is now underway to determine optimum rates and application methods of triclopyr, metsulfuron and glyphosate.

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[1]USDA/ARS Poisonous Plant Research Lab., Logan, UT

SINGLE AND REPETITIVE PICLORAM TREATMENTS ON LEAFY SPURGE AND RESULTING CHANGES IN SHOOT DENSITY, CANOPY COVER, FORAGE PRODUCTION AND UTILIZATION BY CATTLE

David Hein, Harold P. Alley, Stephen D. Miller and Mark A. Ferrell[1]

Abstract: Leafy spurge (*Euphorbia esula* L.) infestations in rangeland grazing sites present a deterrent to grazing of usable forage by cattle and significantly reduce forage production and utilization.

This research was conducted near Grassrange, Montana on a cool season native range site using a randomized complete block with split-block design and four replications. Plots measuring 16 by 70 ft were treated in May of 1985 with rates ranging from 0.25 lb ai/A to 2.0 lb ai/A. Retreatments of 0.5 lb ai/A were applied to selected plots in May of 1986 and 1987.

Comparison of % control of leafy spurge to utilization of forage by cattle in single treatment plots showed a good correlation (r=0.86). The

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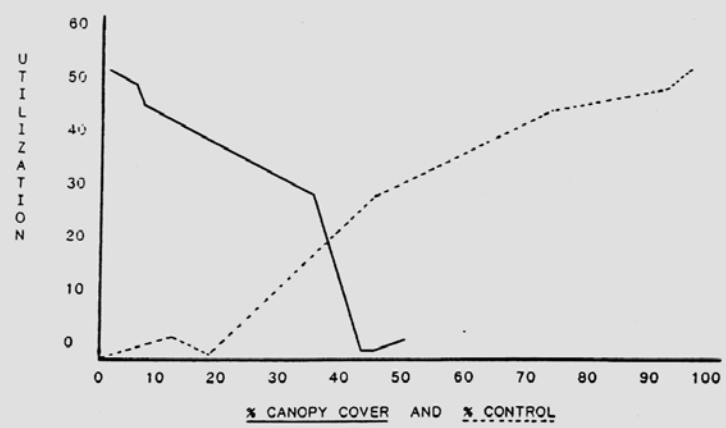
[1]Department of Plant Soil and Insect Sciences, University of Wyoming, Laramie, WY

correlation between spurge canopy cover and utilization was also good (r=-0.79). These data indicate a significant decrease in utilization of native grasses by cattle with increase in leafy canopy cover and an increase in % control.

Leafy spurge % canopy cover, % control and % utilization



[1]Dept. of Plant Soil and Insect Sciences, Univ. of Wyoming, Laramie, WY

MOW/FERTILIZATION TREATMENTS AND THEIR EFFECT ON LEAFY SPURGE (EUPHORBIA ESULA) CONTROL WITH HERBICIDES

Kevin A. Madsen and Stephen D. Miller[1]

Abstract. Leafy spurge has spread throughout southern Canada and the northern United States. Wyoming alone has over 19,000 ha of leafy spurge infested land, most of which is rangeland. Because leafy spurge is difficult to control with herbicides alone, research was conducted to evaluate the influence of mowing and/or fertilization treatments on herbicide effectiveness.

[1]Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, Wyoming 82071

Main-plot mow/fertilizer treatments included different timings of mowing followed by different timings of herbicide treatment combined with fertilization or no fertilization in the fall. Picloram {4-amino-3,5,6-trichloro-2-pyridinecaboxylic acid} at 1.1 kg/ha provided the greatest control of leafy spurge regardless of main-plot treatment based on both stem numbers and ocular yield of leafy spurge. No herbicide treatment reduced grass yield, however, grass yields were increased by fertilization in all cases. Mow/fertilizer treatments influenced leafy spurge numbers prior to spring herbicide application.

Introduction

Chemical control of leafy spurge is difficult since it has a deep and extensive root system with numerous root buds which serve as a means of vegetative reproduction (3, 7, 9). Many of the root buds remain dormant, and this combined with viable seed reserves in the soil make chemical control difficult with single applications.

Considerable research has been conducted to improve herbicide effectiveness on leafy spurge. Several studies have been conducted to increase herbicide translocation to the root buds, through clipping/mowing, addition of nitrogen and the use of growth regulators (1, 4, 5, 6, 8). In addition, studies have been published on the effect of mowing on herbicide effectiveness (2), however, no research has combined mowing, fertilization and herbicide treatments in one study. The mow/fertilization study was initiated to evaluate the interaction of mowing, fertilization and herbicide treatment on leafy spurge control.

Materials and Methods

Three field studies were established in 1986 in the northeast corner of Wyoming, NW of Sundance. The mow/fertilization study and the mow-June/spray August study were located on a high density stand of leafy spurge (~160 stems/m^2) while the fertilization/no fertilization study was located on a low density stand of ~40 stem/m_2.

The experimental design for the mow/fertilization study was a randomized complete block with a split-plot arrangement with four replications. The main plot treatments were: mow-June, with or without fertilizer; mow-July, with or without fertilizer; fertilizer only, and a non-mowed or fertilized check. The sub-plot herbicide treatments were: picloram at 0.56 and 1.1 kg ai/ha, fluroxypyr {4-amino-3,5-dichloro-6-fluro-2-pyridyloxy acetic acid} at 0.28 and 0.56 kg ai/ha, 2,4-D LVE at 4.48 kg ae/ha, dicamba {3,6-dichloro-2-methoxybenzoic acid} at 2.24 kg ae/ha and a non-treated control.

Individual sub-plots were 2.7 by 9.1 m. Soil samples were taken to determine a fertilization recommendation for a 4.5 mg/ha dryland hay crop. All of the fertilization was done in the fall with a Gandy fertilizer spreader applying 105 kg/ha N and 56 kg/ha P_2O_5 on September 19, 1986. Mowing was done with a brush-hog type mower to a height of 8 to 10 cm. 1986 herbicide treatments were applied with a six-nozzle knapsack type sprayer delivering 180 L/ha at 276 Kpa.

The mow-June and mow-June + fertilizer treatments were mowed at the flowering to soft-dough stage of leafy spurge on June 25, 1986. Herbicide treatments were applied July 24, 1986. Leafy spurge was in the vegetative stage with an average height of 9 cm and lateral growth of 15 cm.

An area adjacent to the above plot area which was also mowed on June 25, 1986, was sprayed on August 24, 1986. The leafy spurge was in the flowering to seed-fill stage at the time of herbicide treatment with an average height of 15.5 cm and lateral growth of 9.5 cm. This mow-June/spray August study was a randomized complete block with four replications.

The mow-July and mow-July + fertilizer plots were mowed July 24, 1986 (approximately two weeks after leafy spurge seed dehiscence). The application of the herbicide treatments was postponed until the spring of 1987 because of the lack of fall regrowth.

A third field experiment was established September 19, 1986, on an area adjacent to the mow/fertilization study. The experimental design was a randomized complete block with a split-plot arrangement with four replications. The main plot treatments were fertilization vs. no fertilization. The herbicide treatments were applied in the spring of 1987. The fertilization and herbicide treatments were the same as described in the mow/fertilization study.

In all experiments two permanently marked 0.37 m^2 quadrats were counted per sub-plot initially and also in the spring and one year after herbicide treatment. Visual (ocular) evaluations of leafy spurge and grass yield were taken at peak vegetative production. Only perennial grasses were included in grass yield estimation and consisted primarily of <u>Agropyron intermedium</u> and <u>Poa pratensis</u>.

<u>Results and Discussion</u>

Long-term control of leafy spurge can only be properly assessed the year following treatment. At this time only herbicide applications in the mow-June treatments can be evaluated for long-term leafy spurge control.

Grass yield was increased 24% with fertilization in the mow-June treatments while leafy spurge yield was not significantly influenced by fertilization (Table 1). Further leafy spurge yield was similar in the mow-June treatments regardless whether herbicide treatments were applied in July or August (Table 1). Picloram at 1.1 kg/ha was the only treatment which reduced leafy spurge yield (Table 2). In the mow-June/spray August study all herbicide treatments, except picloram at 1.1 kg/ha and fluroxypyr at 0.56 kg ai/ha, tended to increase leafy spurge yield. Further, picloram at 1.1 kg/ha was the only herbicide treatment which significantly reduced leafy spurge stem numbers the year following herbicide treatment. The reduction in leafy spurge stem numbers was 350% and 467% in the mow-June spray July or mow-June spray August treatments, respectively. In the mow-June/spray August study, all herbicide treatments tended to decrease leafy spurge stem numbers, whereas, with the mow-June spray July treatments, several treatments tended to increase stem numbers; i.e. fluroxypyr at 0.56 kg/ha and 2,4-D at 4.48 kg/ha.

Grass yields were over 20% higher when fertilization was applied after the June mowing (Table 1). In the fertilization/no fertilization study grass yields were increased 39% by fertilization without influencing leafy spurge yield (Table 3); the reason for the greater grass response to fertilization in this study cannot be attributed to the absence of mowing alone since it also had a lower leafy spurge density.

Table 1. Influence of mow or mow/fertilization treatments on leafy spurge and grass yield when averaged over herbicide treatments in 1987.

	MOW-JUNE	MOW-JUNE + FERTILIZATION[1]	MOW-JUNE/ SPRAY AUGUST
	---(% yield)---		
Leafy Spurge Yield	95	100	95
Grass	76*	100	79

[1]Yield of this treatment was used as the basis to compare other yields (100%). *Significant from fertilization at p=0.072, F-test.

Herbicide treatments did not significantly reduce grass yields (Table 2). But, only picloram at 1.1 kg/ha tended to increase grass yields when applied in July. All herbicide treatments applied in August tended to decrease grass yields; especially dicamba at 2.24 kg/ha.

Table 2. Leafy spurge and grass response to herbicide treatments in 1987.

(kg/ha	Pic. (0.56)	Pic. (1.1)	Flur. (0.28)	Flur. (0.56)	2,4-D (4.48)	Dic. (2.24)
	---(% change from the control)---					
	MOW-JUNE/SPRAY JULY					
Leafy Spurge Yield	- 6	- 46[1]	+ 2	+ 4	- 16	+ 6
	MOW-JUNE/SPRAY AUGUST					
	+ 10	- 10	+ 11	- 6	+ 16	+ 13
	MOW-JUNE/SPRAY JULY					
Grass Yield	- 8	- 4	- 5	+ 1	- 2	- 9
	MOW-JUNE/SPRAY AUGUST					
	- 3	- 16	- 9	- 14	- 11	- 28
	MOW-JUNE/SPRAY JULY					
Change in Stem Counts	-133	-350[2]	-133	+ 50	+100	- 83
	MOW-JUNE/SPRAY AUGUST					
	-144	-467[1]	-144	-111	-211	-200

[1]Significant at Student-Newman-Keul's Test, ALPHA = .01; [2]LSD (0.10) = 291

The influence of mow/fertilization treatments on control of leafy spurge with spring applied herbicide treatments will be assessed in the spring of 1988. However, mow/fertilization treatments significantly influenced leafy spurge stem numbers prior to herbicide treatments in the spring of 1987 (Table 4). The mow-July + fertilization treatment increased leafy spurge stem numbers by 95/m^2 from fall to spring, while the non-mowed or fertilized check increased stem numbers by only 24/m^2, nearly a 400% difference. The mowing and fertilization treatments only were similar in their effect on leafy spurge stem numbers and were intermediate between the combination and check treatment. Hunter et al. (4) saw two advantages to increasing stems: the number of dormant buds from which regrowth can occur is reduced and there is a greater amount of foliage to intercept the herbicide.

Table 3. Leafy spurge and grass response to fall fertilization in the fertilization/no fertilization study in 1987.

	Fertilization[1]	No-Fertilization
	--------------(% Yield)--------------	
Leafy Spurge Yield	100	94
Grass Yield	100	61*

[1]Yield of this treatment was used as the basis to compare other yields (100%). *Significant at p=.002, F-test.

Table 4. Influence of mow-July and/or fertilization treatments on leafy spurge stem numbers prior to spring herbicide treatment in 1987.

Treatment	Increase in stem # from[1] 8/12/86 to 5/19/87
	(#/m^2)
Mow-July + fertilization	95[a]
Fertilization only	65[b]
Mow-July	60[b]
No mow and/or fertilization	24[c]

[1]Means followed by same letters are not significantly different (Student-Newman-Keul's Test, ALPHA= .01). Original stand had ~160 stem/m^2.

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LEAFY SPURGE CONTROL NEAR TREES AND WATER

Rodney G. Lym, Calvin G. Messersmith and Orval R. Swenson[1]

Abstract: Leafy spurge (Euphorbia esula L.) is difficult to control with herbicides near trees or open water such as ponds, ditches and rivers because of potential damage to desirable vegetation or water contamination. However, these areas are a constant source of seed for infestation of nearby and downstream areas if no control measures are initiated. The purpose of these experiments was to evaluate several herbicides for both leafy spurge control and injury to desirable vegetation.

[1]Department of Agronomy, North Dakota State University, Fargo, ND

Three experiments for leafy spurge control under trees were established in a shelter belt located in a waterfowl rest area near Valley City, ND. The plots were located in a dense stand of leafy spurge growing under mature ash (Fraxinus spp.) and elm (Ulmus spp.) trees that had been planed 5 ft apart in 12-ft rows. The herbicides were applied either with a hand-held single-nozzle sprayer delivering 40 gpa or with the controlled droplet applicator (CDA) which applied approximately 4 gpa. The treatments were applied when leafy spurge was in the yellow bract to flowering growth stage, seed-set or post-seed set growth stages.

Initial leafy spurge control was poor (<40%) when glyphosate {N(phosphonomethyl)glycine} was applied alone, regardless of rate or treatment date. Control improved to over 90% 12 months after treatment (MAT) following a June but not September application. Grass injury was nearly 100% with all glyphosate treatments.

Sulfometuron {2-[[[[(4,6-dimethyl-2-pyrimidinyl)amino]carbonyl]amino]-sulfonyl]benzoic acid} at 2 oz/A or less alone did not control leafy spurge satisfactorily (<10%). However, control 12 MAT increased by an average of 10 and 35% when applied with glyphosate in the spring and fall, respectively, compared to glyphosate alone. Leafy spurge control 12 MAT averaged 97% with sulfometuron + 2,4-D {(2,4-dichlorophenoxy)acetic acid} at 1 or 2 + 17 oz/A but grass injury was over 50%. Picloram {4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid} applied with the CDA at a picloram (Tordon 22K):water concentration of 1:7 (v,v), provided nearly 100% leafy spurge control with no grass injury. Several ash trees had some leaf curling but no visible permanent damage from this treatment.

An experiment to evaluate leafy spurge control with herbicides that can be used near water was established along a ditchbank in Fargo, ND. Amitrole (1H-1,2,4-triazol-3-amine) at 4 lb/A provided 91 and 95% leafy spurge control 12 and 15 MAT, respectively, but there was 64% grass injury. Increasing the application rate of 8 lb/A increased grass injury but not leafy spurge control. Unfortunately, amitrole is no longer labeled for use near water. Fosamine {ethyl hydrogen(aminocarbonyl)phosphonate} at 8 lb/A provided 90% leafy spurge control 12 MAT but also 57% grass injury. Fosamine applied at lower rates provided unsatisfactory control (<50%) and evaluations varied considerably from plot to plot indicating this herbicide may provide inconsistent control.

An experiment to determine the surface movement of sulfometuron applied to a sloped area was established near Valley City and Dickinson, ND. Sulfometuron was applied at 2 oz/A (125 ppbw) to natural slopes of 0 to 2%, 6 to 8% and 14 to 16%. Movement of sulfometuron was minimal ($\leq$ 0.1 ppbw) on the 0 to 2% and 6 to 8% slopes 12 MAT. Movement of sulfometuron was greatest on the 14 to 16% slope at Dickinson, but the highest concentration detected still was less than 1 ppbw.

CHLORSULFURON AND METSULFURON EFFECTS ON MUSK THISTLE VIABLE ACHENE PRODUCTION

K. George Beck, M. Ann Henson and Robert G. Wilson[1]

Abstract. Experiments were conducted in 1987 at Scottsbluff, NE, Longmont and Kremmling, CO to assess the effects of chlorsulfuron {2-chloro-N-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]benezenesulfonamide] and metsulfuron {2[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]-amino]sulfonyl]benzoic acid} on musk thistle (*Carduus nutans* L.) achene production and viability. The experimental design was a randomized complete block in a split block arrangement with application timing as main blocks and herbicide rates as sub-plots and replicated three times. Chlorsulfuron was applied at 13, 26 and 53 g/ha and metsulfuron at 10 and 21 g/ha. Herbicides were applied in spring and summer when musk thistle plants were in the rosette, bolting, bud, early-bloom and mid-bloom growth stages. Ten terminal and lateral inflorescences were harvested from each plot before achene dissemination. Achenes were cleaned from inflorescences in the laboratory and separated into four weight classes by density using a South Dakota seed blower by the method of McCarty. Achenes in classes III and IV were weighed, examined under a dissecting microscope for the presence of an embryo, then subjected to tetrazolium analysis for viability.

Treatments (all rates and timings of chlorsulfuron) that produced zero achenes and zero viability were separated from the statistical analysis, and a 95% confidence interval for the Poisson mean was determined. Other data (both metsulfuron treatments and non-treated controls) were subjected to analysis of variance and pairwise comparisons of the two metsulfuron rates within an application timing conducted.

Chlorsulfuron at all rates and application timings completely inhibited musk thistle achene production and viability. Both metsulfuron treatments reduced achene weight and viability at all application timings compared to non-treated controls. Mean achene weight in terminal inflorescences was less with metsulfuron at 10 g/ha than at 21 g/ha in the rosette, bolting, bud and early-bloom timings whereas achene weight was less with metsulfuron at 21 g/ha at the mid-bloom application. No differences for achene weight in lateral inflorescences occurred between metsulfuron rates at the rosette, bolting, bud or early-bloom application timings; however, metsulfuron at 21 g/ha caused lower achene weight at the mid-bloom timing than metsulfuron at 10 g/ha. No differences occurred for percent achene viability in terminal and lateral inflorescences between metsulfuron rates at the rosette, bolting, bud and early-bloom application timings; however, metsulfuron at 21 g/ha caused lower percent viability at mid-bloom application than metsulfuron at 10 g/ha. Chlorsulfuron and metsulfuron show good potential to broaden the spring herbicide application timing window to prevent or reduce musk thistle achene production and viability.

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[1]Department of Plant Pathology and Weed Science, Colorado State University, Ft. Collins, CO; E.I. DuPont De Nemours & Co., Longmont, CO; and Department of Agronomy, University of Nebraska, Scottsbluff, NE, respectively

TOXICOLOGICAL INVESTIGATIONS ON ANNUAL GOLDENEYE (VIGUIERA ANNUA) AND RUBY VALLEY POINTVETCH (OXYTROPIS RIPARIA)

M.C. Williams and R.J. Molyneux[1]

Abstract. Annual goldeneye (*Viguiera annua* (M.E. Jones) Blake) is a poisonous member of the Asteraceae indigenous to Texas, New Mexico, Arizona and southern Utah. The poisonous principle was unknown. Ruby Valley pointvetch (*Oxytropis riparia* Litv.) is an introduced legume that is being investigated as a potential forage species for rangeland.

Annual goldeneye and Ruby Valley pointvetch were analyzed for cyanide, soluble oxalates, nitro compounds, alkaloids and nitrates. Ruby Valley pointvetch was analyzed for swainsonine, a loco-causing compound and fed to 1-week-old chicks at 1% of body weight for five days. Annual goldeneye was investigated for its capacity to accumulate nitrates when grown in Hoagland's nutrient solution or when grown in the greenhouse and in the field in soil fertilized with ammonium nitrate at 220 kg N/ha.

Both species tested negative for cyanide, soluble oxalates, nitro compounds and alkaloids. Ruby Valley pointvetch tested negative for swainsonine and was nontoxic to 1-week-old chicks. Annual goldeneye accumulated potentially lethal concentrations of nitrates (in excess of 1.5% dry weight, expressed as KNO_3) when grown in nutrient solution (4 to 5%) and when fertilized with ammonium nitrate in the greenhouse (3 to 4%) and in the field (2 to 3%). Annual goldeneye collected in the field on soil heavily contaminated with cattle manure contained 4.7% nitrate. Annual goldeneye may accumulate toxic concentrations of nitrates if it grows near water tanks, ponds, salt licks and along frequently used trails where unusually high accumulations of animal waste provide abundant available nitrogen.

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[1]USDA/ARS, Logan, UT and Albany, CA

WATER RELATIONS IN CANADA THISTLE IN RESPONSE TO SOIL WATER LIMITATION

Manette Schönfeld and Lloyd C. Haderlie[1]

Abstract. Canada thistle (*Cirsium arvense* (L) Scop.) is a noxious and very persistent weed in the Northern United States. Continuous vigilance in management is needed to limit the damage and spread, which takes place both through seed and through fragmentation of the extensive root system. Several herbicides show reduced effectiveness when applied under conditions of drought stress. The first phase of our research, which we presently report, was aimed at characterizing the physiological and morphological response of Canada thistle to soil water limitation.

Canada thistle plants were raised from seed and transplanted to plastic pots in the greenhouse containing approximately 3 kg Declo fine loam soil.

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[1]University of Idaho, Dept. of Plant, Soil and Ent. Sci. Aberdeen, ID

Table 1. Water relations of Canada thistle plants, grown at three different watering levels (well watered, medium stress, and severe stress). Data are means of 8 replications at each of 2 harvest dates.

Watering level	WP[†]	SP	TP	RWC	g_sH_2O	T
Well-watered	-0.91 a[§]	-1.42 a	0.51 a	86.7 a	0.65 a	5.32 a
Medium stress	-1.18 b	-1.70 b	0.52 a	82.8 b	0.43 b	3.42 b
Severe stress	-1.35 b	-1.87 c	0.52 a	82.6 b	0.41 b	3.22.b

[†]WP: leaf water potential; SP: solute potential; TP: turger potential; RWC: leaf relative water content; g_sH_2O: stomatal conductance to water; and T: transpiration.

[§]Means within a column followed by the same letter are not different at the 5% level of signifiance.

Table 2. Morphology and dry matter production of Canada thistle plants, grown at three different watering levels (well-watered, medium stress, and severe stress). Data are means of 8 replications at each of 2 harvest dates.

Watering level	Height --cm--	Branches	Shoots	Shoot weight -----g/plant-----	Root weight	Root:shoot ratio
Well-watered	11.62 a[†]	6.3 a	5.9 a	6.54 a	6.67 a	1.03 a
Medium stress	8.09 b	2.5 b	2.6 b	3.26 b	4.17 b	1.31 b
Severe stress	7.13 b	2.0 b	3.9 ab	2.22 c	2.79 c	1.23 ab

[†]Means within a column followed by the same letter are not different at the 5% level of signifiance.

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The experimental design was a randomized complete block with eight replications, and the experiment was repeated twice, with one harvest in August and one in January. When the plants were well established, three watering treatments were started and maintained gravimetrically. The watering levels were: well watered, rewatered to 85% of pot water holding capacity (PC); medium stress, rewatered to 45% PC; and severe stress, rewatered to 30% PC. After four weeks of stress treatment, the experiment was finished. Stomatal conductance to water (g_sH_2O) and leaf transpiration (T) were measured on a young, fully developed leaf on the main stem with a Li-1600 steady state porometer. Leaf water potential (WP) and its components, solute potential (SP) and turgor potential (TP) were then determined on the same leaf, using Wescor leaf cutter psychrometers. After that, the same leaf was used to determine the relative water content (RWC). Subsequently, morphological parameters were determined: plant height, number of branches on the main stem and number of shoots from the roots. Finally dry weight of the above ground and the below ground plant parts was determined, and the root:shoot ratio calculated.

All water relations parameters, except the turgor potential, decreased with increasing stress (Table 1). The difference between the medium and severe stress levels was significant for SP. It is remarkable how well Canada thistle maintained its turgor, apparently through a combination of osmotic adjustment and stomatal closure. The effect of these stress levels on morphology and yield was significant for each parameter investigated (Table 2). Stress reduced plant height, number of branches and shoots and dry weight for both shoots and roots. However, size and dry matter production do not have the same importance in a weed as in a crop plant, and survival is the main strategy. The root:shoot ratio was higher in stressed than in well-watered plants.

DIFFERENTIAL TOLERANCE OF CORN INBREDS TO DPX-M6316

C.V. Eberlein, J.L. Geadelmann, T.L. Miller and K.M. Rosow[1]

Abstract. DPX-M6316 {3-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]-carbonyl]amino]sulfonyl]-2-thiophenecarboxylic acid} is a sulfonylurea herbicide that has shown potential for postemergence broadleaf weed control in corn (*Zea mays*). Ten corn inbred lines, representing widely used germplasm families, were evaluated for tolerance to DPX-M6316 in field studies at two Minnesota locations. DPX-M6316 at 0, 32 or 64 g/ha plus surfactant (X-77) at 0.25% (v/v) was applied when inbreds were at the three- to four-leaf stage. Injury ranged from 0 to 94% among inbreds, and yields were reduced to 0 to 96% when compared to the untreated controls. Three inbreds, A619, A641 and ND246 were highly susceptible to DPX-M6316, and three inbreds, A671, A632 and B73 were tolerant. Four inbreds, MO17, A654, CM105 and W153R were intermediate in tolerance. Laboratory studies on the mechanism of differential tolerance have shown that acetolactate synthase (ALS) in tolerant A671 and susceptible A619 was highly susceptible to inhibition by DPX-M6316. In preliminary studies, I_{50} values for ALS inhibition by DPX-M6316 were 12.5 nM for A619 and 20.9 nM for A671. DPX-M6316 metabolism was more rapid in A671

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[1]University of Minnesota and Holden's Foundation Seeds, St. Paul, MN

than in A619, with 94% of the DPX-M6316 metabolized within 11 hours in A671, but only 36% metabolized within the same time period in A619. Considering the susceptibility of ALS to inhibition by DPX-M6316, differential metabolism appears to be the major mechanism involved in the tolerance of A671 and the susceptibility of A619 to DPX-M6316.

GERMINATION RESPONSE OF GALIUM SP. TO TEMPERATURE, NITRATE, GIBBERELLIC ACID AND SOIL MATRIC POTENTIAL

T.J. Fritz, F.L. Young and R.E. Whitesides[1]

Abstract. Three germination studies were conducted on accessions of *Galium* sp. to determine their germination response to temperature, nitrate (NO_3), gibberellic acid (GA_3) and soil matric potential. Seeds were obtained from three accessions; one each from eastern WA, western OR and Nottingham, England. All three accessions were used in the temperature and soil matric studies, whereas only the WA accession was used in the NO_3-GA_3 study. A completely randomized design with two factors and four replications was used in all studies. The temperatures used in both the temperature and the NO_3-GA_3 studies were 2.5, 5, 10, 15, 20, 25, 30, 35 and 40 C. For the temperature study, 50 seeds of each of the three accessions were placed in petri dishes containing germination paper and 5 ml of a $5X10^{-2}$ M KNO_3 + $4X10^{-4}$ M GA_3 solution. The WA and OR accessions germinated best at 10 C, whereas the England accession germinated best at either 10 or 15 C. All accessions germinated at 2.5 C, whereas the highest temperatures that germination occurred were 15 C for the OR accession and 30 C for the WA and England accessions. In the NO_3-GA_3 study, 50 seeds of the WA accession were placed in petri dishes containing 5 ml of one of the following solutions: $5X10^{-2}$ M KNO_3; $4X10^{-4}$ M GA_3; $5X10^{-2}$ M KNO_3 + $4X10^{-4}$ M GA_3; and deionized H_2O. Compared to deionized water, both the NO_3 and NO_3 + GA_3 solutions increased germination similarly, whereas GA_3 alone had little effect on germination. In the soil matric potential study, the three accessions were germinated at 10 C in soil with matric potentials of: 0, -33, -100, -300, -600 and -900 KPa. Twenty-five seeds were placed firmly on the surface of 30 g of soil with the appropriate matric potential established in each petri dish. All accessions germinated rapidly at -33 and -100 KPa. However, germination did occur at all matric potentials for all accessions, with the England accession being the least sensitive and the WA accession being the most sensitive to decreasing soil matric potentials.

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[1]Washington State University, Pullman, WA; USDA/ARS, Pullman, WA; Utah State University, Logan, UT

ROOTING DEVELOPMENT AND ITS RELATIONSHIP TO SHOOT GROWTH IN JOINTED GOATGRASS (AEGILOPS CYLINDRICA)

P.A. Dotray and F.L. Young[1]

Abstract. A greenhouse experiment was conducted to compare the time and pattern of development of jointed goatgrass (*Aegilops cylindrica* Host roots to winter wheat (*Triticum aestivum* L.) roots. Plants from both species were harvested every 1200 growing degree hours (50 growing degree days), from germination to the 8.0-leaf stage of growth, based on the Haun scale. At each harvest, new root development of both species was examined and related to shoot growth. Comparisons between species were based on a model which described root nomenclature and the relationship between root and shoot development in winter wheat. The timing of development of each root axes with respect to shoot development of jointed goatgrass was similar to the production of roots in winter wheat and the wheat model, using the numbering and quadrant systems derived in the model. The numbering system for root nodes is derived from the leaf number which was produced at that node, whereas the quadrant system describes the pattern of growth with respect to the main axis. Based on these wheat model systems, the seminal roots of jointed goatsgrass which commonly appeared were R, -2A, -2B and either -1A or -1B. In contrast, the seminal roots of winter wheat that usually appeared were R, -2A, -2B, -1A, -1B, -1X and sometimes -1Y. Jointed goatgrass plants did not produce a coleoptilar tiller (TO) and, therefore, the only roots at this node were the OA and OB roots. In comparison, winter wheat usually produced a coleoptilar tiller, where additional OX and OY roots developed at node 0. Within each species, roots appear at each crown node about the same time the respective tiller appears, which is about three phyllochrons (3-leaf stages) after the appearance of the leaf from that node. In winter wheat, plants develop two pairs of roots (AB and XY) at each crown node and within each pair, the roots develop simultaneously. In jointed goatgrass, one of the roots of each pair is often missing or development is delayed. Compared to jointed goatgrass, winter wheat had a greater shoot to root dry weight ratio and twice as much leaf area. However, the total root length and tiller number were the same for both species.

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[1]Washington State University, Pullman, WA and USDA-ARS, Pullman, WA

INTERFERENCE BETWEEN YELLOW STARTHISTLE AND PUBESCENT WHEATGRASS

T.S. Prather and R.H. Callihan[1]

Abstract. Yellow starthistle (*Centaurea solstitalis* L. infests rangelands in Idaho where perennial grasses have been depleted. Intensive control is difficult and generally uneconomical. Plant interference could play an important role in a successful control program. species for this role can be

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[1]University of Idaho, Moscow, ID

identified through addition series experiments. An additional series experiment was conducted using yellow starthistle and pubescent wheatgrass (Thinopyrum intermedium spp. barbulatum) seeded in an equidistant arrangement at densities of 0, 129, 258 and 387 plants/m^2 in a factorial treatment arrangement. Above-ground biomass was harvested eight weeks after emergence. Pubescent wheatgrass provided 0.48 times as much interference with yellow starthistle plant for plant than yellow starthistle. Pubescent wheatgrass provided 0.46 times as much interference with pubescent wheatgrass plant for plant than yellow starthisle. Niche separation for the two species was 4.6 indicating seedling pubescent wheatgrass plants do not occupy the same niche as yellow starthistle. Since pubescent wheatgrass seedlings at densities up to 387 plants/m^2 had more interference from yellow starthistle than itself, current seeding rates (200 plants/m^2) could be increased without serious negative impact from intraspecific interference. If yellow starthistle densities are high in pubescent wheatgrass stands, replacement of older wheatgrass plants will most likely come from clonal growth from rhizomes rather than from seedlings.

SEED LONGEVITY OF SPOTTED KNAPWEED (CENTAUREA MACULOSA Lam.)

E.S. Davis and P.F. Fay[1]

Abstract. Burial studies were established in the fall of 1982 to monitor the longevity of spotted knapweed (Centaura maculosa Lam.) seed in soil. The first study involved buried plastic rings containing known amounts of seed. The rings were periodically removed and seed viability was tested. In a second study the longevity of a natural population of spotted knapweed seeds was measured. Spotted knapweed seed production was prevented and the decline of viability of the soil seed reserve was measured for five years.

Under artificial burial, seed viability remains in excess of 60% after five years. Under natural conditions, initial viability declined 80 and 90%, after one and two years, respectively. The decline in viability in the next three years has been negligible indicating spotted knapweed seed can remain viable but dormant for a number of years. A third study was conducted in 1987 to determine the effect of mowing on spotted knapweed seed production. Spotted knapweed was mowed at five different growth stages from early bolt through senescence. A soil sampling and seed screening procedure was developed to measure seed production during the year of mowing. In order to completely eliminate seed production growth stage of spotted knapweed at the time of mowing was crucial. It appears that mowing only at the late bud stage will provide complete control of seed production.

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[1]Montana State University, Bozeman, MT

INHIBITION OF NET PHOTOSYNTHESIS IN DOWNY BROME AND JOINTED GOATGRASS PROTOPLASTS BY METRIBUZIN AND ITS ETHYLTHIO ANALOG

R.A. Buman, D.R. Gealy and A.G. Ogg, Jr.[1]

Abstract. Downy brome (Bromus tectorum) and jointed goatgrass (Aegilops cylindrica) are two major winter annual weeds in winter wheat production areas of the United States. Only two postemergence herbicides, metribuzin {4-amino-6-(1,1-dimethylethyl)-3-methylthio)-1,2,4-triazine-5(4H)-one} and its ethylthio analog {SMY 1500 [4-amino-6-(1,1- dimethylethyl)-3-(ethylthio)-1,2,4-triazine-5(4H)-one} applied postemergence will control downy brome selectively in winter wheat. SMY 1500 is the only herbicide that will control jointed goatgrass selectivity in winter wheat. The activity of both of these as-triazines against downy brome and jointed goatgrass has been inconsistent. The purpose of this study was to determine the influence of temperature on inhibition of net photosynthesis by these two herbicides. Experiments were conducted with protoplasts isolated from 3-week-old plants of both species. As temperature decreased from 25 to 10 C, the concentration of SMY 1500 required to inhibit net photosynthesis 50% (PI_{50}) increased by a factor of 3.5 in jointed goatgrass and by a factor of 4.3 in downy brome. The PI_{50} values of metribuzin increased by a factor of 1.5 in jointed goatgrass and by a factor of 2.5 in downy brome for the same 15 C drop in temperature. This decrease in sensitivity to herbicides at low temperatures is consistent with the activity of most root-absorbed herbicides under field conditions. Based on the PI_{50} values at 10 C, metribuzin was 9.4 times more inhibitory than SMY 1500 in jointed goatgrass and 8.2 times more inhibitory in downy brome. At 25 C, metribuzin was only 4.7 and 3.9 times more inhibitory than SMY 1500 in jointed goatgrass and downy brome, respectively. The results show that SMY 1500 activity was affected more adversely by cold temperatures than was metribuzin activity. Also photosynthesis of protoplasts of jointed goatgrass tended to be more sensitive than photosynthesis of downy brome to both SMY 1500 and metribuzin over 15 C temperature range.

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[1]Washington State University, Pullman, Washington and USDA-ARS, Pullman, WA

EFFECT OF PHOTON FLUX DENSITY DURING GROWTH ON QUANTUM YIELD IN TRIAZINE-RESISTANT AND TRIAZINE-SUSCEPTIBLE NEARLY ISONUCLEAR VARIETIES OF OILSEED RAPE (BRASSICA NAPUS L.)

Jonathan J. Hart and Alan Stemler[1]

Introduction

Resistance to triazine herbicides in a population of Senecio vulgaris was discovered in Washington in 1970 (1). Since then triazine resistance has been observed in other weed species in North America and in other parts of the world (2). While resistance in weeds remains a problem, transfer of

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[1]Botany Department, University of California, Davis, CA

resistance into crop plants has become a goal with large potential benefit. Triazine-resistant crop plants could be a very important tool in weed control. An important drawback, however, is the apparent reduction in fitness that accompanies resistance (3, 4).

In most triazine-resistant weed biotypes so far examined, resistance is brought about by the substitution of a single amino acid of a 32-kD polypeptide active at the reducing side of Photosystem II (PSII) in chloroplast membranes (5). The 32-kD protein normally functions in transport of electrons from PSII to the plastoquinone pool in thylakoid membranes. This process occurs continuously in the light in normal chloroplast membranes and is essential in maintaining electron flow in the light reactions of photosynthesis. In normal plants, triazine herbicides bind tightly to the 32-kD protein and block electron flow, ultimately resulting in damage to the plant (6). The alteration of the 32-kD protein in resistant plants prevents binding of triazine molecules (7), allowing electron flow to occur. However, electron transport is apparently less efficient as a result of the resistance alteration (8). The reduced efficiency is manifested two ways: a reduction in quantum yield; and a decreased rate of electron flow from the primary stable PSII electron acceptor, Qa to the secondary acceptor, Qb. This less efficient electron movement has been thought to result in reduced vigor in whole triazine-resistant plants (3).

The objectives of this study were to determine the effect of growth light conditions on growth of resistant and susceptible plants and to examine the physiological basis for observed effects. Results suggest that reduction in quantum yield in resistant plants is not a direct consequence of resistance, but rather is a secondary effect induced by high photon flux density (PFD).

Materials and Methods

Genetically similar varieties of oilseed rape (*Brassica napus*) were grown in a temperature controlled greenhouse within a temperature range of 10 to 32C. One variety, 'Regent,' is susceptible to triazines and the other, 'Triton," is resistant (9). One set of resistant and susceptible plants was grown under full sunlight conditions (~2000 umol photons m^{-2} s^{-1}) and the other set was maintained behind shadecloth at approximately 100 umol photons m^{-2} s^{-1}. Plants were harvested 61 days after planting, and total plant dry weight was recorded.

Oxygen uptake and evolution from leaf discs was measured polarographically with a Hansatech leaf disc O_2 electrode (10). Photosynthetic measurements were made at 28C and the enclosed chamber contained 5% CO_2 to prevent stomatal and substrate limitation of photosynthesis (10). The leaf disc was illuminated with a slide projector fitted with a xenon bulb. Photon flux density was controlled with neutral density filters. Leaf absorptance was measured with an integrating sphere.

High PFD light treatment of leaf discs was provided by the same xenon bulb projector that was used for photosynthetic O_2 measurements. A leaf disc was floated upside down on water in a petri dish. Light of approximately 2000 um photons m^{-1} s^{-1} was reflected by a mirror up through the bottom of the petri dish into the upper surface of the leaf disc. Each disc was exposed to high light treatment for 10, 20, 45 or 90 minutes. Plants used for photosynthetic O_2 measurement were grown in a growth chamber at 28C day/16C night, 16h light/8h dark at a PFD of 100 umol photons m^{-2} s^{-1}.

Results and Discussion

Since the past measurements (8, 11) indicated that resistant plants have reduced quantum yields, we expected that such plants would grow noticeably more slowly than susceptible plants under low PFD growth conditions, when light is limiting photosynthesis. Conversely at high PFD, photosynthesis is thought to be limited by rates of carbon assimilation rather than electron transport rates. We, therefore, expected that at high PFD, the slower electron transport rates in resistant plants would have less consequence and that resistant and susceptible plants would grow at the same rate. The results of our growth study, shown in Table 1, were completely opposite to expectations. Both varieties grown under low light conditions showed relatively minor differences in growth. Susceptible plants averaged about five percent greater biomass than resistant plants. Under high PFD, the susceptible plants averaged thirty percent greater growth than the resistant variety. Clearly, either our reasoning was based on incorrect assumptions or other processes were responsible for the observed growth patterns.

Respiration at 24C in leaf discs from resistant and susceptible plants grown at high and low PFD was not significantly different (Table 1). Respiration differences were, therefore, not likely to be responsible for the observed growth patterns.

Measurements of light-limited photosynthetic O_2 production in leaf discs of low and high PFD grown resistant and susceptible varieties were made. The initial slope of the light response curve in photosynthetic organisms describes the quantum efficiency of the light reactions of photosynthesis. When appropriate units are used, this slope represents the ratio of moles of O_2 produced per mole of photons absorbed. This ratio (umol O_2 umol photon^{-1}) is referred to as quantum yield. Results of this study revealed that in plants grown under full sunlight conditions, quantum yield in resistant plants was fifteen percent lower than in susceptible plants (Table 1), confirming earlier work (8, 11). The results of quantum yield measurement in low light-grown plants is also shown in Table 1. In this case, the quantum yield is not decreased in resistant plants. This is somewhat surprising because the resistant plants have the altered 32-kD protein that is supposedly less efficient in electron transport. It does, however, explain why susceptible and resistant plants show no difference in growth under low PFD.

Table 1. Dry matter accumulation, respiration rate and quantum yield of triazine-resistant (R) and -susceptible (S) varieties of *Brassica napus* grown under low and high photon flux density (PFD) conditions. Numbers in parentheses represent one standard deviation.

	High PFD		Low PFD	
	S	R	S	R
Dry weight 61 days after planting (g)	15.02 (1.55)	11.99 (2.27)	1.97 (.27)	1.78 (.35)
Dark respiration rate at 24C (μmol O_2 m^{-2} s^{-1})	1.04 (0.07)	1.09 (0.05)	0.45 (0.04)	0.41 (0.03)
Quantum yield (O_2 photon^{-1})	.093	.081	.101	.101

These results suggest that decreased quantum yield in triazine-resistant plants may be induced by high PFD conditions. To test this hypothesis, quantum yield was measured in low PFD-grown leaf discs previously exposed to high PFD conditions. The results are shown in Figure 1. Susceptible plants showed a small decrease in quantum yield over 90 minutes of high light exposure. Quantum yield in resistant plants, however, decreased significantly over the 90-minute period. These results seem to confirm that high PFD induces a decrease in quantum yield in resistant plants. Reduced quantum yield in triazine-resistant plants may, therefore, be due to a light-induced change and may be only an indirect consequence of the 32-kD protein alteration that confers resistance.

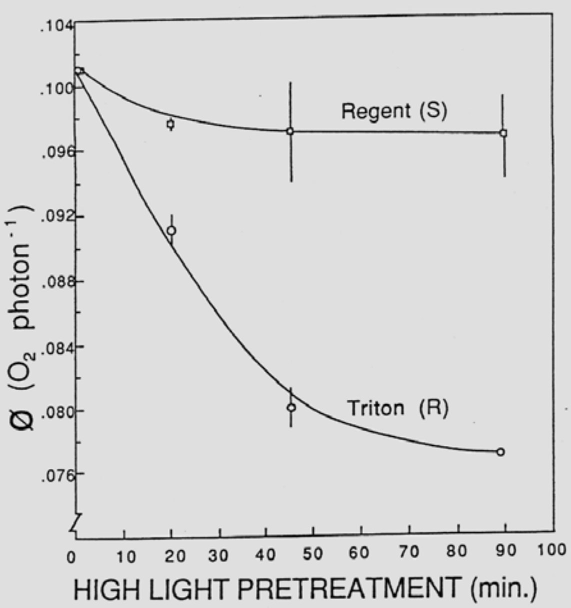

Figure 1. Effect of high light intensity (2000 µmol quanta m^{-2} s^{-1}) exposure on quantum yield in leaf discs taken from resistant and susceptible varieties of oilseed rape grown under low light intensity conditions.

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GROWTH AND COMPETITIVE ABILITY OF DINITROANILINE-HERBICIDE RESISTANT AND SUSCEPTIBLE GOOSEGRASS (ELEUSINE INDICA) BIOTYPES

B.E. Valverde, S.R. Radosevich and A.P. Appleby[1]

Abstract. Leaf area, vegetative dry weight (root and shoot) and calculated parameters (mean net assimilation rate, leaf area ratio and relative growth rate) did not differ among individual goosegrass (*Eleusine indica* (L.) Gaertn.) plants of three susceptible (S) and three resistant (R) biotypes from North Carolina, South Carolina and Mississippi. On average, reproductive weight of R-goosegrass was lower than that of S-goosegrass. Competitive ability of an S- and an R-biotype was determined by planting at different densities and proportions (both in monoculture and in mixture). In monoculture, reproductive output per plant decreased more with increasing density in the R-biotype than in the S-biotype, although no differences in total biomass per plant were observed. Thus the two biotypes differed in their partitioning of resources to seed production. Interbiotype competition affected the R-biotype more severely, causing reduced tiller and inflorescence numbers, total dry weight and, especially, seed production. Results suggest that dinitroaniline R-goosegrass is less ecologically fit than S-goosegrass.

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[1]Crop Science Department, Oregon State University, Corvallis, OR

MATHEMATICAL DESCRIPTION OF TRIFLURALIN DEGRADATION IN SOIL

Carlos C. Reyes and Robert L. Zimdahl[1]

Abstract. Soil degradation of trifluralin {2,6-dinitro-*N*-*N*-dipropyl-4-(trifluoromethyl)benzenamine} in four soils, each represented at the four sites of origin in Colorado, was quantitatively determined and mathematically described. A mixed order equation[2] that resulted from integration of the first-order and second-order (type 1) differential rate equations[3] was usually superior to describe degradation data when compared to the first order kinetic model. Constants determined from the mixed order equation indicate the extent of degradation and that degradation is rapid when the concentration of trifluralin is high initially but slows as concentration decreases. Use of the first-order kinetic description initially underestimated and finally overestimated degradation of trifluralin, thereby implying that a first-order half-life is inadequate for predicting trifluralin persistence.

[2]$C_t = (K_1C_0)/[(K_1 + K_2C_0)e^{K_1t} - K_2C_0]$ where c_t = concentration at time t, and C_0 = initial concentration at t = 0.
[3]$dc/dt = -(K_1C + K_2C^2)$.

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[1]Graduate Research Assistant and Professor, respectively, Department of Plant Pathology and Weed Science, Colorado State Univ., Fort Collins. Present address of Sr. author: Department of Crop Science, Oregon State Univ., Corvallis, OR.

A COMPARISON OF TECHNIQUES FOR ESTIMATION OF ARABLE SOIL SEED BANKS AND THE RELATIONSHIP TO WEED FLORA

Daniel A. Ball and Stephen D. Miller[1]

Abstract. The study of seed banks in arable soils has led to the development of many techniques which estimate seed numbers from soil samples. These techniques consist of germinating seed from soil or physical extraction and counting. Estimates derived from these techniques have frequently been used to evaluate the effects of tillage and/or herbicides on the seed bank. It has been suggested that seed bank estimates from arable soils could also be used to predict weed infestations which could improve decision making relative to the management of specific weed problems. Post-harvest soil samples taken during the fall of 1985 and 1986 were split and estimates made of the weed seed bank using two methods: a physical separation of seed from the soil mineral fraction by a sieving/flotation procedure and by placing soil in shallow containers in a greenhouse where seeds could germinate and be periodically counted over a period of eight months. Seed bank estimates derived from each procedure were analyzed to elucidate treatment differences from an experiment evaluating tillage/herbicide effects on weed populations. This was done to ascertain the usefulness of each procedure for comparing treatment effects on the weed seed bank. Both techniques were suitable for determination of seed bank changes due to different tillage treatments and herbicide inputs. The two techniques also proved effective for detection of individual species in the seed bank and the two techniques provided comparable estimates of the relative frequency of individual weed species in the seed bank. Weed seed bank estimates obtained by the physical extraction procedure from the fall 1985 soil samples were correlated with weed seedling counts made in the spring of 1986. The most cases, weed seedlings represented less than ten percent of the number of seeds estimated by physical extraction the preceding fall. Individual species seed estimates and subsequent weed counts were poorly correlated which indicated that the seed count estimates alone were poor predictors of weed flora.

[1]Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY

EFFECTS OF SOIL TEMPERATURE AND SOIL-APPLIED HERBICIDES ON ON MORPHOLOGICAL CHARACTERISTICS AND MINERAL LEVELS IN CORN

Larry S. Jeffery[1]

Abstract. Occasionally when corn (*Zea mays* L.) is planted under early spring conditions recommended herbicides cause some phytotoxicity. This experiment was conducted to determine if a cool root temperature as may occur in the spring would increase herbicide phytotoxicity. Corn was grown in the greenhouse in soil held at 16 ± 2 and 24 ± 3 C. Three commonly used soil-applied

[1]Department of Agronomy and Horticulture, Brigham Young University, Provo, UT

herbicides, alachlor {2-chloro-N-(2,6-diethylphenyl)-N-(methoxymethyl)-acetamide}, metolachlor {2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl)acetamide} and pendimethalin {N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine} were applied. Alachlor and metolachlor rates were 2.2, 3.3., 4.4 and 6.6 kg/ha and pendimethalin rates were 1.1, 1.7 and 2.2 kg/ha. Morphological characteristics were observed 2, 3 and 4 weeks after planting. The lower temperature decreased leaf number, total leaf length, number of secondary roots and total secondary root length. Significant herbicide rate X temperature interactions occurred. Root temperature had little effect on the corn tolerance when alachlor and metolachlor were applied at the 2.2 and 3.3 kg/ha rates. Some phytotoxicity occurred at the higher rates. When treated with metolachlor more injury was observed when corn plants were grown in 24 C soil than when grown in 16 C soil. The lower temperature increased pendimethalin toxicity regardless of rate. The levels of K, Ca, Mg, Cu, Mn and Zn in corn shoot tissue increased in some cases and decreased in others. The changes did not occur in a consistent manner.

RESPONSE OF ALFALFA AND WEEDS TO AN OAT COMPANION CROP DURING ESTABLISHMENT

W. Thomas Lanini[1], Steve Orloff[2], Ron Vargas[2], Vern Marble[1], Jack Orr[2], Stephen Grattan[1] and N. Lee Smith[1]

Abstract. A study was conducted to evaluate the effect of an oat companion crop on forage yields and composition in the seeding year at three sites (Lancaster, Madera and Walnut Grove, CA). Alfalfa at three seeding rates (16, 24 and 32 lb/A) was planted with an oat companion crop at four seeding rates (0, 8, 16 or 32 lb/A). The addition of oats at planting, increased forage yields in the first cutting and total forage yields for the year. A non-significant, except at 32 lb/A of oats, depression in alfalfa yields was observed in the second cutting, for all treatments that contained oats at two locations, and a slight trend toward yield reductions was noted generally until the final cutting of the year. Oats generally reduced light levels with the exception of the Lancaster site and reduced alfalfa and weed biomass at the first cutting. Alfalfa biomass was observed to respond to oat planting rate in a quadratic manner indicating that some biomass would be produced regardless of the oat seeding rate. Weeds, on the other hand, responded in a linear fashion which means that at some oat planting rate, weed biomass would approach zero. Oat biomass also responded in a quadratic fashion to oat planting rate, indicating that intraspecific competition was occurring among the oat plants causing yields to level as planting rate increased to the higher rates.

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[1]Weed Ecologist, Botany Department; Agronomist, Agronomy Department; Specialist, Land, Air and Water Resources and Staff Research Associate, Botany Department, University of California, Davis, CA
[2]County Director, Cooperative Extension, Sacramento, California; Farm Advisor, Lancaster, California and Farm Advisor, Madera, CA

PERENNIAL GRASS RESPONSE TO ENVRIONMENT AND HERBICIDES IN A YELLOW STARTHISTLE SITE

F.E. Northam and R.H. Callihan[1]

Abstract: Chemical control of yellow starthistle (Centaurea solstitialis L. CENSO) in unimproved semiarid grazing lands requires herbicide applications every 3-4 years to keep the weed population in check. When yellow starthistle is chemcially controlled, weedy annual grasses typically become dominant until the yellow starthistle re-establishes. Sustained control of yellow starthistle and annual grasses on grazing land will involve filling open sites with adapted and competitive perennial grasses before annual grasses establish.

The purpose of this study was to develop methods for renovating yellow starthistle infested land with perennial grasses. The specific areas investigated were (1) establishment and survival of perennial grasses (2) resistance of perennial grasses to re-establishment by yellow starthistle and (3) effects of pre-emergence herbicides on perennial grass species.

The site was disked the fall prior to planting, and a late winter preplant application of glyphosate {N-(phosphonomethyl)glycine} treatment was applied. The soil was a sandy loam alluvium with an annual precipitation average of 13 in. (33 cm). The vegetation on the site was a weed community dominated by downy brome (Bromus tectorum L. BROTE) and yellow starthistle. Yield and density data were collected 4 and 29 months after sowing.

Alkar tall wheatgrass (Thinopyrum ponticum (Podp.) Barkw. and D.R. Dewey), Luna pubescent wheatgrass (Thinopyrum intermedium spp barbulatum (Schur) Barkw. & D.R. Dewey), Nezpar Indian ricegrass (Oryzopsis hymenoides (R&S) Ricker), Nordan crested wheatgrass (Agropyron desertorum (Fischer ex Link) Shultes), Oahe intermediate wheatgrass (Thinopyrum intermedium spp intermedium (Host) Barkw. & D.R. Dewey), Paiute orchardgrass (Dactylis glomerata L.), P-27 Siberian wheatgrass (Agropyron fragile (Roth) Candagry), Secar bluebunch wheatgrass (Pseudoroegneria spicata (Pursh) A. Love), Durar hard fescue (Festuca ovina var. duriscula L.), Reubens Canada bluegrass (Poa compressa L.) and Sherman big bluegrass (Poa secunda Prsel) were seeded at a rate of 34 seeds per square foot (sqft) in March 1985.

Atrazine {6-chloro-N-ethyl-N'-(1-methylethyl-1,3,5-triazine-2,4-diamine}, chlorsulfuron {2-chloro-N-(((4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino)carbonyl)benzenesulfonamide}, cyanazine {2-((4-chloro-6-(ethylamino)-1,3,5-triazin-2-yl)amino)-2-methyl propanenitrile}, ethiozin {4-amino-6-(1,1-dimethylethyl-3-(ethylthio)-1,2,4-triazin-5(4H)-one}, pronamide {3,5-dichloro(N-1,1-dimethyl-2-propynyl)benzamide} and sulfometuron {2-([[[[4,6-dimethyl-2-pyrimidinyl)amino)carbonyl)amino) sulfonyl)benzoic acid} were applid on 25 and 28 March, 1985, two weeks after the grasses were planted but 10 days before the first grasses emerged.

Density and forage production were used as indicators of species adaptability. Hard fescue, Canada bluegrass and big bluegrass did not establish adequate stands for evaluation. Four months after seeding, grass densities ranged from 6.57 plants/sqft (tall wheatgrass) to 3.18 plants/sqft

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[1]University of Idaho, Moscow, ID

(bluebunch wheatgrass). Twenty-nine months after seeding, grass densities ranged from 1.56 plants/sqft (intermediate wheatgrass) to 0.01 plants/sqft (Siberian wheatgrass). Intermediate and pubescent wheatgrass densities at 29 months were 1.56 and 1.53 plants/sqft respectively) which were signficantly higher ($P<0.05$) than the densities of all other species. Intermediate wheatgrass (12.6 g/sqft), tall wheatgrass (10.4 g/sqft) and pubescent wheatgrass (10.1 g/sqft) produced higher ($P<0.05$) herbage weights than all other species. The remaining species produced less than 6.1 g/sqft).

Stand counts and forage production indicated that Oahe intermediate wheatgrass performed best at this site. Luna pubescent wheatgrass was a close second and Alkar tall wheatgrass performed well but not as well as the intermediate and pubescent wheatgrasses.

Yellow starthistle density and shoot weight after 29 months were used as indicators of grass resistance to yellow starthistle invasion. The average yellow starthistle density for all plots was 1.2 plants/sqft with a range of 0.13 plants/sqft (intermediate wheatgrass plots) to 3.3 plants/sqft (crested wheatgrass plots). The average weight of yellow starthistle was 1.6 g/sqft with the weights ranging from 0.17 g/sqft (pubescent wheatgrass plots) to 4.05 g/sqft (orchardgrass plots). Grass density correlated fairly well with yellow starthistle weight ($r=-.879$). Species with biomass over 10.0 g/sqft (intermediate, pubescent and tall wheatgrasses) had the lowest yellow starthistle densities (0.13, 0.55 and 0.48 plants/sqft respectively).

After 29 months Oahe intermediate wheatgrass was the best grass for maintaining low yellow starthistle populations. Luna pubescent wheatgrass and Alkar tall wheatgrass were also good at maintaining low yellow starthistle stands. Even though Nordan crested wheatgrass density was good, yellow starthistle density was not reduced by this grass. The remaining grasses were unacceptable because they either did not survive or production was too low to inhibit yellow starthistle re-establishment.

Overall grass density four months after treatment showed a reduction of 25% to 80% for all grasses in the atrazine plots (0.5 and 1.0 lb ai/a rates). Twenty-nine months after planting, yields of all species except orchardgrass and Siberian wheatgrass were higher in the atrazine-treated plots than in the control plots.

Grass densities in the orchardgrass plots four months after treatment with cyanazine (1.0 and 2.0 lb ai/a) were reduced by 68% to 90%. Densities of remaining species were not apparently affected by cyanazine. Forage weight of pubescent, crested, intermediate and bluebunch wheatgrasses and Indian ricegrass in the 2.0 lb ai/a cyanazine plots was 115% to 307% higher than their controls 29 months after planting.

Densities at four months of Indian ricegrass, orchardgrass, Siberian wheatgrass and bluebunch wheatgrass were increased in the chlorsulfuron (.25 oz ai/a) plots. Densities of other grasses were not affected by chlorsulfuron at four months. Average grass herbage weights twenty-nine months after planting were reduced 35% to 60% in chlorsulfuron plots. Pubescent wheatgrass was an exception, for it produced 50% to 90% more forage in chlorsulfuron plots.

Pronamide at .5 lb ai/a had reduced tall wheatgrass, Indian ricegrass and orchardgrass densities by 26% to 69% after four months. The densities of the other grasses were unaffected by pronamide after four months. Grass weight was 19% to 45% less in the pubescent wheatgrass and Indian ricegrass plots treated with pronamide. Biomass of tall, intermediate and bluebunch wheatgrass was 150% to 197% greater where treated with 0.25 lb ai/a pronamide after 29 months.

Indian ricegrass densities were not influenced by sulfometuron (1.0 and 2.0 oz ai/a), but sulfometuron had reduced the density of remaining grasses 43% to 96% at four months. Weight of pubescent wheatgrass, crested wheatgrass, Indian ricegrass and intermediate wheatgrass at 29 months was 31% to 49% higher when treated with 1.0 oz ai/a of sulfometuron. Sulfometuron had reduced the biomass of the other species after 29 months.

Pubescent wheatgrass, Indian ricegrass and Siberian wheatgrass densities were 118% to 209% higher where treated with 1.5 lb ai/a ethiozine. Densities of other species treated with ethiozine were not affected. Tall, pubescent, crested, intermediate and bluebunch wheatgrass had 125% to 1,431% more weight in ethiozine treated plots.

The best combination of pre-emergence herbicides and well adapted grass species for revegetating this yellow starthistle site was Oahe intermediate wheatgrass treated with either 1.0 lb ai/a atrizine or 1.5 lb ai/a ethiozine. Luna pubescent wheatgrass treated with 1.0 lb ai/a atrazine was the second best combination. Alkar tall wheatgrass treated with 1.0 lb ai/a atrazine or 1.5 lb ai/a ethiozine also produced good grass populations at this site.

Other combinations that produced considerably better stands included Nordan crested wheatgrass treated with either 1.0 or 2.0 oz ai/a sulfometuron and Secar bluebunch wheatgrass treated with 1.0 lb ai/a cyanazine or 1.5 lb ai/a ethiozine.

Herbicides used in this experiment were detrimental to Paiute orchardgrass density and biomass.

The increases of density and biomass in the herbicide-treated plots were attributed to the observed weed control (mainly annual grasses) which allowed more of the perennial grass seedlings to establish and develop with less interference.

A PLANT GROWTH STUDY OF SEVERAL DRYLAND AND IRRIGATED PERENNIAL GRASSES TREATED WITH METSULFURON

B. McLain and J.O. Evans[1]

Abstract: Metsulfuron {2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino] carbonyl]amino]sulfonyl]benzoic acid} was applied in the field to 15 dryland and 7 irrigated perennial grass species. Fifteen cultivars represented the 7 irrigated species. Rates of 3.5, 7.0, 10.5, 14.0 and 70.0 g/ha were applied preemergence and postemergence to dryland grasses, and preemergence to irrigated grasses. Stands and plant height were significantly reduced with 70.0 g/ha preemergence treatment. The 3.5, 7.0, 10.5 and 14.0 g/ha preemergence applications and most postemergence treatments did not reduce grass stands nor height of dryland species. The 70.0 g/ha treatment noticeably reduced grass emergence and stand development among the irrigated grasses. Some irrigated cultivars were damaged with 10.5 and 14.0 g/ha metsulfuron while others were not.

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[1]Utah State University, Logan, UT

Introduction

Weed control is an important practice in establishment and maintenance of perennial grass stands. Weed competition for limited soil moisture and nutrients on arid rangelands is often the reason for poor stands. Weed competition often weakens and inhibits the stand of grass seedlings so that they are either lost or take several years to establish (1,3,5).

Weed control is also important in grass seed production. It has been estimated that 15 to 20 percent of the new grass seedlings are plowed up before seed is produced, due to poor stands. If seed is produced the seed quality and yield are often low (2).

Metsulfuron, a recently developed sulfonylurea herbicide, is used for selective weed control in cereal crops. It controls a wide spectrum of broadleaf weeds at very low application rates (4). Metsulfuron may have potential as a selective herbicide in perennial grasses. This study was designed to determine the response of several dryland and irrigated perennial grasses to metsulfuron during the first year of establishment. The quality of seed produced by perennial grasses treated with metsulfuron was a second objective.

Materials and Methods

Three sites were selected in Utah, two dryland sites, Nephi and North Logan, and one irrigated site in Trenton. The ground was tilled to prepare for planting. The grass entries were selected according to their adaptability to the particular sites. Tables 1,2, and 3 list the entries and location(s) where they were planted.

The grasses were planted late fall 1986 in randomized block designs. Plantings were made with a five row modified John Deere Flexiplanter[R] with depth band regulators on the double disk openers and about 70 kg of weight on each compaction wheel. These modifications improve penetration, seed depth consistency, and seed to soil contact. Seeds were placed 15 to 20 mm below the soil surface, at a rate of 6.7 to 9.0 kg/ha. Each grass plot consisted of five rows with 0.3 m row spacings.

Metsulfuron was applied preemergence and postemergence to dryland grasses and preemeregence to irrigated grasses at dosage of 3.5, 7.0, 10.5, 14.0 and 70.0 g ai/ha. The preemergence treatments were applied immediately after planting, and the postemergence applications were made the following spring when the grasses were in the two to four leaf stage. Herbicide applications were made across the grass entries, perpendicular to the direction of the rows, with a compressed air bicycle sprayer. The sprayer calibrated to deliver 178 L/ha at 207 kpa.

The plots were evaluated during the summer. The three center rows were evaluated, using the outside two rows as borders. Plant densities were measured for all treaatments within each grass entry, and height was measured in the dryland grasses.

Results and Discussion

Results from this study indicate that preemergence metsulfuron treatment at 70.0 g ai/ha significantly reduced stand and plant height of dryland grasses in comparison to other rates. In some plots, grass establishment was better in the 3.5, 7.0, 10.5 and 14.0 g ai/ha rates than in the control, probably because weed competition was removed in the treated plots.

The postemergence treatments resulted in little or no reduction in dryland grass stands, except Alkar tall wheatgrass (Thinopyrum ponticum), where the 10.5, 14.0 and 70.0 g ai/ha treatments produced significant reductions. Most dryland grass heights were not reduced by postemergence treatments, but the 70.0 g ai/ha treatment caused height reductions in quackgrass x bluebunch wheatgrass (Elytrigia repens x Pseudoroegneria spicata) hybrid, Nordan crested wheatgrass (Agropyron desertorum), Fairway crested wheatgrass (Agropyron cristatum), and Greenar intermediate wheatgrass (Thinopyrum intermedia) at one location (Tables 4 to 7).

The native grasses (Table 8) and Paiute orchard grass (Dactylus glomerata) were not evaluated because poor stands throughout the experiment including the untreated controls resulted in an unacceptably high coefficient of variation. These native grasses are often difficult to establish in rangeland plantings.

The 70.0 g ai/ha preemergence treatment noticeably reduced grass emergence and stand development among the irrigated grasses. The 14.0 g ai/ha treatment slightly reduced the Hallmark orchard grass (Dactylus glomerata), Bastion tetraploid ryegrass (Lolium perenne), and quackgrass x bluebunch wheatgrass (Elytrigia repens x Pseudoroegneria spicata) stands, while Rancho orchard grass (Dactylus glomerata), Mohawk timothy (Phleum pratense), Grimalda tetraploid ryegrass (Lolium perenne), and both tall fescues (Festuca arundinacea) were sensitive to the 10.4 and 14.0 g ai/ha treatments (Table 9).

In conclusion, metsulfuron can be safely applied to most dryland grasses at rates up to 14.0 g ai/ha preemergence and up to 70.0 ai/ha postemergence. Some irrigated grasses are tolerant to the 14.0 g ai/ha rate, while others are sensitive at the 10.5 and 14.0 g ai/ha rates.

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Table 1. Introduced dryland grasses planted at Nephi and/or North Logan.

	Nephi	N. Logan
Hycrest crested wheatgrass (*Agropyron destertorum* x *Agropyron cristatum*)	X	X
Nordan crested wheatgrass (*Agropyron desertorum*)	X	X
Fairway crested wheatgrass (*Agropyron cristatum*)	X	X
Ephraim crested wheatgrass (*Agropyron cristatum*)	X	X
P-27 Siberian crested wheatgrass (*Agropyron fragile*)	X	X
Greenar intermediate wheatgrass (*Thinopyrum intermedia*)	X	X
Luna pubescent wheatgrass (*Thinopyrum intermedia* ssp. *barbulata*)	X	
Alkar tall wheatgrass (*Thinopyrum ponticum*)	X	
Quackgrass x bluebunch wheatgrass hybrid (*Elytrigia repens* x *Pseudoroegneria spicata*)		X
Paiute orchard grass (*Dactylus glomerata*)	X	
Vinall Russian wildrye (*Psathyrostachis juncea*)	X	X
Synthetic A Russian wildrye (*Psathyrostachis juncea*)	X	X

Table 2. Native dryland grasses planted at Nephi and/or North Logan.

	Nephi	N. Logan
Rosana western wheatgrass (*Pascopyrum smithii*)	X	X
Critana thickspike wheatgrass (*Elymus lanceolatus*)	X	X
Secar Snake River wheatgrass (*Elymus lanceolatus* ssp. *wawawai*)		X
Magnar basin wildrye (*Leymus cinereus*)	X	X
Prairieland altai wildrye (*Leymus angustus*)	X	

Table 3. Irrigated grasses planted at Trenton.

Latar orchard grass (*Dactylus glomerata*)
Hallmark orchard grass (*Dactylus glomerata*)
Comet orchard grass (*Dactylus glomerata*)
Rancho orchard grass (*Dactylus glomerata*)
Manchar smooth bromegrass (*Bromus inermis*)
Regar meadow bromegrass (*Bromus erectus*)
Climax timothy (*Phleum pratense*)
Mohawk timothy (*Phleum pratense*)
Timfor timothy (*Phleum pratense*)
Grimalda tetraploid ryegrass (*Lolium perenne*)
Bastion tetraploid ryegrass (*Lolium perenne*)
Reveille tetraploid ryegrass (*Lolium perenne*)
Alta tall fescue (*Festuca arundinacea*)
Forager tall fescue (*Festuca arundinacea*)
Quackgrass x bluebunch wheatgrass hybrid (*Elytrigia repens* x *Pseudoroegneria spicata*)

Table 4. Influence of metsulfuron treatments on crested wheatgrasses[1].

Entry		Control	3.5	7.0	10.5	14.0	70.0
			Preemergence Treatments[2]				
Hycrest[3]	Plants/m^2	76 a	80 a	80 a	87 a	96 a	36 b
	Height (cm)	32 a	29 a	27 a	33 a	28 a	9 b
Hycrest[4]	Plants/m^2	78 a	75 a	76 a	77 a	80 a	43 b
	Height (cm)	19 a	53 b	55 b	53 b	53 b	31 c
Nordan[3]	Plants/m^2	39 a	32 a	42 a	30 ab	24 ab	14 b
	Height (cm)	28 a	28 a	28 a	28 a	25 a	9 b
Nordan[4]	Plants/m^2	42 a	57 b	57 b	63 b	59 b	43 a
	Height (cm)	13 a	48 b	49 b	51 b	50 b	34 c
Fairway[3]	Plants/m^2	40 a	41 a	39 a	36 a	33 a	8 b
	Height (cm)	24 a	24 a	21 ab	23 ab	18 ab	13 b
Fairway[4]	Plants/m^2	38 ab	40 ab	48 ab	44 ab	51 a	32 b
	Height (cm)	18 a	47 b	51 b	52 b	51 b	30 c
Ephraim[3]	Plants/m^2	47 a	40 a	52 a	52 a	51 a	11 b
	Height (cm)	34 a	29 a	33 a	33 a	32 a	15 a
Ephraim[4]	Plants/m^2	54 a	61 b	67 b	69 b	62 b	40 a
	Height (cm)	16 a	41 bc	50 b	49 b	45 b	34 c
P-27[3]	Plants/m^2	13 a	14 a	15 a	17 a	13 a	5 b
	Height (cm)	23 ab	24 ab	28 a	27 a	19 ab	10 b
P-27[4]	Plants/m^2	4 a	25 bc	31 b	30 b	27 bc	18 c
	Height (cm)	8 a	51 b	53 b	51 b	54 b	41 c
			Postemergence Treatments[2]				
Hycrest[3]	Plants/m^2	96 a	79 a	91 a	114 a	92 a	99 a
	Height (cm)	28 a	29 a	27 a	27 a	28 a	24 a
Hycrest[4]	Plants/m^2	62 a	64 ac	61 a	79 b	77 bc	75 abc
	Height (cm)	20 a	21 a	23 ab	25 bc	28 cd	29 d
Nordan[3]	Plants/m^2	38 ab	31 ab	49 b	42 ab	31 a	36 ab
	Height (cm)	27 a	27 a	24 a	25 a	25 a	19 b
Nordan[4]	Plants/m^2	35 a	40 ab	54 b	51 ab	55 b	55 b
	Height (cm)	13 a	15 ab	20 bc	20 bc	23 cd	28 d
Fairway[3]	Plants/m^2	37 a	42 ab	52 b	39 a	46 ab	54 b
	Height (cm)	20 a	21 a	20 a	21 a	20 a	15 b
Fairway[4]	Plants/m^2	54 a	36 a	61 a	49 a	45 a	46 a
	Height (cm)	19 a	20 ab	23 abc	26 bc	29 c	29 c
Ephraim[3]	Plants/m^2	53 a	47 a	54 a	53 a	46 a	52 a
	Height (cm)	28 a	27 a	29 a	27 a	28 a	24 a
Ephraim[4]	Plants/m^2	62 a	57 a	51 a	58 a	61 a	65 a
	Height (cm)	16 a	17 ab	21 abc	22 bc	24 cd	29 d
P-27[3]	Plants/m^2	25 a	15 a	20 a	21 a	14 a	15 a
	Height (cm)	28 a	27 a	25 a	24 a	26 a	21 a
P-27[4]	Plants/m^2	18 a	14 a	22 ab	34 bc	37 c	28 bc
	Height (cm)	12 a	18 ab	21 bc	23 bc	27 c	26 c

[1]Numbers in a row followed by the same letter are not significantly different at 5% level.
[2]Treatments are in g ai/ha.
[3]Located at the Nephi site.
[4]Located at the North Logan site.

Table 5. Influence of metsulfuron treatments on intermediate wheatgrass, pubescent wheatgrass, and tall wheatgrass[1].

Entry		Control	3.5	7.0	10.5	14.0	70.0
			Preemergence Treatments[2]				
Greenar[3]	Plants/m^2	44 a	36 a	42 a	34 a	35 a	18 b
	Height (cm)	57 a	58 a	63 a	61 a	62 a	17 b
Greenar[4]	Plants/m^2	47 ab	61 b	57 b	51 a	53 ab	27 c
	Height (cm)	32 a	73 b	74 b	73 b	74 b	50 c
Luna3	Plants/m^2	41 a	42 a	31 a	29 a	23 ab	11 b
	Height (cm)	60 a	60 a	60 a	58 a	58 a	23 b
Alkar[3]	Plants/m^2	19 a	24 a	19 a	10 ab	19 a	0 b
	Height (cm)	30 a	34 a	33 a	26 a	23 a	0 b
			Postemergence Treatments[2]				
Greenar[3]	Plants/m^2	49 ab	48 ab	56 a	48 ab	42 ab	38 b
	Height (cm)	56 ab	63 a	63 a	65 a	60 a	50 b
Greenar[4]	Plants/m^2	42 a	51 ab	51 ab	58 ab	66 b	59 ab
	Height (cm)	24 a	30 ab	33 ab	43 c	51 c	52 c
Luna3	Plants/m^2	31 a	29 a	40 a	31 a	37 a	36 a
	Height (cm)	63 a	59 ab	59 ab	57 b	58 ab	59 ab
Alkar[3]	Plants/m^2	25 ab	31 a	14 bc	5 c	4 c	3 c
	Height (cm)	32 a	31 a	20 a	24 a	30 a	25 a

[1]Numbers in a row followed by the same letter are not significantly different at 5% level.
[2]Treatments are in g ai/ha.
[3]Located at the Nephi site.
[4]Located at the North Logan site.

Table 6. Influence of metsulfuron treatments on a dryland orchard grass and quackgrass x bluebunch wheatgrass hybrid[1].

Entry		Control	3.5	7.0	10.5	14.0	70.0
			Preemergence Treatments[2]				
Paiute[3]	Plants/m^2	16 a	10 ab	9 ab	4 ab	5 ab	0 b
	Height (cm)	12 a	12 a	12 a	10 a	12 a	0 b
Quackgrass x bluebunch[4]	Plants/m^2	31 a	38 a	31 b	38 a	30 a	6 b
	Height (cm)	12 a	20 b	20 b	18 b	18 b	10 a
			Postemergence Treatments[2]				
Paiute[3]	Plants/m^2	14 ab	18 ab	11 ab	20 a	12 ab	8 b
	Height (cm)	9 ab	10 a	7 bc	7 bc	6 c	6 c
Quackgrass x bluebunch[4]	Plants/m^2	21 a	25 ab	37 c	28 abc	33 bc	23 a
	Height (cm)	12 a	13 b	14 c	14 c	13 b	8 d

[1]Numbers in a row followed by the same letter are not significantly different at 5% level.
[2]Treatments are in g ai/ha.
[3]Located at the Nephi site.
[4]Located at the North Logan site.

Table 7. Influence of metsulfuron treatments on Russian wildrye.

Entry		Control	3.5	7.0	10.5	14.0	70.0
			Preemergence Treatments[2]				
Vinall[3]	Plants/m^2	33 a	31 ab	28 ab	16 ab	15 ab	0 b
	Height (cm)	7 a	7 a	8 a	6 b	7 a	0 c
Vinall[4]	Plants/m_2	5 a	46 b	44 b	39 b	40 b	7 a
	Height (cm)	5 a	13 b	13 b	11 b	12 b	6 a
Synthetic A[3]	Plants/m^2	26 a	28 a	25 a	27 a	23 a	0 b
	Height (cm)	10 a	9 ab	8 b	8 b	8 b	0 c
Synthetic A[4]	Plants/m^2	20 a	56 b	56 b	57 b	40 ab	22 a
	Height (cm)	10 a	15 b	15 b	13 b	16 b	8 a
			Postemergence Treatments[2]				
Vinall[3]	Plants/m^2	47 a	37 a	39 a	39 a	46 a	37 a
	Height (cm)	8 a	8 a	7 b	7 b	8 a	7 b
Vinall[4]	Plants/m_2	19 a	36 bc	29 ab	39 bc	50 c	34 abc
	Height (cm)	9 a	9 a	8 ab	8 ab	7 b	8 ab
Synthetic A[3]	Plants/m^2	29 a	34 a	43 a	27 a	34 a	39 a
	Height (cm)	9 a	9 a	8 ab	9 a	7 b	8 ab
Synthetic A[4]	Plants/m^2	26 a	23 a	31 a	36 a	31 a	36 a
	Height (cm)	11 a	11 a	13 ab	13 ab	15 b	10 a

[1]Numbers in a row followed by the same letter are not significantly different at 5% level.
[2]Treatments are in g ai/ha.
[3]Located at the Nephi site.
[4]Located at the North Logan site.

Table 8. Influence of metsulfuron treatments on some native perennial grasses[1].

Entry		Control	3.5	7.0	10.5	14.0	70.0
			Preemergence Treatments[2]				
Rosana[3]	Plants/m²	3 a	1 a	3 a	3 a	3 a	0 a
	Height (cm)	10 a	6 a	11 a	6 a	13 a	0 a
Rosana[4]	Plants/m²	4 a	22 b	24 b	26 b	25 b	7 a
	Height (cm)	11 a	23 b	23 b	24 b	24 b	11 a
Critana[3]	Plants/m²	70 a	65 a	55 a	64 a	51 a	25 b
	Height (cm)	12 a	11 a	11 a	10 a	11 a	4 b
Critana[4]	Plants/m²	13 a	41 bc	52 b	46 b	39 c	26 a
	Height (cm)	9 a	15 b	16 b	15 b	15 b	9 a
Secar[4]	Plants/m²	7 a	18 ab	28 b	23 b	18 ab	9 a
	Height (cm)	18 a	32 b	37 b	35 b	32 b	21 a
Magnar[3]	Plants/m²	6 ab	7 a	3 abc	5 abc	1 bc	0 c
	Height (cm)	17 a	17 a	14 b	13 b	15 ab	0 c
Magnar[4]	Plants/m²	2 a	8 b	7 b	3 ab	2 a	0 a
	Height (cm)	17 a	23 a	22 a	20 a	16 a	0 b
Prairieland[3]	Plants/m²	10 a	9 a	7 abc	1 bc	6 abc	0 c
	Height (cm)	12 a	13 a	9 ab	6 ab	9 ab	0 b
			Postemergence Treatments[2]				
Rosana[3]	Plants/m²	6 a	5 a	5 a	8 a	4 a	3 a
	Height (cm)	11 a	10 a	13 a	5 a	9 ab	10 a
Rosana[4]	Plants/m²	2 a	7 ab	12 bc	9 b	15 c	10 bc
	Height (cm)	7 a	8 ab	12 c	11 bc	13 c	11 bc
Critana[3]	Plants/m²	74 a	69 a	79 a	68 a	62 a	77 a
	Height (cm)	11 ab	10 a	9 b	9 b	9 b	10 ab
Critana[4]	Plants/m²	32 a	38 a	36 a	41 a	63 b	58 b
	Height (cm)	11 ab	10 a	12 bc	13 c	12 bc	10 a
Secar[4]	Plants/m²	10 a	17 ab	22 ab	28 b	24 b	17 a
	Height (cm)	10 a	20 b	21 b	21 b	19 b	18 b
Magnar[3]	Plants/m²	1 a	4 a	4 a	3 a	4 a	6 a
	Height (cm)	13 ab	17 a	6 c	13 ab	12 b	13 ab
Magnar[4]	Plants/m²	0 a	1 b	1 b	1 b	1 b	0 a
	Height (cm)	0 ac	7 b	5 bc	4 bc	4 bc	0 ac
Prairieland[3]	Plants/m²	7 a	9 a	5 a	11 a	4 a	7 a
	Height (cm)	13 a	9 ab	9 ab	10 a	5 b	10 a

[1]Numbers in a row followed by the same letter are not significantly different at 5% level.
[2]Treatments are in g ai/ha.
[3]Located at the Nephi site.
[4]Located at the North Logan site.

Table 9. Influence of preemergence metsulfuron treatments on the plant density of some irrigated grasses[1].

Entry		Control	Preemergence Treatments[2] 3.5	7.0	10.5	14.0	70.0
Manchar	Plants/m^2	16 ab	18 b	18 b	16 ab	14 a	8 c
Regar	Plants/m^2	20 a	18 ab	19 abc	16 bc	17 b	9 d
Latar	Plants/m^2	21 a	23 b	20 ac	19 cd	17 d	8 e
Hallmark	Plants/m^2	18 a	19 a	19 a	19 a	16 b	9 c
Comet	Plants/m^2	19 a	19 a	20 a	18 a	17 a	8 b
Rancho	Plants/m^2	19 a	19 a	18 a	14 b	15 b	6 c
Climax	Plants/m^2	20 a	29 b	27 bc	23 ac	21 a	10 d
Mohawk	Plants/m^2	23 ad	28 b	24 bd	18 c	19 ac	8 e
Timfor	Plants/m^2	26 a	24 ab	22 ab	23 ab	20 b	7 c
Grimalda	Plants/m^2	18 a	21 b	17 ac	15 c	12 d	1 e
Bastion	Plants/m^2	20 ab	21 a	20 ab	18 bc	17 c	6 d
Reveille	Plants/m^2	20 a	21 a	20 a	20 a	18 a	3 b
Alta	Plants/m^2	19 a	20 a	19 a	15 b	11 c	2 d
Forager	Plants/m^2	20 a	19 a	18 ab	15 bc	13 c	2 d
Quackgrass x bluebunch	Plants/m^2	23 a	21 b	23 a	21 b	18 c	10 d

[1]Numbers in a row followed by the same letter are not significantly different at 5% level.

[2]Treatments are in g ai/ha.

THE EFFECTS OF FLUROXYPYR ON SEEDLING GRASSES IN THE GREENHOUSE

M.A. Ferrell, T.D. Whitson and D.W. Koch[1]

Abstract. The effects of fluroxypyr {4-amino-3,5-dichloro-6-fluro-2-pyridyl-oxyacetic acid} were determined on the following perennial grass species: crested wheatgrass (Agropyron desertorum) var. Ephraim; western wheatgrass (A. smithii) var. Rosana; thickspike wheatgrass (A. dasystachyum) var. Critana; intermediate wheatgrass (A. intermedium) var. Oahe; pubescent wheatgrass (A. trichophorum) var. Luna; bluebunch wheatgrass (A. spicatum) var. Secar; big bluegrass (Poa ampula) var. Sherman; smooth bromegrass (Bromus inermis) var. Manchar; Russian wildrye (Elymus juncus) var. Bozoisky; mountain rye (Secale montanum); and quackgrass (A. repens) x bluebunch wheatgrass, experimental line, RS1. The data indicated that several grass varieties were sensitive to fluroxypyr resulting in weight reductions. However, all varieties reached maturity and did not show any serious visual injury effects. Therefore, all of the varieties tested in this experiment were included in a field study to determine the ability of perennial grasses to compete with fluroxypyr suppressed leafy spurge.

Introduction

Whitson (8) reported that fluroxypyr had considerable activity on leafy spurge. Therefore, perennial grass tolerance to fluroxypyr is an important consideration if this herbicide is to be useful in a leafy spurge control program.

Leafy spurge (Euphoriba esula L.) is a perennial herbaceous plant which can tolerate a wide variety of habitats and environmental conditions. It produces an extensive underground root system and due to its vigorous nature creates dense stands which crowd out more desirable vegetation (7). It is a serious weed pest on rangelands in many northern states and Canada where it affects at least 2.5 million acres (5).

Herbicides currently available are expensive and do not provide long-term control, with a single application. In spite of the millions of dollars spent each year on chemical control, it is still spreading geographically. Other more effective and less expensive methods must be found if leafy spurge is to be effectively controlled.

Biological control of leafy spurge in North America has met with little success. Carlson and Littlefield (2) reported that, to date, three insect species have been released in the United States and Canada with little hope for success.

Very little work has been done to integrate the use of newly developed herbicides for initial control and establishment of perennial grasses for long-term control of leafy spurge. If perennial grasses are to be successful in competing with leafy spurge in a rangeland situation, they must be adapted to range conditions and be acceptable to livestock. Several varieties of perennial grasses show promise for competitive control of leafy spurge. Using herbicides to adequately suppress leafy spurge would allow perennial grass species with good seedling vigor to become established before leafy spurge recovery.

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[1]Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY.

Selleck (6) reports crested wheatgrass has been used successfully in Saskatchewan to decrease the rate of vegetative spread, limit density, reduce seed production and suppress top growth of leafy spurge. He also discovered that if 2,4-D is applied to such stands twice a year the hay may be safely removed for feed, and seed production will be prevented.

Morrow (4) also found that leafy spurge growth may be suppressed by planting an early emerging crop, that will compete for early moisture, such as crested wheatgrass.

In a tilled and no-tilled seeding of perennial grasses in August 1986, in northeastern Wyoming, crested wheatgrass (Agropyron desertorum) var. Ephraim showed vigorous establishment following treatment of leafy spurge with glyphosate. However, all species were slower to germinate in the no-till seedbeds. Ephraim is a relatively new rhizomatous variety which germinates early in the spring and, therefore, should provide early season competition for moisture with leafy spurge.

Quackgrass (A. repens), although not intentionally used as a forage, often provides the bulk of grazed forage in pastures. Under natural conditions quackgrass often dominates. Studies by Kommendahl (3) have shown the adverse non-competitive effects of quackgrass on the germination and growth of many species. A recently crossed quackgrass with bluebunch wheatgrass to produce a species (A. repens x A. spicatum) may show promise as a range species.

Rye (Secale cereale) has been shown to be effective under a wide range of soil and climatic conditions in suppressing weeds, leading to its use as a cover crop and, before the advent of chemical weed control, as a smother or clean-up crop (1). Mountain rye (S. montanum), a perennial, may have promise on many of the habitats occupied by leafy spurge.

The objective of this greenhouse study was to determine the tolerance of several perennial grass species to fluroxypyr. Those showing tolerance were included in a field experiment to study the ability of perennial grass species to compete with leafy spurge following suppression with herbicides.

Materials and Methods

The following eleven perennial grass species were screened for tolerance to fluroxypyr: crested wheatgrass (A. desertorum) var. Ephraim; western wheatgrass (A. smithii) var. Rosana; thickspike wheatgrass (A. dasystachyum) var. Critana; intermediate wheatgrass (A. intermedium) var. Oahe; pubescent wheatgrass (A. trichophorum) var. Luna; bluebunch wheatgrass (A. spicatum) var. Secar; big bluegrass (Poa ampula) var. Sherman; smooth bromegrass (Bromus inermis) var. Manchar; Russian wildrye (Elymus juncus) var. Bozoisky; mountain rye (Secale montanum); and quackgrass (A. repens) x bluebunch wheatgrass, experimental line, RS1.

Grasses were seeded at a rate of 100 seeds/ft^2 in 21 by 10 by 2.5 inch flats. Soil was a greenhouse mixture with a loamy sand texture (83% sand, 8% silt, and 9% clay) with 2.0% organic matter and a 7.5 pH. Experimental design was completely randomized with three replications. Fluroxypyr was applied postemergence when grasses were in the seedling to 2-leaf stage (early) and when grasses were tillered (late). Fluroxypyr was applied at 0.25 and 0.5 lb ai/a at both growth stages. All herbicide treatments were applied with a moving nozzle sprayer delivering 30 gpa at 40 psi. Untreated checks were included. Flats were kept in a greenhouse maintained at 70 $\pm$ 5^{o}F and watered as needed.

Data collected included grass tolerance ratings and grass weights. Grass tolerance was rated visually on a 0 to 9 scale (0 = no tolerance and 9 = no adverse affect) at weekly intervals. Grasses were clipped at maturity to the soil surface and oven dried at 40°C to determine dry weights.

Data from this experiment were analyzed as a factorial; three rates by two times of application. The intent of this experiment was to determine the tolerance of the grass species to fluroxypyr based on rates and time of application. Treatment means were separated by Duncan's multiple range test at the 5% level of probability.

Results and Discussion

Based on weekly visual observations there were no significant differences in grass varieties based on tolerance to fluroxypyr, consequently this data is not presented.

There was no significant rate by time of application differences for the varieties Rosana, Luna, Secar, Manchar, RS1, Critana, or Oahe based on dry weight (Table 1).

The weight of Sherman was significantly reduced by early applications of fluroxypyr at the 0.5 lb ai/a rate (Table 1). Mountain rye weights were also reduced by early applications of fluoxypyr at 0.5 lb ai/a and also by late applications at both the 0.25 and 0.5 lb ai/a rates. With the variety Ephraim all timings and rates significantly reduced clipped weights when compared to the untreated check. However, the greatest reduction resulted from an early treatment of fluroxypyr at 0.5 lb ai/a. Bozoisky was also reduced from this timing and rate.

Table 1. Dry weight of grass seedlings as influenced by rate and time of fluroxypyr application.

	Timing[a]					
	Early		Late			
	Fluroxypyr Rate (lb ai/a)		Fluroxypyr Rate (lb ai/a)			
Grass	0.25	0.5	0.25	0.5	Untreated	CV
(variety)	(grams)[b]					(%)
Rosana	13.9 a	11.7 a	16.3 a	8.7 a	17.4 a	22
Luna	9.7 a	6.3 a	12.1 a	5.8 a	9.2 a	29
Secar	7.2 a	8.1 a	8.5 a	7.9 a	11.2 a	37
Manchar	10.2 a	12.1 a	12.0 a	12.1 a	18.6 a	32
RS1	18.9 a	10.6 a	12.8 a	12.5 a	15.9 a	37
Critana	11.4 a	9.6 a	9.5 a	8.7 a	13.8 a	18
Oahe	6.1 a	3.0 a	4.5 a	4.9 a	6.0 a	36
Sherman	16.4 a	11.0 b	12.5 ab	15.9 a	15.6 a	12
Mt. Rye	12.7 a	7.8 b	6.6 b	7.4 b	11.9 a	15
Ephraim	8.0 b	4.4 c	7.2 bc	11.6 b	14.3 a	18
Bozoisky	5.9 b	3.8 c	7.5 a	6.6 ab	5.3 b	13

[a]Early = seedling to 2 leaf; Late = tillering.

[b]Means followed by the same letter within a row are not significantly different according to Duncan's multiple range test (P = 0.05).

When the data was averaged over time of fluroxypyr application there were no significant weight reductions for the varieties Rosana, Luna, Sherman, Secar, Manchar, RS1, Critana, Oahe, or Bozoisky (Table 2). However, mountain rye had greater weight reductions from late applications of fluroxypyr while Ephraim had greater weight reductions from early applications.

Table 2. **Dry weight of grass seedlings as influenced by time of fluroxypyr application.**

Grass	Time of application[a] Early	Late	Untreated	CV
(variety)		(grams)[b]		(%)
Rosana	12.8 a	12.5 a	17.4 a	27
Luna	8.0 a	8.9 a	9.2 a	40
Sherman	13.7 a	14.2 a	15.6 a	19
Secar	7.7 a	8.2 a	11.2 a	31
Manchar	11.1 a	12.1 a	18.6 a	32
RS1	14.8 a	12.7 a	15.9 a	38
Critana	10.5 a	9.1 a	13.8 a	20
Oahe	4.6 a	4.7 a	6.0 a	42
Bozoisky	4.9 b	7.1 a	5.3 b	17
Mt. Rye	10.3 a	7.0 b	11.9 a	24
Ephraim	6.2 c	9.4 b	14.3 a	30

[a]Early = seedling to 2 leaf; Late = tillering.

[b]Means followed by the same letter within a row are not significantly different according to Duncan's multiple range test (P = 0.05).

When only taking fluroxypyr rates into consideration most of the varieties showed weight reductions (Table 3). Manchar, Critana, mountain rye, and Ephraim had significant weight losses at both rates, whereas, Rosana and Luna show reductions only at the 0.5 lb ai/a rate.

Table 3. Dry weight of grass seedlings as influenced by rate of fluroxypyr application.

Grass	Fluroxypyr rate (lb ai/a) 0.25	0.5	Untreated	CV
(variety)	(grams)[a]			(%)
Sherman	14.5 a	13.5 a	15.6 a	12
Secar	7.9 a	8.0 a	11.2 a	37
RS1	15.9 a	11.6 a	15.9 a	37
Oahe	5.3 a	4.0 a	6.0 a	36
Bozoisky	6.7 a	5.2 b	5.3 b	13
Rosana	15.1 a	10.2 b	17.4 a	22
Luna	10.9 a	6.0 b	9.2 a	29
Manchar	11.1 b	12.1 b	18.6 a	32
Critana	10.5 b	9.2 b	13.8 a	18
Ephraim	7.6 b	8.0 b	14.3 a	18
Mt. Rye	9.6 b	7.6 c	11.9 a	15

[a]Means followed by the same letter within a row are not significantly different according to Duncan's multiple range test (P = 0.05).

The data indicate that the grass varieties examined in this study differed in their sensitivity to fluroxypyr. Nonetheless, all of the varieties reached maturity and did not show any visual damage. Therefore, all of the varieties tested in this experiment were included in a field study to determine the ability of these perennial grasses to compete with fluroxypyr suppressed leafy spurge.

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POTENTIAL USE OF FLUROXYPYR ALONE AND IN MIXTURES FOR PINE RELEASE

E.C. Cole and M. Newton[1]

Conventional pine release treatments, such as 2,4-D {(2,4-dichlorophenoxy)acetic acid} and triclopyr ester {[3,5,6-trichloro-2-pyridinyl)oxy]-acetic acid} have been effective in reducing cover of greenleaf manzanita (Arctostaphylos patula Greene) and snowbrush ceanothus (Ceanothus velutinus Dougl.). However, these treatments are generally injurious to ponderosa pine (Pinus ponderosa Dougl.) and determining the "window" of pine tolerance has been difficult. Herbicide screening trials have been conducted to ascertain if other treatments could effectively release pines from these shrubs without causing injury. Fluroxypyr {4-amino-3,5-dichloro-6-fluoro-2-pyridyloxy acetic acid methyl heptylester}, which is chemically related to triclopyr, has proven promising.

A series of seasonal experiments was established beginning in mid-July, 1986 and following in mid-May and early June 1987. The location was on the eastside of the Cascade Mountains, near Bend, Oregon. The objectives were to determine 1) conifer tolerance to fluroxypyr, 2) efficacy of fluroxypyr on greenleaf manzanita and snowbrush ceanothus, and 3) whether the addition of sulfometuron {2-[[[[(4,6-dimethyl-2-pyrimidinyl)amino]carbonyl]amino] sulfonyl]benzoic acid} would influence the spectrum of control or selectivity of fluroxypyr. All sets of plots were located in the same general area. The three experiments have the substance of a timing series. However, they differe in certain important respects. There was an equipment change between 1986 and 1987 that resulted in an increase in volume applied and smaller drop size. Also, the different seasons did not all test the same combinations even though some treatments remained essentially the same.

The site selected was considered typical for eastside ponderosa pine (Site III, SI_{100}=30 meters). Elevation of the site is 1300 to 1500 meters. Climate is characterized by approximately 50 centimeters precipitation,

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[1]Oregon State University, Corvallis, OR

mostly as snow. Rain falls mainly in April and May. Frost may occur at any time of the year. Soils are light-textured sandy loam pumice with negligible profile development and numerous cobbles of volcanic ejecta. The slope of the plots varied from 5 to 20 percent.

The site is part of a large wildfire in 1979. Ceanothus and manzanita germinated after the fire and revegetated the site. Shrubs ranged from 30 to 90 centimeters at the time of treatment. The site had been planted with 2-0 ponderosa pine in 1983.

Materials and Methods

1986 Plots

Each herbicide was tested in a complete factorial experiment with three replications, where one replication is equivalent to one plot. Three untreated control plots were included in the design. Herbicide and dosage are shown in Table 1. Fluroxypyr was tested at low, medium, and high rates of application (.6, 1.1, 2.2 kg ai/ha) and compared to a conventional treatment with triclopyr ester (1.7 kg ai/ha) and a mixture of 1.7 kg ai/ha triclopyr ester and 1.1 kg ai/ha clopyralid {3,6-dichloro-2-pyridine-carboxylic acid}.

All treatments were applied at 93.5 liters/ha, the nominal rate for aerial application. The 8.8 by 4.6 meter plots (.01 acre) were sprayed with a backpack sprayer with a single adjustable Chapin nozzle using the "waving wand" technique. Volume per plot was calibrated by measuring the delivery rate of the nozzle per second and applying coverage in two passes, usually in opposite directions. On a few plots, heavy slash dictated that both passes be from the same direction. For all plots, spray time was recorded so that the second pass could compensate for inadvertant variation during the first pass. Nearly all plots received ± five percent of the planned dosage.

Before treatment, up to ten shrubs of each species were tagged for later evaluation. Shrubs were not tagged if they showed significant pretreatment damage from disease, browsing, or frost. The number of pines on the plots was recorded for evaluation of pine injury.

1987 Plots

Each herbicide was tested in a complete factorial experiment with two replications, where one replication is equivalent to one plot. The design included two untreated control plots. Herbicide, dosage, and timing are shown in Table 1. Fluroxypyr was tested at a low and medium rate (.6 and 1.1 kg ai/ha) and in a mixture with sulfometuron at .14 kg ai/ha. Sulfometuron was included for grass control.

Treatments were applied with a nitrogen pressurized hand-held plot sprayer, using 30 PSI and 8015 nozzles. The sprayer had seven nozzles on the boom, for an effective swath width of 3.2 meters. Delivery rate was 1 liter per 18.5 seconds at 30 PSI; plots were sprayed at the rate of 120 liters/ha. Each plot was 3.2 by 22 meters.

Before treatment, up to 15 of each major species were tagged for later evaluation. Shrubs were not tagged if they showed significant pretreatment damage from disease, browsing, or frost. Ponderosa pines were tagged for evaluation of pine tolerance. In the time between treatments, some frost injury occurred on the ceanothus.

Results and Discussion

Shrubs were ocularly evaluated for crown and stem reduction in summer, 1987, giving one year results for the 1986 plots and one growing season results for 1987 plots. Pine seedlings were rated for injury on a 6-point scale: 0--no injury; 1--minor injury to foliage; 2--injury to foliage and loss of buds; 3--slight terminal dieback; 4--terminal dieback and major loss of foliage (greater than thirty percent); and 5--dead. Results were analyzed using analysis of variance and Tukey's comparison among means.

Snowbrush Ceanothus: Both of the triclopyr treatments displayed significant damage to ceanothus with crown and stem reductions of 91 to 92 percent and 86 percent, respectively (Table 2). For crown reduction, all of the fluroxypyr treatments, except for the low rate in July, were significantly different from the respective controls (Tables 2 and 3). Only the fluroxypyr plus sulfometuron treatments were significantly different from the controls in terms of stem reduction. Although differences in crown reduction were minimal when comparing fluroxypyr treatments among seasons, stem reduction was greater with the July applications. Overall, with fluroxypyr, rate of application seems to have a greater effect on ceanothus than those seasons tested. Treatments of fluroxypyr alone ranged from 25 to 56 percent crown reduction and 1 to 37 percent stem reduction.

Adding sulfometuron to fluroxypyr increased efficacy on ceanothus in May and June. Crown and stem reduction at the medium rate ranged from 58 to 63 and 36 to 46 percent, respectively. These treatments produced similar results to the high rate of fluroxypyr alone in July.

Crown reduction with the May application of sulfometuron was significantly different from the control, but resulted in only 17 percent reduction. None of the other values were significantly different, and sulfometuron was generally ineffective on ceanothus during the dates applied.

Greenleaf Manzanita: All treatments, except for the sulfometuron treatments, were significantly different from the respective control plots (Tables 2 and 3). Crown reduction in the triclopyr treatments was 96 to 97 percent, and stem reduction was 80 to 91 percent. Adding clopyralid to triclopyr did not increase efficacy.

Some seasonal differences occurred among the fluroxypyr treatments. Crown and stem reduction at the medium rate in July (80 and 63 percent) was comparable to the low rate in May and June (73 to 83 and 58 to 73 percent). Mortality was not as high with the medium rate in May and June (94 to 97 and 87 to 92 percent crown and stem reduction) compared to the high rate in July (100 and 99 percent crown and stem reduction). However, all of these treatments gave excellent control on manzanita. In general, at equivalent rates, crown and stem reduction was better with the May and June applications than the July applications. The medium rate treatments in May and June and the high rate in July were comparable to the triclopyr treatments in July. Adding sulfometuron to fluroxypyr did not increase efficacy.

Sulfometuron alone treatments were generally ineffective on manzanita. Significant crown reduction occurred only with the May application. Crown reduction ranged from 14 to 24 percent and stem reduction from 2 to 3 percent.

Pine Injury: The greatest injury occurred with the triclopyr treatments. Top dieback, major foliage loss, and loss of terminal buds were common in these plots. Although there was some lessening of injury with the addition of clopyralid, injury still resulted in loss of terminal buds and some terminal dieback (Table 4).

Injury to pine with fluroxypyr treatments varied with rates and seasons. Injury in May and June was difficult to assess due to the nature of the herbicide injury. Frequently, pines would lose greater than thirty percent of foliage, but buds would appear uninjured. It is not known if these seedlings will recover from injury without significant growth losses. Injury to pine was more severe with the May and June applications than with the July applications. There was also a trend for the injury to be more severe in June than May, but this was not always consistent. In July, only the high rate caused severe injury to pine. However, in May and June, severe injury was found at all rates. With the low and medium rates in July, injuries were limited to minor loss of foliage, and seedlings in these plots were expected to recover.

Seedlings in the sulfometuron treatments generally exhibited little or no injury, and these seedlings are expected to recover.

Summary

Triclopyr ester gave the best control of both greenleaf manzanita and snowbrush ceanothus. However, injury to pine was common and severe, principally through top dieback and loss of buds. Adding clopyralid to triclopyr may have reduced injury to pines, but not to acceptable levels.

At the low and medium rates, fluroxypyr treatments were similar among seasons on ceanothus. Adding sulfometuron to fluroxypyr at the medium rate in May and June increased efficacy on ceanothus. This treatment was comparable to the high rate of fluroxypyr in July. None of the fluroxypyr treatments gave excellent control on ceanothus. For manzanita, both season and rate determined efficacy. Mortality was highest with the high rate in July, but control was also excellent with the medium rate in May and June. These treatments were comparable to the triclopyr treatments. The low and medium rates in July were less effective. All rates of fluroxypyr caused less injury to pine than the triclopyr alone treatments. Injury was least in July with the low and medium rates. With the May and June treatments, injury to pine was more severe than in July, especially with the medium rate of application.

Sulfometuron was generally ineffective on the shrub species, but caused little or no injury to pines.

Refinement of timing and rate is needed to determine the best treatment for pine release.

Acknowledgements

The authors wish to thank Dow Chemical Company and E.I. duPont de Nemours & Company, Inc. for grants-in-aid for this research and Cavenham Industries, Inc. for allowing the establishment of plots on Cavenham land.

Table 1. Summary of treatments.

Chemical	Rate/Hectare	Date
Fluroxypyr	0.6, 1.1, 2.2 kg ai	July 1986
	0.6, 1.1 kg ai	May, June 1987
Triclopyr ester	1.7 kg ai	July 1986
Sulfometuron	0.14 kg ai	May, June 1987
Fluroxypyr + Sulfometuron	0.6, 1.1 + 0.14 kg ai	May, June 1987
Triclopyr + Clopyralid	1.7 + 1.1 kg ai	July 1986
Control	0	July 1986
	0	May, June 1987

Table 2. Crown and Stem Reduction for Snowbrush Ceanothus and Greenleaf Manzanita (from July 1986 plots).

		Ceanothus[1]		Manzanita[1]	
Treatment	Rate/Ha	%Crown Reduction	%Stem Reduction	%Crown Reduction	%Stem Reduction
Fluroxypyr	0.6 kg ai	30 bc	15 b	62 b	40 c
	1.1 kg ai	39 b	18 b	80 ab	63 bc
	2.2 kg ai	56 b	37 b	100 a	99 a
Triclopyr	1.7 kg ai	91 a	86 a	97 a	80 ab
Triclopyr + Clopyralid	1.7 kg ai + 1.1 kg ai	92 a	86 a	96 a	91 a
Control	0	4 c	1 b	3 c	1 d

[1] Means in the same column followed by the same letter are not significantly different at alpha=0.05 using Tukey's.

Table 3. Crown and Stem Reduction for Snowbrush Ceanothus and Greenleaf Manzanita (from the May and June 1987 plots).

Treatment	Rate/Ha	Date	Ceanothus[1] %Crown Reduction	Ceanothus[1] %Stem Reduction	Manzanita[1] %Crown Reduction	Manzanita[1] %Stem Reduction
Fluroxypyr	0.6 kg ai	May	26 cde	1 c	79 b	62 b
	1.1 kg ai	May	34 bcd	2 c	94 a	87 a
	0.6 kg ai	June	25 de	2 c	83 ab	73 ab
	1.1 kg ai	June	41 b	7 bc	95 a	90 a
Fluroxypyr + Sulfometuron	.6+.14 kg ai	May	34 bcd	10 bc	75 b	64 b
	1.1+.14 kg ai	May	63 a	46 a	94 a	87 a
	.6+.14 kg ai	June	36 bc	15 b	73 b	58 b
	1.1+.14 kg ai	June	58 a	36 a	97 a	92 a
Sulfometuron	0.14 kg ai	May	17 ef	4 bc	24 c	3 c
	0.14 kg ai	June	9 fg	2 c	14 cd	2 c
Control	0		2 g	0 c	1 d	0 c

[1]Means in the same column followed by the same letter are not significantly different at alpha=0.05 using Tukey's.

Table 4. Pine Injury from July 1986 plots.

Treatment	Rate/Ha	Injury Rating[1]	% Injury	% Minor Injury	% Severe Injury
Fluroxypyr	0.6 kg ai	0.7 cd	67	67	0
	1.1 kg ai	0.9 c	90	90	0
	2.2 kg ai	1.4 c	100	82	8
Triclopyr	1.7 kg ai	4.0 a	100	7	93
Triclopyr + Clopyralid	1.7 kg ai + 1.1 kg ai	2.7 b	100	46	54
Control	0	0.0 d	0	0	0

[1]Means followed by the same letter are not significantly different at alpha=0.05 using Tukey's. Values based on 6-point rating scale.

Table 5. Pine Injury from May and June 1987 plots.

Treatment	Rate/Ha	Date	Injury[1] Rating	% Injury	% Minor Injury	% Severe Injury
Fluroxypyr	0.6 kg ai	May	1.9 bc	90	70	20
	1.1 kg ai	May	1.9 bc	100	75	25
	0.6 kg ai	June	0.9 de	71	64	7
	1.1 kg ai	June	2.7 ab	100	46	54
Fluroxypyr +	0.6+.14 kg ai	May	0.8 de	60	60	0
Sulfometuron	1.1+.14 kg ai	May	2.6 ab	100	46	54
	0.6+.14 kg ai	June	1.3 cd	83	75	8
	1.1+.14 kg ai	June	3.1 a	100	33	67
Sulfometuron	0.14 kg ai	May	0.1 e	12	12	0
	0.14 kg ai	June	0.1 e	6	6	0
Control	0		0.0 e	0	0	0

FOREST WEEDING TO PROTECT DOUGLAS-FIR FROM DEER BROWSING

M. Gourley, M. Vomocil and M. Newton[1]

Abstract. Three-year-old Douglas-fir transplants were established in four cutover locations in the Oregon Coast Range where deer browsing was expected. Protection was provided against browsing by eight mechanical or chemical protective treatments, each of which was tested with and without complete weed control with directed applications of glyphosate. After five years, none of the protective treatment involving mechanical or chemical barriers provided any growth advantages; some caused losses of growth. In contrast, complete chemical weed control, with or without additional protective measures, consistently improved growth. By the fifth year, weeded trees consistently averaged twice the biomass of unweeded trees, regardless of whether or not they were browsed. Frequency of browsing was the same regardless of weeding, but the largest average tree size occurred in the treatment with no weed competition and with no barriers to prevent browsing. Advantages of weeding were greatest on the poorest site.

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[1]Starker Forests, Inc., and Oregon State University, Corvallis, OR

FIRST-YEAR RESULTS OF A HERBICIDE SCREENING TRIAL IN A NEWLY ESTABLISHED RED ALDER PLANTATION WITH 1+0 BARE-ROOT AND PLUG SEEDLING STOCK

P.F. Figueroa[1]

Introduction

This paper discusses the results of an experiment to investigate first-year effects of vegetation competition on red alder (*Alnus rubra* Bong.) planted following a broadcast burn for site preparation. Included in this study was a herbicide screening trial to evaluate efficacy of 16 herbicides in 24 application combinations (Table 1). Two red alder stock types, 1+0 bare-root and 1+0 plug seedlings, were planted to evaluate chemical phytotoxicity.

Little work has been published on the long-term effects of competing vegetation on managed red alder plantations. The literature does support the need for vegetation control at time of establishment in alder plantations. Worthington (8) reports that brush competition is a major problem for successful red alder regeneration. Kenady (6) reports 20% to 90% increases in first-year red alder survival following vegetation control with herbicides. In a roadside spray test of Italian alder (*Alnus cordata* Desf.), Davies (1) reports that grasses significantly impacted survival. Davies demonstrated survival increases from 0% to 27% using herbicides; when herbicides were combined with banded plastic, survival was increased to 67%.

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[1]Weyerhaeuser Company, Centralia, WA

Table 1. Sucker Creek Red Alder Plantation Chemical Screening Trial. Treatment Rates and Application Dates.

Chemical	Rate (lb./acre)	1987 Application Date
Check	-	-
Glyphosate, Atrazine, Terbutryn	2.0, 3.4, 2.0	Feb 17
Glyphosate, Napropamide, Oryzalin	2.0, 2.0, 1.7	Feb 17
Glyphosate, Napropamide, Oryzalin	2.0, 4.0, 3.4	Feb 17
Hexazinone (MCI 7G)	2.0	Feb 17
Hexazinone (MCI 7G)	3.0	Feb 17
Hexazinone (Pronone 5G)	2.0	Feb 17
Hexazinone (Pronone 5G)	3.0	Feb 17
Imazapyr	0.5	Feb 17
Imazapyr	1.0	Feb 17
Atrazine, Dalapon, 2,4-D, Triclopyr	3.4, 2.9, 1.9, 0.5	Mar 10
Glyphosate, Simazine	2.0, 4.0	Mar 10
Glyphosate, Atrazine	2.0, 3.4	Mar 10
Pronamide	2.0	Mar 10
Sulfometuron	0.2	Mar 10
Sulfometuron	0.4	Mar 10
Sulfometuron, Hexazinone (Velpar L)	0.2, 2.0	Mar 10
Sulfometuron, Terbutryn	0.2, 2.0	Mar 10
Glyphosate	2.0	Mar 16
Glyphosate, 2,4-D	2.0, 1.9	Mar 16
Metsulfuron methyl	1 oz.	Mar 16
Metsulfuron methyl	2 oz.	Mar 16
Clopyralid	0.25	Mar 27
Clopyralid	1.0	Mar 27
Sethoxydim, 2,4-D	0.4, 1.9	Mar 27

This study was located on Weyerhaeuser's Sucker Creek plantation (Sec. 15 T9N R1W) in Cowlitz county in southwest Washington. The study was located at 800 feet elevation on gentle terrain with adequate cold air drainage to prevent frost. The soils are deep, well drained sandy clay loams in the Morgan series (2) which has developed from basic igneous rock. Soil depth ranges from 48 to 60 inches. Organic content of the 0-8 inch horizon was 12%. Red alder site index was estimated at 105 feet at 50 years (5).

The site was broadcast burned in the fall of 1986 after the 50-year-old residual second growth Douglas-fir (Pseudotsuga menziesii (Mirbel.) Franco) was harvested. The broadcast burn consumed all above ground vegetation and a large portion of the logging debris.

Treatment Procedures

The experimental design for this study was a randomized complete block design with split-plots and four blocks, as shown in the following ANOVA table:

Analysis of variance, partioning of degrees of freedom.

Source of Variation	Degrees of Freedom
Main effect	
Blocks	3
Herbicide treatment	24
Error	72
Main plot total	99
Subplot effect	
Stock	1
Herbicide x stock	24
Error	75
Subplot total	100
Total	199

Treatment differences were analyzed using analysis of variance procedures described by Steel and Torrie (7) and hypothesis tested at 0.05 probability level. Main plot effect was herbicide treatment and plot size was 0.01 acre (7x62.2 feet). Each of the 25 treatments (Table 2) were randomly assigned within a block. Each herbicide plot was split in half for the random assignment of planting stock (subplots). Duncan's new multiple range T-test was used to test differences among herbicide treatments. Percent survival and vigor class percentages were transformed using a square root arcsine transformation.

A single 3.3 foot square vegetation sampling plot was installed on the center line between subplots. A visual assessment was made to determine the percent ground covered by vegetation groups of grasses and sedges, forbs (without ferns), ferns and shrubs.

Red alder was shovel planted on March 30, 1987. The 1+0 bare-root stock was from seed zone 400 south of Mt. St. Helens and grown in the U.S. Forest Service nursery at Wind River. Stock averaged 49 cm (SE 0.9) tall and had a

Table 2. 1987 Sucker Creek Red Alder Plantation Chemical Screening Trial. Plant Species Observed In Test Plots.

Common Name	Species
Grasses and Sedges	
Red Top	*Agrostis alba* L.
Spike Bentgrass	*Agrostis exarata* Trin.
Carex	*Carex laeviculmis* Meinsh.
Slender Hairgrass	*Derchampsia elongata* (Hook.) Munro ex Benth.
Blue Wildrye	*Elymus glaucus* Buckl.
Western fescue	*Festuca occidentalis* Walt.
Tall Trisetum	*Trisetum canescens* Buckl.
Forbs	
Pearly Everlasting	*Anaphalis margaritacea* (L.) B.& H.
Lady Fern	*Athyrium filix-femina* (L.) Roth.
Canadian Thistle	*Cirsium arvense* (L.) Scop.
Bull Thistle	*Cirsium vulgare* (Savi) Airy-Shaw
Fireweed	*Epilobium angustifolium* L.
Burnweed	*Erechites* (Rath.)
Aster	*Erigeron* L.
Sword Fern	*Polystichum munitum* (Kaulf.) Presl.
Bracken Fern	*Pteridium aquilinum* (L.)Kuhn in Von Der Decken
Tansy Ragwort	*Scencio jacobae* L.
Clover	*Trifolium* L.
Vetch	*Visia sativa* L.
Shrubs	
Oregon Grape	*Berberis aquifolium* Pursh
Currant	*Ribes* L.
Red Flowered Current	*Ribes sanguineum*
Rose	*Rosa gymnocarpa* Nutt.
Hymalayan Blackberry	*Rubus ideaeus* L.
Thimbleberry	*Rubus parviflorus* Nutt.
Salmonberry	*Rubus spectabilis* Pursh
Trailing Blackberry	*Rubus ursinus* Cham. & Schlecht.
Red Elderberry	*Sambucus racemosa* L.
Snowberry	*Symphoricarpos albus* (L.) Blake

minimum pack standard of 3 mm caliper and 20 cm total height. The 1+0 plug seedlings were grown in 3 cubic inch containers at the Washington State Department of Natural Resources Webster nursery. Plug seed was collected in the same seed zone as the bare-root seedlings. Plugs averaged 22 cm (SE 0.2) in height and had the same minimum pack standards as the bare-root. In each plot, 10 bare-root and 10 plug seedlings were planted along the center line on 3-foot spacings.

All liquid chemical treatments were applied at 15 gallons per acre mixture using a multi-tip boom sprayer (3) which sprays a 4-foot swath. Surfactants were added as per label instructions. The granular hexazinone {3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1H,3H)-dione} treatments were applied by hand spreading granules across the plot in two passes. Application dates ranged between February 17 and March 27, 1987 (Table 1). Hexazinone and the imazapyr {(±)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-3-pyridinecarboxylic acid} treatments were applied on February 17 to allow the greatest length of time between application and planting to help minimize phytotoxicity to planted red alder (4). All other treatments were applied to coincide with label requirements and vegetation development at the site.

First-year assessments were made on August 31, 1987. Red alder survival, tree vigor and total height were recorded for each tree. Percent ground cover was visually estimated and plots were assumed to be similar prior to treatment. Plant species observed on the site are listed in Table 2.

Results

Herbicide Efficacy

Herbicide treatment effects on vegetation were significantly different among treatments. The overall efficacy of herbicide treatments for grass, forb, fern and shrub classes combined is shown in Table 3. Of these treatments only sethoxydim {2-[1-(ethoxyimino)butyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-2-one} plus 2,4-D {(2,4-dichlorophenoxy)acetic acid}, and clopyralid {3,6-dichloro-2-pyridinecarboxylic acid} (0.25 lb/ac) did not significatnly reduce total vegetation cover. Herbicides that had high vegetation control include hexazinone (Pronone 5G; MCI 7G); imazapyr, all atrazine {6-chloro-N-ethyl-N'-(1-methyl-ethyl)-1,3,5-triazine-2,4-diamine} treatments, all sulfometuron {2-[[[[(4,6-dimethyl-2-pyrimidinyl)amino] carbonyl]amino]sulfonyl]benzoic acid} treatments and all glyphosate {N-(phosphonomethyl)glycine} combinations.

The untreated check plots averaged 45% ground coverage by grasses and sedges. Grass cover on treated plots ranged between 0 and 68% as shown in Table 4. The clopyralid treatments appeared in the field to have either stimulated or changed the vegetation structure that allowed increases in grass cover. The highest grass and sedge control was obtained with imazapyr, pronamide {3,5-dichloro(N-1,1-dimethyl-2-propynyl)benzamide}, hexazinone (Pronone 5G, MCI 7G), sulfometuron plus hexazinone (Velpar L), glyphosate plus napropamide {N,N-diethyl-2-(1-naphthalenyloxy)propanamide} plus oryzalin {4-(dipropylamino)-3,5-dinitrobenzenesulfonamide}, sulfometuron plus terbutryn {N-(1,1-dimethylethyl)-N'-ethyl-6-(methylthio)-1,3,5-triazine-2,4-diamine}, atrazine plus dalapon {2,2-dichloropropanoic acid} plus 2,4-D plus triclopyr {[3,5,6-trichloro-2-pyridinyl)oxy] acetic acid}; glyphosate plus 2,4-D and glyphosate plus atrazine.

Table 3. Sucker Creek Red Alder Plantation Chemical Screening Trial. Effects of Herbicides on Percent Ground Cover for All Vegetation.

Chemical	Rate (lb. ai/acre)	Percent Ground Cover[1] Mean	(SE)
Hexazinone (Pronone 5G)	3.0	34	(12)
Hexazinone (Pronone 5G)	2.0	35	(5)
Imazapyr	1.0	37	(11)
Hexazinone (MCI 7G)	3.0	49	(12)
Imazapyr	0.5	59	(17)
Atrazine,Dalapon, 2,4-D,Triclopyr	3.4,2.9,1.9,0.5	62	(26)
Sulfometuron, Hexazinone(Velpar L)	0.2, 2.0	65	(9)
Sulfometuron	0.2	75	(18)
Hexazinone (MCI 7G)	2.0	78	(15)
Glyphosate, Atrazine	2.0, 3.4	79	(15)
Glyphosate, Napropamide, Oryzalin	2.0, 4.0, 3.4	89	(16)
Glyphosate	2.0	95	(23)
Metsulfuron methyl	2 oz.	96	(21)
Sulfometuron	0.4	97	(13)
Glyphosate, 2,4-D	2.0, 1.9	100	(23)
Glyphosate, Atrazine, Terbutryn	2.0, 3.4, 2.0	101	(25)
Metsulfuron methyl	1 oz.	104	(13)
Glyphosate, Napropamide, Oryzalin	2.0, 2.0, 1.7	109	(24)
Pronamide	2.0	119	(32)
Clopyralid	1.0	120	(9)
Glyphosate, Simazine	2.0, 4.0	125	(12)
Sulfometuron, Terbutryn	0.2, 2.0	133	(16)
Clopyralid	0.25	150	(10)
Sethoxydim, 2,4-D	0.4, 1.9	165	(34)
Check	-	204	(20)

[1] Treatments with overlap of bars are not significantly different at $\alpha = 0.05$ using Duncan's New Multiple Range T-test.

Table 4. Sucker Creek Red Alder Plantation Chemical Screening Trial. Effects of Herbicides on Percent Ground Cover for Grasses and Sedges.

Chemical	Rate (lb. ai/acre)	Percent Ground Cover[1] Mean	(SE)
Imazapyr	1.0	0	(0)
Imazapyr	0.5	0	(0)
Pronamide	2.0	3	(3)
Hexazinone (Pronone 5G)	3.0	3	(3)
Sulfometuron, Hexazinone(Velpar L)	0.2, 2.0	4	(4)
Glyphosate, Napropamide, Oryzalin	2.0, 4.0, 3.4	6	(5)
Hexazinone (MCI 7G)	3.0	7	(3)
Sulfometuron	0.4	7	(5)
Hexazinone (Pronone 5G)	2.0	8	(1)
Sulfometuron, Terbutryn	0.2, 2.0	8	(1)
Atrazine,Dalapon, 2,4-D,Triclopyr	3.4,2.9,1.9,0.5	8	(7)
Glyphosate, 2,4-D	2.0, 1.9	10	(4)
Glyphosate, Atrazine	2.0, 3.4	10	(5)
Sulfometuron	0.2	13	(5)
Glyphosate	2.0	16	(15)
Glyphosate, Atrazine, Terbutryn	2.0, 3.4, 2.0	16	(11)
Hexazinone (MCI 7G)	2.0	18	(5)
Glyphosate, Simazine	2.0, 4.0	23	(13)
Glyphosate, Napropamide, Oryzalin	2.0, 2.0, 1.7	26	(12)
Sethoxydim, 2,4-D	0.4, 1.9	33	(15)
Metsulfuron methyl	1 oz.	40	(23)
Metsulfuron methyl	2 oz.	40	(20)
Check	-	45	(22)
Clopyralid	1.0	48	(19)
Clopyralid	0.25	68	(15)

[1] Treatments with overlap of bars are not significantly different at $\alpha = 0.05$ using Duncan's Multiple Range T-test.

Table 5. Sucker Creek Red Alder Plantation Chemical Screening Trial. Effects of Herbicides on Percent Ground Cover for Forbs (w/o Ferns).

Chemical	Rate (lb. ai/acre)	Percent Ground Cover[1/] Mean	(SE)
Hexazinone (MCI 7G)	3.0	8	(3)
Hexazinone (Pronone 5G)	3.0	9	(3)
Clopyralid	0.25	11	(1)
Glyphosate	2.0	14	(4)
Hexazinone (Pronone 5G)	2.0	15	(5)
Clopyralid	1.0	16	(9)
Atrazine,Dalapon, 2,4-D,Triclopyr	3.4,2.9,1.9,0.5	18	(6)
Imazapyr	0.5	19	(8)
Metsulfuron methyl	1 oz.	19	(8)
Sulfometuron, Hexazinone(Velpar L)	0.2, 2.0	20	(10)
Imazapyr	1.0	21	(7)
Hexazinone (MCI 7G)	2.0	23	(5)
Metsulfuron methyl	2 oz.	23	(5)
Glyphosate, Napropamide, Oryzalin	2.0, 2.0, 1.7	26	(6)
Glyphosate, Napropamide, Oryzalin	2.0, 4.0, 3.4	28	(9)
Sulfometuron	0.2	28	(6)
Glyphosate, Atrazine	2.0, 3.4	30	(9)
Glyphosate, Simazine	2.0, 4.0	30	(11)
Glyphosate, 2,4-D	2.0, 1.9	35	(13)
Sulfometuron	0.4	35	(6)
Sethoxydim, 2,4-D	0.4, 1.9	43	(13)
Glyphosate, Atrazine, Terbutryn	2.0, 3.4, 2.0	45	(18)
Pronamide	2.0	60	(18)
Sulfometuron, Terbutryn	0.2, 2.0	73	(11)
Check	-	83	(5)

[1] Treatments with overlap of bars are not significantly different at $\alpha = 0.05$ using Duncan's New Multiple Range T-test.

Table 6. Sucker Creek Red Alder Plantation Chemical Screening Trial. Effects of Herbicides on 1+0 Bare-root Stock Survival After One Year.

Chemical	Rate (lb. ai/acre)	Percent Survival[1] Mean	(SE)
Glyphosate, 2,4-D	2.0, 1.9	95	(5)
Atrazine,Dalapon, 2,4-D,Triclopyr	3.4,2.9,1.9,0.5	93	(3)
Glyphosate, Atrazine	2.0, 3.4	93	(8)
Clopyralid	1.0	90	(7)
Hexazinone (MCI 7G)	2.0	90	(6)
Glyphosate	2.0	88	(6)
Metsulfuron methyl	2 oz.	88	(9)
Glyphosate, Napropamide, Oryzalin	2.0, 2.0, 1.7	83	(6)
Imazapyr	0.5	83	(8)
Hexazinone (Pronone 5G)	3.0	80	(4)
Glyphosate, Atrazine, Terbutryn	2.0, 3.4, 2.0	78	(13)
Sethoxydim, 2,4-D	0.4, 1.9	78	(11)
Sulfometuron, Hexazinone(Velpar L)	0.2, 2.0	78	(13)
Glyphosate, Napropamide, Oryzalin	2.0, 4.0, 3.4	75	(17)
Hexazinone (Pronone 5G)	2.0	75	(3)
Check	-	73	(17)
Glyphosate, Simazine	2.0, 4.0	70	(10)
Hexazinone (MCI 7G)	3.0	70	(11)
Pronamide	2.0	70	(12)
Sulfometuron, Terbutryn	0.2, 2.0	68	(5)
Metsulfuron methyl	1 oz.	65	(5)
Clopyralid	0.25	55	(18)
Imazapyr	1.0	55	(10)
Sulfometuron	0.2	53	(14)
Sulfometuron	0.4	48	(17)

[1] Treatments with overlap of bars are not significantly different at $\alpha = 0.05$ using Duncan's New Multiple Range T-test.

Forb cover, excluding ferns, was significantly reduced by various herbicide treatments. As shown in Table 5, the untreated check plots averaged 83% ground covered while treated plots ranged between 8% and 73%. Treatments that gave the highest reduction in forb cover include hexazinone (Pronone 5G and MCI 7G), clopyralid, glyphosate, atrazine plus dalapon plus 2,4-D plus triclophyr, imazapyr and metsulfuron methyl {methyl 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl]benzoic acid}. Of the treatments tested, only pronamide and the sulfometuron plus terbutryn treatments were not significantly different from the check plots.

None of the herbicide treatments significantly effected levels of fern or shrub cover. This study was not sensitive enough to detect differences although hexazinone (Pronone 5G, MCI 7G), imazapyr, glyphosate plus 2,4-D and glyphosate plus atrazine treatments did show a trend for reduced cover.

Red Alder Survival

Analysis of variance on subplot alder seedling survival showed significant differences between stock types. Overall 1+0 bare-root survival was 76% (SE 2) while 1+0 plug seedlings was 55% (SE 3).

The effects of herbicide treatments on bare-root stock is shown in Table 6. There was a statistically significant difference among treatments with respect to seedling survival; survival ranged from 48% to 95%, with the untreated check plots at 73% survival. Relative to the check, survival tended to be higher on the glyphosate plus 2,4-D, atrazine plus dalapon plus 2,4-D plus triclopyr and the glyphosate plus atrazine treatments. Conversely, survival tended to be reduced with the sulfrometuron and the imazapyr (1.0 lb/ac) treatments due to chemical toxicity and in the clopyralid treatment (0.25 lb/ac) probably because of its stimulation of grass competition.

Herbicides affected plug seedling survival similarly. Glyphosate in combinations with napropamide, oryzalin or 2,4-D, or atrazine plus terbutryn or simazine {6-chloro-N,N'-diethyl-1,3,5-triazine-2,4-diamine} treatments had the highest survival. Sulfometuron, metsulfuron methyl, imazapyr (1.0 lb/ac), sulfometuron plus hexazinone (Velpar L) and hexazinone (Prone 5G, 3 lb/ac) showed a trend of lower plug survival (Table 7).

Tree Vigor

Tree vigor was assessed using a 5 point rating system (1 = healthy with 100% foliage retention and 5 = dead). To test improvement in tree vigor due to vegetation reduction and decrease in vigor from toxicity, we tested the percent of trees that had high vigor (classes 1 and 2) by treatment. Those class trees with at least 50% foliage retention, have green color and no visible herbicide damage.

There was greater treatment differentiation for bare-root stock as shown in Table 8. Check plots had 50% of the trees in the high vigor classes while glyphosate plus 2,4-D had 95% of the trees with high vigor. Phytotoxic effects were evident for sulfometuron, imazapyr and metsulfuron methyl.
Those effects were more pronounced for plug seedlings (Table 9). The glyphosate treatment combinations had the greatest positive effects, while sulfometuron (and combinations); and imazapyr (1.0 lb/ac) had the largest reductions in plug seedling vigor.

Table 7. Sucker Creek Red Alder Plantation Chemical Screening Trial. Effects of Herbicides on 1+0 Plug Stock Survival After One Year.

Chemical	Rate (lb. ai/acre)	Percent Survival[1/] Mean	(SE)
Glyphosate, Napropamide, Oryzalin	2.0, 2.0, 1.7	85	(9)
Glyphosate, 2,4-D	2.0, 1.9	80	(4)
Glyphosate, Atrazine	2.0, 3.4	75	(10)
Glyphosate, Atrazine, Terbutryn	2.0, 3.4, 2.0	75	(12)
Glyphosate, Simazine	2.0, 4.0	75	(5)
Clopyralid	0.25	70	(15)
Glyphosate, Napropamide, Oryzalin	2.0, 4.0, 3.4	70	(10)
Atrazine,Dalapon, 2,4-D,Triclopyr	3.4,2.9,1.9,0.5	68	(17)
Hexazinone (MCI 7G)	2.0	63	(10)
Sethoxydim, 2,4-D	0.4, 1.9	60	(16)
Clopyralid	1.0	58	(19)
Glyphosate	2.0	58	(14)
Imazapyr	0.5	53	(11)
Check	-	50	(15)
Hexazinone (MCI 7G)	3.0	50	(4)
Hexazinone (Pronone 5G)	2.0	48	(6)
Pronamide	2.0	48	(5)
Sulfometuron, Terbutryn	0.2, 2.0	48	(13)
Metsulfuron methyl	2 oz.	45	(16)
Hexazinone (Pronone 5G)	3.0	38	(12)
Sulfometuron	0.2	38	(8)
Sulfometuron, Hexazinone(Velpar L)	0.2, 2.0	35	(12)
Imazapyr	1.0	33	(12)
Metsulfuron methyl	1 oz.	30	(7)
Sulfometuron	0.4	15	(9)

[1] Treatments with overlap of bars are not significantly different at $\alpha = 0.05$ using Duncan's New Multiple Range T-test.

Table 8. Sucker Creek Red Alder Plantation Chemical Screening Trial. Effects of Herbicides on 1+0 Bare-root, Percent of Trees in High Vigor Classes.

Chemical	Rate (lb. ai/acre)	Percent Trees [1/] w/ High Vigor Mean	(SE) [2/]
Glyphosate, 2,4-D	2.0, 1.9	95	(5)
Atrazine,Dalapon, 2,4-D,Triclopyr	3.4,2.9,1.9,0.5	83	(3)
Clopyralid	1.0	83	(12)
Glyphosate	2.0	80	(9)
Glyphosate, Atrazine	2.0, 3.4	80	(14)
Hexazinone (MCI 7G)	2.0	78	(10)
Hexazinone (Pronone 5G)	3.0	75	(5)
Hexazinone (MCI 7G)	3.0	68	(12)
Sethoxydim, 2,4-D	0.4, 1.9	68	(11)
Glyphosate, Atrazine, Terbutryn	2.0, 3.4, 2.0	63	(17)
Hexazinone (Pronone 5G)	2.0	63	(3)
Metsulfuron methyl	2 oz.	63	(11)
Glyphosate, Napropamide, Oryzalin	2.0, 4.0, 3.4	58	(25)
Glyphosate, Napropamide, Oryzalin	2.0, 2.0, 1.7	55	(15)
Pronamide	2.0	55	(12)
Check	-	50	(11)
Sulfometuron, Hexazinone(Velpar L)	0.2, 2.0	50	(19)
Imazapyr	0.5	45	(3)
Glyphosate, Simazine	2.0, 4.0	43	(8)
Clopyralid	0.25	38	(13)
Sulfometuron, Terbutryn	0.2, 2.0	33	(5)
Metsulfuron methyl	1 oz.	25	(12)
Imazapyr	1.0	20	(7)
Sulfometuron	0.4	20	(20)
Sulfometuron	0.2	18	(9)

[1] Trees with at least 50% foliage, have green needles and no visible herbicide damage.

[2] Treatments with overlap of bars are not significantly different at α = 0.05 using Duncan's New Multiple Range T-test.

Table 9. Sucker Creek Red Alder Plantation Chemical Screening Trial. Effects of Herbicides on 1+0 Plugs, Percent Trees in High Vigor Classes.

Chemical	Rate (lb. ai/acre)	Percent Trees w/ High Vigor [1/] Mean	(SE) [2/]
Glyphosate, 2,4-D	2.0, 1.9	73	(11)
Glyphosate, Napropamide, Oryzalin	2.0, 2.0, 1.7	70	(16)
Glyphosate, Napropamide, Oryzalin	2.0, 4.0, 3.4	63	(14)
Glyphosate, Atrazine	2.0, 3.4	58	(14)
Atrazine,Dalapon, 2,4-D,Triclopyr	3.4,2.9,1.9,0.5	55	(16)
Glyphosate, Simazine	2.0, 4.0	55	(13)
Clopyralid	1.0	48	(17)
Sethoxydim, 2,4-D	0.4, 1.9	48	(23)
Glyphosate, Atrazine, Terbutryn	2.0, 3.4, 2.0	47	(15)
Glyphosate	2.0	45	(16)
Hexazinone (Pronone 5G)	2.0	45	(6)
Clopyralid	0.25	43	(18)
Hexazinone (MCI 7G)	2.0	43	(10)
Hexazinone (MCI 7G)	3.0	43	(5)
Hexazinone (Pronone 5G)	3.0	33	(11)
Check	-	30	(12)
Imazapyr	0.5	30	(14)
Pronamide	2.0	28	(6)
Metsulfuron methyl	2 oz.	23	(11)
Metsulfuron methyl	1 oz.	20	(4)
Sulfometuron, Hexazinone(Velpar L)	0.2, 2.0	20	(12)
Sulfometuron, Terbutryn	0.2, 2.0	15	(9)
Imazapyr	1.0	8	(8)
Sulfometuron	0.2	8	(3)
Sulfometuron	0.4	5	(3)

[1] Trees with at least 50% foliage, have green needles and no visible herbicide damage.

[2] Treatments with overlap of bars are not significantly different at $\alpha = 0.05$ using Duncan's New Multiple Range T-test.

Table 10. Sucker Creek Red Alder Plantation Chemical Screening Trial. Effects of Herbicides on 1+0 Bare-root Stock, Total Height After First Year.

Chemical	Rate (lb. ai/acre)	Total Height[1/] (cm)	(SE)
Glyphosate, Atrazine	2.0, 3.4	102	(9)
Atrazine,Dalapon, 2,4-D,Triclopyr	3.4,2.9,1.9,0.5	99	(7)
Glyphosate, 2,4-D	2.0, 1.9	98	(4)
Clopyralid	1.0	97	(3)
Sethoxydim, 2,4-D	0.4, 1.9	97	(5)
Hexazinone (Pronone 5G)	3.0	94	(5)
Glyphosate, Simazine	2.0, 4.0	93	(8)
Glyphosate, Napropamide, Oryzalin	2.0, 2.0, 1.7	92	(5)
Check	-	92	(5)
Hexazinone (MCI 7G)	3.0	90	(7)
Hexazinone (MCI 7G)	2.0	90	(1)
Hexazinone (Pronone 5G)	2.0	88	(5)
Pronamide	2.0	86	(3)
Glyphosate, Napropamide, Oryzalin	2.0, 4.0, 3.4	86	(3)
Metsulfuron methyl	2 oz.	85	(2)
Glyphosate, Atrazine, Terbutryn	2.0, 3.4, 2.0	84	(5)
Metsulfuron methyl	1 oz.	82	(5)
Clopyralid	0.25	82	(2)
Glyphosate	2.0	80	(13)
Sulfometuron	0.4	79	(8)
Imazapyr	0.5	76	(5)
Sulfometuron, Terbutryn	0.2, 2.0	74	(4)
Sulfometuron, Hexazinone(Velpar L)	0.2, 2.0	69	(8)
Imazapyr	1.0	68	(9)
Sulfometuron	0.2	66	(2)

[1] Treatments with overlap of bars are not significantly different at $\alpha = 0.05$ using Duncan's New Multiple Range T-test.

Table 11. Sucker Creek Red Alder Plantation Chemical Screening Trial. Effects of Herbicides on 1+0 Plug Stock, Total Height After First Year.

Chemical	Rate (lb. ai/acre)	Total Height[1] (cm)	(SE)
Glyphosate, 2,4-D	2.0, 1.9	65	(10)
Glyphosate	2.0	57	(10)
Clopyralid	1.0	56	(10)
Hexazinone (Pronone 5G)	2.0	54	(3)
Glyphosate, Simazine	2.0, 4.0	52	(6)
Hexazinone (MCI 7G)	3.0	52	(12)
Glyphosate, Napropamide, Oryzalin	2.0, 2.0, 1.7	50	(5)
Glyphosate, Atrazine	2.0, 3.4	50	(3)
Sethoxydim, 2,4-D	0.4, 1.9	50	(7)
Glyphosate, Napropamide, Oryzalin	2.0, 4.0, 3.4	49	(5)
Hexazinone (MCI 7G)	2.0	48	(2)
Glyphosate, Atrazine, Terbutryn	2.0, 3.4, 2.0	48	(3)
Clopyralid	0.25	48	(4)
Atrazine,Dalapon, 2,4-D,Triclopyr	3.4,2.9,1.9,0.5	46	(5)
Check	-	44	(5)
Pronamide	2.0	43	(4)
Hexazinone (Pronone 5G)	3.0	42	(10)
Imazapyr	0.5	35	(2)
Metsulfuron methyl	1 oz.	33	(6)
Imazapyr	1.0	30	(3)
Metsulfuron methyl	2 oz.	30	(3)
Sulfometuron	0.4	30	(9)
Sulfometuron	0.2	29	(5)
Sulfometuron, Terbutryn	0.2, 2.0	29	(4)
Sulfometuron, Hexazinone(Velpar L)	0.2, 2.0	27	(3)

[1] Treatments with overlap of bars are not significantly different at = 0.05 using Duncan's New Multiple Range T-test.

Tree Height

The summary of treatment effects on total height for bare-root stock is shown in Table 10. There was a statistically significant difference among treatments with respect to total height. A trend towards reduced height was observed. Sulfometuron (and combinations) and imazapyr treatments had total tree height as great as 26 cm below the check plots.

These treatments had similar effects on the plug seedlings (Table 11). The glyphosate alone, glyphosate combinations, clopyralid (1.0 lb/ac), and hexazinone (Pronone 5G 2 lb/ac) treatments had the greatest positive height effects after one year. The sulfometuron combination, metsulfuron and imazapyr (1.0 lb/ac) had the greatest negative trends with respect to total height.

Summary and Conclusions

This study demonstrated that competing vegetation can negatively impact first-year red alder plantation survival, vigor and growth. Under the conditions of this study bare-root stock survived and grew better than plug seedlings. There was also greater sensitivity of plug seedlings to certain herbicides than bare-root stock.

The most effective herbicides for first-year vegetation control were hexazinone, imazapyr, atrazine plus dalapon plus 2,4-D plus triclopyr, sulfometuron, metsulfuron methyl and glyphosate in combination with 2,4-D or atrazine. Those having the least effect on this vegetation community were sethoxydim, clopyralid and pronamide.

Red alder plug seedlings appeared to be more sensitive to herbicide treatments than bare-root, but the relative ranking of growth improvement and toxicity were similar. Treatments that have the highest survival, vigor and height included glyphosate plus 2,4-D or atrazine, atrazine plus dalapon plus 2,4-D plus triclopyr and hexazinone (2 lb/ac). Treatments that had greatest toxicity include sulfometuron, metsulfuron methyl, hexazinone (3 lb/ac) and imazapyr.

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AN INTEGRATED PEST MANAGEMENT SYSTEM FOR CROP PRODUCTION IN THE PACIFIC NORTHWEST

F.L. Young and A.G. Ogg, Jr.[1]

The Pacific Northwest was selected for the implementation of an Integrated Pest Management Project for crop production because of its intense wheat production, unique weed problems and severe erosion. In this area, soil erosion is considered the foremost problem in agriculture. Average annual losses in the Palouse Region have been estimated at 22 metric tons/ha and may exceed 350 metric tons/ha. The adoption of conservation tillage is recognized as the most cost-effective practice available for erosion control; however, the implementation of conservation production systems has been slowed because of inadequate pest control. Field research for a USDA/ARS federally-funded IPM project began two years ago in cooperation with the University of Idaho and Washington State University. Research is conducted on a 32-hectare site consisting of 144 individual plots. Each plot is 46 m long and 12 m wide and allows large-field size equipment to be used which reproduces actual farming practices of the area. The broad, overall objectives of the IPM project are to: a) Investigate the interactions among crop rotations, tillage practices and weed management levels in relation to differences in weed, insect and pathogen infestations and to measure their impacts on yield and quality of cereals and grain legumes; and b) use the data and information to develop economically feasible and environmentally sound crop management systems that effectively prevent erosion and control pests. Experimental variables to be examined include: a) Two 3-year crop

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[1]USDA-ARS, Pullman, WA

rotations of either winter wheat-winter wheat-spring wheat or winter wheat-spring barley-spring peas; b) two tillage systems of conservation or conventional tillage; and c) three weed management levels of minimum, moderate or intense levels of weed control. The cooperative research represents a multidisciplinary approach by 11 professional scientists from five disciplines as well as technology transfer. Each discipline has three to four specific objectives to examine including interactions due to the variety of pests present. Weed science objectives include: a) Evaluate the weed flora and changes in population, biomass and seed production over time; b) determine the concentration of seeds and their distribution in the soil; and c) determine nitrogen uptake by the crops and weeds. Two satellite studies to the main core IPM have been initiated to examine factors and/or solve problems which were not included in the IPM project. These studies include: a) The effect of crop rotation, weed management levels and seed treatment on pest levels and yield of crops grown under no-till production practices; and b) the effect of weed management and fertility levels on continuous no-till wheat. It is hoped that the biological, agronomic and economic data generated from this study will enable a rapid implementation of conservation production systems for control of soil erosion and for more economical crop production.

EVALUATION OF THREE POST EMERGENCE HERBICIDES FOR WILD OAT CONTROL AND CROP TOLERANCE IN SPRING BARLEY

V.R. Stewart and Todd K. Keener[1]

A post-emergence wild oat herbicide study was established on spring barley to evaluate the efficacy of PP604 {2-[1-(ethoxyimino)propyl]-3-hydroxy-5-(2,4,6-trimethylphenyl)cyclohex-2-enone} in comparison with AC222,293 {methyl-6-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)-m-toluate} and diclofop methyl {methyl-2-[4-(2,4-dichlorophenoxy)phenoxy]-propanoate}. The barley cultivar Lewis was seeded in drill strips 12 feet wide, which were planted parallel to one another and separated by five feet cultivated alleys. Plots were positioned at right angles to the drilled strips in an RCB design, replicated four times and were 10 x 12 feet in size. Herbicides were applied using a tractor mounted research-sprayer with 8002 nozzles at 32 psi applying 24.85 gpa. There was a very high population of wild oats in the area in which the experiment was established. Wild oat control readings were made July 2, 1987. A 48-square-foot area was harvested with a Hege combine to secure yield data.

PP604 applied when the wild oats were in the two and one-half to three-leaf stage gave 50 to 82% control, whereas AC222,293 and diclofop methyl gave 47.5 and 30% control respectively. PP604 applied with 1% v/v crop oil concentrate gave significantly better control than PP604 with the .5 v/v crop oil concentrate. Diclofop methyl, AC222,293 and PP604 at the 2-ounce rate with 1% crop oil concentrate or 4-ounce rate at .5% crop oil concentrate, provided poor wild oat control. These data would indicate that to obtain

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[1]N.W. Agric. Research Center, Montana State University, Kalispell, MT

satisfactory wild oat control PP604 would have to be applied at 4 ounces ai/A with 2% v/v crop oil concentrate.

Yields of barley were reduced significantly because of the wild oat population. The check had a yield of 65.9 bu/a, whereas where weeds were controlled at the 80% level yields exceeded 100 bu/a. Test weights were significantly higher where there was good wild oat control, which was found in all PP604 and AC222,293 treatments. Percent plump was significantly higher in all the herbicide treatments when compared to the check, except for the diclofop-methyl treatment with no surfactant.

Table 1. Agronomic data from the Wild Oat Herbicide study grown on the Northwestern Agricultural Research Center in Kalispell, Montana.
Seeded: April 22, 1987 Harvested: August 20, 1987

Treatment	Rate oz ai/A	% Control	Yield Bu/A	Test Wt Lbs/Bu	% Plump	Ht (in)
PP604 + 1% C.O.C.[1]	2 oz	30	103.2a	50.88a	94.00a	37.6
PP604 + 1% C.O.C.	4 oz	67	114.4a	51.80a	95.25a	37.7
PP 604 + 1% C.O.C.	6 oz	75	117.6a	51.50a	95.00a	37.1
PP604 + .5% C.O.C.	4 oz	31	96.6a	50.00a	92.75a	37.9
PP604 + 1.5% C.O.C.	4 oz	38	104.3a	50.92a	93.50a	37.8
PP604 + 2% C.O.C.	4 oz	76	120.5a	52.15a	95.50a	36.4
AC222,293 + R11	.45 lb	17	74.6	49.35a	89.25a	38.0
Diclofop-m no surf.	.75 lb	35	93.7a	48.90	87.00	37.3
Check	0	0	65.90	47.58	83.00	37.2
Overall Mean			99.00	50.34	91.69	37.44
F-Ratio Trts			5.434**	9.130**	4.423**	.8951
CV (Se/Mean)			8.127	.9915	2.255	1.397
LSD (0.05)			23.48	1.457	6.037	1.526

** Indicates statistical significance at the 0.01 level
a/ Values significantly greater than the check at the 0.05 level
1/ C.O.C. - Crop Oil Concentrate
R11 Surfactant used with AC 222,293

Planting and Application Data:
Plant Growth Stages - Barley 4-5 leaf
- Wild Oats 1-3 leaf, 75% in 2 1/2- to 3-leaf stage
Seeding Depth - 1 1/2" to 2"
Seeding Rate - 60 lbs/A
Soil: Type - Silt Loam
pH - 7.2
OM - 4%

Herbicide Application:
Date - 5/12/87
Air Temp. - 62°F
Soil Temp. - 65°F
R.H. - 35%
Wind Velocity - 3-5 mph
Soil Moisture - good

WILD OAT CONTROL IN SPRING BARLEY

K.C. Volker[1]

Abstract. Wild oat (*Avena fatua* L.) is consistently a problem in the production of small grains throughout the Pacific Northwest and elsewhere. A trial for postemergent wild oat control was conducted in Bonner's Ferry, Idaho, to evaluate PP604 {2-[1-(ethoxyimino)propyl]-3-hydroxy-5-(2,4,6-trimethylphenyl)cyclohex-2-enone}.

The trial site was in spring barley (var. Minuet) with a heavy, uniform infestation of wild oats. Experimental design was randomized complete block with four replications. Plot size was 2.4 m by 10.4 m. Treatments were applied by backpack sprayer equipped with five TeeJet 8002 nozzles at 50.8 cm spacings on a straight boom calibrated to deliver 187 l/ha at 275 kPa. At the time of application (May 19, 1987), the barley was 10-13 cm high with 3-4 leaves and wild oats were 5-10 cm high with 2-4 leaves.

PP604 provided very good to excellent control of wild oats at 0.28-0.56 kg ai/ha plus 1-2% v/v crop oil concentrate. PP604 increased barley yields 160-225% over the untreated check and 16-44% over the standard, barban at 0.42 kg ai/ha. No phytotoxicity to the crop was observed.

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[1]ICI Americas, Goldsboro, NC

WILD OAT AND FOXTAIL CONTROL IN CEREALS WITH A TRIALLATE/TRIFLURALIN GRANULE

Dennis D. Rasmusson and David G. Hanson[1]

Abstract. Wild oats and green and yellow foxtail jointly infest 3-4 million acres in the spring grain regions of North Dakota and Minnesota. A tank mix of triallate {S-(2,3,3-trichloro-2-propenyl)bis(1-methylethyl)carbamothioate} and trifluralin {2,6-dinitro-N,N-dipropyl-4-(trifluoromethyl)benzenamine} was widely used after planting and incorporated with a harrow for control of both weeds on these acres. Post plant harrowing does not fit in with the trend to reduced tillage so growers requested a granular formulation that could be fall or spring applied prior to planting and incorporated with normal seedbed preparation.

In 1983 we initiated fall testing of a combination granule with a ratio of 1.0 lb/a triallate to 0.5 lb/a trifluralin. This ratio was unacceptable because of injury to spring wheat. In 1984 we tested two granular formulations; a 1.0 lb/a triallate to 0.4 lb/a trifluralin and a 1.0 lb/a triallate to 0.3 lb/a trifluralin. It was determined that the 1.0:0.3 ratio (MON 7952) provided acceptable crop safety and weed control when fall applied.

Fall applications of MON 7952 at 1.3 lb/a resulted in injury of 3% in durum wheat, 6% in hard red spring wheat and 0% in barley. Increasing the rate to 1.63 lb/a increased hard red spring injury to 10% but did not increase injury to durum wheat or barley. Wild oat control averaged 91% and foxtail control averaged 86% when MON 7952 was fall applied at 1.63 lb/a. Spring applications of MON 7952 at 1.3 lb/a resulted in injury of 6% in durum

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[1]Monsanto Company, Mankato, MN and West Fargo, ND

wheat, 12% in hard red spring wheat and 2% in barley. Wild oat control averaged 83% and foxtail control averaged 74% when MON 7952 was spring applied at 1.3 lb/a.

MON 7952 is currently labeled for fall application prior to planting durum wheat or barley at 1.3 to 1.63 lb/a for control of wild oat and green and yellow foxtail. A spring application label has been submitted to E.P.A. for approval.

INTERACTION OF DPX-M6316 AND DPX-R9674 WITH DICLOFOP-METHYL ON OAT SHOOT DRY WEIGHT

Robert W. Downard and John O. Evans[1]

Abstract. Greenhouse experiments were conducted to determine the influence of DPX-M6316 {methyl 3-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino carbonyl]amino sulfonyl]-2-thiophenecarbonylate} and DPX-R9674 {methyl 3-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino carbonyl]amino sulfonyl]-2-thiophenecarbonylate and methyl 2[[[[N-(4-methoxy-6-methyl-1,3,5-triazin-2-yl)methylamino]carbonyl]amino]sulfonyl]benzoate} in combination with diclofop-methyl {methyl-2-[4-(2,4-dichlorophenoxy)phenoxy]propanoate} on oat (*Avena sativa* L. 'Otana') shoot dry weight. Herbicide treatments were applied when the oat plants were at the 2- to 3-leaf stage. The spray volume was 187 L/ha delivered at 207 kPa. Oat plants were given a 16-hour photoperiod with night temperatures 18^{o}C ± 2^{o}C and day temperatures 30^{o}C ± 2^{o}C. Seventeen days after herbicide application, oat shoots were harvested, dried and weighed. The experimental design was a factorial with four replications. Research indicated that DPX-M6316 at 0.009, 0.018 and 0.036 kg/ha was not antagonistic to the activity of diclofop-methyl at 0.50, 0.75 and 1.00 kg/ha except the combination of DPX-M6316 at 0.036 kg/ha and diclofop-methyl at 0.50 kg/ha. DPX-R9674 at 0.009, 0.018 and 0.036 kg/ha also indicated that it was not antagonistic to the activity of diclofop-methyl at 0.50, 0.75 and 1.00 kg/ha except for DPX-R9674 at 0.036 kg/ha plus diclofopmethyl at 0.50 kg/ha.

[1]University of Idaho Research and Extension Center, Aberdeen, ID and Plant Science Department, Utah State University, Logan, UT

AC-222,293 - RESULTS OF THE 1987 FIELD PROGRAM IN SMALL GRAINS

Steven J. Carlson[1]

Abstract. AC-222,293 {(±)methyl-6-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)-m-toluate} is a new herbicide which has been developed by American Cyanamid Company for control of wild oats (*Avena fatua*) and several broadleaf weeds in wheat, barley and sunflowers.

[1]American Cyanamid Company, Princeton, NJ

Tests were established at 24 sites in Washington, Oregon, Idaho and Montana to evaluate wild oat and broadleaf weed control with AC-222,293 through an experimental use permit. The tests also included commonly used wild oat postemergence herbicides such as difenzoquat {1,2-dimethyl-3,5-diphenyl-1H-pyrazolium} and diclofop {(±)-2-[4-(2,4-dichlorophenoxy)phenoxy]-propanoic acid} as comparative treatments. AC-222,293 was applied at 0.42, 0.47 or 0.53 kg ai/ha, difenzoquat was applied from 0.56 to 1.12 kg ai/ha, and diclofop was applied from 0.84 to 1.12 kg ai/ha. All herbicides were applied at rates commonly used in the area of the experimental site.

Wild oat control with AC-222,293 at 0.42, 0.47 and 0.53 kg/ha averaged 85, 84 and 93% respectively. Range of control was 62 to 90%, 80 to 92% and 82 to 99% for each of the respective AC 222,293 rates. Wild oat control with difenzoquat averaged 91% and ranged from 83 to 99%. Wild oat control with diclofop averaged 77% and ranged from 55 to 99%. No crop damage was observed with AC-222,293 at any rate in either wheat or barley. Control of several broadleaf weeds, such as catchweed bedstraw (Galium aparine), was observed with AC-222,293.

EVALUATION OF CLOMAZONE AND RE 40885 FOR WEED CONTROL IN SAFFLOWER

D.M. Wichman, P.K. Fay and N. Riveland[1]

Abstract. Currently there are not any postemerge or preemerge herbicide treatments labeled for Northern Plains safflower (Carthamus tinctorius) production which provide broadspectrum weed control. The goal of this research is to evaluate the potential of clomazone and RE 40885 to meet this need.

Safflower exhibited good to fair tolerance of preemergence applied clomazone at 8, 12 and 16 oz ai/a. The clomazone controlled annual grassy weeds, including cereals and some broadleaf weeds. Fall applied RE 40885 at 8, 16 and 32 oz ai/a provided fair to good control of tansy mustard (Descurainia pinnata) with no apparent effect on the safflower. Safflower was tolerant of preemergence applied RE 40885 also. RE 40885, fall or preemergence applied did not provide any control of spring barley.

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[1]Central Ag. Research Center, Montana Agric. Exp. Station, Moccasin, MT; Plant and Soils Dept., Montana State University, Bozeman, MT and Williston Agric. Exper. Station, North Dakota State University, Williston, ND.

TOLERANCE OF CORN, PROSO MILLET AND SAFFLOWER TO FMC-57020

R.L. Anderson[1]

Replacing tillage operations with herbicides have increased the storage efficiency of non-crop precipitation in the soil, thus stimulating a shift in cropping rotations. A winter wheat-spring planted crop-fallow rotation is gradually replacing the prevalent winter wheat-fallow rotation. This 2-crop-in-3-years program relies on atrizine {6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine} for effective weed control after wheat harvest and during the growing season of the spring planted crop such as corn or proso millet. Triazine-resistant weeds are developing in this region, and if no-till production systems are to succeed, herbicides with different modes of action than the triazines will be needed for successful weed control. FMC-57020 {2-[(2-chlorophenyl)methyl-4,4-dimethyl-3-isoxazolidinone} is currently being developed for chemical fallow in this region and could supply an alternative to atrazine in a no-till production system. The objectives of this experiment were to determine: a) tolerance of four spring-planted crops to FMC-57020; and b) if FMC-57020 could be applied after winter wheat harvest without injuring a crop planted the following spring.

A laboratory study examined crop sensitivity to FMC-57020. A sand soil was treated with FMC-57020 to obtain a series of concentrations: 0, 40, 80 120, 160 and 200 ppb. Five crops: winter wheat, barley, corn, proso millet and safflower, were grown in treated soil in a greenhouse. Above ground fresh weight, plant height and a visual estimate of percent bleaching of leaves were recorded 21 days after emergence. Data evaluation indicated that the percent bleaching value was the most sensitive measurement in detecting FMC-57020 in soil. The ranking of crop tolerance to FMC-57020 was safflower > corn > proso millet > barley > winter wheat, as shown in Table 1.

A field study was conducted on two soils: fine sandy loam and silt loam. FMC-57020 was applied to winter wheat stubble on October 31, 1986, at 0.5, 0.75 and 1.0 lbs ai/ac in a no-till production system. The control treatment was a conventional tillage system of sweep plowing in the fall and disking in the spring before planting. Safflower was planted on April 15, 1987, corn on May 14, 1987 and proso millet on June 3, 1987.

Symptoms of FMC-57020 injury (bleaching of leaves, delay of anthesis or reduced plant height) was not observed with safflower or proso millet on either soil. Limited bleaching (5-10%) of corn occurred at the fine sandy loam site, but this effect was not lethal and did not affect date of silking or plant height. Grain yields of safflower and proso millet and above ground biomass of corn indicated that FMC-57020 did not affect season-long crop growth as yields were either equal to or greater than the conventional-tilled treatment (Figure 1). The no-till production system using FMC-57020 for non-crop weed control increased grain yields of safflower at both sites 17% compared to the conventional tillage system, while corn biomass was increased 16% at the silt loam site with the no-till system.

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[1]USDA-ARS Akron,CO

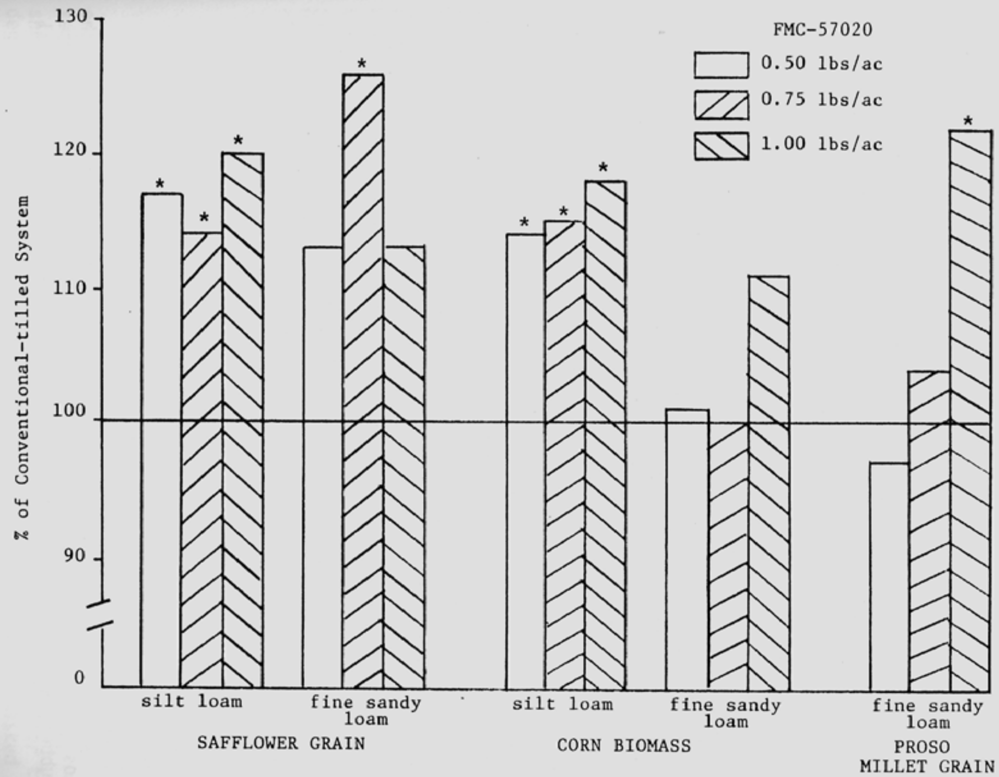

Figure 1. Crop response to FMC-57020 on two soils: silt loam and fine sandy loam. Data expressed as % of conventional-tilled production system for each crop. * Indicates treatment mean was significantly greater than the conventional tillage system at the 0.05 level of significance.

Table 1. Crop response to FMC-57020 at three concentrations in a sand soil. Phototoxicity expressed as percent bleaching of leaves, estimated visually.

	FMC-57020 concentration (ppb)		
Crop	40	120	200
	-------------% bleaching-------------		
Safflower	0	0	0
Corn	0	3	28
Proso millet	0	7	51
Barley	4	83	100
Winter Wheat	39	94	100
LSD (0.05)	7	4	10

Two in-crop weed management systems were also compared: A standard system of preemergence application of 1.2 lbs/ac of pendimethalin (N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine) for safflower and 1.0 and 0.5 lbs/ac of atrazine for corn and proso millet, respectively; and a reduced rate system of 1/2 of the above rates for each crop. Visual evaluations six weeks after crop emergence showed that > 95% weed control was achieved by all herbicide treatments in both systems. Only safflower experienced late season weed competition, causing some difficulties in mechanical harvesting. The corn and proso millet were relatively weed-free throughout the growing season. The silt loam site experienced a severe hail storm on August 4, 1987. The proso millet was completely destroyed, all the leaves stripped from the corn, yet safflower yielded over 1200 lbs/ac, thus demonstrating its tolerance to hail at that stage of growth.

TIMING OF HERBICIDE APPLICATIONS FOR WEED CONTROL IN GUAYULE

M.A. Foster, V.J. Gomez, Jr. and Jaroy Moore[1]

Abstract. Guayule (*Parthenium argentatum*) is a perennial shrub native to the Trans Pecos of southwest Texas and northcentral Mexico. The plant produces natural rubber, a critical and strategic material. Guayule was a commercial

[1]Texas Agricultural Experiment Station, Fort Stockton, TX

source of rubber in the early 1900's and more recently during World War II. Economic and political situations worldwide have re-emphasized the need for a domestic rubber source.

Weed control in cultivated guayule stands is a significant problem. Herbicide applications must occur before planting or when the established plants are dormant. The objectives of this research were to evaluate timing of herbicide applications and methods of application.

Field plots, four rows 1 m apart and 6 m long, were established on a Delnorte, very gravelly loam at the Texas Agricultural Experiment Station Guayule Research Site near Fort Stockton, Texas. The treatments were arranged in a randomized complete block design with four replications. The percentage weed canopy cover and frequency were estimated prior to treatment.

The following chemicals were applied as broadcast sprays in March 1987 to test their effect on broadleafed weeds and toxicity to guayule: glyphosate {N-(phosphonomethyl)glycine]-0, 0.6, 1.1, 2.2 kg ai/ha; 2,4-D {(2,4-dichlorophenoxy)acetic acid]-0, 0.6, 0.8 1.1 kg ai/ha; and bromoxynil {3,5,-dibromo-4-hydroxybenzonitrile)-0, 0.6, 0.8 kg ai/ha. Chlorosulfuron {2 chloro-N-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]benzenesulfonamide}-13, 26, 53 g ai/ha; metsulfuron {2-[[[[4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl]benzoic acid}-11, 26, 53 g ai/ha; and sulfometuron {2-[[[[(4,6-dimethyl-2-pyrimidinyl)amino]carbonyl]amino]sulfonyl]benzoic acid}-26, 53, 79 g ai/ha were applied in October 1987 as broadcast and directed sprays to evaluate their toxicity to guayule. All herbicides were applied with a backpack sprayer in 187 L of water at 138 kPa pressure. A nonionic surfactant was added to all spray mixtures at 0.25% (v/v).

Broadleafed weed control averaged 93% and 99%, respectively, with 1.1 and 2.2 kg ai/ha of glyphosate 60 days following treatment. The mean percentage weed control in plots treated with 2,4-D was 93% with both the 0.8 and 1.1 kg ai/ha rates. Weed control with bromoxynil averaged 92% and 94% at the 0.8 and 1.1 kg ai/ha, respectively. The guayule was dormant at the time of spraying and was not affected by the chemicals. Guayule was not affected by chlorsulfuron and sulfometuron thirty days following application. However, there were traces of guayule toxicity to the metsulfuron broadcast spray treatments.

Prior to the guayule growing season, broadleafed weeds were effectively controlled by glyphosate, 2,4-D and bromoxynil. Chlorsulfuron and sulfometuron may prove to be acceptable as fall treatments.

SURVEY OF WEEDS IN CONSERVATION AND CONVENTIONALLY TILLED GRAIN FIELDS IN MONTANA

Kent Schweitzer[1], Barbra Mullin[2], Dave Wichman[1] and James Nelson[1]

Introduction

Soil erosion is a predominate agricultural issue in Montana. Research shows that past management techniques are directly responsible for the steady degradation of soil quality. But this decline has been masked by major

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[1]Montana State University and Montana Department of Agriculture

technological advances in mechanical efficiency, fertilization and pest control. The potential on-site benefits from fighting soil losses through wind and water erosion lie in the value of lost nutrients that must be replaced and non-recoverable crop yield that is permanently lost. Off-site benefits include lower structure maintenance, improved wildlife habitat and reduced water impairment which includes sedimentation, eutrophication and pesticide contamination.

Soil conservation has long been viewed favorably, but practiced reluctantly because of the inconvenience and cost of installing permanent soil conservation structures or taking land out of production. Soil Conservation Service officials estimate that 1,632,000 acres in Montana have been damaged by wind and water erosion and that an additional 2,106,000 acres are susceptible to blowing. For the past 15 to 20 years, new tillage techniques have emerged as a means of managing crop production to protect soil. Terms such as conservation tillage, reduced tillage, minimum tillage and zero tillage are commonly used to describe these tillage systems. Conservation tillage systems attempt to optimize soil and water conservation, while maximizing economic returns from crop production. Conservation tillage practices protect the soil from erosion by maintaining a surface residue cover at all times. Recropping, reducing or eliminating tillage operations and altering the use of tillage equipment are conservation management practices employed in Montana.

A 1987 survey conducted by the Conservation Technology Information Center, Purdue Research Park, West Lafayette, Indiana 579906-1334, ranked weed control as the second most important factor limiting more rapid adoption of conservation tillage. The survey also indicated that greater herbicide use restrictions and curtailed herbicide registrations are believed to be the number one obstacle facing conservation tillage in the future. Herbicide costs and uncertain herbicide performance are frequently mentioned by growers practicing conservation tillage.

Studies have shown that the depth of seed burial and the time of tillage affects weed emergence (2, 3, 5, 8, 9, 10, 12 13). Moldboard plowing distributes weed seeds uniformly through the depth of the operation while chisel plowing retains weed seeds near the soil surface (3, 9). Studies show also that accelerated aging of weed seeds on the soil surface results in dramatic germination reductions (7). The depth of cultivation may determine the weed population of a field by encouraging or inhibiting germination of different weeds which results in a population shift as the seed of favored weed species compounds in the soil seed reservoir.

A large reduction in wild oat viability over time was seen when the seeds were placed shallowly in soil, rather than deeply (7). Deep burial of wild oat seed may initially reduce numbers, but in the long run, the population in the field increases. Similarly, shallow burial may increase populations of the first year, but if the weeds are prevented from going to seed, the long-term infestation will be reduced.

Donaghy and Stobbe (2) demonstrated that under zero-tillage wild oats, green foxtail, smartweed and wild buckwheat declined dramatically and that quackgrass and Canada thistle increased. Miller and Nalewaja (8) reported that populations of wild oat, green foxtail, kochia and wild mustard were generally greater in reduced-till compared to zero-till or conventional-till systems where no herbicide was used. Canada thistle and perennial sowthistle were more abundant in zero-till compared to the reduced-till system and did not become established in a conventional-till system. Herbicide use prevented the establishment of these perennial weeds in the zero- and reduced-till systems. Kapusta (5) reported that specific weed species varied greatly between years regardless of tillage system and no tillage system consistently reduced weed densities compared to others.

Observation by North Dakota State University weed scientists (4) indicates that zero-tillage favors perennial weed establishment, including foxtail barley, Canada thistle, quackgrass, milkweed, perennial sowthistle, leafy spurge, field bindweed, absinth wormwood and wild rose. Research has also demonstrated that by breaking up rhizomes and root stalks, cultivation stimulates root buds to release dormancy and spreads them around the field (6, 10).

The purpose of this survey was to determine weed spectrum and population changes that occur under conservation tillage.

Methods

The weed survey was conducted during May, June and July of 1987. Survey methods were patterned after weed surveys conducted in Canada by Dr. Gordon Thomas, Agricultural Canada, Research Station, Regina, Saskatchewan and North Dakota State University (1). The objective was to survey 50 locations where conventional and conservation farming was practiced on adjacent fields for a total of 100 fields. Soil Conservation Service criteria were used to define conservation farming practices. Conservation farming practices are defined as any residue management program which provides for at least 30 percent of the soil surface to be covered by residue at all times.

A letter was sent to District Soil Conservation Service offices requesting names and addresses of local farmers who currently use conservation farming practices. Prospective growers were telephoned and asked a series of questions to determine the suitability of their farming system to the survey criteria. Farms with a high potential for satisfying survey criteria were recontacted to arrange to conduct the field survey. No attempt was made to limit the number of fields surveyed in any one county or area because of the restrictive specifications imposed by the survey criteria.

Results and Discussion

Eighty-eight fields, 44 conservation and 44 conventional, were surveyed in fourteen counties during June and July (Table 1). Thirty-three winter wheat, 23 spring wheat and 32 barley fields were surveyed (Table 2). The same crop was grown in all except three of the paired field comparisons. The 100 field goal was not met for the following reasons: 1) the field scout was not available until June 15, 2) it was difficult to locate fields that satisfied survey criteria and 3) an advanced growing season was 2 to 3 weeks ahead of average.

The use of conservation farming practices during the last four years (1984-87) was zero for conventional fields and averaged 2.7 years for conservation fields. Surface residue cover in 1987 averaged 12% and 42% with ranges of 2-29% and 30-74% in conventional and conservation fields, respectively (Table 3). Cropping systems ranged from alternate crop-fallow to continuous cropping for both classes. Five cropping systems were used in conventional fields with an average of 2.5 crops per four years and eight systems were used in conservation tillage with an average of 3.0 crops per four years (Table 4). Eighteen of the conservation fields were no-till drilled in 1987 and seven of these had been in no-till until 1984.

The weeds are ranked by weed index in Tables 5 and 6 for conventional and conservation fields. Weed pressures were low relative to similar surveys conducted in North Dakota and Canada. Thirty weed species were found in conventional fields and thirty-four weed species in conservation fields. Twenty-three weed species were common to both production systems. The weed index values for eleven of the twenty-three weed species that were common to both production systems differed by less than 33%. Wild oats, Russian thistle and downy brome ranked in the top five of both tillage classes by weed index. Eight weed species ranked in the top ten in both production systems. The weed index values for five of these eight weeds differed by less than 33%. Tansymustard was counted separately from flixweed. Combining these two similar species would produce a ninth place ranking in both conventional and conservation fields.

A greater number of biennial and perennial weed species were found in conservation fields, however, the weed index values for the creeping perennial weeds, Canada thistle and field bindweed, were higher in conventional fields. Field bindweed ranked sixth and sixteenth and Canada thistle ranked thirteenth and was not counted in conventional and conservation fields, respectively.

These results indicate that conservation farming practices have little influence on the kinds and number of annual weeds in cereal grains. Research by Miller and Nalewaja (8) demonstrated that weed species and density changes occur in cereal grain plots when subjected to the same practice year after year. The field history information collected for this survey indicates that Montana growers practice flexible conservation farming practices in which tillage practices, crop rotation and herbicide use may be altered annually to maximize agronomic and economic productivity. Field history information also indicated that cropping intensity was greater and notill practices were used on only a portion of the conservation fields.

Table 1. 1987 Montana Grain Field Weed Survey: Number of crop sites surveyed in each county.

County	Number of Sites	
	Conventional	Conservation
Fergus	7	7
Judith Basin	6	6
Chouteau	4	4
Hill	4	4
Teton	4	4
Cascade	3	3
Pondera	3	3
Sheridan	3	3
Fallon	2	2
Liberty	2	2
McCone	2	2
Toole	2	2
Dawson	1	1
Roosevelt	1	1
14	44	44

Table 2. 1987 Montana Grain Field Weed Survey: Number of sites surveyed of each cereal grain crop.

Tillage Class	Number of Sites		
	Winter Wheat	Spring Wheat	Barley
Conventional	17	12	15
Conservation	16	11	17
Total	33	23	32

Table 3. 1987 Montana Grain Field Weed Survey: Surface residue cover in conventional and conservation fields.

Tillage Class	Surface Residue Cover		
	High	Low	Average
	%		
Conventional	2	29	12
Conservation	30	74	42

Table 4. 1987 Montana Grain Field Weed Survey: Number of sites surveyed of each cropping system.

Cropping System[1]	Number of Sites		
	Conventional	Conservation	Total
84 - 85 - 86 - 87			
SF - C - SF - C	22	1	23
SF - C - CF - C	--	5	5
SF - C - CT - C	4	--	4
CF - C - CF - C	--	5	5
SF - C - C - C	--	3	3
C - C - SF - C	7	3	10
C - C - CF - C	--	3	3
C - SF - C - C	5	7	12
C - CF - C - C	1	7	8
C - C - C - C	4	9	13
Not reported	1	1	2

[1] Crop year = 1984-1985-1986-1987; C = crop, SF = summer fallow, fallow using only tillage, CF = chemical fallow (fallow using only chemicals), CT= combination fallow (fallow using chemicals and tillage).

Table 5. Weed Infestation in Conventional Tillage Systems Based on Forty-four Surveyed Fields.

Weed Species	Weed Frequency (%)	Field Uniformity Percent All	Field Uniformity Percent Inf.	Weed Density Plants/m² All	Weed Density Plants/m² Inf.	Density Range Plants/m² Lo	Density Range Plants/m² Hi	Weed Index
Wild oats	39	4.3	11.2	0.9	2.3	0.2	22.8	36.2
Russian thistle	32	5.9	18.6	0.5	1.7	0.2	6.6	31.8
Downy brome	39	4.4	11.5	0.4	0.9	0.2	6.6	29.1
Wild buckwheat	30	4.1	13.8	0.5	1.6	0.2	10.2	26.9
Field pennycress	18	2.7	1.5	0.3	1.8	0.2	6.4	16.7
Field bindweed	11	4.4	3.9	0.1	5.5	0.6	15.6	15.4
Kochia	9	1.8	2.0	0.2	2.4	0.2	8.2	10.1
Green foxtail	7	2.0	30.0	0.2	2.6	0.6	6.4	9.9
Persian darnel	2	0.7	30.0	0.3	11.8	11.8	--	6.7
Prostrate spurge	5	2.0	4.5	0.3	5.5	1.4	9.6	6.5
Cowcockle	5	0.8	17.5	0.1	1.8	0.2	3.4	5.0
Flixweed	7	1.1	16.7	<0.1	0.9	0.2	2.4	5.0
Canadian thistle	7	0.6	8.3	<0.1	0.7	0.2	1.4	3.9
Common sunflower	5	0.9	2.0	<0.1	1.2	0.4	2.0	3.9
Tansy mustard	7	0.5	6.7	<0.1	0.4	0.2	0.6	3.6
Volunteer wheat	5	0.8	17.5	<0.1	11.0	0.4	1.8	3.7
Cutleaf nightshade	5	0.5	1.0	<0.1	0.4	0.2	0.6	3.0
Japanese brome	5	0.5	10.0	<0.1	0.7	0.4	1.0	3.0
Prostrate knotweed	5	0.5	1.0	<0.1	1.3	0.2	2.4	3.0
Prostrate pigweed	5	0.3	7.5	<0.1	0.8	0.2	1.4	2.5
Redroot pigweed	5	0.3	7.5	<0.1	0.3	0.2	0.4	2.5
Crested wheatgrass	2	0.3	1.5	<0.1	1.0	1.0	--	1.5
Barnyardgrass	2	0.2	10.0	<0.1	0.4	0.4	--	1.3
Jointed goatgrass	2	0.2	1.0	<0.1	0.8	0.8	--	1.3
Cereal rye	2	0.1	5.0	<0.1	0.2	0.2	--	1.0
Common lambsquarters	2	0.1	5.0	<0.1	0.2	0.2	--	1.0
Corn gromwell	2	0.1	5.0	<0.1	0.2	0.2	--	1.0
Foxtail barley	2	0.1	5.0	<0.1	0.2	0.2	--	1.0
Volunteer barley	2	0.1	5	<0.1	0.2	0.2	--	1.0
Western sticktight	2	0.1	5.0	<0.1	0.4	0.4	--	1.0

Table 6. Weed Infestation in Conservation Tillage Systems Based on Forty-four Surveyed Fields

Weed Species	Weed Frequency (%)	Field Uniformity Percent All	Inf.	Weed Density Plants/m² All	Inf.	Density Range Plants/m² Lo	Hi	Weed Index
Kochia	14	5.1	37.5	4.8	34.9	0.2	165.8	87.0
Russian thistle	34	7.0	20.7	0.8	2.4	0.2	8.4	39.4
Wild oats	39	6.3	16.2	0.7	1.8	0.2	7.6	38.0
Downy brome	43	5.6	12.9	0.5	1.2	0.2	4.6	34.7
Green foxtail	14	2.7	20.0	1.0	7.6	0.2	44.0	25.6
Field pennycress	21	2.5	12.2	0.2	0.8	0.2	2.2	15.8
Wild buckwheat	14	2.8	20.8	0.2	1.5	0.2	3.0	14.1
Volunteer wheat	14	1.8	13.3	0.2	1.3	0.2	3.6	11.8
Prostrate spurge	5	1.7	37.5	0.2	3.2	0.4	6.0	8.6
Tansy mustard	11	1.3	11.0	<0.1	0.5	0.2	0.6	6.8
Redroot pigweed	9	0.8	8.8	<0.1	0.6	0.2	1.4	5.0
Foxtail barley	9	0.5	5.0	<0.1	0.2	0.2	--	4.3
Japanese brome	7	0.7	10.0	<0.1	1.3	0.4	2.4	4.1
Cutleaf nightshade	2	0.8	35.0	0.1	4.2	4.2	--	4.0
Desert alyssum	7	0.6	8.3	<0.1	0.6	0.2	1.0	3.9
Field bindweed	5	0.6	12.5	<0.1	1.3	1.0	1.6	3.2
Common sunflower	5	0.5	10.0	<0.1	0.3	0.2	0.4	3.0
Flixweed	5	0.5	10.0	<0.1	0.5	0.4	0.6	3.0
Jointed goatgrass	5	0.5	10.0	<0.1	1.4	0.6	2.2	3.0
Prostrate knotweed	5	0.2	5.0	<0.1	1.0	0.2	1.8	2.3
Alfalfa	2	0.5	20.0	<0.1	1.6	1.6	--	2.0
Prickly lettuce	2	0.5	20.0	<0.1	0.8	0.8	--	2.0
Common dandelion	2	0.3	15.0	<0.1	0.8	0.8	--	1.5
Wild mustard	2	0.3	15.0	<0.1	1.2	1.2	--	1.5
Persian darnel	2	0.3	15.0	<0.1	2.2	2.2	--	1.5
Common lambsquarters	2	0.2	10.0	<0.1	0.4	0.4	--	1.3
Crested wheatgrass	2	0.2	10.0	<0.1	0.3	0.8	--	1.3
Green pepperweed	2	0.2	10.0	<0.1	0.6	0.6	--	1.3
Prostrate pigweed	2	0.2	10.0	<0.1	0.8	0.8	--	1.3
Cowcockle	2	0.1	5.0	<0.1	0.2	0.2	--	1.0
Virginia groundcherry	2	0.1	5.0	<0.1	0.4	0.4	--	1.0
Quackgrass	2	0.1	5.0	<0.1	2.2	2.2	--	1.0
Sweetclover	2	0.1	5.0	<0.1	0.8	0.8	--	1.0
Witchgrass	2	0.1	5.0	<0.1	0.2	0.2	--	1.0

Weedy plants were counted in twenty 0.25 square meter quadrants in the selected field. The first count was 100 steps from a field corner and 100 steps into the field. The other 19 samples were taken at random in a zigzag pattern across the field. Surface residue was measured at ten of the 20 weed count locations by laying a yard stick at an angle across the rows and determining the frequency with which residue intersects the one inch increments. The number of residue intersection counts is divided by the total number of possible counts and multiplied by 100 to arrive at percent of surface covered by residue.

Weed counts and crop residue were recorded on a data collection form. Weeds unidentifiable by the surveyor were listed as "Weed X" and a weed specimen was sent for identification to the MSU diagnostic laboratory. After identification, the name of the weed was entered on the data sheet. A field history form which compiled a four-year history of production information was completed during the farm visit or it was left with the producer and returned when completed. Survey data was compiled using dBase III and analyzed as described in the Agricultural Canada and North Dakota State University weed surveys.

Definition of Terms Used in Report

County - A political subdivision of the state. Montana has 56 counties.

Weed frequency - The percentage of the fields surveyed which contained the weed in one or more of the 20 0.25 square meter quadrants.

Field uniformity (all) - The percentage of the 0.25 square meter sample quadrants which contained the specific weed based on all sampled fields.

Field uniformity (inf) - The percentage of the 0.25 square meter sample quadrants infested with the specific weed based on fields where the weed occurred in one or more of the 20 sample quadrants.

Weed density (all) - The average weed populations or density per square meter based upon all sample quadrants in all fields.

Weed density (inf) - The average weed population or density per square meter based on infested fields, i.e., where the weed occurred in one or more of the sample quadrants.

Density range - The lowest and highest density in plants per square meter recorded for a specific weed in the state.

Weed index - A calculated value which gives an indication of the abundance of a particular weed and can be used to make comparisons between cropping systems. Weed frequency, field uniformity in all fields and weed density in all fields are weighted to have an approximately equal effect on the weed index. The ratio of weed frequency:field uniformity (all):weed density (all) was 1:7:44 when averaged over all weeds. The formula used was:

Weed index =

$$\frac{(\text{weed frequency})+(7 \times \text{field uniformity all}) + (44 \times \text{weed density all})}{3}$$

These annual farming practice changes may be sufficient to halt annual weed spectrum and density shifts or adjustments in herbicide selection may be sufficient to control changes that occur.

Survey results also indicate that Canada thistle and field bindweed are favored by conventional tillage practices. The predominate use of sweep tillage equipment may be responsible for the increase in these creeping perennial weeds in conventional tillage. Sweep tillage equipment undercuts plants and distributes root, crown and stem parts across the field. This may serve to spread the weed problem if not supplemented with an effective herbicide program.

Weather influences the grower's choice of farming operations. Dry falls encourage growers to till in fall even though weed numbers and moisture losses are generally low. Conversely, higher weed numbers and greater moisture losses generally occur during wet falls, but, fall tillage may not be possible. Chemical fallow will become more popular among Montana growers following wet falls as they become better acquainted with its benefits.

Acknowledgments

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A SURVEY OF CATCHWEED BEDSTRAW (GALIUM SPP.) IN THE EASTERN PALOUSE

M. Reid, A.G. Ogg, Jr. and R. Whitesides[1]

Abstract. Catchweed bedstraw (*Galium* spp., L.) was surveyed in winter wheat fields on the eastern edge of the Palouse region. This area included parts of four counties and involved the states of Washington and Idaho. The land surveyed was divided into four regions each containing 223-259 hectare (640 acre) sections. Within each of the four regions, sections to sample were randomly selected. The names of the growers on the selected sections were obtained from the local Agricultural Stabilization and Conservation Service offices. The growers were then contacted to gain permission to check their land for bedstraw infestations. Individual fields were sampled from two perpendicular sides. The first side was selected as the one closest to a road, railroad or farmyard. The other side was then selected randomly from the remaining sides with the stipulation that it be approximately perpendicular to the first side. On each of the two sides, three 75-meter sampling lines were run. Each of these transactions contained 17 individual square meter sampling areas in which the number of bedstraw plants was counted. Of the 72 fields sampled (22 fields per region), 41 fields contained bedstraw which was detected with the sampling methods employed. There was no correlation between the side from which samples were taken to the number of bedstraw plants observed. The number of plants decreased as the distance from the edge of the field increased to 30 meters. Beyond 30 meters, the density of bedstraw varied widely.

[1]Washington State University, Pullman, WA, USDA-ARS, PUllman, WA and Utah State University, Logan, UT.

WEED CONTROL AND CROP RESPONSE WITH SEVERAL FALLOW SYSTEMS IN WINTER WHEAT

Alan W. Dalrymple and Stephen D. Miller[1]

Abstract. Great Plains winter wheat producers have several fallow methods available for soil moisture storage and weed control. A study was initiated in 1985, to evaluate the effects of conventional tillage fallow, chemical fallow and chemical plus tillage fallow systems on wheat production at three locations in Wyoming -- Archer, Chugwater and Sheridan. Conventional treatments consisted of primary tillage in the spring fallowed by different frequencies of secondary tillage. Cyanazine {2-[[4-chloro-6-(ethylamino)-1,3,5-triazin-2-yl]amino]-2-methyl propanenitrile} plus metribuzin {4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one} was applied in the early spring to chemical and chemical plus tillage fallow systems with no follow-up treatment, glyphosate {N-(phosphonomethyl)glycine} plus dicamba {3,6-dichloro-2-methoxybenzoic acid} application or sweep tillage in July or

[1]Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY

August. Plots were 83.6 m^2 and were arranged in a randomized complete block with four replications.Weed control data were collected in mid-August from 1.4 m^2 area per plot. Total weed biomass (kg/ha) was influenced by fallow system ($P = 0.10$). The conventional fallow system tended to produce the greatest amount of weed growth while the chemical + tillage system gave the best weed control over all locations. Fallow systems did not influence grain yields in 1986 at either Archer or Chugwater, but differences were observed in 1987 with the chemical fallow systems producing the greatest yields at Archer and the conventional system the highest yield at Sheridan. Residue production was not affected by fallow systems at Chugwater, however, differences were observed at Archer in 1986 and Sheridan in 1987.

USE OF ETHYL-METRIBUZIN FOR SELECTIVE CONTROL OF VOLUNTEER RYE (SECALE, SPP.), DOWNY BROME (BROMUS TECTORUM), AND JOINTED GOATGRASS (AEGILOPS CYLINDRICA) IN WINTER WHEAT (TRITICUM AESTIVUM)

P. Westra[1]

Abstract. Ethyl-metribuzin {4-amino-6-(1,1-dimethylethyl-3-(ethylthio)-1,2,4-trazin-5(4H)-one} is a new herbicide which has shown promise for selective winter annual grass control in wheat. Several replicated yield studies in 1986-87 evaluated the performance of ethyl-metribuzin for selective control of volunteer rye (SECCE), downy brome (BROTE), and jointed goatgrass (AEGCY) when applied postemergence in winter wheat (TRZAX). Volunteer rye was controlled 99-100% at rates of 1.12, 1.4 and 1.68 kg ai/ha under optimum conditions where 3.8 cm of rainfall occurred in the 10 days following herbicide application. Wheat yields were increased as much as 67%, while wheat contamination by rye was dramatically reduced.

In one downy brome study, where a light rain was falling during application, ethyl-metribuzin at rates of 1.12, 1.4 and 1.68 kg ai/ha provided 99-100% control with as much as a 113% increase in wheat yield (applications made at the two tiller stage). Therefore in two studies in 1986-87 optimum conditions occurred for ethyl-metribuzin activation and selective control of volunteer rye and downy brome was excellent. The reliability of such optimum conditions in Colorado is dubious. In a second downy brome study (at the same site) at the 4 tiller stage, where optimum rainfall did not follow, best control was only 45% and yield increased only 13%. In a third downy brome study, under more typical conditions, applications at the one- to two-leaf stage were superior to those made at the two- to three-leaf stage. Ethyl-metribuzin applied at 1.12 kg ai/ha provided 87% control at harvest but increased wheat yield 171% over the untreated check. Under Colorado conditions, 1.4 kg ai/ha ethyl-metribuzin will be necessary for consistent downy brome control.

Ethyl-metribuzin applied at 0.84 kg ai/ha provided only 10% jointed goatgrass control; 1.68 kg ai/ha provided 80% control and 44% increase in yield. Other researchers have shown that at 2.24 kg ai/ha, jointed goatgrass control can reach 90-95%, although the cost of such a treatment may be too high. However, the arrival of the Russian wheat aphid (which finds jointed

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[1]Plant Pathology and Weed Science, Colorado State University, Ft. Collins, CO

goatgrass to be an excellent alternate host) has added impetus to the need to control jointed goatgrass in wheat and in fallow.

In general, ethyl-metribuzin is most effective on these three winter annual grasses when applied at the two- to three-leaf stage and when activating moisture occurs within 10 days after herbicide application. Averaged over years and species, best rates of ethyl-metribuzin provided an average of 90% weed control and a 92% increase in yield which represents approximately 850 kg/ha increased wheat yield.

CONTROLLING YELLOW (CYPERUS ESCULENTUS) AND PURPLE (CYPERUS ESCULENTUS) NUTSEDGE ON FALLOW GROUND

J.P. Chernicky, E.S. Heathman, C. Farr, D. Howell and B. Barstow[1]

Abstract. In 1987 the authors established three experiments in heavily nutsedge infested fallowed fields in Yuma and Pinal County, AZ. The objectives of these experiments were to measure the response of purple (Yuma) and yellow (Pinal) nutsedge to fallow applications of EPTC {S-ethyl carbamothioate} and butylate {S-ethyl bis(2-methylpropyl) carbamothioate} at 3.7 and 7.4 kg/ha. To determine the influence of irrigation on efficacy, herbicides were applied before, after or without an irrigation. Butylate was replaced by metolachlor {2-chloro-N-(2-ethyl-6-methyl-phenyl)-N-(2-methoxy-1-methylethyl)acetamide} (4.4 and 8.8 kg/ha) at the Yuma location. Herbicide application dates varied from June 24 in Yuma to August 15 in Casa Grande, Arizona. A tractor mounted sprayer applied herbicides at a spray volume of 187 l/ha and were immediately incorporated to a depth of 5 to 10 cm. Variables measured included nutsedge shoot, corm and tuber control in the top 15 cm of the soil profile.

At the Yuma county location, purple nutsedge control varied between thiocarbamates (EPTC, butylate) and irrigation regime. Purple nutsedge shoot control obtained with butylate averaged over 80% across irrigations and exceeded 90% in fallow plots. In contrast, EPTC appeared most active on purple nutsedge when applied after an irrigation (77%). EPTC gave fewer than 50% control when applied before or without an irrigation. All herbicide treatments significantly reduced the number of tubers and corms produced when compared with the untreated check plots.

At Casa Grande, fallow applications of EPTC gave similar control of yellow nutsedge. EPTC gave 85% control of yellow nutsedge if the application followed an irrigation; however, control declined to 30% if application preceded an irrigation. Yellow nutsedge control obtained with metolachlor never exceeded 50% over irrigation regimes. Both metolachlor and EPTC provided 100% control of yellow nutsedge shoots if left without an irrrigation; however, these results are difficult to interpret since no shoots emerged from the untreated plots. An evaluation will be made in 1988 to determine in fallow applications of nutsedge active herbicides can significantly reduce the population of nutsedge tubers the following year. Fallow applications of thiocarbamate herbicides appear to be active on tubers and corms in the top 20 cm of the soil but further research is needed to determine their effect on deeper tubers.

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[1]University of Arizona, Maricopa Agricultural Center, Maricopa, AZ

IMZETHAPYR FOR WINTER ANNUAL WEED CONTROL IN ARIZONA ALFALFA

B.R. Tickes, E.S. Heathman, J.P. Chernicky and K. Umeda[1]

Abstract. Annual broadleaf and grass weeds are often a problem in the establishment of non-dormant alfalfa in the desert valleys. Imazethapyr {(±)-2[4,5-dihydra-4 methylethyl)-5-oxo-1H-imidazol-2-yl}-5 ethyl-3-pyridine-carboxylic acid} was evaluated from 1985 through 1987 for efficacy and crop safety to newly seeded alfalfa. Alfalfa is normally planted between September and November in Arizona. The following were the principal weed species evaluated: common lambsquarters (*Chenopodium album* L.), little malva (*Malva parviflora* L.), London rocket (Sisymbrium ireo L.), Nettleleaf goosefoot, (*Chenopodium murale* L.) and littleseed canarygrass (*Phalaris minor retz*.). This report summarizes 10 randomized complete block tests conducted at different locations in three Arizona counties. Plot size was generally 10 x 40 ft replicated four times. Herbicides were applied in 30 to 40 gpa water using a compressed air sprayer. Herbicides were applied as preplant incorporated (PPI); preemergence after planting and before germination irrigation (PE); postemergence at the 2 trifoliate leaf stage of alfalfa (2-leaf) and 4 to 6 trifoliate leaf stage of alfalfa (4- to 6-leaf). Application rates of imazethapyr varied from 0.063 to .22 lb/A.

Weed Control. Annual broadleaf weeds were controlled with all rates of imazethapyr applied PPI, PE and at the 2-leaf stage. Annual broadleaf weed control declined to below 80% control or less with the lowest rate tested 0.063 lb/A when applied at the 4- to 6-leaf stage. Control of annual grass weeds was not satisfactory when applied postemergence, 55% or less control and only 70 to 85% when applied PPI or PE. However, while the grass was not killed, it was less competitive with the alfalfa seedlings.

Alfalfa Tolerance. The growth of seedling alfalfa was reduced particularly by PPI and PE applications. The distance between stem nodes was shortened and the size of the trifoliate leaves were reduced. These symptoms were usually reduced with applications made postemergence. Little, if any, reduction of alfalfa growth was observed when imazethapyr was applied at the 2-leaf stage and at the lowest rate 0.063 lb/A. No reduction in alfalfa growth or vigor was observed following the first harvest with any treatment.

These results would indicate that imazethapyr would provide effective control of most annual broadleaf weeds in seedling alfalfa when applied at rates near 0.063 lb/A when the crop is in the 2 trifoliate leaf stage. More information is needed to determine what other annual broadleaf weed species are controlled as well as the persistence of this herbicide in desert soils and when other crops in the rotation may be planted.

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[1]University of Arizona, Yuma, AZ

METRIBUZIN APPLICATION TIMING INFLUENCE ON THREE POTATO CULTIVARS

Lloyd C. Haderlie and Stephen L. Love[1]

Abstract. Metribuzin {4-amino-6-(1,1-dimethylethyl-3-(methylthio)-1,2,4-triazin-5(4H)-one} at 0.8 kg/ha was applied preplant, late preemergence and postemergence to three potato (*Solanum tuberosum* L.) cultivars to determine time of greatest sensitivity. Potato cultivars were field-grown during 1987 in 1.8 by 9.1 m plots in a randomized complete block design at 1.8 by 9.1 m plots in a randomized complete block design at Aberdeen, Idaho. Soil was a Declo loam with pH 7.9 and 1.2% organic matter. Metribuzin was applied by tractor-mounted or hand-held sprayers. Nozzles were TJ8002 spaced 45.7 cm apart. Two cultivars were russets (A74114-4 and A7411-2) and the third was white-skinned (A76147-2). All three are near commercial release. Preplant timing caused the greatest injury, followed by postemergence and then late preemergence. White-skinned cultivar (A76147-2) was severely injured whereas A74114-4 and 17411-2 were injured only one-fourth to one-tenth as much. Tuber yield and grade were reduced by the preplant application with the greatest reduction observed for A76147-2.

[1]University of Idaho, Department Plant, Soil and Ent. Sciences, Research and Extension Center, Aberdeen, ID

CONTROL OF WILD PROSO MILLET (*PANICUM MILIACEUM*) AND VENICE MALLOW (*HIBISCUS TRIONUM*) IN CORN (*ZEA MAYS*)

P. Westra and R.L. Zimdahl[1]

Abstract. Replicated studies at tow locations in each of two years evaluated 24 herbicide mixes for wild proso millet (PANMI) control in furrow irrigated corn (ZEAMX). Best season-long control was obtained with a pre-plant incorporated (PPI) treatment of EPTC {(S-ethyl dipropylthiocarbamate)} + dichlormid {2,2-dichloro-N,N-di-2-propenylacetamide} followed by an early postemerge treatment of pendimethalin {N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine} + cyanazine {2-[[4-chloro-6-(ethylamino)s-triazin-2-yl]amino]-2-methylpropionitrile}, pendimethalin + tridiphane {2-(3,5-dichlorophenyl)-2-(2,2,2-trichloro-ethyl)oxirane}, or metolachlor {2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl)acetamide} + linuron {3-cyclohexyl-6,7-dihydro-1H-cyclopentapyrimidine-2,4 (3H, 5H) dione}. Substitution of cycloate {S-ethyl cyclohexylethylcarbamothioate} + dichlormid for EPTC + dichlormid gave similar results with some of the above combinations, although cycloate + dichlormid appeared to be slightly less effective than EPTC + dichlormid for wild proso millet control and optimizine corn yields. EPTC + dichlormid applied PPI followed by a late post-directed

[1]Plant Pathology and Weed Science, Colorado State University, Ft. Collins, CO

application of sethoxydim {2-[1-(ethoxyimino)butyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one} also provided excellent control when applied at .11 kg ai/ha; some corn injury occurred at .17 kg ai/ha. Use of a thiocarbamate herbicide as a PPI treatment provided better control than PPI or preemerge use of acetanilide herbicides. Best season long control ranged from 90-98%, and corn yields were increased as much as 147%. Reliable season long wild proso millet control is still not possible in Colorado because depleted soil herbicide levels near the end of the growing season allow development of late wild proso millet flushes.

Replicated studies at two locations in each of two years evaluated nine herbicide mixes for the control of Venice mallow (HIBTR) in irrigated corn. Herbicides used in various combinations included dicamba {3,6-dichloro-o-anisic acid}, 2,4-D {(2,4-dichlorophenoxy)acetic acid}, bromoxynil {3,5-dibromo-4-hydroxy benzonitrile}, cyanazine {2-[[4-chloro-6-(ethylamino)s-triazin-2-yl]amino]-2-methylpropionitrile}, atrazine {6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine}, linuron {3-cyclohexyl-6,7-dihydro-1H-cyclopentapyrimidine-2,4(3H,5H)dione}, and DPX-M6316 {methyl 3-[[4-methoxy-6-methyl-1,3,5-triazine-2-yl)amino]carbonyl]amino sulfonyl]-2-thiopehecarbonylate}. With the exception of DPX M6316 + 2,4-D, all combinations provided 89 - 100% control at harvest, while corn yields were increased as much as 7%. Although this weed does not appear to seriously lower corn yields, it can have a devastating effect on onion yields (frequently used in rotations in Colorado). Corn is a good crop in which to control venice mallow because good herbicide options exist for postemerge control of venice mallow.

GROWTH AND DEVELOPMENT OF THREE WILD PROSO MILLET BIOTYPES

T.L. Miller, C.V. Eberlein, E.L. Lurvey and J.B. Michael[1]

Abstract. Growth and development of three wild proso millet (Panicum miliaceum L.) biotypes collected in Minnesota and a cultivated proso millet ('Crown') were compared in experiments conducted at the University of Minnesota Experiment Station near Rosemount, MN. Seedlings of cultivated and wild proso millet were greenhouse-grown to the 2-leaf stage and then transplanted in the field. Height, shoot dry weight, leaf area and number of tillers were measured weekly for six weeks and biweekly thereafter. Time of tillering, jointing, heading and anthesis was noted. Total seed production and percent shattering were also measured. In general, wild and cultivated proso millet grew similarly for four weeks after transplanting. By six to eight weeks after transplanting, two wild types were taller than the cultivated type and all wild types had greater leaf area than the cultivated type. Two wild types produced greater dry weight late in the season than the cultivated type. The cultivated type headed one to two weeks earlier than the wild types, ut the wild types produced more seed. Seed production y the cultivated type was 48,000 seed/plant; the wild types produced 1.4 to 2 times more seed. Percent shattering varied with biotype and with environmental conditions. One biotype ("non-shattering") had only 3 to 20% shattering compared to 40 to 80% shattering by the other two biotypes. Seed dormancy was greater in the shattering biotypes than in the nonshattering biotype.

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[1] University of Minnesota, St. Paul, MN

INCREASED WEED CONTROL AND DECREASED SUGARBEET INJURY WITH SPLIT APPLICATIONS OF PHENMEDIPHAM PLUS DESMIDIPHAM

Robert F. Norris[1]

Abstract. The commercial 50:50 (w:w) mixture of phenmedipham {3-[(methoxycarbonyl)amino]phenyl(3-methylphenyl)carbamate} plus desmedipham {ethyl-13-[[[(phenylamino)carbonyl]oxy]phenyl]carbamate} is typically used at between 1.0 and 1.4 kg/ha for postemergence annual broadleaf weed control in sugarbeets when the crop has two to four true-leaves. Some weed species are not completely controlled by these treatments and under conditions of high temperatures and long days the herbicide can cause substantial injury to the crop. A series of field experiments, supplemented by growth chamber studies, was conducted in the 1986 and 1987 growing seasons to evaluate the impact of split applications of the herbicide. In all trials single rates of 0.7, 1.1 and 1.4 kg/ha were the herbicide. In all trials single rates of 0.7, 1.1 and 1.1 kg/ha were applied; each rate was also applied as two treatments of 50% of the single rate at each application. The length of time between the first treatment and the second treatment of a split application varied between approximately one hour to as long as 21 days. Two treatments of 0.35 kg/ha applied 1 to 6 days apart provided weed control equal or superior to that obtained with a single application at 1.4 kg/ha; redroot pigweed (*Amaranthus retroflexus* L.) control was, for example, 90% versus 55%, respectively. Control of weeds that are normally difficult to control with phenmedipham plus desmedipham, such as common purslane (*Portulaca oleracea* L.), was substantially improved with split applications; 70% control was achieved with a single application at 1.4 kg/ha but control was 98% when two applications of 0.35 kg/ha were applied 3 days apart. Split applications totalling 1.4 kg/ha were more injurious to sugarbeets than single applications; 30% versus 5% stand loss, respectively, was recorded in one trial. A separation of 0.5 to 3 days between applications resulted in the highest levels of crop injury. Split applications totalling 0.7 kg/ha did not cause significant injury to sugarbeets under any conditions. Phenmedipham plus desmedipham can thus be applied as split applications of rates 50% lower than the maximum on the label with less chance of injury to the crop and while maintaining, or even improving, weed control. The necessity for two trips over the field is a negative aspect of such applications.

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[1]Botany Department, University of California, Davis, CA

REGULATIONS WHICH ARE IMPACTING CALIFORNIA AGRICULTURE

Howard M. Kempen[1]

Introduction

California has the largest population in the nation which might account for it. Presently there are over 20 million "environmentalists" in California and only 1 to 2 million people who have enough rural roots to know enough about agriculture to understand what it is and what growers have to face from Mother Nature.

Never mind that agriculture is California's number one industry. The legislators represent people in both the Assembly and the Senate (the one man, one vote Supreme Court ruling) and the people live in the cities. So when the people read the newspapers and they say agriculture is contaminating the environment, the politicians vote in that direction. Note that the Sierra Club petition to rid the President's cabinet of Secretary of Interior James Watt got over a million signatures. That made the politicians believers!

So California's activist legislature with environmental advocacy groups writing new laws to prevent groundwater contamination or human chronic injury, or human birth defects, or risk to firemen, or danger from storage, or danger from disposal, or danger to endangered species, found it difficult to not be for cleanliness. And how little is too much? How safe is safe? In reality, detection is construed as too much. And if the detection technique improves, then the new, lower level is too much.

I have asked several people how toxic does some unit of soil or metal or food or water have to be to be "toxic" so that corrective action shall be taken. No one knows. Recently a grower to specialty crops who used sulfuric acid to digest plant foliage in order to determine nutritional levels, was advised by a hazardous products public agency official that she cannot dilute the left-over vials and run them down the drain. That takes a permit! "We have control over the last molecule, based on legislation dealing with toxics."

With these kinds of non-scientific attitudes prevailing, it is not unexpected to have laws that will be impacting agriculture and the industrial industries that service it, both of whom of course, service the end-user--the consumer.

The Birth Defects Act

The first major law which now is impacting California agriculture was Senator Petris's SB 950, the "Birth Defects Act." It has a decade-long timetable and has been in effect since 1984. What it calls for is that all chemical we call pesticides be run through a standardized series of tests to make sure that none will cause birth defects. Note that 7% of our human babies are born with birth defects, with little or no change in the period since records have been kept. And cancer takes 25% of our people in the USA, mostly (as in rats), the elderly, again without significant change over years. Of course that is not important; we do not want any more.

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[1]Cooperative Extension, University of California, Bakersfield, CA

SB 950 required, first of all, that the California Department of Food and Agriculture, determine which pesticides had data gaps. Of course, essentially all did, since CDFA did not keep the original data prior to then. It was kept at the Environmental Protection Agency. But that didn't look good when it hit the press headlines.

Priorities were required for the first unit of 200 active ingredients. these priorities were based on: 1) the most significant data gaps, 2) widespread use and 3) suspected hazard to people. Examples of criteria included: a. illness reports, b. calls to Los Angeles Poison Control Center, c. suspected carcinogens, d. suspected teratogens, e. possible groundwater contaminants, and f. those that the Department of Health Services requested e included. Tests mandated included: Chronic Feeding (Rats, Dogs); Oncogenicity (Rat, Mouse); Reproduction (Rodent); Teratology (Rat, Rabbit); Mutagencity (Gene Mutation; Chromosome Aberration and DNA Repair) and Neurotoxicity (hen). Recent estimates to do these many studies, which are not done with the same protocols as EPA tests, are in the $2-3 million range. If manufacturers do not intend to fill these gaps by this year, then the products will be dropped from California registration, or the bill for doing the tests will be "awarded" to those registrants still marketing the pesticide.

Needless to say, there is clamor to rid oneself of products that have only minor markets. A survey of 16 major manufacturers by the Western Agricultural Chemical Association in late 1987, suggested that they would not defend 25% of their pesticides from a group of 871 active ingredients. This is due in large part of the extensive cost of SB 950. Secondly, they will need to prioritize where they put their efforts at filling 950 data gaps. So the minor crops will take the hit. And, of course, California grows essentially minor crops, about 280 of them.

But to not fill the new gaps, incurs a risk to the manufacturers, that other nations on earth might develop concerns that the products i not "safe" if not cleared by CDFA. That is a very important issue. Also, where several manufacturers sell a generic product, they must get together and do the necessary California studies or lose the product in California.

Needless to say, the impact will be large to California agriculture. In a state where exports of specialty fruits, nuts and vegetables amount of 25-45% of production, we are susceptible to international competition. So if rules prevent protection of the crop quality or yield, growers will soon hurt. And on many of these vegetables and fruit crops, it is the older generics that were mentioned in the National Academy of Science report, that are protecting them from fungal and bacterial infections.

Weed management programs in tree crops can be reduced without as much consequence, but fungicides and insecticides are usually very important.

<u>Groundwater Contamination Prevention Act</u>

AB 2021, "The Groundwater Contamination Prevention Act" by Senator Connelley was passed by the legislature and signed by Governor Deukmejian in late 1985. The substance of this bill is to require review of any pesticide that is either found in the groundwater or found over eight feet in the soil. It also required special evaluation procedures prior to registration of new pesticides which, the lawmakers hope, will eliminate any new contaminants prior to usage. Pesticides will need to meet certain numerical requirements prior to registration, or may be permitted but join almost all herbicides that will be on a list of those "having the potential to pollute."

As of this date, atrazine, simazine, diuron, bromacil and prometone have been reviewed by the special "Pesticide Evaluation and Registration Committee" which is made up of one member each from the Food and Agriculture, Health and Water Quality departments in Sacramento. All five have been detected in one or more usage areas of the state at levels of 0.25-5 ppb. $\pm$, in several groundwater samples.

The first public hearings were held during the January California Weed Conference. The procedure that the Director of CDFA will follow to mitigate the "problem" is to "set up Pesticide Management Zones and to prohibit some uses." In PMZ zones, the director is planning to prohibit use, based on the first herbicide, atrazine, which was included in the PMZ concept. Elsewhere in the state, its usage would be restricted and require reporting where and when it is used. Pesticides found in groundwater will be an "a" list. Nearly all herbicides will be on a "b" list of pesticides "with a potential to pollute" due to the numerical requirements that have been set. For example, all those which have a water solubility over 17 ppm will be on that list. This list will require additional data to verify groundwater safety. Also all sales by all dealers and distributors must be reported to CDFA, becoming public documents.

The impact of this on agriculture will probably be less than SB 950, but will nonetheless be severe. For example, in our 250,000 acre citrus industry--a $815 million industry in California--the major herbicides used are simazine, diuron or bromacil. To lose those in the major citrus growing regions would mean replacing them with either cultivation or herbicides that are used in almonds (glyphosate plus oxyfluorfen plus oryzalin), at a cost about $100/acre more. But some growers may be able to use simazine just across a section line, yet their neighbor would not. Also the zones may be able to use simazine just across a section line, yet their neighbor would not. Also the zones ;may contract or enlarge as time goes by, depending on the outcome of SB 950 research-mandated results down the road.

Also AB 2021 requires that a recommendation be given by a licensed PCA who has had CDFA-approved training in groundwater. Most PCA's, as I predicted, and from whom we heard at the California Weed Conference, will not provide such a recommendation, because of potential for later litigation by some attorney who has a list of all the users. Whether growers will seek a "hold harmless" clause from manufacturers remains to be seen.

Between the $250,000 research cost to comply with 2021 requirements and the $2,500,000 to comply with 950, companies are beginning to remove registrations in California. Dupont has elected not to reregister atrazine and terbacil in 1988. Ciba-Geigy has 14 labels not registered in California in 1988. Some new products haven't cleared California requirements; others previously labeled are no longer labeled, such as the herbicides terbutryn and prometon. United Ag Products, which is a nationwide distributor of many generic and major manufacturer products, estimates that about 25% of its herbicides will be kept out of California.

How serious the ground water problem from herbicides is, is indicated by a survey that Sandoz conducted at the recent WSSA meeting of weed scientists at Las Vegas. Below are results.

1. *Groundwater contamination sometimes is linked to crop protection chemicals. How would you define your outlook on the groundwater contamination issue?* (Check one)
   - A. is a very serious problem (78)
   - B. is somewhat of a problem (60)
   - C. is not a serious problem (7)
   - D. The public perception of it is greater than the actual problem (65)
2. *What is the most serious aspect of the groundwater problem?*
   - A. Nitrates (62)
   - B. Pesticides (42)
3. *Do you think EPA, in its national groundwater monitoring program is doing:*
   - A. An adequate job (73)
   - B. Too much (17)
   - C. Not enough (73)

These results suggest that there is a serious problem, a large part of which is in perception, with the danger from nitrates being greater than pesticides, and with mixed reactions to how EPA is doing on its monitoring of the problem. (Other questions dealt with who should do what: EPA, the states or the counties).

Endangered Species Act

This act was passed in 1983 or thereabouts with the intention of endangered species be factored into the use, restrictions, etc., of pesticides when registered by EPA. Because it was so complex a matter, it was deferred to a contractor for EPA on how to do the task. Upon completion of the task he allegedly threated to sue EPA. EPA decided in 1987 to implement the regulations in February, 1988, by using a "cluster" system suggested by the contractor, in which several similar crops would be dealt with at one time. My first indication of this came in an addendum to the annually revised Wiley publication, 3rd Crop Protection Chemicals Reference, which arrived in January, 1987. By April, the popular agricultural press carried enough about the risks to agriculture from such a program in California, to where political pressures induced a deferral of the program for a year. CDFA agreed to administer the program in California for EPA and has a committee of public agency personnel who, it is hoped, will provide a system that will accomplish endangered species protection as well as crop protection.

The initial indications of how the ESA law was to be implemented were very disconcerting to the agricultural community. The range of endangered species were not well defined and would have made enforcement very damaging to our many specialty crops. The revised consensus, as I read it, is that the range of species will be determined more closely, and usage of pesticides will is limited outside of crop production areas, not in these areas. But there will, no doubt is exceptions. And in noncrop areas--which are major land areas in California--and in forest areas, many chemicals called pesticides may be prohibited. We will wait to see what ESA does to California agriculture and whether it will be the "straw that brakes the camel's back."

Proposition 65

This was a most interesting proposition to follow from inception to implementation. An environmental advocacy group, the Environmental Defense Fund, got it on the ballot, then obtained 1966 approval by 67% of the electorate, and now is monitoring its implementation during the past year by the Governor. It stands as an amendment to the Constitution, requiring a 2/3 vote to remove or all of it. It is entitled, "The Safe Drinking Water and Toxic Enforcement Act." On the ballot, the Attorney-General's office, which determined how it was worded on the ballot, had it summarized as, "Will prevent putting toxics in groundwater." That alone, in my estimation, guaranteed a large vote against toxics.

It calls for the prevention of all chemicals that may cause cancer or birth defects, or if they might get into the groundwater. It required the Governor to develop a list of carcinogens and birth defect chemicals and to use an expert panel on matters of the law. The 13-member panel is headed by University of California, Davis, toxicologist Wendell Kilgore, my professor UCD 20 years ago. But other notables from many universities and health institutions are present including Dr. Bruce Ames, internationally recognized expert on cancer research.

The law also has a bounty provision whereby, commencing in February of 1988, individuals who note that someone is polluting with a known carcinogen or birth defect agent, can sue. If a District Attorney will not take the case, he or she can pursue it privately and collect 25% of the award of successful litigation. On advocacy individual, Albert Meyerhof with the Natural Resources Defense Council, indicated in a news article that he expected to win many sizable awards as a result of the proposition.

The list of carcinogens and birth defect chemicals grows quarterly, when the committee meetings. As of January 1, 1988, the California Department of Health and Welfare Agency listed 172 and 14, respectively. Few pesticides are included in the lists, and most are no longer registered. Examples include aramite, DDT, DBCP, dES, EDB, Warfarin and toxaphene. Amitrole is the only herbicide. But interesting carcinogen inclusions are aflatoxins, a toxin produced in many crop plant foods and feeds from the fungi, <u>Aspergillus flavus</u>; arsenic, benzo[l]pyrene, a common auto exhaust contaminant; chloroform a contaminant in chlorinated water but also used as a potato disinfectant; many nitroso analogs; saccharin, soots, tars, used engine and most other oils; urethane and vinyl chloride. Among reproductive toxicants such as DBCP, DES, Lead, thalidomide and warfarin is listed ethyl alcohol in drinking beverages.

The result of this is that just recently, the committee ruled that in absence of better data and better ways to control these substances, that existing tolerances would prevail and businesses would be given exemptions to warn consumers of risks in most foods, drugs, medical devices and cosmetics. However, many businesses, including supermarkets, are displaying decals stating that some products may cause cancer.

Additionally, the committee is determined to set some lower limit on the oncogenic effect of given substances. Likely, it will be that equal to exposure to chlorinated water, which contains approximately 100 ppb of chloroform.

Such a limit might keep a number of herbicides off of the list, which are weakly oncogenic when test animals are fed massive amounts of relatively non-toxic compound. Dr. Ames, in particular, has been publicly critical of the methodology of rodent testing at these high rates, which he suggests may be triggering other toxic responses in the organism, thereby allowing tumors to form.

So the expert committee may shed more perspective on this very complex issue of how toxic is toxic or how safe is safe. It may end up saving the day.

Summary

The public media continues to carry considerable coverage of the "food safety" issue. Some supermarket chains are attempting new monitoring systems which allegedly are more stringent than the EPA tolerance standards. They may attempt to exclude all foods which leave a detectable residue, by preventing their producers from using certain pesticides. Public concern is always made worse (if one assumes that American food is safe) by studies on pesticides for EPA, such as the National Academy of Science report, done under the direction of Charles Benbrook, executive director of the National Research Council. Such studies by prominent groups only lathers up the press and the readers who know little about it all but are nonetheless greatly concerned.

I have studied this area, provided insights to my growers on safety, written news releases and exhorted the agricultural community to cultivate their politicians, but it all seems to be of no avail.

In my analysis, it seems that there will be more regulation of hazardous wastes, more litigation because of the way hazardous wastes laws are written, and more expense in farming due to the increasing regulations from the top and the increasing complexity on the farm. Separate markets are developing for "organic foods" because there is a demand which yields good returns. How I or others who are more knowledgeable about the real versus the imagined risks of how we protect our crops feel, does not matter; it is the perception of risk among the 20 million urbanites that will determine how farming is conducted in California. Farmers, in my estimation, will pay for it by being less competitive in an international market, but the consumer in the end, will pay for what he wants.

It seems to me that it is the combination of the environmental advocacy groups, who pose as experts to the ready press, eager for a good story which "presents both sides of the story," that is making the unreal problems so horrid. A good scare story is worth at least a million dollars of solid scientific research. And the scare stories elicit money for the continuation of the advocacy groups, so there is more than one agenda being played. Whether American and the poor will be the better for it is inconceivable to me.

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ANNUAL GRASS CONTROL IN SPRING PLANTED CARROTS

R.N. Arnold, E.J. Gregory and D. Smeal[1]

Abstract. The purpose of this study was to evaluate the effectiveness of several new herbicides for control of barnyardgrass (*Echinochloa crus-galli* (L.) Beauv.) and green foxtail (*Setaria viridis* (L.) Beauv.) in spring planted carrots.

Crop injury and weed control were assessed 12 weeks after planting. The percentage of crop injury and weed control was estimated visually for each treatment by comparison to the controls. All treatments provided excellent control of barnyardgrass. Green foxtail control was excellent (100%) with all treatments except haloxyfop {2-[4-[[3-chloro-5-(trifluoromethyl)-2-pyridinyl]oxy]oxy]phenoxy]propanoic acid}, and fluazifop {(±)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl]oxy]phenoxy]propanoic acid} both applied at 0.13 ai/A. All treatments resulted in substantial yield increases as compared to the untreated check.

Materials and Methods

A field experiment was conducted in 1987 on a Wall sandy loam (less than 1 percent organic matter) at Farmington, New Mexico, to evaluate the response of spring planted carrots and two annual grasses to six herbicides.

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[1]New Mexico State University, Farmington, NM

Soils were fertilized according to New Mexico State University recommendations based on soil tests.

The experimental design was a randomized complete block with four replications. Individual plots were 6 feet 6 by 30 feet long. Treatments were applied with a CO_2 backpack sprayer calibrated to deliver 30 gal/A at 25 psi. Carrots (variety Imperator 58) were planted 8 rows per bed at 6 lb/A with flexi-planters equipped with disk openers on April 16, 1987.

Postemergence (POST) treatments were applied May 26, 1987, when carrots were 4 inches in height. Weed heights during application were the 4-leaf stage (3-in height). All postemergence treatments were applied with a crop oil concentrate (COC) at 1 qt/A. Preemergence surface applied (PES) treatments were applied April 21, 1987, and immediately incorporated with 0.75 inches of sprinkler applied water. The preplant incorporated (PPI) treatment was applied water. The preplant incorporated (PPI) treatment was applied April 16, 1987, and immediately incorporated to a depth of 2- to 3-in with a tractor-driven disk and spring-tooth harrow.

Crop injury and weed control was assessed on July 17, 1987. The percentage of crop injury and weed control was estimated visually for each treatment by comparison to the controls. Handweeded controls were hoed, starting May 7, 1986, about every two weeks until mid-July.

The two weed species, green foxtail (_Setaria_ _viridis_ (L.) Beauv.) and barnyardgrass (_Echinochloa_ _crus-galli_ (L.) Beauv.), were planted on April 17, 1987, at 1.0 lb/A in separate rows 20 in apart, using a tractor-driven cone seeder. Remaining weed growth was removed by hand throughout the growing season.

Weed yields were taken July 16, 1987, by hand pulling the center 6.5 ft of each row. Each weed species was then weighed, and a small sample taken to determine dry weight percentage.

Carrots were harvested for yield September 4, 1987, from the same area used to determine the yields of weeds. The harvested carrots were then weighed with and without tops and graded into marketable carrots of 3/4 to 1 in and 1 in and bigger. Cull carrots, such as splits or less than 3/4 in, are not included.

Results obtained were subjected to analysis of variance at p=0.05.

The chemical designations for the proprietary herbicides evaluated were as follows: fluazifop, (±)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl]oxy]-phenoxy]propanoic acid; 3-chloro-4-(chloromethyl)-1-[3-(trifluoromethyl)-phenyl]-2-pyrrolidinone; haloxyfop, {2-[4-[[3-chloro-5-(trifluoromethyl)-2-pyridinyl]oxy]-phenoxy]propanoic acid}; linuron {N'-(3,4-dichlorophenyl)-N-methoxy-N-methylurea}; sethoxydim, 2-[1-(ethoxyimino)butyl]-5-[2-(ethylthio)-propyl]-3-hydroxy-2-cyclohexen-1-one}; and trifluralin {2,6-dinitro-N,N-dipropyl-4-(trifluoromethyl)benzenamine}.

Results and Discussion

Weed Control and Injury Evaluations. Carrot injury and weed control ratings are presented in Table 1. All treatments gave 100 percent control of green foxtail except haloxyfop and fluazifop, both applied POST at 0.13 lb ai/A. Barnyardgrass control was excellent with all treatments. Trifluralin applied preplant incorporated at 1.0 lb ai/A and linuron applied preemergence surface at 1.0 lb ai/A resulted in injury ratings of 14 and 24, respectively.

Weed and Crop Yields. Effect of herbicide treatments on yield of weeds and carrots are presented in Table 2. The lighter rate of fluazifop resulted

Table 1. Control of two annual grasses with herbicides in Imperator 58 spring planted carrots at Farmington, New Mexico in 1987.

Treatments	Timing[1]	Rate	Crop Injury[2]	% Weed Control SETVI[3]	% Weed Control ECHCG[3]
		lb ai/A	%	%	%
fluorochloridone	PES	0.5	0	100.0	100.0
fluorochloridone	PES	1.0	0	100.0	100.0
sethoxydim	POST	0.14	0	100.0	100.0
sethoxydim	POST	0.28	0	100.0	100.0
haloxyfop	POST	0.25	0	100.0	100.0
fluazifop	POST	0.25	0	100.0	100.0
trifluralin	PPI	1.0	14	100.0	100.0
linuron	PES	1.0	24	100.0	100.0
haloxyfop	POST	.13	0	92.3	100.0
fluazifop	POST	.13	0	88.0	99.5
handweeded control				100.0	100.0
control				0	0
LSD 0.05				1.9	.2

1. POST = postemergence, PES = preemergence surface, and PPI = preplant incorporated
2. Based on a visual scale from 0-100 where 0 = no control or crop injury and 100 = dead plants.
3. SETVI = green foxtail, and ECHCG = barnyardgrass.

Table 2. Effect of herbicide treatments on yield of weeds and Imperator 58 spring planted carrots at Farmington, New Mexico in 1987.

Treatments	Weed yields[1] (lb/A)		------Crop yields----- (Tons/A)	
	SETVI	ECHCG	3/4 to 1 in	>1 in
fluorochloridone	0	0	8.3	9.6
fluorochloridone	0	0	8.5	9.3
sethoxydim	0	0	8.9	9.9
sethoxydim	0	0	9.1	9.6
haloxyfop	0	0	9.1	10.5
fluazifop	0	0	8.4	9.7
trifluralin	0	0	7.1	10.1
linuron	0	0	6.8	10.5
haloxyfop	132.8	0	8.9	10.6
fluazifop	166.0	9.6	8.3	10.3
handweeded control	0	0	8.7	10.2
control	1660.0	2102.7	3.5	4.1
LSD 0.05			1.3	2.0

1. SETVI = green foxtail, and ECHCG = barnyardgrass.

in green foxtail and barnyardgrass yields of 166.0 and 9.6 lb/A, respectively. Furthermore, the lighter rate of haloxyfop showed green foxtail yields of 132.8 lb/A and none for barnyardgrass. Marketable carrot yields were good to excellent in all treatments except the controls.

The results of this test show that all the herbicides evaluated were effective for annual grass control in spring planted carrots. Trifluralin and linuron were the only treatments to show evidence of carrot injury.

CONTROL OF RUSSIAN THISTLE (SALSOLA PESTIFER) IN DRY BULB ONIONS (ALLIUM CEPA)

Steve B. Orloff and David W. Cudney[1]

Abstract. The effectiveness of applications of oxyfluorfen {2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene} and bromoxynil {3,5-dibromo-4-hydroxybenzonitrile} for the control of Russian thistle (Salsola pestifer A. Nels.) in onions (Allium cepa L. 'Fiesta') were measured in a two-year study conducted in the high desert region of southern California. A single application of oxyfluorfen, bromoxynil or combinations of the two applied at the two-leaf growth stage of the onions did not control Russian thistle. Bromoxynil lowered Russian thistle counts more than oxyfluorfen but oxyfluorfen suppressed Russian thistle weight more than bromoxynil. When a first application was followed 14 days later with a second herbicide application, a first application of oxyfluorfen plus a high rate of bromoxynil was most effective. As a second application oxyfluorfen alone was least effective, but bromoxynil alone or bromoxynil plus oxyfluorfen gave improved control. The addition of crop oil concentrate to the combination treatment of oxyfluorfen plus bromoxynil improved Russian thistle control.

[1]University of California Cooperative Extension, Lancaster and Riverside, CA

EVALUATION OF COMPETITION BETWEEN THREE ANNUAL WEEDS AND TWO VEGETABLE CROPS

Michelle Le Strange and W. Thomas Lanini[1]

Abstract. A field study was initiated in April 1987 at the University of California West Side Field Station (approximately fifty miles west of Fresno, CA) to evaluate various durations of competition between three annual weeds: barnyardgrass (Echinochloa crusgalli (L.) Beauv.), redroot pigweed (Amaranthus retroflexus L.) and common purslane (Portulaca oleracea L.) in two vegetable crops: bell peppers (var. Jupiter) and pickling cucumbers (var. Perfecto Verde 17).

Each weed species was broadcast throughout the cropping area at planting. Treatments included plots which were kept weed free for 0, 2, 4, 6, 8,

[1]University of California Cooperative Extension, Visalia and Davis, CA

10 weeks and full season in addition to plots where weeds were allowed to remain for 2, 4, 6, 8, 10 weeks and full season.

Data collection included weed and crop stand counts, percent weed cover, weed biomass and crop yield. Bell peppers were harvested three times and cucumbers were harvested six times at weekly intervals.

Bell pepper and cucumber yields increased with increasing weed free duration up to eight and six weeks, respectively. When weeds were allowed to remain for periods greater than two and four weeks, yields were reduced by twenty and sixteen percent, respectively. Six weeks of weed competition dropped yields more than seventy-five percent in the peppers, while cucumber yields dropped less than thirty percent. Total crop yield correlated negatively to weed biomass with r values of .69 in peppers and .40 in cucumbers.

EFFECT OF SOME HERBICIDES ON ETHYLENE PRODUCTION BY TOMATOES AND BEANS

M.M.F. Abdallah[1], F.M. Ashton[2] and C.L. Elmore[2]

Abstract. Tomato seedlings (Lycopersicon esculentum var. UCT6) sprayed with acifluorfen {5-[2-chloro-4-(trifluoromethyl)phenoxyl]-2-nitrobenzoic acid} and metribuzin {4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one} exhibited marked increases in rates of ethylene production by leaves and apices. Both herbicides enhanced ethylene production by the apex and the youngest leaves much more than by the older leaves. The increased rates of ethylene production were to some extent correlated with the visual effects on growth.

Treatment of bean (Phaseolus vulgaris) plants with sethoxydim {2-[1-(ethoxyimino)butyl]-5-[[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one}, bentazon {3-(1-methylethyl)-(1H)-2,1,3-benzothiadiazin-4(3H)-one 2,2-dioxide} and MCPA {(4-chloro-2-methylphenoxy)acetic acid} enhanced ethylene production by leaves. It was demonstrated that application of 2,4-DB {4-(2,4-dichlorophenoxy)butanoic acid} to bean cotyledon disks leads to enhanced rates of ethylene production especially at lower concentration (10 and 100 ppm). These effects can be partly inhibited by using -aminooxyacetic acid (AOA) as an ethylene inhibitor.

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[1]Department of Hort. Fac. of Agric. Ain Shams Univ., Cairo, Egypt
[2]Botany Dept. Univ. of CA, Davis, CA

CONTROL OF JOHNSONGRASS IN GRAPES WITH FLUAZIFOP-P-BUTYL

L.C. Hearn[1]

Abstract. Fluazifop-P-butyl {(R)-2[4-[[5-(trifluoromethyl)-2-pyridinyl]oxy]-phenoxy]propanoic acid} is a highly selective grass herbicide being developed by ICI Americas Inc. under the trade name of Fusilade 2000. A field trial in California was evaluated from 1984 through 1987 to determine the effectiveness of fluazifop-P-butyl to control johnsongrass (*Sorghum halepense* (L.) Pers.) in grapes (*Vitis vinifera*). Fluazifop-P-butyl was applied as a directed-strip spray for four (4) consecutive years to the same plots. Sequential treatments were applied yearly at two (2) spray intervals (GSI-14 day interval and GSII-28 day interval). The treatment list included (GSI) 0.21 + 0.21 kg/ha, 0.28 + 0.28 kg/ha, 0.42 + 0.42 kg/ha, and (GS II) 0.21 + 0.21 kg/ha, 0.28 + 0.28 kg/ha, 0.42 + 0.42 kg/ha, and 0.28 + 0.21 kg/ha. A 40 to 60% reduction in the johnsongrass stand was observed following the first year's application and 15-30% stand reduction for the next three (3) seasons. Total eradication was not observed with any treatment, however, sequential treatments of 0.28 kg/ha and above consistently provided 75 to 87% seasonal control from the second year onward. No injury to the grapes was observed from dosages as high as 0.84 kg/ha.

Introduction

Johnsongrass is a perennial weed species that grows vigorously, spreads rapidly and produces an extensive rhizome system (2). It is well adapted to the grape growing regions of the San Joaquin Valley and can be dispersed throughout a field by both seeds and rhizome segments. The severity of the problem in grapes is due to the poor competitiveness of the crop and the lack of rhizome fragmentation after the berms have been established.

Fluazifop-P-butyl is a highly selective grass herbicide being developed by ICI Americas Inc. under the trade name of Fusilade 2000. Extensive worldwide testing has shown fluazifop-P-butyl to possess a wide margin of safety when applied postemergence to non-graminaceous crops.

Since 1984, field research has been conducted to determine the effectiveness of fluazifop-P-butyl in controlling rhizomatous johnsongrass in grape vineyards when administered to the berm as a directed-strip treatment.

The objectives of the study were to: 1) determine the optimum rate and application timing, 2) evaluate the seasonal- and long-term effectiveness of sequential treatments applied yearly for four (4) consecutive years, 3) assess the potential for johnsongrass eradication when treating only the berms.

Materials and Methods

This field experiment was conducted from 1984 through 1987 in a grape vineyard located in the central portion of the San Joaquin Valley. The vineyard selected was planted to French Colombard grapes in 1981 and had a well established rhizomatous johnsongrass population when the trial was initiated (3-5 plants/0.09 sq. meter). The soil texture was a sandy loam (pH 6.9) and contained less than 2 percent organic matter.

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[1]ICI Americas, Inc., Visalia, CA

Plots were subjected to normal cultural practices which included discing the row middles 3-4 times per growing season. Slanting knives were used on the berms in early March 1984 before the johnsongrass emerged. The berm was also reduced from 0.59 meter to 0.29 meter prior to the 1987 treatments. The berm was rebuilt to 0.45 meter during the 1987 season. The irrigation used was drip with emitters spaced every 2.1 meters. Irrigation timing was regulated by the grower according to the maturity of the crop and the weather conditions. The row/plant spacing was 3.6 meters x 2.4 meters. Plot size was 13 vines (31.5 meters by 0.9 meter), and all treatments were replicated four (4) times in a randomized block design.

Treatments were applied as directed--strip sprays to a 0.45 meter band on each side of the berm allowing the spray to overlap the top of the berm. All treatments were initiated each year in mid-April when the johnsongrass was 20 to 60 cm in height. All herbicide treatments were administered with a tractor mounted compressed air sprayer at 158 to 279 l/ha. Flat fan nozzles (Teejet 8001-8003) that were attached to a double swivel nozzle on a drop boom were used to insure adequate coverage of the johnsongrass on the berms.

Fluazifop-P-butyl was applied as directed-strip spray for four (4) consecutive years to the same plots. Sequential treatments were applied yearly at two (2) spray intervals (GSI-14 day interval and GSII-28 day interval). The treatment list included (GSI) 0.21+0.21 kg/ha, 0.28+0.28 kg/ha and 0.42+0.42 kg/ha; (GSII) 0.21+0.21 kg/ha, 0.28+0.28 kg/ha and 0.42 + 0.42 kg/ha and 0.28+0.21 kg/ha. A crop oil concentrate was added to all treatments at a rate of 1% of the spray volume.

In October of 1987 johnsongrass stand counts were made for each plot. Counts were made of all johnsongrass plants (seedling and rhizome) found on the berm (0.45 meter wide) for a length of 15.24 meters. Counts of seedling and rhizome plants were kept separate. However, for this paper only total johnsongrass plants will be discussed.

Visual estimations of percent control and crop injury evaluations were conducted at 2, 14, 25, 45 and at harvest (75-100 DAT2) following the final treatment during the four (4) years of evaluation. Ratings were based on a scale of 0 = no injury and 100% = complete kill. All data were subjected to analysis of variance. LSD and T-tests were used to determine significant difference among means at the 0.05 level of probability.

Results and Discussion

This study compared sequential treatments of fluazifop-P-butyl at three (3) rates and two (2) spray intervals from 1984 through 1987. The comparative effectiveness of fluazifop-P-butyl was examined when applied to johnsongrass and grape berms. Sequential treatments were applied yearly at spray intervals of 14 days (GSI) and 28 days (GSII) in each of the four (4) years. Initial treatments were made after all rhizome johnsongrass had emerged and attained a height of 20-60 cm. In season treatments of fluazifop-P-butyl at each growth stage included: 0.21+21 kg/ha, 0.28+0.28 kg/ha and 0.42+0.42 kg/ha.

These data indicate that fluazifop-P-butyl was numerically less effective in controlling johnsongrass when applied on a 14-day schedule (GSI), particularly at the 0.21 kg/ha rate (Tables 1 and 2), than when applied on a 28-day schedule (GSII). These differences in percent johnsongrass control were obvious in all years except 1986. In 1986 when testing was initiated the growth of the grape canes was approximately 30% more than was observed in any other year. This advanced growth was attributed to the early spring that occurred in 1986 (3-4- weeks ahead of other years during the test). When the GSII applications were made in 1986 the grape canes had already dropped preventing adequate spray coverage. The GSI applications were not hindered by the cane drop.

Table 1 - Effect of spray interval and rate of fluazifop-P-butyl on johnsongrass control 1/

Treatment	Rate 2/ kg/ha	Growth 3/ Stage	Percent Control at Harvest 4/ 1984	1985	1986	1987
fluazifop-P-butyl	0.21+0.21	I	67.5 e	72.5 d	78.8 bc	82.5 e
fluazifop-P butyl	0.21+0.21	II	72.0 d	83.8 c	76.3 c	85.0 cde
fluazifop-P-butyl	0.28+0.28	I	77.5 bc	87.5 bc	85.0 a	84.8 de
fluazifop-P-butyl	0.28+0.28	II	81.3 ab	90.0 ab	81.3 ab	85.0 cde
fluazifop-P-butyl	0.42+0.42	I	81.3 ab	88.8 abc	81.3 ab	87.5 abc
fluazifop-P-butyl	0.42+0.42	II	83.8 a	93.8 a	83.8 a	90.0 a
fluazifop-P-butyl	0.28+0.21	II	76.3 cd	85.0 bc	85.0 a	86.3 bcd

1/ Initial treatments were applied to johnsongrass approximately 20-60 cm in height.
2/ A crop oil concentrate was added to all treatments at 1.0% (v/v).
3/ Growth Stage I = 14 day spray interval.
Growth Stage II = 28 day spray interval.
4/ Means followed by the same letter are not significantly different at the 0.05 level of probability as determined by Least Significant Differences and the T-test.

TABLE 2 - Effects of spray interval of fluazifop-P-butyl on johnsongrass control 1/

Spray Interval	Percent control of johnsongrass at harvest 2/ 1984	1985	1986	1987
GS I = 14 day-split	75.0 b	82.9 b	81.6 a	84.9 b
GSII = 28 day-split	79.0 a	89.2 a	80.4 b	86.6 a

1/ Initial treatments were applied to johnsongrass approximately 20-60 cm in height.
2/ Means followed by the same letter are not significantly different at the 0.05 level of probability as determined by the Least Significant Difference and the T-test.

In 1984, 1985 and 1987 all applications were made prior to canes dropping. Plowman et al. (1) have reported fluazifop to be most effective when applied to johnsongrass in an active state of growth. Higher dosages may be required if the weed is drought-stressed, growing under conditions of low relative humidity or if rhizomes are not well fragmented. Since it is not easy to fragment the rhizomes on the berms, spray coverage and actively growing johnsongrass become even more important to achieve effective control.

The effectiveness of each of the three rates of fluazifop-P-butyl was most obvious at harvest each season. In the first three (3) years of testing the sequential treatments of 0.21 kg/ha showed less control than did the 0.28 kg/ha rate. During this period the control of the 0.28 kg/ha rate equaled 0.42 kg/ha. In 1987 the cumulative effect of multiple applications over four (4) years resulted in 0.21 kg/ha equaling 0.28 kg/ha and 0.42 kg/ha was the superior treatment (Table 3). Throughout the testing period the 0.42+0.42 kg/ha consistently showed the best johnsongrass control at harvest (Table 1). In addition 0.42 kg/ha also gave faster burndown at the 28 DAT rating (data not shown) in each of the four (4) years.

TABLE 3 - Effects of three rates of fluozifop-P-butyl on johnsongrass 1/

Treatment	Rate 2/ kg/ha	Percent Control at Harvest 3/ 1984	1985	1986	1987
fluazifop-P-butyl	0.21+0.21	70 b	78 b	77.5 b	83.8 b
fluazifop-P-butyl	0.28+0.28	79 a	89 a	83.1 a	84.4 b
fluazifop-P-butyl	0.42+0.42	82 a	91 a	82.5 a	88.8 a

1/ Initial treatments were applied to johnsongrass approximately 20-60 cm in height.
2/ A crop oil concentrate was added to all treatments at 1.0% (v/v).
3/ Means followed by the same letter are not significantly different at the 0.05 level of probability as determined by Least Signigicant Difference and the T-test.

Johnsongrass stand counts made prior to test initiation in 1984 showed all plots to have 3-5 johnsongrass plants/0.09 sq. meter. At the completion of the test, johnsongrass (1987) stand counts were made for each plot to determine the effect of four (4) years of fluazifop-P-butyl applications. Counts were made of all johnsongrass plants (seedling and rhizome) found on the berm for a length of 7.6 meters. All treatments significantly reduced the number of johnsongrass plants as compared to the untreated plots. Each 28-day treatment provided better control than did the 14-day treatment; however differences were not statistically significant except at the 0.21 kg/ha rate. The plant stand count assessments showed that the 0.28 kg/ha and 0.42 kg/ha treatments provided the superior johnsongrass stand reduction but were not statistically better than the 0.21 kg/ha treatments (Table 4).

TABLE 4 - Effect of four years of fluazifop-P-butyl applications on johnsongrass populations on grape berms 1/

Treatment	Rate 2/ kg/ha	Growth 3/ Stage	Johnsongrass plants/ .09 square meter 4/	% control as compared to the untreated
fluazifop-P-butyl	0.21+0.21	I	1.84 ab	59
fluazifop-P-butyl	0.21+0.21	II	0.97 c	78
fluazifop-P-butyl	0.28+0.28	I	1.18 bc	74
fluazifop-P-butyl	0.28+0.28	II	0.60 c	87
fluazifop-P-butyl	0.42+0.42	I	0.94 c	79
fluazifop-P-butyl	0.42+0.42	II	0.72 c	84
fluazifop-P-butyl	0.28+0.21	II	0.89 c	80
Untreated check			4.46 a	--

1/ Initial treatments were applied to johnsongrass approximately 20-60 cm in height.

2/ A crop oil concentrate was added to all treatments at 1.0% (v/v).

3/ Growth Stage I = 14 day spray interval.
Growth Stage II = 28 day spray interval.

4/ Means followed by the same letter are not significantly different at the 0.05 level of probability as determined by Least Significant Difference and the T-test.

Conclusion

The overall objective of this study was to determine if johnsongrass could be eradicated from grape berms by yearly treatments with fluazifop-P-butyl. These data indicate that with the spray regime described in this paper, eradication of johnsongrass is not possible. However, a 60-87% reduction in johnsongrass plants can be expected. To achieve eradication the following program would have to be employed: (1) a preemergence herbicide applied in the spring at a rate that would prevent emergence of seedling johnsongrass season long; (2) fluazifop-P-butyl applied as a broadcast spray over the entire vineyard floor to effectively control all rhizome johnsongrass or strip tillage to plow or harrow down weeds that develop in the row middles; (3) use directed-strip sprays of fluazifop-P-butyl on the berms to control rhizome johnsongrass before cane drop; (4) use good cultural practices to prevent reinfestation of johnsongrass seeds or rhizomes into the vineyard.

These data indicated that there was a direct response between the rate of fluazifop-P-butyl and the percent control observed for johnsongrass. The higher the rate the better the long-term control. This test also showed that good spray coverage is essential, and in most years, the best spray interval is 28 days.

Literature Cited

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2. McWhorter, C.G. 1971. Growth and development of johnsongrass ecotypes. Weed Sci. 19:141-147.

CANTALOUPE (CUCUMIS MELO L.) RESPONSE TO CHLORSULFURON

Ben B. Barstow and J.P. Chernicky[1]

Cantaloupes *Cucumis melo* L. showed little or no response to chlorsulfuron {2-chloro-*N*-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]-benzenesulfonamide} in 1984-86 field evaluations of potential sulfonylurea carryover into rotational crops. Further investigations in 1987 compared preplant incorporated and preemergence over-the-bed chlorsulfuron and DPX-6316 {3-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2yl)amino]carbonyl]amino]sulfonyl]-2-thiopenecarboxylic acid} treatments for effect on cantaloupe stand establishment, weed control and yield. Plots were arranged in a split plot design with four replications.

There were no statistical differences between application methods. DPX-6316 at 33 g/ha showed no effect on stand or weed control. This treatment increased yield of size 27 melons compared to untreated areas but did not alter yield in other classes. Chlorsulfuron did not appear to influence stands and provided acceptable weed control at 33, 16.5 and 8.2 g/ha. Weed control at 4.1 g/ha chlorsulfuron was better than untreated DPX-6316. Yields of cull, size 45 and size 23 melons were unaffected. Plots receiving higher chlorsulfuron rates produced more size 36 melons. Plots receiving higher chlorsulfuron rates produced more size 27 melons than untreated or chlorsulfuron 4.12 g/ha treated areas.

[1]Plant Science Department, University of Arizona Maricopa Agricultural Center, Maricopa, AZ

WEED PROBLEMS IN ORNAMENTALS UNDER PROTECTED CONDITIONS IN ISRAEL

Menashe Horowitz[1]

Abstract. Flowering and foliage plants grown under protected conditions are an important part of Israel ornamental production. Several weeds causing problems and their control are discussed.

Gypsophilia, grown on light soil under shelter, is often exposed to severe weed competition at early growth stage, particularly from chickweed (*Stellaria media*). Preplant-incorporated application of following herbicides, effective against chickweed, injured gypsophilia: dinitramine {N^3,N^2-diethyl-2,4,dinitro-6-(trifluoromethyl)-1,3-benzenediamine}, ethalfluralin {N-ethyl-N-(2-methyl-2-propenyl)-2,6-dinitor-4-(trifluoromethyl)benzenamine}, pendimethalin {N-(1-ethylpropyl)-3-,4-dimethyl-2,6-dinitrobenzenamine}, trifluralin {2,6-dinitro-N,N-dipropyl-4-(trifluoromethyl)benzenamine}, simazine {6-chloro-N,N'-diethyl-1,3,5-triazine-2,4-diamine} (at 0.5 ppm) and DCPA {dimethyl 2,4,5-6-tetrachloro-1,4-benzenedicarboxylate} (at 5 ppm). However, when sprayed after planting, gypsophila tolerance to these herbicides increased with age. Preplant, gyposphila tolerates oxadiazon {3-

[1]Department of Ornamental Horticulture, Agricultural Research Organization, Bet-Dagan P.O.6, Israel.

[2,4-dichloro-5-(1-methylethoxy)phenyl]-5-(1,1,-dimethylethyl)-1,3,4-oxadiazol-2-(3H)-one} and oxyfluorfen {2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluromethyl)benzence} very well, but they cause temporary scorching when applied as an overhead spray. Fomesafen {5-[2-chloro-4-(trifluoromethyl)phenoxy]-N-(methylsulfonyl)-2-nitrobenzamide} at 250 g/ha and terbacil {5-chloro-3-(1,1-dimethyl-ethyl)-6-methyl-2,4(1H,3H)-pyrimidinedione at 800 g/ha sprayed on gypsophila at various stages did not affect the plant. Among the latter four herbicides only terbacil was effective against chickweed. Gypsophilia was sensitive to bentazon {3-(1-methylethyl)-(1H)-2,1,3-benzothiadiazin-4(3H)-one 2,2-dioxide} soon after planting and again close to flowering. Fluazifop-butyl {(R)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl]oxy]-phenoxy]propanoic acid} and sethoxydim {2-[1-(ethoxyimino)butyl]-5-[2-(ethylthio)propyl]3-3hydroxy-2-cyclohexen-1-one} at 500 g/ha sprayed six weeks after planting did not affect gypsophila.

Bittercress (Cardamine hirsuta) is a common weed in greenhouses. Bittercress control experiments were conducted on container-grown araucaria in organic medium. Oxyfluorfen at 480 g/ha sprayed on 10 to 50 cm tall araucaria plants before the emergence of bittercress, prevented its establishment for 1 to 2 months without plant damage; higher rates required for longer control scorched the foliage. Applied through drip irrigation, oxyfluorfen produced a weed-free area around the emitter, inversely related to the organic matter content of the growth medium; on peat mix, the diameter of the controlled area was approximately 10 cm. In preliminary trials, incorporation of oxyfluorfen in the growth mix at 240 ppm prevented bittercress establishment for more than four months without damage.

Rorippa prostrata, a cruciferous perennial, probably introduced from the Netherlands with imported bulbs and cuttings, has become in recent years a serious weed of flower crops under shelter due to the considerable propagation and expansion capacity of its root system. Applied on established Rorippa, glyphosate {N-phosphonomethyl)glycine} at 4 kg/ha gave only slow and partial control, while 2,4-D {(2,4-dichlorophenoxy)acetic acid} (ammoniacal salt) at 2 kg/ha provided good control; with both, spray volume of 300 L/ha was more effective than 600 L/ha.

MON-15100 EFFICACY TRIALS FOR ANNUAL GRASS CONTROL IN TURFGRASS

Nelroy E. Jackson[1]

Abstract. MON-15100 {S,S,-Dimethyl 2-(difluoromethyl)-4-(2-methylpropyl)-6-(trifluoromethyl)-3,5-pyridinedicarbothioate} is a new experimental compound from Monsanto for the control of annual grasses such as crabgrass in turf. Results of 1987 field tests show that MON-15100 provided excellent preemergent and postemergent large crabgrass (Digitaria sanguinalis) control in turf with good turf safety on both cool and warm season turfgrasses. MON-15100 at 0.56 kg ai/ha gave 100% control of large crabgrass eight months after preemergence application and six months after postemergence application.

[1]Monsanto Company, El Toro, CA

IMAZAQUIN FOR PURPLE NUTSEDGE (CYPERUS ROTUNDUS L.) CONTROL IN ESTABLISHED TURFGRASSES[1]

K. Umeda and R.E. Deems[1]

Imazaquin {2-((4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl))-3-quinolinecarboxylic acid} at rates of 0.25-0.50 lb ae/A is registered as a postemergence herbicide for the control of purple nutsedge (*Cyperus rotundus* L.) in established bermudagrasses (*Cynodon dactylon* L. Pers.), zoysiagrasses (*Zoysia japonica* Steud.), St. Augustinegrasses (*Stenotaphrum secundatum* Walt. Kuntze) and centipedegrass (*Eromochloa ophiuroides* Munro. Hack). Weed control performance and turfgrass tolerance of singular and multiple applications will be discussed. Particular emphasis will be on Arizona and Southern California.

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[1]American Cyanamid Company, Chandler, AZ

MINUTES OF BUSINESS MEETING
WESTERN SOCIETY OF WEED SCIENCE
FRESNO, CALIFORNIA
MARCH 10, 1988

The Business Meeting for the 41st Meeting of the Western Society of Weed Science was held at the Centre Plaza Holiday Inn in Fresno, CA on March 10, 1988. President Mitich called the meeting to order at 7:30 a.m. with introductory comments including thanks to Elanco for sponsoring the Business Meeting Breakfast, to Mobay for sponsoring the Graduate Student Breakfast and to Sandoz for providing travel expenses to Dr. Don Wyse to participate as a General Session speaker.

1. Spouse's Program. Mrs. R. Callahan asked for an opportunity to address the WSWS Business Meeting. Speaking for the spouses who participated in the Spouse's Program, a thank you was extended to the membership of the WSWS for providing support and programs for the spouses over the years.

2. Reading of Minutes. The minutes of the Summer Executive Meeting were read and approved.

3. Financial Committee Report, Dave Cudney and LaMar Anderson.

Cudney: The Research Progress Reports and other costs have been increasing causing the WSWS to operate at a loss. The Committee has recommended that the Executive Committee explore ways to increase revenues.

Anderson: Income in 1987 was $18,310 with expenses of $19,160 indicating a net loss of $850 which was offset by interest on checking and savings accounts. WSWS currently has about $48,200 in savings which is equal to about 2 1/2 years of Operating Expenses but the trend over the past 2 years of not meeting expenses is dangerous. Registration in 1988 of 309 is down 50 from 1987 resulting in a decrease in revenues of about $1200 from last year. Efforts are being made to contain costs. One example is keeping numbers of Research Progress Reports close to needs. Also thanks should be extended to industry for added support in sponsoring coffee breaks.

4. Report on 1989 Hawaii Meeting, Ken Dunster. Decision was made to proceed with the 1989 plans for the Hawaii Meeting, and this report is being made to update the membership on that status of those plans. It had been assumed that the Hawaii location would be as economical as a U.S. mainland location but that will not be the case. The WSWS has a contract with the Ala Moana Hotel for the meeting with room costs of $90/day single or double and $100/day triple.

Meeting room costs could be substantial at approximately $4000; however, if there is a Food Service and Catering demand by the WSWS of about $8000, the hotel will waive the meeting room costs. Therefore, in 1989, it is essential that we use all the conference facilities in order to help offset the catering cost requirements. It would be helpful in planning if industry could indicate typical dollars spent in support of WSWS activities. Air fare from the U.S. will run about $500-600. No tours are planned as yet but the potential for tours similar to the Fresno tour of sugar or pineapple operations are possible.

WESTERN SOCIETY OF WEED SCIENCE
Financial Statement
March 6, 1987 - February 29, 1988

Income	1987-88	1986-87	1985-86
Registration, Annual meeting		9,055.00	8,885.00
Registration, Boise (126x$30)	$4,140.00		
Preregistration, Fresno (144x$25)	3,600.00		
Spouse preregistration, Fresno (9x$20)	180.00		
Tour	420.00	250.00	190.00
Dues, members not attending annual meeting, 102	515.00	475.00	485.00
Extra luncheon tickets		120.00	280.00
Current year's Res. Prog. Rept. sales	2,452.70	2,526.52	3,592.69
Current year's Proceedings sales	2,827.70	2,850.63	4,417.72
Next year's Res. Prog. Rept. sales	1,320.00	1,356.00	
Next year's Proceedings sales	1,392.00	1,500.00	
Page charges, review articles			910.00
Sale of back issues of publications	251.00	260.50	323.26
Payment of outstanding invoices, previous year	12.00	51.25	223.50
Coffee break donations	1,200.00	1,100.00	1,025.00
Total fiscal year income	$18,310.40	19,544.90	20,332.17
Expenditures			
Annual meeting incidental exp., last yr.	1,064.59	2,387.73	1,683.62
Annual meeting incidental exp, current yr.	653.44	750.99	574.74
Luncheon, annual meeting	3,553.36	4,799.81	4,061.07
Guest speaker expenses	748.00	200.00	264.00
Graduate student room subsidy	990.00	450.00	620.00
Graduate student paper awards	310.05	286.05	304.05
Business Manager honorarium	1,000.00	1,000.00	1,000.00
CAST dues	604.50	560.00	571.20
CAST, development program		1,000.00	
Tour	260.00	330.00	
Res. Prog. Rept., publication costs	3,551.23	2,838.60	2,703.58
Proceedings, publication costs	3,306.69	4.024.95	3,444.76
Postage	987.30	927.33	866.60
Newsletters, printing costs	361.42	293.10	281.63
Office supplies	526.42	386.86	281.53
Refunds		90.00	70.00
Program, printing costs	660.00	650.00	611.82
Spouse program	219.80		
Executive expenses	364.21		
Total fiscal year expenditures	$19,161.01	20,975.42	17,388.60
Fiscal year operational balance	-850.61	-1,430.52	2,993.57
Interest on checking	247.59	336.00	388.06
Interest on savings certificates (matured)	3,921.86	3,415.70	2,913.79
	3,318.84	2,321.18	6,295.42
Assets			
Savings certificates	$39,447.24	35,000.00	30,500.00
Checking account balance	8,830.75	9,959.15	12,137.97
Cash on hand	50.00	50.00	50.00
	$48,327.99	45,009.15	42,687.97

Alternatives to the Hawaii site were explored; however with a signed contract, we would not be able to easily change at this point. We need to stress that member support of WSWS by staying at the Ala Moana and using the facilities of the hotel is essential.

President Mitich asked for a show of hands of people intending to attend the Meeting in Hawaii (Response indicated good support) and encouraged support of the WSWS by using the facilities of the Ala Moana.

5. Local Arrangements, Bob Dunlap. Acknowledged the quality of support given WSWS by the Centre Plaza Holiday Inn. Introduced other members of the Local Arrangements Committee including: Bill Fisher (Bus Tour), Dick Nielsen, Ed Voles, Fred Timbe (Registration) and Brian Dieter (Equipment)

6. Program Committee, Don Thill. Acknowledged support and activities of Steve Miller (Research) and Sheldon Blank (Education and Regulatory). Seventy-one abstracts including 17 posters were submitted. Fourteen student presentations are included in that total. Thill emphasized the importance of completely and properly filling out the submission forms.

7. Research Committee, Steve Miller. Acknowledged and gave thanks to Peter Fay and Montana State University for printing the Research Progress Reports which contained 207 reports by 112 authors. Identified the Section Chairmen for 1989 and 1990:

	Chairman	Chairman Elect
Project 1	George Beck	Mike Foster
Project 2	Steve Whisenant	George Beck
Project 3	Tom Lanini	Michael Newton
Project 4	Stott Howard	Steve Bowe
Project 5	Dennis Rasmusson	Rod Warner
Project 6	Lars Anderson	Shaffeek Ali
Project 7	Rick A. Boydston	Jill Schroeder

8. Education/Regulatory Committee, Chairman: Sheldon Blank
A Groundwater Symposium was held with the following participants:

Dr. D. Mackay
UCLA School of Public Health: A Public Perspective

Mr. G. Kotas
EPA, Washington, DC: The EPA Perspective

Dr. G. Barnett
Monsanto Co., St. Louis, MO: An Industry Perspective

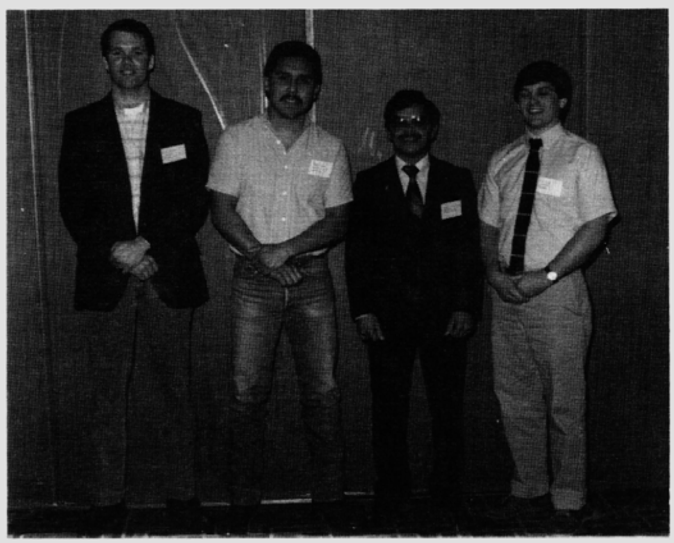
After each speaker addressed their aspect of the topic with opening remarks, a panel discussion was held with questions from the audience.

The section concluded with a paper and discussion on 2,4-D exposure and toxicity by Wendell Mullison

Chairman for 1989: Paul Ogg
Chairman Elect: Celestine Lacey

9. Graduate Student Paper Contest, Celestine Lacey. Recognized the 10 individuals who assisted in judging the 14 student papers. Noted that the quality of the papers was improving and in some cases differences between individuals were only fractions of a point. Awards presented to:

First Place:	P. Dotray, WSU, Root Development and Its Relationship to Shoot Growth in Jointed Goatgrass
Second Place:	C. Reyes, CSU, Mathematical Description of Trifluralin Degradation in Soil
Third Place: (Two-way tie)	T. Fritz, WSU, Germination Response of Galium sp. to Temperature, Nitrate, Gibberellic Acid and Soil Matric Potential
	B. Velverde, OSU, Growth and Competitive Ability of Dinitroaniline-Herbicide Resistant and Susceptible Goosegrass (Eleusine indica) Biotypes.



1988 WSWS Student Paper Award Winners (L to R): 1st Place, Peter A. Dotray, Washington State Univ.; 2nd Place, Carlos C. Reyes, Colorado State Univ.; 3rd Place (tie), Bernal E. Valverde, Oregon State Univ,; and Timothy J. Fritz, Washington State Univ.

10. WSSA Representative, Peter Fay. WSSA had losses due to publications of $26,000 in 1987 and projected 1988 losses of $50,000. WSSA encourages WSWS members to purchase WSSA publications. The 1989 WSSA meeting will be increased in length by 1/2 to 1 day to reduce the number of concurrent sessions and to allow for more Symposia. Program in 1989 will include a workshop for preparing grant proposals. Historically, Weed Science proposals are not competitive and are not generating sufficient dollars.

11. CAST Representative, Lowell Jordan. CAST now has 28 member societies. Income has doubled but expenses are high and CAST has been running a deficit the past two years. Steps to reduce expenses are being taken. Mailing of the Food and Ag Science Magazine (160,000 copies times 3 issues per year) is the biggest budget expense. However, the free mailings have generated only about 1,600 paid subscriptions (or about a 70% non-renewal rate). The Science Magazine Committee has been directed to make proposals for a new vehicle for teaching young people.

The first priority of CAST are the Task Force Reports. CAST retains high credibility in Washington, DC, due to the reports and the CAST Representatives.

12. Member-at-Large, Rod Lym. Reported on cost savings to WSWS by use of computer-generated signs. Acknowledged support of Mobay in providing a complimentary Graduate Student Breakfast. Thirty-one students attended.

13. Resolutions Committee, George Beck. Distributed copies of three proposed Resolutions to membership.

RESOLUTION I

WHEREAS, losses to weeds constitute a major deterrent to agricultural production in the developing world and all concerned organizations should move to decrease those losses and develop environmentally safe and efficacious weed management programs; and

WHEREAS, the weed management specialist at FAO provided world-wide leadership and stimulated the development of appropriate weed management programs in many of the world's countries; and

WHEREAS, there has been no apparent weed management program within FAO since March, 1987.

BE IT RESOLVED that the Western Society of Weed Science at its annual meeting in Fresno, California from March 8 to 10, 1988 urges the Director General of the United Nations Food and Agriculture Organization and the Associate Director General of the UN/FAO Agricultural Department to move with all due haste to fill the weed management position at FAO.

RESOLUTION II

WHEREAS, Dr. Thomas Sutherland, the Colorado State University professor who is serving as Dean of Agriculture at the American University of Beirut, was taken hostage on June 9, 1985; and

WHEREAS, Dr. Sutherland is dedicated to the principles that knowledge should be used in the service of mankind and that interaction of people should be governed by reason rather than violence; and

WHEREAS, Dr. Sutherland is dedicated to serving international agriculture and believes in educating and training agriculturists as a means of improving food production, alleviating hunger, and improving the quality of life for people of developing nations; and

WHEREAS, the need exists to remind ourselves to search constantly for solutions to fundamental injustice throughout the world with reason and patient diplomacy.

BE IT RESOLVED that the Western Society of Weed Science and its members show their continued support for Tom's wife, Jean, and his family; and

BE IT FURTHER RESOLVED that the Western Society of Weed Science pledge its support to measures deemed appropriate to gain his release; and

BE IT FURTHER RESOLVED that the Western Society of Weed Science urges the President and Members of Congress to pursue all appropriate means to obtain Dr. Sutherland's release and the release of other hostages in Lebanon.

RESOLUTION III

WHEREAS, the facilities and arrangements for the 41st meeting of the Western Society of Weed Science are of excellent quality and efficiently organized; and

WHEREAS, the organization and content of the program for this meeting are of excellent quality and of prime importance to the Society's continued progress.

BE IT RESOLVED that the Western Society of Weed Science expresses its sincere thanks and appreciation to Chairperson Robert Dunlap and members of the 1988 Local Arrangements Committee; to the Management of the Hotel for their efforts; to Chairperson Donn Thill and members of the Program Committee; and to the various Sectional Chairpersons for developing well-organized, timely, and excellent programs.

#1 - Support of FAO Weed Specialist position - Passed.
#2 - Support for Sutherland Hostage release - Passed.
#3 - Appreciation for Local Arrangements - Passed.

14. Nominations Committee, Ken Dunster. New officers elected include:

President Elect:	Sheldon Blank
Secretary:	Peter Fay
Research Chair Elect:	Jodie Holt
Educ/Regul Chair Elect:	Celestine Lacey

15. Awards Committee, Paul Ogg. Discussed creation of the Outstanding Weed Scientist Award in 1987. No nominations were received in 1988. Encouraged nominations for 1989.

16. Ad Hoc Legislative Committee, Celestine Lacey. Created in April 1987. Met in January 1988 with INWAC to discuss overlap of objectives. Committee is to be reformed and responsibilities determined. Will report on status in 1989.

17. Intermountain Noxious Weed Ad Hoc Committee, George Beck. Committee has reviewed federal laws relating to noxious weed control. Committee recommends formulation of a comprehensive National weed law and is working on a draft. Some members traveled to Washington, DC in April.

18. WSSA Newsletter, Dr. Meade, the new Editor for the Newsletter is soliciting items for publication.

19. Poster Committee, Dan Kidder. This is the third year for Poster Session and overall success adds to the quality of the meeting. Guidelines are sent out with the Call for Papers. WSWS expects to maintain conformity with WSSA Guidelines in order to encourage use in other meetings.

20. Necrology Committee, Joan Lish. Requested moment of silence for WSWS members who passed away during the preceeding year:

Mike Jackson, MSU	Sept. 8, 1987
Chuck Huston, USDA	Oct. 15, 1987

21. New Business.

A. Changes are needed in By-Laws to add the Awards Committee.

B. Intermountain Agricultural Foundation, Elaine Hale. (See attached report). At the San Diego Meeting, the WSWS voted $2500 for use in producing a film to improve the image of agriculture among young people. Nothing was done at that time and the money was lost. In 1987, the Intermountain Agricultural Foundation was formed in Cheyenne, WY as a non-profit corporation for educating young people about agriculture. The IAF is currently working on a project with Hallmark to produce a 2 hour TV movie for children.

C. Western Aquatic Plant Management Society, Barb Mullin. Extended thanks to WSWS for support and an invitation to any WSWS members who might want to attend the WAPMS Meeting.

D. President Mitich thanked WSWS for support during the past year, offered congratulations to the President-elect Don Thill and turned over the gavel of the office. Don Thill presented a plaque to Larry Mitich commemorating his past year of service.

The Business Meeting was adjourned at 9:00 a.m.

INTERMOUNTAIN AGRICULTURE FOUNDATION

The Intermountain Agriculture Foundation (IAF) is a newly-formed non-profit tax exempt corporation dedicated to producing basic agriculture-related education programs for American Youth and other interested groups.

The initial IAF project is a two-hour television movie to be produced by the Hallmark Properties of Kansas City, MO, featuring Hallmark Zoobilee Zoo in an agricultural theme. This program will be aired during the 1988 Thanksgiving season with additional 30 minute spin-offs featured through Spring 1989. The intent of the movie is to expose American youth to the bounty of America at a time when minds are concentrating on the holiday table and thanksgiving for that which we have.

The budget for this project is $798,000 with IAF's participation at $500,000. We must meet this amount by April 15 to fit scheduling needs.

IAF is headquartered in Cheyenne, WY. Its purposes are:

1. To provide the children of this country an opportunity to learn about agriculture through their creative ability, their curiosity and by promoting their interaction with the agriculture industry;

2. To encourage them to explore and develop their own imaginative perspective of agriculture;

3. To recognize and stimulate the humanistic side of our children, allowing imagination and curiosity to keep pace with academic learning; and

4. To share with the young children of America an insight of the diversity of professionalism involved in the agricultural process (i.e. the workers involved in applesauce, hamburgers and french fries), thus demonstrating that agriculture stands as a foundation for this "living system."

We request moral and philosophical support from the WSWS.

Submitted by: Elaine G. Hale
Vice President, IAF

1988 RESEARCH PROJECT SUMMARIES

Summary of Project 1: Perennial Herbaceous Weeds
George Beck, Colorado State University

The meeting was called to order by Chairman Phil Westra at 3:00 p.m. Topics discussed included: 1) Does a lack of well-differentiated vascular tissue from a parent plant into vegetative root or rhizome buds affect herbicide translocation into buds? 2) Does perennial bud sink strength have a greater influence on herbicide translocation into buds than vascularization of buds? 3) How can vascularization and/or sink strength be altered or stimulated in perennial weeds.

The presence of perennial or adventitious buds in some instances is obvious; i.e., cell division and elongation has started and buds are visually apparent outside the root or rhizome. Some buds may be beginning to develop in the pericycle while others have developed to the point of having leaf initials and lay dormant under the epiderm and are not readily apparent. The literature indicates that adventitious buds in Canada thistle originate in the pericycle and develop distinct vascular bundles and an apical meristem that is larger than root initials, and this size difference can be used to distinguish adventitious buds from root initials. Field bindweed perennial buds also are broader than root initials. Xylem differentiation proceeds obliquely to parent tissue in field bindweed bud initials while root primordia xylem develops at a right angle to parent tissue. Also in field bindweed, one terminal protoxylem element of parental origin loops up through a bud primordium and taken back into parent vascular tissue.

Plant growth regulators (PGR) influence bud development and growth. Phytochrome affects field bindweed bud dormancy. Buds grown in the dark remained quiescent and elongated only a few millimeters. If those buds were subjected to red-light, they produced etiolated shoots, and shoot growth was subsequently inhibited with far-red light. Light quality and temperature are important to break bud dormancy in leafy spurge. In adder's tongue, low auxin and high cytokinin stimulates adventitious bud development in a very localized region. If root tip growth is stopped, bud primordia develop. Root apex cells retain their integrity while adventitious buds develop. However, if the root apex is removed, remaining cortical cells differentiate into adventitious buds.

Bud location along a root or rhizome affects herbicide accumulation into buds. More glyphosate accumulated in more recently formed distal buds of quackgrass rhizomes than older, proximal buds. ^{14}C-glyphosate distribution (dpm/mg dry weight) in quackgrass was greatest in the treated leaf followed by a lesser amount in the culm of the treated leaf, then low levels were found in the rhizome internode beneath the treated culm, then an increased level in the closest bud, then a decreased amount in the next internode, and an increased amount in the next bud, and this pattern continued along the rhizome.

Don Wyse presented data on common milkweed research conducted at Minnesota. When no adjuvants were used or modifications to leaf tissue made, only 35% of applied glyphosate was absorbed by milkweed. When cuticles were disrupted, an increase in absorption occurred but no increased translocation was observed. It was thought that the herbicide was being sequestered in laticifers. Experiments with radioactive herbicide indicated that sequestering of herbicide into laticifers did not occur. When individual adventitious milkweed buds were treated with cytokinin (benzyladenine) growth rates increased 70% over six days, thereby increasing sink strength. The latter was verified with ^{14}C-glyphosate treatments where buds without cytokinin treatment were still viable whereas only 17% of cytokinin treated buds remained viable. Other research reported by Wyse indicates that xylem and phloem are developed early in milkweed bud primordia and thus vascularization is not limiting herbicide translocation into buds. In milkweed, cell division and elongation occurrence, i.e. sink strength, is more important than vascularization for herbicide translocation into buds. Wyse's group is pursuing research on the physiology of bud development and growth.

Rod Lym presented data on leafy spurge research conducted at North Dakota State University. Leafy spurge root sucrose content fluctuations correlate well with changes in air temperature but not with soil moisture or relative humidity. They are trying to find the ideal time to apply herbicides relative to sucrose and weather changes. Previous field research indicates that spring, when flowers emerge, or fall are optimum times to apply picloram, dicamba, or 2,4-D. Studies currently in progress at NDSU indicate that ^{14}C-picloram accumulation in roots and buds follows the same general pattern as observed for optimum timing for herbicide application; peak dpm/gm of root occurred in June but flattened thereafter with no peak in fall whereas peak dpm/gm of root bud occurred prior to flowering. When data were expressed on percent of applied dose, a general increase in herbicide accumulation occurred throughout the growing season and peaked in fall. This discrepancy was attributed to roots growing all season and dilutes the dpm/gm data. However, Lym indicated that dpm/gm of root was more meaningful information to determine a lethal dose than percent of applied. Sometimes percent of applied data can be misleading depending on plant size.

Adequate soil moisture is very important to control some perennial species. In drought stressed milkweed, herbicide absorption and translocation is stopped. Leafy spurge, however, may not be affected similarly because roots grow deep, often into the water table and show little signs of drought stress even during a drought year. Sufficient relative humidity to hydrate leafy spurge cuticles may influence control.

Sink strength as a determinant of control success was further discussed in relation to research on reed canarygrass and creeping red fescue. Spring applications of glyphosate control reed canarygrass but not creeping red fescue. Absorption and translocation studies indicate no differences between these two species. Fall glyphosate treatments control creeping red fescue equally well and possibly indicate that growth stage and sink strength are important factors for adequate control to occur.

Pre-treatments with PGR or herbicides to break bud dormancy sometimes can increase herbicide efficacy. Fall applications of fluroxypyr to leafy spurge followed by low rates of picloram have been effective in Wyoming. Amitrole remains in the plant for more than one growing season as indicated by root bud derived shoots from plants treated the previous year with amitrole showing typical chlorotic symptoms. However, amitrole as a pre-treatment to or tank-mix with picloram in leafy spurge did not increase efficacy. Time between the pre-treatment and herbicide application was discussed. Wyoming researchers examined 2,4-D at various time intervals as a pre-treatment to picloram on leafy spurge. No differences occurred when 2,4-D was applied 7, 14 or 21 days before picloram treatments.

Tillage before or after herbicide application has different effects with different weed species. Disking Canada thistle in Colorado 3, 7, 10, 14 or 30 days after dicamba, picloram, 2,4-D, chlorsulfuron or glyphosate treatments caused no greater efficacy than not disking. In Minnesota, quackgrass control is greater when a moldboard plow treatment follows herbicide application. In California and Oregon, it is commonly recommended to till, wait for regrowth and apply herbicides. Tillage may cause greater leaf:root ratio and allow greater surface area for herbicide interception and absorption.

Mike Foster was nominated and elected Chairman-elect for Project 1 in 1989 by unanimous ballot. Fifty-nine people attended and the session adjourned at 4:52 p.m.

Summary of Project 2: Herbaceous Weeds of Range and Forest
Thom Whitson, University of Wyoming

Subject: 1: Poisonous Plants of Range and Forest

Mike Ralphs, USDA-ARS, Logan, UT made a short presentation on "Lupine, Larkspur and Locoweed species"--Poisonous plants are pests in that they are injurious to animals causing death, abortion, birth defects, infertility, debilitation and reduced weight gains; and they are an annoyance to humans causing economic loss, increased operating costs and anxiety. Annual livestock losses in the 17 western states from death and reduced reproduction exceed $235 million.

Tall larkspur (Delphinium spp.) is the greatest cause of cattle death on mountain rangelands. It occurs on every National Forest in the Western U.S. More than 1000 cattle died from larkspur poisoning in the Intermountain Forest Service Region in 1986. Herbicides registered for rangeland use have not been effective when applied at recommended rates. Glyphosate at 2.2-6.6 kg/ha killed 73% of regenerating buds. Triclopyr at 2.2-8.8 kg/ha and picloram at 1.1-4.4 kg/ha killed 50% of buds. Clopyralid was not effective. More research will be conducted on selective application methods of glyphosate and repeated annual applications of triclopyr, picloram and metsulfuron at lower rates. Other research is being conducted on grazing behavior to develop management strategies to reduce risk of poisoning. Sequential grazing of sheep before cattle to reduce larkspur availability or acceptability is being evaluated. Conditioned taste aversion is being tested to see if cattle can be trained to avoid eating larkspur.

Lupine (Lupine spp.) has been responsible for more sheep deaths than any other plant in Montana, Idaho and Utah. It is also teratogenic causing crooked calf disease when cows ingest it during the 40-70 day gestation. Lupine has declined in importance as range conditions have improved and sheepmen have learned to manage around it. Yet it still presents a threat and can be controlled resulting in increased forage production.

Populations of semi-desert locoweed species (Astragalus spp.) are cyclic. Outbreaks occur in wet years and seldom remain a problem for more than two or three years. Livestock are poisoned in the winter and early spring when locoweed is green and other forage is dormant or in short supply. Locoweeds (predominantly Oxytropis spp.) on the plains and mountain rangelands are more stable and cause persistent problems. The immature succulent seed pod of white locoweed is the only plant part palatable to cattle. Cattle will not graze other locoweed parts if other forage is available. Poisoning can be prevented by restricting access during the immature pod stage. Oxytropis species on both high mountain grasslands and short-grass prairies are very sensitive to clopyralid. Triclopyr, picloram and 2,4-D also give good control. However, a large number of viable seed remains in the soil and will germinate and establish when environmental conditions are favorable.

Coburn Williams, USDA-ARS, Logan, UT made a short presentation on "Milkvetch species and Falsehellebore." Approximately 265 species and varieties of North American Astragalus synthesize toxic aliphatic nitro compounds, 26 species accumulate selenium and about four species contain swainsonine, which causes locoism. All selenium- and swainsonine-containing species are dangerous to livestock. The following nitro-containing milk-vetches have caused moderate to severe livestock losses: Astaragalus miser varieties oblongifolius and serotinus, A. atropubescens, A. whitneyi and A. emoryanus. Each of these species contains miserotoxin, which catabolizes to the highly toxic 3-nitro-1-propanol in the rumen. Nitro compounds are very stable and have been detected and characterized in leaves of herabarium specimens up to 150 years old. Wastach milkvetch (A. miser var. oblon-gifolius) has been successfully controlled on mountain rangeland with 2.2 kg ai/ha of triclopyr and a 1.1 plus 1.1 kg ai/ha mixture of triclopyr and dicamba.

Western falsehellebore (Veratrum californicum) grows on moist, open meadows and hillsides at elevations of 5,000 to 11,000 ft. The plant flowers in July and August and produces seed in September. The plant causes severe poisoning in sheep and may also affect cattle and goats. If pregnant ewes eat falsehellebore on the 14th day of gestation, the young may have severe congenital deformities of the head and limbs. Ewes carrying deformed fetuses may fail to lamb at the end of the normal gestation. The fetus continues to grow to abnormal size and may kill the ewe unless the lamb is surgically removed. Losses can be avoided by keeping sheep, cattle and goats away from falsehellebore during early gestation. The plant can be controlled by applying an amine formulation of 2,4-D at 2.2 kg/ha after the last leaf has expanded in the spring. A second treatment may be required the following year. Western falsehellebore-infested areas near Logan, Utah, treated two successive years with 2,4-D at 2.2 kg/ha, have remained free of the plant for 18 years.

Kirk McDaniel, New Mexico State University, Las Cruces, NM made a short presentation on "Broom Snakeweed." Perennial snakeweeds (Gutierrzia spp.) are common on about 57 million ha of western rangeland from Canada to Mexico. Gutierrezia is a genus of 7 woody shrubs, 3 herbaceous perennials and 6 suffrutescent annuals in North America. Gutierrezia sarothrae is the most widely distributed species and is responsible for large economic losses to ranchers in the central plains, prairies and desert regions. Dense snakeweed stands can reduce grass production by 70% or more, and they are toxic to livestock. The plants have low forage value and livestock seldom graze them unless other forage supplies are low. The poisonous compound in Gutierrezia is saponin which may result in abortion or death. Mechanical, biological and burning methods have been used to control snakeweed but, in general, herbi-cides are the most common and practical control method. Fall applications of picloram at 0.3 kg/ha controls snakeweed and increases grass production by 10 fold.

Election of Chairman: Keith Duncan nominated George Beck, Colorado State University as Chairman for the 1990 discussion section. Motion carried by acclamation and approved by unanimous voice vote.

Summary of Project 3: Undesirable Woody Plants
Vanelle Carrithers, Dow Chemical Company

Subject 1 - Competitive differences between woody plants was introduced by Steve Ralosevich. Topics addressed included the concept of thresholds, the use of weedy and no weed control six experimental studies, tree growth response (or none response) in field studies and differences in growth and survival response curves.

- Mechanisms of competition, i.e. resource use, was felt to be a weak link in many of the previous studies.

- Height growth is the poorest indicator of conifer growth.

- Species differences - do they indicate resource differences on a site and, therefore, should we manage the site differently?

Subject 2 - Economics of various control measures were introduced by Vanelle Carrithers, including manual control, animal (sheep) control, chemical control.

- Single herbicide applications are the norm with difficult sites requiring two or more treatments.

- Range managers feel that $30.00 per acre is about the most that could be spent for brush control.

- Certain woody species are considered desirable in range habitats and, therefore, herbicides that are selective are currently considered to be optimum.

- Other factors, i.e. water yield, nutrient availability, etc. need to be considered in any economic analysis.

Subject 3 - Integrated vegetation management was introduced by Vanelle Carrithers and Michael Newton, OSU.

Prevention: Decrease interaction between crop and undesirable.

Planning: Not to have most highly competitive plants.

1. Expectation of what is the maximum growth (weed-free areas):

   Weeds/undesirable plants carry other problems than just competition - diseases, insects, fire hazard, wind damage, wildlife damage, etc.

   Crop managed to optimum for site.

   Public perceptions.

2. Silvicultural strategy - what is the initial management scheme?

   Relates to infestation levels. Development of resistant weed populations.

3. Crop quality, planting, good competitive plants appropriate to site.

4. Vegetation management strategy:

   Weed free needed more for survival.

   Use of effective materials/appropriate rates.

   Cost.

Business Meeting:

No old, new or business resolutions. Nominated Michael Newton chairman-elect by unanimous vote.

Summary of Project 4: Weed Control in Horticultural Crops
Rick Boydston, USDA-ARS

Regina Sarracino, Ed Kurtz, Joe Dorr and Stewart Turner, representing regulatory agencies, commodity groups, chemical industry and the legal system, addressed the issue of herbicide registrations in horticultural and specialty crops.

It was generally agreed that the two major obstacles to the registration of herbicides in minor crops are: 1) the high cost of collecting registration data required by the EPA and state regulatory agencies; and 2) the crop injury liability a registrant must undertake in a crop with limited acreage and limited product sales.

Much of the cost of registration of pesticides on minor crops can be waived or undertaken by the IR-4 program. However, the IR-4 program is inadequately funded and unable to research and process all the requests that come in annually. It was suggested that funding of the IR-4 program be increased over its present $2,000,000 annual budget.

California has met many of the industry's needs by utilizing Section 24(c) and Section 18 of FIFRA. Section 24(c) registrations have no expiration dates but can be cancelled by the EPA, state or manufacturer. Section 18 registrations are for emergency situations and extend only one growing season.

Third-party registrations in which a grower organization commodity group or individual farmer requests a 24(c) have been implemented in California. The herbicide manufacturer must submit a letter of authorization in each case.

Other states mentioned that had some type of third-party registrations in effect were Florida, Arizona, New Mexico and New York. It was stressed that each state should encourage grower groups and interested parties in developing third-party registrations in minor crops. Some of the chemical industry voiced concern on whether a company's liability can be waived or not in these types of agreements.

In most third-party registrations, a third-party signs a letter of indemnification to release the primary registrant of crop injury liability. It was suggested that the third party also be required to sign a "covenant not to sue" document to further prevent legal recourse over crop injury claims.

One alternative would be to amend FIFRA so that minor crop registrations contained special labels containing a warranty that would exempt primary registrants from crop injury liability. Most of those present felt that it would be best to develop third-party registrations independently in each state, case by case, since laws differ from state to state.

Another problem of registration of herbicides in minor crops was the excessive residue data that is required by EPA to establish tolerances. It was suggested that the EPA be more lenient in the residue data required to add minor crops to labels, in which previous tests in many similar crops had shown residues to be low. It was suggested that EPA revise the definition of a minor crop. Currently industry views many crops not labeled as minor crops, as minor based on acreage and profit potential.

In addition to obtaining new registrations in minor crops, re-registration of many older useful herbicides is now being required. This may cause a substantial loss of much of the progress we have made in minor crop registrations over the last 20 years since industry may not be willing to bear the cost of re-registration.

Summary of Project 5: Weeds in Agronomic Crops

Doug Ryerson, Monsanto Company

The Weeds in Agronomic Crops project met on Thursday, March 10, with 26 people in attendance. Rod Warner of DuPont was nominated and elected Chairman-elect for 1989.

The topic opened for discussion was pesticides in groundwater. It was obvious from the discussion that this subject is of big concern in a majority of the states in the west. Many states are or will become more involved in testing for pesticides in water.

The general consensus of the group was that this is an extremely emotional issue with the general public. It was felt that because of the emotion involved, any pesticides detected in water would be viewed negatively by the general public regardless of the levels detected. Dealing with this issue will, therefore, become an increasing challenge in the future.

It was mentioned that everyone involved in agriculture needs to be sensitive to this area and as an industry we should be taking a leadership role in addressing the public's concerns. Programs to deal with this issue need to be positive and proactive making sure agricultural chemicals are used correctly to minimize or eliminate the potential for water contamination problems. Assuming a leadership position is critical if we hope to avoid progressing to the point that the restrictions placed on agricultural chemical use become unmanageable.

Concern was voiced that it appeared that each state was going to approach this issue differently. It was felt that some mechanism should be in place to insure that the problem is dealt with in uniform fashion on a state-by-state basis.

No easy solutions for dealing with this issue were suggested. It will take a unified effort by the agricultural industry to make sure that it is addressed in a sensible manner based on fact rather than on emotion.

Summary of Project 6. Aquatic, Ditchbank and Non-Crop Weeds
Barbra Mullin, Montana Department of Agriculture

Discussion Topic: Management of Aquatic and Terrestrial Weeds Near Environmentally-Sensitive Areas.

Managing Canalbank Vegetation for Agriculture While Enhancing Wildlife Habitat Needs - Jim McHenry, University of California, Davis, California and Jerry Markel, California Department of Fish and Game.

Initial discussion centered around a CDFG program designed to benefit game species along canals. This has expanded to include other wildlife, including threatened and endangered species. The program was funded by Region IV of CDFG and included planting mesquite, Atriplex, cottonwood, blackberries and Arizona cedar on the outside of levees and pearlgrass within the levees to provide cover as well as corridors for travel for wildlife.

Discussion included the importance of communication between CDFG and local ag producers to mitigate potential problems caused by establishment of vegetation for wildlife near croplands. Problems encountered include increase in abundance of crop pests (such as beet leafhoppers) that use established wildlife vegetation as alternate hosts. Consultation with CDFA to prevent spraying in areas of establishment is also critical.

The general consensus use that establishment of wildlife cover around canals can be used effectively but communication with all interested parties is essential.

Use of Plug Planting for Revegetation - Peter K. Fay, Montana State University, Bozeman, Montana.

Pete Fay discussed a program developed for establishment of grasses in flood plains of reservoirs by using plug plantings similar to those used in forest situations. Herbicides do not have a role in long-term vegetation management around these areas and revegetation of the areas to provide competition is important. Revegetation efforts are complicated by fluctuation of water levels. The project started with assessment of 15 species of grasses and Garrison creeping foxtail was the final choice. The plugs were planted with the help of local sportsmen groups at 100-foot intervals. The Bureau of Reclamation is currently planting approximately 20,000 plugs per year with a 98% survival rate. It is expected that frequent floodings will help spread grass seed across the area.

Weed Management at the Tiber Reservoir, Liberty County, Montana - Tom Parks, Bureau of Reclamation, Billings, Montana

The Tiber Reservoir in Montana has had a serious problem with invasion of noxious weeds (specifically leafy spurge and spotted knapweed) since a flood in 1975 brought these weed species into flood plains in the area. Local landowners have been concerned about the spread of these weeds onto private lands.

A group of Montana weed scientists met in 1984 to assess the problem and develop a long-term weed management plan for the Reservoir area. The program includes: - handgun spraying of herbicides, targeting gully areas around the reservoir and using a spray dye to mark the areas that have been sprayed;- sheep and goat grazing in riparian areas with serious leafy spurge infestations and the plug plantings in flood plain areas. It was suggested that the BOR try using helicopters to drop grass plugs to speed up the process.

Herbicide Application Techniques: Rope Wick and Wiper Applications of Herbicides - Dick Comes, USDA, ARS, Prosser, Washington.

Redtop, as a desirable ditchbank weed species, grows in the understory of reed canarygrass and foxtail barley. All of these plants are sensitive to Rodeo herbicide. A ropewick applicator can be used to kill only the taller vegetation. A "dangler" applicator has been developed by the USDA in Washington to effectively control weeds along canal banks. A speed of about 2 mph is most effective, using 5:2:3/4 (water:Rodeo:X-77 surfactant). 2,4-D also works well in this system, 2:1:1/2 is effective on mildweed.

Denuded ditchbanks cause serious erosion problems and impact wildlife adversely, but too much woody vegetation also causes serious management problems. Selective control is critical. It was noted that Amitrol is no longer legal for use in irrigation systems.

Efficacy of 2,4-D and Garlon Controlled Release Herbicides on Leafy Spurge and Russian Knapweed in Riparian Areas - John E. Boutwell (presented by Fred Nibling), Bureau of Land Management, Denver, CO.

The Bureau of Reclamation has been doing some work on development of controlled release pellets for use in riparian and flood plain areas. Several formulations were applied near the Tiber Reservoir in Montana. 2,4-D and Garlon were incorporated into a vinyl resin paint and starch-borate complex. The pellets were evaluated for longevity, release rates and efficacy in controlling target weed species. It was noted that rates seemed extremely high for use around water areas (i.e.-179 to 360 lbs ai. per acre of triclopyr). Suggestions included a more defined study, comparing current control recommendations with the pelleted formulations and possibly a more realistic rate.

Summary of Project 7: Chemical and Physiological Studies

Jodie S. Holt, University of California, Riverside

The meeting was conducted from 2:00 to 3:45 p.m. on March 9, with a maximum of 60 people in attendance. Two major topics were discussed, (1) herbicide resistance and (2) herbicide degradation in soil; approximately 45 minutes were devoted to each.

J. Holt presented a brief background on cases of herbicide resistance in the United States and on the activities presently going on at the national level regarding herbicide resistance. Currently, the most widely recognized and studied case around the world is that of triazine resistance, which has been reported in 48 species to date. Other herbicides for which resistant biotypes of weeds have been detected in the field include diclofop-methyl (Lolium rigidum in Australia), paraquat (several species outside the U.S.) and trifluralin (Eleusine indica in the Southeastern U.S.). The Weed Science Society of America now has a Herbicide Resistant Weeds Committee devoted to addressing herbicide resistance issues. After this introduction, discussion followed on new cases of resistance that are currently under investigation in the Western U.S., including resistance to diclofop-methyl and to the sulfonylureas. There was also much discussion on management of resistance and on our responsibility as weed scientists to inform growers about the threat of resistance. For most cases, it was agreed that herbicide or crop rotation could be used to prevent resistance, although little research has been conducted on these strategies. The consensus and ending note of this discussion was that if resistance becomes a national problem, such as has occurred in insects and fungi, then we as weed scientists working with herbicides have not done our job; resistance is both predictable and preventable.

Robert Zimdahl presented and moderated the second topic, herbicide degradation in soil, which followed from the presentation earlier in the day by C. Reyes. The first-order kinetic model traditionally has been used to describe herbicide degradation in soil because of its ease and relative simplicity. However, recent evidence from research with the sulfonylurea herbicides suggests that degradation is not linear and that mixed-order models are more realistic to describe the decrease in herbicide concentration in soil over time. Specifically, the plot of concentration vs. time shows a very negative slope initially (short half-life, labile pool) then levels to a slower rate of decrease (long half-life pool). Much discussion followed on research methodology to investigate herbicide degradation, possible mechanisms of degradation in soil that result in both fast and slow portions of the decay curve and observations of herbicide behavior that support mixed-order rather than first-mentioned included variable environmental conditions over time, a shift from microbial to hydrolytic breakdown over time, adsorption/-desorption onto clay, soil organic matter content and depth of herbicide placement. The discussion closed with the comment that this new evidence has profound implications for understanding groundwater and other environmental contamination.

1988 Honorary Member
Western Society of Weed Science

Logan A. Norris

Dr. Logan A. Norris is a native Californian whose family has a strong agricultural heritage in the bay area. He entered Oregon State University in 1954, earning his B.S., M.S. and Ph.D. degrees in Forestry, Chemistry and Plant Physiology respectively. Logan and his wife Betty live in Corvallis, Oregon; she also graduated from OSU and is a skilled calligrapher. Their eldest son Mike is an OSU graduate in mechanical engineering and works for McDonnel-Douglas; their other sons, Joe and Matt are studying pharmacy and mechanical engineering at OSU.

Between 1961 and 1968, Norris was a faculty member in the Department of Agricultural Chemistry at OSU. He then moved to the USDA Forest Service, Pacific Northwest Forest and Range Experiment Station where he eventually became Chief Research Chemist and Project Leader for research on Managed Forest Watersheds. In 1983 he was appointed Professor and Head of the Department of Forest Science at OSU.

Since the early 1960's, Norris has been active in research on the movement and persistence of pesticides and other chemicals in forest environments and the evaluation of their environmental risk. The majority of his research has dealt with herbicides; his objective is to provide a technical basis for decisions on the use and regulation of forest chemicals.

His research has resulted in more than 85 scientific and technical publications, several of which were preceded by the more than 20 articles he published in the Research Progress Reports of the Western Society of Weed Science. He has also presented the results of his research in numerous national and international meetings of scientists, natural resource managers and regulatory officials.

Norris is active professionally, having served as chairman of WSWS Section 4 and on the Membership Committee of WSSA, the Aerial Applications Task Force of CAST, the coordinator of Region 10 for the Society of Environmental Toxicology and Chemistry and in several posts in the Society of American Foresters, including a national herbicides task force. He was the national leader of the USDA/EPA/States 2,4,5-T RPAR team and is active as consultant/and expert witness in hearings and litigation involving herbicides in the forest and on right-of-ways nationwide.

For his research and professional accomplishments he was awarded the national USDA Superior Service Award in 1976 and was elected Fellow in the Society of American Foresters in 1986.

1988 Fellow
Western Society of Weed Science

E. Stanley Heathman

Stan Heathman was born and raised in Missouri, where he worked on farms and ranches during summers while in high school. Upon graduation he enrolled at Kansas State University. After one year in college, he joined the U.S. Army and served in Korea from 1945-1947. Upon his discharge, he returned to KSU earning a B.S. degree in animal science in 1950. For the next 10 years he was a farm manager for commercial growers of livestock and field crops in Missouri, Kansas and Pennsylvania.

In 1960 Stan accepted the County Agricultural Extension Agent position at Yuma, Arizona, and in 1967, he was appointed Extension Weed Specialist for the University of Wyoming, where he earned his M.S. degree in Plant Science in 1970.

Stan has developed weed control methodologies for local conditions and educational programs for growers of the many field and horticultural crops produced in Arizona. These include cotton, alfalfa, small grains, safflower, peanuts, pastures, numerous vegetable crops, grapes and tree fruits. He also has developed educational programs for urban and noncrop weed control.

Stan has been very active in the Western Society of Weed Science, having served on numerous committees and offices. He was chairman of the Education and Regulatory Section in 1972-73, Vice-President and Program Chairman in 1983-84 and Society President in 1984-85.

1988 Fellow
Western Society of Weed Science

Harvey D. Tripple

Harvey D. Tripple is the Small Grains Regional Manager for Product Development for Monsanto Agricultural Products Company. He has worked for Monsanto for 19 years, developing new herbicides and new uses for commercial herbicides. He has been instrumental in the development of Roundup and Landmaster for no tillage and reduced tillage production systems in western agriculture. Before this assignment, he was an international manager and a Product Development Representative in Ohio and Michigan.

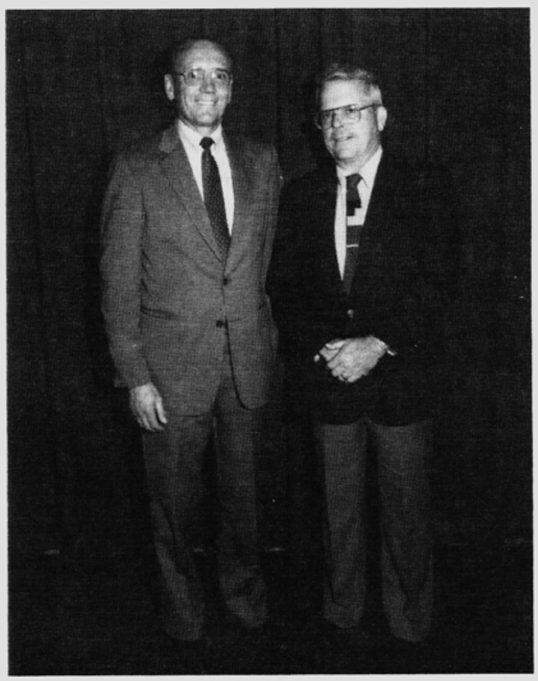
Harvey was raised on a farm in western Nebraska. He received his B.S. and M.S. degrees in agriculture from the University of Nebraska in 1956 and 1962. He served on active duty with the U.S. Navy and continued as a Naval Reservist, retiring as a Commander in 1983.

Before joining Monsanto, Harvey was Director of Agricultural Research and Crop Control for Pioneer Mill Sugar Cane Plantation on Maui, Hawaii.

Tripple was President of the Western Society of Weed Science during 1985-86, Program Chairman for the 1985 meeting, Chairman of the Research Section 1983, Chairman for the Local Arrangements 1982, Chairman for the Site Selection Committee 1980; and Chairman of the Financial Committee. During the past year he was a member of the committee that updated the operating guide for all officer and committee positions.

Tripple has served the Weed Science Society of America as a member of the Finance Committee, Local Arrangements, and he has served as Chairman of the Publications Promotions Committee and is currently a member of that committee.

Harvey and his wife, Beverly, reside in Littleton, Colorado; they have three children.



1988 WSWS Fellows (L to R):

Harvey D. Tripple and E. Stanley Heathman

CORRIGENDA

In the article "Isoxaben for Broadleaf Weed Control in Ornamentals, Turf and Nonbearing Trees and Vines," by F.O. Colbert and D.H. Ford, the authors note that Table 3 on page 157 is incomplete as published in Volume 40, in the 1987 Proceedings.

Please include this table in your 1987 Proceedings.

Table 3. Percent of assayed isoxaben and oryzalin found in the upper soil profile at 29 and 92 days after surface application of the chemicals[1]

Sampling Depth (cm)	% Isoxaben		% Oryzalin	
	Days After Application			
	29	92	29	92
0 - 7.5	95	89.2	100	100
7.5 - 15	5	9.3	0	0
15 - 22.5	0	1.5	0	0

[1]The experiment was established in Fresno, California, on October 18, 1985, with soil texture as described in Table 4. Isoxaben 75DF at 1.12 kg/ha and oryzalin 85DF at 3.36 kg/ha were surface applied to bare ground and received 1.4 cm of sprinkler irrigation within three hours after application. Total rainfall and irrigation moisture was 15.5 and 23.6 cm at 29 and 92 days after application, respectively. All assays were run on 20 composite soil subsamples drawn from three replicates.

Membership List of the Western Society of Weed Science, May 1, 1988

Edward B. Adams
WSU Cooperative Extension
N 222 Havana
Spokane, WA 99202

Harry S. Agamalian
Univ. Calif. Coop. Extension
118 Wilgart Way
Salinas, CA 93901

Norman B. Akesson
Agricultual Engineering Dept.
University of California
Davis, CA 95616

Ted Alby
Mycogen Corporation
5451 Oberlin Drive
San Diego, CA 92056

Jack Aldridge
Nor-Am Chemical Company
P.O. Box 728
Sonora, CA 95370

Jamal Al-Henaid
235 Bread & Milk Street
Coventry, CT 06238

Shaffeek Ali
Alberta Agriculture
7000 - 113 Street, 2nd Floor
Edmonton, Alberta CANADA
T5H 5T6

Harold P. Alley
121 Reynolds
Laramie, WY 82070

Madeline Ames
California Dept. Food & Agr.
1362 Monarch Lane
Davis, CA 95616

J. LaMar Anderson
Plant Science Department
Utah State University
Logan, UT 84322-4820

Lars W. J. Anderson
USDA ARS Aquatic Weed Lab
Botany Dept., Univ. California
Davis, CA 95161

Monte D. Anterson
Hoechst-Roussel Agri-Vet Co.
South 11611 Keeney Road
Spokane, WA 99204

Randy L. Anderson
USDA - ARS
Central Great Plains Res. Sta.
P.O. Box K 40335 Co. Rd. GG
Akron, CO 80720

Mike Andreatta
246 N. Minnewawa
Fresno, CA 93727

W. L. Anliker
Ciba-Geigy Corporation
811 S.E. 97th Avenue
Vancouver, WA 98664

M. J. Ansolabehere
Chevron Chemical Company
5910 N. Monroe
Fresno, CA 93722

Arnold P. Appleby
Crop Science Department
Oregon State University
Corvallis, OR 97331

Thomas F. Armstrong
Monsanto
15039 Manor Creek Drive
Chesterfield, MO 63017

Richard N. Arnold
NMSU Ag Science Center
P.O. Box 1018
Farmington, NM 87499

Jon H. Arvik
Monsanto Agr. Products Co.
24551 Raymond Way, Suite 285
El Toro, CA 92630

Richard W. Bagley
MAAG Agrochemicals R&D
P.O. Box Q
Port Orford, OR 97465

Paul G. Bartels
Plant Sciences Department
University of Arizona
Tucson, AZ 85721

Jafar Asghari Berbaneh
Plant Science Department
Utah State University
Logan, UT 84322-4820

Floyd M. Ashton
602 East 12th Street
Davis, CA 95616

Alvin A. Baber
DuPont Company
673 Rosecrans Street
San Diego, CA 92106

Oakford G. Bain
American Cyanamid Company
838 E. Bedford
Fresno, CA 93710

Robert B. Balcom
4720 44th Street N.W.
Washington, DC 20000

Dan A. Ball
University of Wyoming
P.O. Box 3354, Univ. Station
Laramie, WY 82071

James A. Barron
Rhone-Poulenc Ag. Company
Box 12014
Res. Triangle Park, NC 27709

Ben Barstow
Univ. Idaho Coop. Extension
P.O. Box 9 510 Oak St.
Nez Perce, ID 83543

Brooks Bauer
Sandoz Crop Protection
20592 Ayers Avenue
Escalon, CA 95320

George H. Bayer
Gilmore, Inc.
121 East Buffalo Street
Ithaca, NY 14850

Rick Beardmore
American Cyanamid
P.O. Box 400
Princeton, NJ 08540

K. George Beck
115 Weed Research Lab.
Colorado State University
Fort Collins, CO 80523

Lance Beem
Rhone Poulenc Ag Company
1329 Silverado Drive
Modesto, CA 95356

Wayne S. Belles
Sandoz Crop Protection
1240 Joyce Road
Moscow, ID 83843

Warren E. Bendixen
University of California
624 West Foster Road
Santa Maria, CA 93455

Larry R. Benner
Boulder County Extension
9595 Nelson Road, Box B
Longmont, CO 80501

Lawrence J. Bernardi
Western Farm Service
603 Bruce Street
Madera, CA 93637

Larry G. Bezark
Calif. Dept. Food & Agriculture
Biological Control Services
3288 Meadowview Road
Sacramento, CA 95832

Sheldon Blank
Monsanto Company
3805 S. Dennis
Kennewick, WA 99337

Bert L. Bohmont
116 Weed Science Bldg
Colorado State University
Fort Collins, CO 80523

Dale W. Bohmont
Bohmost Consultants
Box 3032
Reno, NV 89505

Steven Bowe
Sandoz Crop Protection
112 S. Howard
Roselle, IL 60172

E. J. Bowles
Licensed P.C.A
3979 North Drexel Avenue
Fresno, CA 93726

Rick Boydston
USDA-ARS
Box 30, IAREC
Prosser, WA 99350

Steve Bradburn
Lincoln County Noxious Weed Bd.
P. O. Box 241
Davenport, WA 99122

William S. Braunworth, Jr.
Horticulture Department
Oregon State University
Corvallis, OR 97331

Ronald G. Brenchley
Mobay Chemical Corporation
Rt. 1, Box 31
Ashton, ID 83420

Bill D. Brewster
Crop Science Department
Oregon State University
Corvallis, OR 97331

Bart Brinkman
Sandoz Crop Protection Corp.
5130 2nd Avenue S.E.
Salem, OR 97306

John H. Brock
Agbusiness & Env. Resources
Arizona State University
Tempe, AZ 85287-3306

Jonathan Brown
Norpac Foods, Inc.
4755 Brooklake Rd. N.E.
Salem, OR 97305

Carl Buchholz
Ciba-Geigy Corporation
12413 Wide Hollow Rd.
Yakima, WA 98908

Robert Buman
USDA/ARS 215 Johnson Hall
Washington State University
Pullman, WA 99164

Stephen T. Burningham
Utah Dept. of Agriculture
350 N. Redwood Road
Salt Lake City, UT 84116

Ronald J. Burr
Rhone-Poulenc Ag. Company
13446 Waldo Hills Dr. S.E.
Sublimity, OR 97385

Larry C. Burrill
Crop Science Department
Oregon State University
Corvallis, OR 97331

Robert H. Callihan
Plant, Soil & Entomol. Scinece
University of Idaho
Moscow, ID 83843

David Cammack
341 Dodson Road
Ephrata, WA 98823

Thomas Camp
Glendale Community College
P.O. Gox 14516
Phoenix, AZ 85063

Mick Canevari
Univ. Calif. Coop. Extension
420 S. Wilson Way
Stockton, CA 95205

Keith Cargill
Turlock Irrigation District
333 East Canal Drive
Turlock, CA 95381

Steven J. Carlson
American Cyanamid
104 Raymond Place
Boise, ID 83704

Vanelle Carrithers
Dow Chemical Company
28884 S. Marshall Rd.
Mulino, OR 97042

Jon P. Chernicky
University of Arizona
Route 2, Box 751-F
Maricopa, AZ 85239

William J. Chism
Plant Path, Phys, & Weed Sci.
Virginia Tech
Blacksburg, VA 24061

M. Dale Christensen
CIBA-Geigy Corporation
1951 Chateau Ct.
Walnut Creek, CA 94598

M. Brent Chugg
Del Monte Corporation
P.O. Box 59
Franklin, ID 83237-0059

C. A. Clark
Helena Chemical Company
5100 Poplar Ave., Suite 3200
Memphis, TN 38137

Donald R. Colbert
American Cyanamid Company
2133 Jackson Street
Lodi, CA 95240

Floyd O. Colbert
Crop Science Department
Calif. Poly. State University
San Luis Obispo, CA 93407

Elizabeth Cole
Forest Science Department
Oregon State University
Corvallis, OR 97331-5704

Craig Collins
Collins Agr. Consultants, Inc.
Rt. 2, Box 344
Hillsboro, OR 97123

Ron Collins
Collins Agr. Consultants, Inc.
Rt. 2, Box 344
Hillsboro, OR 97123

Dale R. Comer
NOR-AM Chemical Company
5150 N. Sixth, Suite 118
Fresno, CA 93710

Richard D. Comes
USDA/ARS
P.O. Box 30
Prosser, WA 99350

Craig Conley
USBR
246 G Street Southeast
Ephrata, WA 98823

Gilbert E. Cook
DuPont Company
S. 303 Barker Road
Greenacres, WA 99016

John S. Corkins
Research For Hire
1696 South Leggett
Porterville, CA 93257

Garvin Crabtree
Horticulture Department
Oregon State University
Corvallis, OR 97331-2911

Roe D. Crabtree
E. 11613 4th Avenue
Spokane, WA 99206

A. S. Crafts
Botany Department
University of California
Davis, CA 95616

Ron P. Crockett
Monsanto
17004 NE 37th Circle
Vancouver, WA 98682

Crook County Weed & Pest Dist.
P.O. Box 7
1321 Main
Sundance, WY 82729

David W. Cudney
Univ. Calif. Coop. Extension
Batchelor Hall, Univ. Calif.
Riverside, CA 92521

Alan W. Dalrymple
Plant, Soil & Insect Science
Box 3354, University Station
Laramie, WY 82071

Lee C. Darlington
BASF
4609 Englewood Avenue
Yakima, WA 98908

Edward S. Davis
Plant & Soil Science Dept.
Montana State University
Bozeman, MT 59717-0002

Jean H. Dawson
USDA, Research Center
P.O. Box 30
Prosser, WA 99350

Boysie E. Day
University of California
43 Western Drive
Richmond, CA 94801

Jeffrey V. Dearborn
Southern Oregon Analytical
P.O. Box 538
Malin, OR 97632

Nathan Dechortez
CDFA - C&E
1220 N St., Rm A357
Sacramento, CA 94271-0001

Howard Deer
Extension Pesticide Specialist
Utah State University
Logan, UT 84322-4620

Brian D. Deeter
Rhone-Poulenc Ag. Company
P.O. Box 2420
Wickenburg, AZ 85358

Pete Desai
Dow Chemical Company
601 University Ave., Suite 130
Sacramento, CA 95825

Steven A. Dewey
Plant Science Department
Utah State University
Logan, UT 84322-4820

Thomas C. DeWitt
Chevron
8358 N. First Street
Fresno, CA 93710

Mike Dial
Plant, Soil & Entomol. Sci.
University of Idaho
Moscow, ID 83843

Len Dobbins
FMC Corporation
11128 John Galt Blvd.
Omaha, NE 68137

Diane Dolstad
Washington State Dept. Agr.
2015 South First Street
Yakima, WA 98903

William W. Donald
USDA
Metabolism & Radiation Res. Lab
Fargo, ND 58105

Joseph E. Dorr
CIBA-Geigy Corporation
5510 Birdcage St., Suite 110
Citurs Heights, CA 95610

Peter Dotray
USDA/ARS 215 Johnson Hall
Agronomy Dept, Wash. State U.
Pullman, WA 99164

Charles Doty
ICI Americas
498 North Mariposa Avenue
Visalia, CA 73277

Robert Downard
University of Idaho
P.O. Box AA
Aberdeen, ID 83210

Brian Drew
University of Saskatchewan
1549 East Heights
Saskatoon, Saskatchewan
CANADA S7N OWO

Dan Drummand
University of Idaho
1330 Filer Avenue E.
Twin Falls, ID 83301

Chuck Duerksen
ICI Americas
31588 Rd 144
Visalia, CA 93291

Keith W. Duncan
New Mexico State University
67 E. Four Dinkus Road
Artesia, NM 88210

Robert L. Dunlap
Rhone-Poulenc Ag Company
3239 E. Vartikian Avenue
Fresno, CA 93710

Ken W. Dunster
Rhone Poulenc Ag Company
P.O. Box 598
Byron, CA 94514-0598

Donal P. Dwyer
Nor-Am Chemical Company
4190 North Sherman
Fresno, CA 93726

Charlotte Eberlein
Agronomy Dept, 404 Borlaug
Univ. Minn., 1991 Buford Circle
St. Paul, MN 55113

Warren Edmonds
Nor-Am Chemical Company
11230 Wakely Road
Colorado Springs, CO 80908

Martin K. Ekeh
ICI Americans, Inc.
7660 Shelborne Drive
Loomis, CA 95650

Clyde L. Elmore
Botany Department
University of California
Davis, CA 95161

Steven R. Eskelsen
Horticulture Department
Oregon State University
Corvallis, OR 97331

John O. Evans
Plant Science Department
Utah State University
Logan, UT 84322

Richard Evans
Plant, Soil & Entomol. Science
University of Idaho
Moscow, ID 83843

Peter Fay
Plant & Soil Science Dept.
Montana State University
Bozeman, MT 59717

John Fenderson
Sandoz Crop Protection
902 Hardtner
Kiowa, KS 67070

Mark A. Ferrell
Plant, Soil & Insect Sci Dept.
University of Wyoming
Box 3354, University Station
Laramie, WY 82071

Paul F. Figueroa
Weyerhaeuser Company
505 North Pearl Street
Centralia, WA 98531

Bill B. Fischer
University of California
1720 S. Maple
Fresno, CA 93702

Duane G. Flom
University of Nevada Reno
441 Shipley Drive
Yerington, NV 89447

James C. Forbes
Monsanto, V1A
800 N. Lindbergh Blvd
St. Louis, MO 63167

Kevin D. Forner
California State Univ, Fresno
5922 E. McKenzie Ave.
Fresno, CA 93727

R. A. Fosse

1601 E. French Camp Rd
Manteca, CA 95336

Gus Foster
Sandoz Crop Protection
812 East Elizabeth Street
Fort Collins, CO 80524

Mike Foster
Texas Agr. Experiment Station
Box 9000
Fort Stockton, TX 79735

Virgil H. Freed
Agricultural Chemistry Dept.
Oregon State University
Corvallis, OR 97331

James S. Freeman
Cascade County Weed Control
521 1st Avenue N.W.
Great Falls, MT 59404

Fremont County Weed Control
County Court House, Basement
Lander, WY 82520

Mark Fricker
Turf Seed, Inc.
P.O. Box 250
Hubbard, OR 97032

Tim Fritz
USDA/ARS 215 Johnson Hall
Agronomy Department
Washington State University
Pullman, WA 99164

Dean Gaiser
Dow Chemical USA
E. 15407 Mission Ave, Suite 200
Veradale-Spokane, WA 99037

Leland A. Gardner
Jefferson County Weed Control
Courthouse, Room 34
Rigby, ID 83442

Don R. Gargano
Pennwalt Corporation
51 Anne Marie Ct.
Hollister, CA 95023

David Gealy
USDA ARS, 215 Johnson Hall
Agronomy & Soils Department
Washington State University
Pullman, WA 99164

G. Pat Gentry
BASF
48 Woodleaf Court
Novato, CA 94945

Susan Going
Bannock County Weed Control
5500 South 5th
Pocatello, ID 83204

James C. Graham
Monsanto Co., C3SH
800 N. Lindbergh Blvd.
St. Louis, MO 63167

John M. Green
Unit #44
3411 South Camino Seco
Tucson, AZ 85730

E. J. Gregory
New Mexico State University
Box 1018
Farmington, NM 87499

Robert Gunnell
AgraServ
P.O. Box 99
Arimo, ID 83214

Lloyd C. Haderlie
University of Idaho Res. Center
Box AA
Aberdeen, ID 83210

Neal R. Hageman
Monsanto
3720 Avenue A, Suite E
Kearney, NE 68847

Elaine A. Hale
Hale Agricultural Services
P.O. Box 734
Santa Marie, CA 93456

Donald H. Hall
Brea Agricultural Services, Inc.
P.O. Box 201059
Stockton, CA 95201

K. C. Hamilton
Plant Sciences Department
University of Arizona
Tucson, AZ 85721

Jack V. Handly
Dow Chemical Company
Rt 1, Box 1313
Davis, CA 95616

Jonathan J. Hart
Botany Department
University of California
Davis, CA 95616

W. A. Harvey
University of California
14 Parkside Drive
Davis, CA 95616

Louis C. Hearn
ICI Americas
P.O. Box 3959
Visalia, CA 93278

E. Stanley Heathman
Plant Sciences Department
University of Arizona
Tucson, AZ 85721

Eugene Heikes
Colorado State University
716 Garfield
Fort Collins, CO 80524

David Hein
Plant, Soil & Insect Sci. Dept.
University of Wyoming
Laramie, WY 82071

Charles D. Heinzman, Jr.
Monsanto
800 N. Lindbergh V2B
St. Louis, MO 63167

Larry W. Hendrick
BASF, Ag Chem. Group
100 Cherry Hill Road
Parsippany, NJ 07054

Ann Henson
DuPont Company
926 Yucca Ct
Longmont, CO 80501

Robert M. Herrick
American Cyanamid Company
P.O. Box 400
Princeton, NJ 08540

Marvin K. Hess
Hoechst-Roussel Agri-Vet
2218 Hwy 1 South
Greenville, MS 38701

Jeffery M. Higgins
Monsanto Company
P.O. Box 916
Hays, KS 67601

James E. Hill
Agronomy & Range Sci. Extension
University of California
Davis, CA 95616

Larry K. Hiller
Horticulture & LA, 149 Johnson
Washington State University
Pullman, WA 99164-6414

George F. Hittle
Wyoming Dept of Agriculture
P.O. Box 4101
Cheyenne, WY 82003

Jodie S. Holt
Botany & Plant Sciences Dept.
University of California
Riverside, CA 92521

Andreas Hopf
BASF
987 Chaleswood Road
Winnipeg, Manitoba
CANADA R3S 1A1

Robert Hornford
Plant Science Department
University of Alberta
Edmonton, Alberta
CANADA T6G-2E1

Menashe Horowitz
Botany Department
University of California
Davis, CA 95616

Stott Howard
Washington State University
1468 Memorial Hwy
Mt. Vernon, WA 98273

Neil Humburg
6615 Evers Blvd
Cheyenne, WY 82009

Charles D. Hunter
Calif. Dept. Food & Agriculture
P.O. Box 942871
Sacramento, CA 94271-0001

Myron O. Isherwood, Jr.
Hawaii Dept. of Agriculture
P.O. Box 22159
Honolulu, HA 96822

Charles E. Jackson
Uniroyal Chemical Company
7112 E. Alluvial
Clovis, CA 93612

Nelroy Jackson
Monsanto Agr. Products Company
24551 Raymond Way, Wuite 285
El Toro, CA 92630

Terry James
BASF Canada, Inc.
P.O. Box 1616
Vegreville, Alberta
CANADA TOB-4LO

Larry S. Jeffery
Agronomy & Horticulture Dept.
Brigham Young University
Provo, UT 84602

Brian Jenks
Plant Science Department
Utah State University
Logan, UT 84322-4820

James I. Jessen
ICI Americas, Inc.
Box 889
Glendive, MT 59330

Douglas E. Johnson
Rhone-Poulenc Ag Company
1123 W. Tenaya Way
Fresno, CA 93711

Douglas L. Johnson
Cascade County Weed Control
521 1st Avenue NW
Great Falls, MT 59404-2885

Roy Johnson
Waldrum Specialties
1727 Butler Pike
Ambler, PA 19002

Ivan B. Jones
USU Extension Agent
160 North Main
Nephi, UT 84645

Phil Jones
Pan Ag Labs
12627 E. Paul
Fresno, CA 93712

Carl E. Joplin
Mobay Corporation
Rt. 7, Box 7165-D
Nampa, ID 83651

Lowell S. Jordan
Botany & Plant Sciences Dept.
University of California
Riverside, CA 92521

Donald N. Joy
Uniroyal Chemical
4205 Barge Street
Yakima, WA 98908

Larry K. Justesen
Carbon County Weed & Pest Dist.
P.O. Box 1126
Rawlins, WY 82301

J. Phillip Keathley
Keathley Agricultural Services
25330 S. Ruess Road
Ripon, CA 95366

Paul E. Keeley
USDA Cotton Research Station
17053 Shafter Avenue
Shafter, CA 93263

Bruce Kelpsas
Northwest Chemical Corporation
4560 Ridge Drive, NE
Salem, OR 97303

Harold M. Kempen
Univ. Calif. Coop. Extension
P.O. Box 2509
Bakersfield, CA 93303-2509

K. Khodayari
ICI Americas
498 N. Mariposa Avenue
Visalia, CA 93277

Elmar Kibler
BASF
10181 Avenue 416
Dinuba, CA 93618

Dan Kidder
Univ. Idaho Coop. Extension
1330 Filer Avenue E.
Twin Falls, ID 83301

David L. King
Sandoz Crop Protection
975 California Avenue
Palo Alto, CA 94303-1104

Wayne O. King
Horticulture Department
Oregon State University
Corvallis, OR 97331-2911

Jim Klauzer
Rohm & Haas Company
1520 E. Shaw Avenue #119
Fresno, CA 93710

Mary M. Kleis
130 New Street
Bridgeton, NJ 08302

Paul J. Kloft
Collins Agr. Consultants Inc.
Rt. 2, Box 344
Hillsboro, OR 97123

Jeffrey C. Kollenkark
Ciba-Geigy Corporation
5381 N. McCall
Clovis, CA 93612

Bill Kral
E.I. DuPont
1739 Julie Lane
Twin Falls, ID 83301

James M. Krall
University of Wyoming
Route #1, Box 374
Torrington, WY 82240

Edward A. Kurtz
P.O. Box 1763
Salinas, CA 93902

Leslie Kvasnicka
Chevron Chemical Company
P.O. Box 4010
Richmond, CA 94804-0010

Celestine Lacey
Montana Department of Agric.
Capitol Station
Helena, MT 59620

Arthur H. Lange
Herbicide Res. Institute
9400 S. LacJac
Reedley, CA 93654

Tom Lanini
Botany Dept., 106 Robbins Hall
University of California
Davis, CA 95616

Lawrence W. Lass
Dept. Plant, Soil & Entomol Sci
University of Idaho
Moscow, ID 83843

Jerry D. Lavoy
Rhone Poulenc Ag Company
1046 Senora Avenue
Billings, MT 59105

Homer M. LeBaron
Ciba-Geigy Corporation
P.O. Box 18300
Greensboro, NC 27419

Gary A. Lee
Idaho Agr. Exp. Station
University of Idaho
Moscow, ID 83843

Richard D. Lee
New Mexico State University
Box 3AE
Las Cruces, NM 88003

Philip W. Leino
Univ. of Idaho Research Center
P.O. Box AA
Aberdeen, ID 83210

Robert J. Leonard
Grant County Noxious Weed Board
P.O. Box 115
Ephrata, WA 98823

Raylene LeRoy
Ciba Geigy Corporation
P.O. Box 268
Clovis, CA 93612

Kenneth W. Linville
Ball Research
P.O. Box 1411
East Lansing, MI 48823

Robert Liptrap
Nor-Cal Geotechnical
13822 Hwy 99
Chico, CA 95928

Joan Lish
Dept Plant, Soil & Ent. Sci.
University of Idaho
Moscow, ID 83843

Branislav Lovic
Plant Science Department
Utah State University
Logan, UT 84322-4820

Kelvan R. Luff
PPG Industries
6809 Leisure Lane
Nampa, ID 83651

Allan J. Luke
Rhone Poulenc Ag Company
P.O. Box 12014
Res. Triangle Park, NC 27709

Rodney G. Lym
Agronomy Department
State Univ. Station, Box 5051
Fargo, ND 58105

Craig B. MacConnell
Washington State University
1000 N. Forest
Bellingham, WA 98225

Monique M. Mackasey
Dow Chemical U.S.A.
P.O. Box 1706
Midland, MI 98640

Douglas Mackay
School of Public Health
UCLA
Los Angeles, CA 90024

Nicholas D. Macris
Agricultural Consultant
111 N. Trout Lake Drive
Sanger, CA 93657

Kevin A. Madsen
University of Wyoming
Box 3354
Laramie, WY 82071

Carol Mallory
Plant, Soil & Entomol Sci. Dept.
University of Idaho
Moscow, ID 83871

Michael Mavrev
California State University
4347 E. Indianapolis
Fresno, CA 93726

Bruce Maxwell
Forest Science Department
Oregon State University
Corvallis, OR 97331

John W. May
DuPont
Barley Mill Plaza
Wilmington, DE 19898

Terrel W. Mayberry
Nor-Am Chemicals
Rt. 1, Box 218
Pendleton, OR 97801

Paul G. Mayland
Hoechst-Roussel Agri-Vet Co.
2962 Southgate Drive
Fargo, ND 58103

Kirk C. McDaniel
Box 31, Dept Animal & Range Sci.
New Mexico State University
Las Cruces, NM 88001

Hugh McEachen
South Columbia Basin Irr. Dist.
P.O. Box 96
Mesa, WA 99343

Daniel McGrath
Oregon State Univ. Extension
3180 Center St. NE, Rm 160
Salem, OR 97301

W. B. McHenry
Botany Department
University of California
Davis, CA 95616

James R. McKinley
Rhone Poulenc
424 Aero View
Yakima, WA 98908

Mary McKone
Dow Chemical, Suite 115
1001 S. 24th Street W.
Billings, MT 59102

Brian McLain
Plant Science Department
Utah State University
Logan, UT 84322-4820

Charles Melton
1247 W. Millbrae Avenue
Fresno, CA 93711

Robert J. Meyer
Weed Control Mgt, Inc.
156 Pasatiempo Drive
Bakersvield, CA 93305

Larry Mickelsen
USDA/ARS, Utah State Univ.
1150 E. 1400 North
Logan, UT 84321

Stephen D. Miller
Plant, Soil, Insect Sci. Dept.
University of Wyoming
Laramie, WY 82071

Tim Miller
Room 411 Borlaug Hall
University of Minnesota
St. Paul, MN 55113

William C. Miller
Elanco Products Company
1970 S.W. Quinney Place
Pendleton, OR 97801

Larry W. Mitich
Botany Department
University of California
Davis, CA 95616

John R. Monnich
Cactec
P.O. Box 6155
Modesto, CA 95355

Allen Mooney
Campbell County Weed & Pest
Box 191
Gillette, WY 82716

Don W. Morishita
S.W. Kansas Exp. Station
4500 E. Mary Street
Garden City, KS 67846

Sud Morishita
Bonneville County Weed Control
605 N. Capital
Idaho Falls, ID 83402

Howard L. Morton
USDA, ARS
2000 E. Allen Road
Tucson, AZ 85719

George Mueller-Warrant
USDA, Crop Science Department
Oregon State University
Corvallis, OR 97331

Barbra Mullin
Montana Dept. of Agriculture
920 N. Benton
Helena, MT 59601

W. R. Mullison
Consultant
1412 North Parkway
Midland, MI 48640

Greg Munden
Idaho Transportation Dept.
P.O. Box D
Coeur d'Alene, ID 83814

Glen A. Mundt
Yellowstone, Int.
610 Central Avenue
Billings, MT 59102

Gail G. Munk
Western Nevada Seed Service
P.O. Box 892
Lovelock, NV 89419

Guy H. Nagai
Hawaii Dept of Agriculture
P.O. Box 226
Captain Cook, HA 96704

Seth Neibaur
Power County Weed Control
Box 179
American Falls, ID 83211

Tom J. Neidlinger
13016 N.E. Pacific Court
Portland, OR 97230

W. Richard Neilson
PPG Industries, Inc.
P.O. Box 115
Alpine, CA 92001-9535

Jim Nelson
Plant & Soil Sience Dept.
Montana State University
Bozeman, MT 59717

Marlyn J. Nelson
Bingham County Weed Control
P.O. Box 583
Blackfoot, ID 83221

Michael Newton
Dept of Forest Science
Oregon State University
Corvallis, OR 97331

Dale W. Nicol
ICI Americas, Inc.
17629 Magnolia
Shafter, CA 93263

Richard S. Nielsen
2727 W. Bluff Ave. #108
Fresno, CA 93711

R. Scott Nielsen
Spokane County Noxious Weed Bd
N 222 Havana Street
Spokane, WA 99202

Calvin Nolke, Jr.
University of Wyoming
P.O. Box 982
Laramie, WY 82070

Logan A. Norris
Dept. of Forest Management
Oregon State University
Corvallis, OR 97331

Robert F. Norris
Botany Department
University of California
Davis, CA 95616

Francis E. Northam
Plant, Soil & Entom. Sci. Dept.
University of Idaho
Moscow, ID 83843

Alex G. Ogg, Jr.
USDA-ARS, 215 Johnson Hall
Washington State University
Pullman, WA 99164

Paul J. Ogg
American Cyanamid Company
3619 Mountain View
Longmont, CO 80501

Ron Oliver
BASF Corporation
930 E. Frederick
Fresno, CA 93710

Phillip D. Olson
Hoechst-Roussel Agri-Vet Corp.
Rt. 1, Box 125
Hayden Lake, ID 83835

Steve Orloff
University of California
1110 West Ave. J, Rm 5
Lancaster, CA 93534

Jack P. Orr
Univ. Calif. Coop Extension
4145 Branch Center Rd.
Sacramento, CA 95827

John E. Orr
ICI Americas, Inc.
2018 Coloma Way
Boise, ID 83712

Charles E. Osgood
BASF Corporation
11134 Chickadee Drive
Boise, ID 83709

Karen W. Ott
ICI Americas
P.O. Box 760
Mt. View, CA 94042

Joe L. Pafford
Elanco
3131 S. Vaughn Way, Suite 111
Aurora, CO 80014

Louis T. Palmer
DuPont
2612 Pinewood Drive
Madera, CA 93637

Robert Parker
Washington State University
IAREC, P.O. Box 30
Prosser, WA 99350

Tom Parks
U.S. Bureau of Reclamation
P.O. Box 36900
Billings, MT 59107

Chris S. Payne
Rhone Poulenc
Rt. 3, Box 6499
Twin Falls, ID 83301

Dwight Peabody
Rt. 1
Box 1917
Lopez, WA 98261-9801

John O. Pearson
BASF Corporation
1384 Greenborough Drive
Roseville, CA 95661

Daniel Peek
Crop Science Department
Oregon State University
Corvallis, OR 97331

Phil J. Petersen
CENEX
910 Gromore Road
Yakima, WA 98908

Mark Peterson
Dow Chemical
RR 1, Box 51 R
Brookings, SD 57006

Irvine L. Phillips
Experimental Farms Company
P.O. Box 68
Greenfield, CA 93927

Emmanuel Pomela
Plant Science Department
Utah State University
Logan, UT 34322-4820

Tim Prather
Plant Soil & Entom. Sci. Dept.
University of Idaho
Moscow, ID 83843

C. L. Prochnow
11509 N.E. 3rd Avenue
Vancouver, WA 98685

L. Joe Purchase
SSI Moibley Company
2523 Frontier Lane
Franktown, CO 80116

Mickey Qualls
Cenex Research
374 Dodson Rd
Ephrata, WA 98823

Steven R. Radosevich
Forest Science Department
Oregon State University
Corvallis, OR 97331-5704

Dan W. Ragsdale
852 Foxsprings Drive
Chesterfield, MO 63017

Michael Ralphs
USDA/ARS Poisonous Plant Lab
1150 East 1400 North
Logan, UT 84321

Dennis Rasmusson
Monsanto Chemical Company
1600 Madison Avenue
Mankato, MN 56001

Thomas A. Reeve
USU Extension Service
County Courthouse
Brigham City, UT 84302

Roy Reichenbach
1269 Sweetwater Road
Douglas, WY 82633

Mark Reid
USDA/ARS 215 Johnson Hall
Washington State University
Pullman, WA 99164

Carlos Reyes
Crop Science Department
Oregon State University
Corvallis, OR 97331

Jesse Richardson
Dow Chemical USA
9330 10th Avenue
Hesperia, CA 92345

James D. Riggleman
DuPont Co., Agchem Products
Walker's Mill BMP
Wilmington, DE 19898

Mark A. Risley
American Cyanamid Company
1502 Belmont Avenue
Yakima, WA 98902

R. Barry Rogers
Innovative Equipment Inc.
240 103rd Street
Saskatoon, Sask.
CANADA S7N 1X7

Norman D. Ronemus
Stuart W. Turner & Co., Inc.
4665 N. Delno
Fresno, CA 93705

Edward M. Rose
Agricultural Consultant
12150 E. Kings Canyon Road
Sanger, CA 93657

Claude Ross
FMC Corporation
4343 Redbird Ct.
Loveland, CO 80537

Louis Russo
Sandoz Crop Protection
9269 E. Mesa Avenue
Clovis, CA 93612

Donald J. Rydrych
Oregon State University-CBARC
Box 370 Hwy. 11/Exp. Sta. Rd.
Pendleton, OR 97801

Doug Ryerson
Monsanto Agr Products Company
1201 10th Ave S., Suite 206
Great Falls, MT 59405

Eric S. Sachs
Monsanto Agr Products Company
7134 E. Teilman
Fresno, CA 93711

Joseph N. Sagaser
Mobay Chemical Corporation
6197 N. Millbrook Avenue
Fresno, CA 93710

John L. Saladini
E.I. DuPont de Nemours & Co.
2612 Stephenson Dr.
Wilmington, DE 19808

Gregory L. Santos
University of Hawaii
Hawaii Volcanoes Nat'l Park
Hawaii 96718

James E. Saxton
Bear Lake County Weed Control
P.O. Box 237, 9 North Main
Paris, ID 83261

Roland Schirman
Wash. State Univ. Coop. Ext.
202 S. Second
Dayton, WA 99328

John T. Schlesselman
Rohm & Haas Company
726 E. Kip Patrick Drive
Reedley, CA 93654

Don R. Schomer
25422 Del Cobre
Laguna Niguel, CA 92677

Manette Schonfeld
Univ. of Idaho R&E Center
P.O. Box AA
Aberdeen, ID 83210

Galen L. Schroeder
Sandoz Crop Protection
1233 4th Street North
Fargo, ND 58102

Jill Schroeder
New Mexico State University
Box 3BE
Las Cruces, NM 88003-0003

Tim W. Schultz
Adams County Noxious Weed Bd.
210 W. Broadway
Ritzville, WA 99169

R. W. Schumacher
Monsanto Company, C3SH
800 N. Lindbergh Blvd.
St. Louis, MO 63166

Edward E. Schweizer
USDA,ARS Sugarbeet Prod. Res.
1701 Center Avenue
Fort Collins, CO 80526

Allen C. Scoggan
Mobay Chemical Corporation
1900 N. Gateway Blvd, Suite 152
Fresno, CA 93727

Clarence Seely
University of Idaho
430 Lewis
Moscow, ID 83843

Becky Sherman
ICI Americas
Delaware Corporate Center
1 Righter Parkway
Wilmington, DE 19800

David A. Shields
BASF Corporation
10181 Avenue 416
Dinuba, CA 93618

Thomas H. Shrader
U.S. Bureau of Reclamation
700 E San Antonio St, Rm B-318
El Paso, TX 79901

Edwin E. Sieckert
Monsanto Agr Products Company
7806 Madison Ave., Suite 146
Fairoaks, CA 95628

Ricardo Silberman
Monsanto
5452 North Delno Avenue
Fresno, CA 93711

Sewell Simmons
Calif. State Dept. Food & Agr.
1220 N Street, Rm A-149
P.O. Box 942871
Sacramento, CA 94271-0001

Darryl E. Smika
9901 N. Co. Rd. 17
Fort Collins, CO 80524

Nelson L. Smith
Botany Department
University of California
Davis, CA 95616

Randy L. Smith
Rohm & Haas Company
4407 N. Forestiere
Fresno, CA 93722

Leslie W. Sonder
Calif. Dept. Food & Agric.
1220 N Street, Rm A-357
Sacramento, CA 95814

Ronald E. Sosebee
Dept. Range & Wildlife Mgt.
Texas Tech University
Lubbock, TX 79409

David F. Spencer
USDA/ARS Aquatic Weed Res Lab
Botany Dept, Univ. California
Davis, CA 95616

Bob Spinney
Crop Science Department
Oregon State University
Corvallis, OR 97331

Wayde Squires
BASF Canada Inc.
P.O. Box 7590
Saskatoon, Saskatchewan
CANADA S7K 4R4

Phillip Stahlman
Fort Hays Exp. Station
Route 2
Hays, KS 67601

Mary Stallings
Larimer County Weed District
P.O. Box 1190
Fort Collins, CO 80522

Gil Stallknecht
So. Montana Agr. Res. Center
748 Railroad Hwy
Huntley, MT 59037

Kevin Staska
Hoechst-Roussel Agri-Vet Co.
1812 Terrace Drive
Minot, ND 58701

James Steadman
Morgan & Myers
146 E. Milwaukee
Jefferson, WI 53549

James F. Stewart
Nor-Am Chemical
68 N. Cindy
Clovis, CA 93612

Vern R. Stewart
N.W. Agr. Res. Center, MSU
4570 Montana 35
Kalispell, MT 59901

Loyd L. Stitt
Field Seed Mgt.
1085 Johnson Place
Reno, NV 89509

Richard M.G. Stoltz
American Cyanamid Company
506 W. Tenaya Avenue
Clovis, CA 93612

Clair Stymiest
South Dakota State University
801 San Francisco Street
Rapid City, SD 57701

Gary Suthers
Brea Agricultural Service, Inc.
P.O. Box 201059
Stockton, CA 95201

Dean G. Swan
Agron. Dept. 173 Johnson Hall
Washington State University
Pullman, WA 99164-6412

Mark G. Sybouts
Sandoz Drop Protection
42490 Alpha Place
Temecula, CA 92390

Larry S. Tapia
Dept Plant Soil & Entom Science
University of Idaho
Moscow, ID 83843

Donn C. Thill
Dept Plant Soil & Entomol. Sci.
University of Idaho
Moscow, ID 83843

James M. Thomas
FMC Corporation
219 N. 65th Place
Yakima, WA 98908

Lafayette Thompson, Jr.
Editor, WSSA Newsletter
1142 E. Maynard Rd.
Cary, NC 27511

W. T. Thomson
Thomson Publications
P.O. Box 5317
Fresno, CA 93755

Bruce Thornton
1507 Peterson
Fort Collins, CO 80521

Joan S. Thullen
U.S. Bureau of Reclamation
P.O. Box 25007, D-1522
Denver, CO 80225

Jeff Tichota
Sandoz Crop Protection
4949 S. Syracuse Pkwy,
Suite 3700
Denver, CO 80237

Barry Tickes
Univ. of Arizona Ext. Service
1047 4th Avenue
Yuma, AZ 85364

Thomas C. Tillett
Rhom & Haas Company
1520 E. Shaw Ave, Suite 119
Fresno, CA 93710

F. L. Timmons
1047 North Caribe
Tucson, AZ 85710

D. C. Tingey
653 East 400 North
Logan, UT 84321

John Toriano
California Dept. Food & Agric.
1200 N Street, Rm A-149
Sacramento, CA 95814

Dan Toya
Rt. 1
Box 328 F
Warden, WA 98857

Paul Tresham
Wilbur-Ellis
P.O. Box 609
Umatilla, OR 97882

Harvey D. Tripple
Monsanto Agr. Products Company
Meridian Office Building
9785 Maroon Circle, Suite 110
Englewood, CO 80112

Stuart A. Turner
Stuart W. Turner & Company
P.O. Box 10539
Bainbridge Island, WA 98110

Stuart W. Turner
Stuart W. Turner & Company
P.O. Box 10539
Bainbridge Island, WA 98110

Kai Umeda
American Cyanamid Company
4531 West Gail Drive
Chandler, AZ 85226

R. Phillip Upchurch
College of Agriculture
University of Arizona
Tucson, AZ 85721

Bernal E. Valverde
Crop Science Department
Oregon State University
Corvallis, OR 97331

L. A. Vance
Idaho Dept. of Agriculture
120 Klotz Ln
Boise, ID 83705

Joe Vandepeute
Calif. Dept. Food & Agric.
1220 N. Street Rm A-447
Sacramento, CA 94271-0001

Ron Vargas
Univ. Calif. Coop. Extension
328 Madera Avenue
Madera, CA 93637

Tim C. Vargas
Varco Ag Res. & Consulting
180 W. 100th North
Jerome, ID 83338

Kurt C. Volker
ICI Americas, Inc.
7610 Scenic Drive
Yakima, WA 98908

Paul Walgenback
American Cyanamid
789 Lakecrest Drive
El Dorado Hills, CA 95630

Ted R. Warfield
FMC Corporation
11128 John Galt Blvd
Omaha, NE 68137

Roderick W. Warner
E.I. DuPont Company
502 Montain View Drive
Bozeman, MT 59715

G. F. Warren
1130 Cherry Lane
W. Lafayette, IN 47906

L. E. Warren
5623 Greenbrae Road
Sacramento, CA 95822

Steven D. Watkins
ICI Americas Inc.
2210 Lorie Lane
Yuma, AZ 85365

Leonard L. Welch
Chevron
1052 E. Shaw
Fresno, CA 93710

Barbara H. Wells
Crop Science Department
Oregon State University
Corvallis, OR 97331

Philip Westra
Plant Path/Weed Science
Colorado State University
Fort Collins, CO 80523

Steve Whisenant
Botany & Range Sci., 401 WIDB
Brigham Young University
Provo, UT 84602

Tom Whitson
Plant, Soil & Insect Sci Dept
University of Wyoming
P.O. Box 3354, Univ. Station
Laramie, WY 82071

David M. Wichamn
Montana State University
Central Agr Research Center
Moccasin, MT 59462

Cheryl Wilen
Monsanto Ag Chemical Company
800 N. Lindbergh Blvd. V2A
St. Louis, MO 63167

Duke C. Wiley
BASF
95 Signature
Woodland, CA 95695

Roger W. Willemsen
Rhone Poulenc, Inc.
2491 W. Shaw, Suite 123
Fresno, CA 93711

Ray D. William
Extension, Horticultre Dept.
Oregon State University
Corvallis, OR 97331

M. Coburn Williams
USDA, Biology Department
Utah State University
Logan, UT 84322-4563

Blake D. Willis
Plant Science Department
Utah State University
Logan, UT 84322-4820

C. Barry Wingfield
United Agr. Services
P.O. Box E
Greeley, CO 80632

Sandra Wingfield
Agrisan Pest Management
P.O. Box 323
Eaton, CO 80615

Winn Winkyaw
Water C&M (X Cut)
P.O. Box 1980
Phoenix, AZ 85001

Steven Wright
Univ. Calif. Coop Extension
County Civic Center
Visalia, CA 93291

Donald Wyse
411 Borlaug Hall
University of Minnesota
1991 Buford Circle
St. Paul, MN 55108

Ken Yelle
Agri Search
P.O. Box 667
Elk Grove, CA 95624-0667

Genjiro Yoshida
Nisso America Inc.
11 East 44th Street, Rm 600
New York, NY 10017

Cletus Youmans
American Cyanamid
P.O. Box 400
Princeton, NJ 08540

Frank L. Young
USDA/ARS Johnson Hall, Rm 215
Washington State University
Pullman, WA 99164

Barry Younkin
BASF Corporation, Chemicals Div
10181 Avenue 416
Dinuba, CA 93618

David L. Zamora
Dept Plant Soil & Entomol Sci.
University of Idaho
Moscow, ID 83843

Robert L. Zimdahl
Weed Research Lab
Colorado State University
Fort Collins, CO 80523

Ellen Bentley
Wash. State Dept. Agric.
408 General Adm. Buld. AX-41
Olympia, WA 98504

R. C. Hildreth
Agricultural Consultant
1031 White Gate Road
Danville, CA 94526