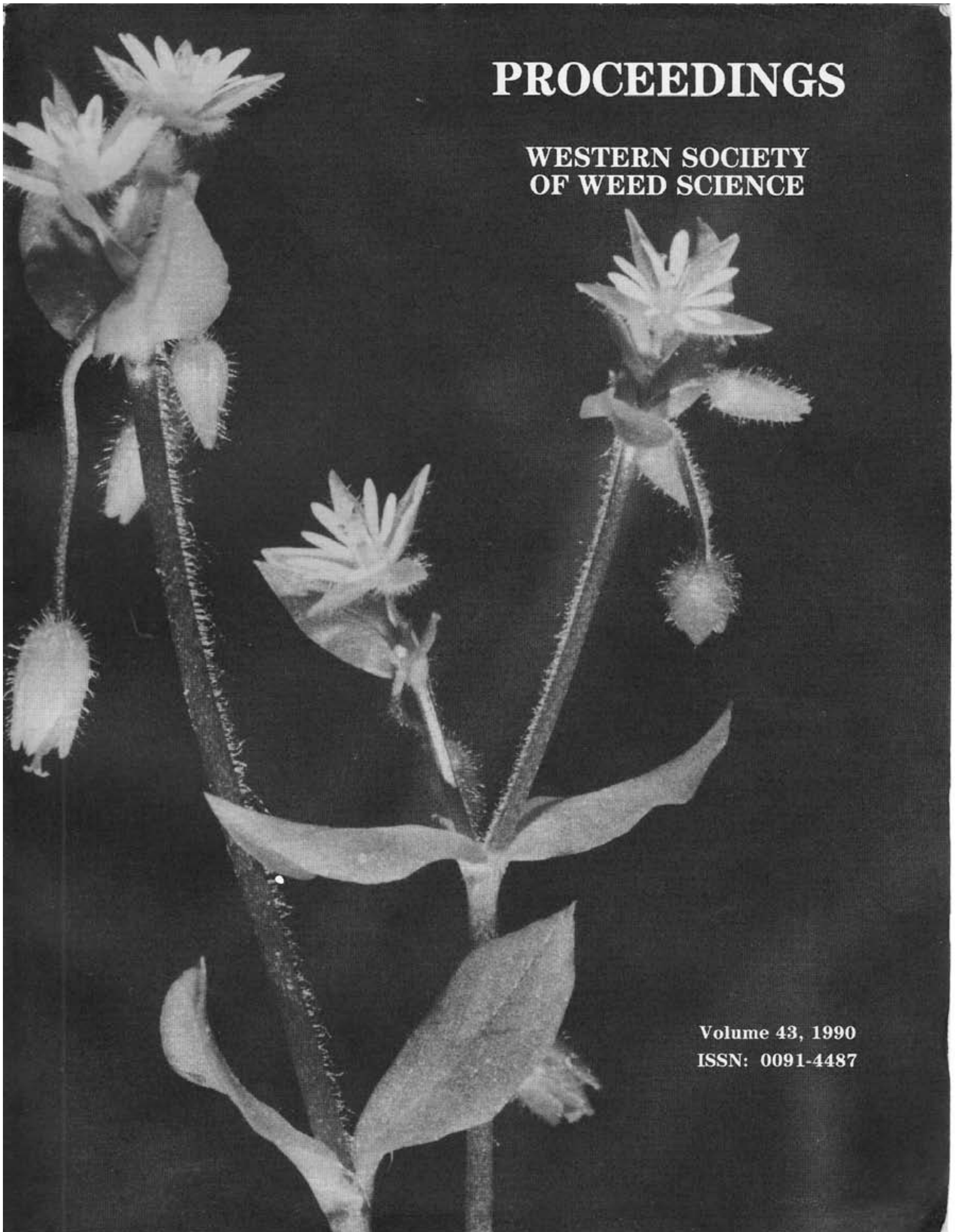
PROCEEDINGS

WESTERN SOCIETY OF WEED SCIENCE



Volume 43, 1990
ISSN: 0091-4487

1990 PROCEEDINGS

OF

THE WESTERN SOCIETY OF WEED SCIENCE

VOLUME 43

PAPERS PRESENTED AT THE ANNUAL MEETING

MARCH 13, 14, 15, 1990

THE NUGGET HOTEL

SPARKS, NEVADA

PREFACE

The Proceedings contain the written summary of the papers presented at the 1990 Western Society of Weed Science Annual Meeting plus summaries of the research discussion groups and of the business transacted by the Executive board. Authors submitted either abstracts or full papers of their presentations.

In these Proceedings, herbicide application rates are given as acid equivalent or active ingredient unless otherwise specified. Chemical names of the herbicides mentioned in the text are given in the herbicide index. Botanical names of crops and weeds are given in the appropriate index and are not repeated in the text unless their omission may cause confusion. Common and botanical names follow those adopted by the Weed Science Society of America as nearly as possible and Hortus third.

Copies of this volume are available at $15.00 per copy from Wanda Graves, WSWS Business Manager, P.O. Box 963, Newark, CA 94560.

Cover and other photographs courtesy: Jack Schlesselman

Proceedings Editor: Rodney G. Lym

TABLE OF CONTENTS

GENERAL SESSION

POSTER SESSION

GENERAL SESSION

PRESIDENTIAL ADDRESS

Sheldon E. Blank
Senior Product Development Associate
Monsanto Co.
Kennewick, WA 99336

Members, honored guests, Fellows, visitors, ladies and gentlemen--Welcome to this 43rd meeting of the Western Society of Weed Science. Phil Martinelli and his local arrangements committee have done an excellent job in seeing that this meeting runs smoothly. All of us will be able to enjoy the next two and one-half days of meetings because of Phil and his groups hard work on local arrangements the last year. I extend my sincere thanks to them.

I am pleased to report that our society continues to maintain a strong financial position with in excess of a two-year operational budget. I know there was considerable concern financially about holding last years meeting in Hawaii, but it appears that on a fiscal year basis, our society about broke even. The Western Society of Weed Science ushered in a new Treasurer/Business Manager this past year--Wanda Graves. Please introduce yourself and get to know Wanda during this weeks meeting. She is doing an excellent job for us. My appreciation to LaMar Anderson for his invaluable assistance to Wanda during this transitional year.

Attendance at last years meeting in Hawaii was 300 members, while registration for this years conference equals or exceeds that number. While attendance at the annual meeting appears to be a strength of our Society, participation in the meeting may be a point for concern. There were in excess of 100 papers presented last year, while only 53 presentations were received for this years meeting. This is the lowest number of papers since the 1981 meeting in San Diego. I would hope that the requirement of a computer disc this year in addition to hard copy of presentations was not a contributing factor to the reduction in papers. One advantage of having fewer papers this year is that there should be ample time for open discussions in the research project groups.

Of equal concern relative to participation in our Society is that only 147 individuals voted in this years election of officers compared to 168 in 1986. With only about 50 members involved in committees and the operation of this annual meeting, it appears that there are only half of us contributing in some manner to the accomplishments of the Western Society of Weed Science. I would like to invite and challenge each and every member to participate in this excellent Society. Volunteer to serve on a committee or start planning your poster or presentation for the 1991 meeting in Seattle.

Pete Fay, your program chairman, along with Jodie Holt and Celestine Lacey, members of the program committee, have prepared an excellent agenda for our meeting. You had the opportunity this morning to view some outstanding poster presentations which will be displayed for the rest of the day. The Education and Regulatory section this year will be devoted entirely to Extension, with information on computers, videos and other media techniques. I hope each of you will take advantage of the time allotted for discussion during the conference. These discussion periods have been, and continue to be, something that makes our meetings different and, in my opinion, more productive. This year for the first time in the history of the Western Society of Weed Science there will be an evening session concerning the teaching of Weed Science.

A highlight for me this past year was a trip to Washington, D.C., where I represented the WSWS on a team comprised of senior officers of the WSSA and presidents of the Regional weed science societies. We met with several key Congressmen and Senators to discuss legislative issues important to weed science. Position papers on water quality, sustainable agriculture, IR-4 programs, Federal Noxious Weed Act, herbicide resistant weeds, food safety and endangered species program were presented during these meetings. I encourage the WSWS to continue sending their President on this trip. Please let members of your Executive Board know about legislative issues that you think are important to weed science--especially in the West.

Our Society has the distinction of being the first conference of its kind in the United States. Since our inception in 1936 and first meeting at Denver, Colorado in 1938, there certainly have been accelerating changes in the science, technology and regulation of weed control. In a few minutes, you will have the opportunity to hear from four distinguished gentlemen. Each speaker will be discussing very different but timely topics. Container disposal, food safety, alternatives to pesticides, low-input agriculture, ground water and biologically derived pesticides are all very pertinent topics relative to the 1990's. Today as never before, our discipline of weed science is coming under scrutiny and attack from individuals or groups who are demanding a say in how we do our jobs. Gone are the days where we could pat each other on the back for a "job well done", with the satisfaction that our endeavors were helping to feed an ever growing world population. Every agricultural discipline, particularly those associated with pesticide use, must become more pro-active in dealing with public perceptions and concerns in the 1990's.

"Environmental pressure groups have forced zealous regulatory agencies to impose unwarranted restrictions on the use of herbicides. Unwise regulations are often made by uninformed individuals. People are often misinformed concerning herbicides because we do not provide them with adequate, accurate information". This quote was taken from Dr. Lowell Jordan's Presidential address to the Western Society of Weed Science at this hotel in 1976. How far, if any, has our discipline progressed the past 14 years in terms of dealing with public perceptions and concerns about herbicide use? Could you not make that very same statement today!

I suggest that anyone that is still doing their job the same today as they did five or even one year ago is not prepared for the future because they are functioning in the past. If we do not integrate the future with tradition, we may perish. The best young people will not be attracted to agriculture, let alone disciplines of agriculture dealing with weed control and pesticides unless agriculture's perception among the general public improves dramatically. We all take pride and self-satisfaction in what we do, but we must start "beating our own drum", if the positive attributes of our discipline are ever going to be heard.

It has been a privilege to serve as President of your Society this year. I especially have enjoyed the relationships that were developed with many of you whom I had not been closely associated with in the past. The leadership provided by committee chairmen and members of the Executive Committee has been especially gratifying. I would like to take this opportunity to sincerely express my appreciation to all of these members for the cooperation, advice and loyal support they have given me. As long as our members continue to give unselfishly of their time and talent to the affairs of the Society, we will remain in a position to meet the challenges that lie ahead.

EMPTY PESTICIDE CONTAINER COLLECTION/RECYCLING PROGRAM. Dr. Earl C. Spurrier, Vice President for State Affairs, National Agricultural Chemicals Association, Washington, D.C. 20005.

Two very successful pilot programs for collection, disposal and recycling of empty pesticide containers were implemented in the states of Minnesota and Mississippi in 1989. Two concepts were embraced: (1) demonstration and education in Minnesota; and (2) commercial collection and recycling in Mississippi. There were two main objectives: (1) educate farmers and applicators on the need to properly rinse pesticide containers in an effort to avoid adverse environmental consequences and save money in the process; and (2) determine and assess the practical and economic feasibility of such collection/recycling concepts.

Minnesota. Using the theme "Rinse and Win", some ten farm, industry, state and university representatives, under the leadership of the Minnesota Department of Agriculture, organized and implemented an extensive statewide educational program. It demonstrated and taught farmers and applicators the reasons for and the correct in-field procedures to properly rinse emptied pesticide containers.

In 1989, eight field demonstrations dealing with container rinsing and preparation for proper disposal were completed: six at University of Minnesota research fields in conjunction with field meetings; and two at state agricultural trade shows. Publication of "Rinse and Win" fact sheets, promotional and other educational materials were widely distributed to the farm community through the Minnesota State University Extension Service and Department of Agriculture personnel. Media support of the program was encouraged and well received. Industry representatives assisted Extension personnel at the sites, provided empty containers for demonstration and promoted field demonstration attendance through dealers and farmer contact. Field meeting turnout to the demonstrations was excellent as was the general acceptance of the entire program. Even the Governor of Minnesota appeared on-site to support the program.

Future plans in 1990 will expand similar educational efforts and implement pilot container collection and recycling programs throughout the state. The 1989 Minnesota Ground Water Protection Act has mandated that a pilot program for collection and recycling of pesticide containers be completed and a report made to the legislature by November 30, 1991.

Mississippi. The key objective of the Mississippi program was to identify and demonstrate practices that will enhance the rinsing, collection and recycling of empty pesticide containers. Before any recycling program can be implemented, all containers must be appropriately rinsed and properly prepared for recycling. Containers must qualify as solid waste to be accepted by recyclers for processing.

Fourteen Mississippi farm, industry, state and university entities formed a coalition to organize a voluntary container collection/recycling program; the Mississippi Department of Agriculture was asked to provide leadership. A staff person was assigned supervisory responsibilities for the project. The coalition identified one county (Washington County) to be the site for the pilot program.

Educational, promotional and operational committees were formed. Program segments were identified. They were: (1) development of educational materials on pressure and triple rinsing of containers; (2) assigning and publicizing economic and environmental value gained by proper rinsing and recycling; (3) preparation of educational slide sets for farmer/dealer meetings; (4) selection of container collection sites; (5) preparation for media and newspaper promotion, public service announcements and dealer/customer letters; (6) identifying and selecting metal and plastic recyclers who can handle containers; (7) procurement and distribution of pressure rinsing probes to each Washington County farmer; (8) proper handling, storage and transport of containers to local collection sites; (9) inspection and certification of empty containers; (10) transport of containers to central collection and baling sites; (11) identification, separation and preparation of empty containers for residue analysis; (12) transportation of finally prepared containers to recycling operations; and (13) development of an educational/promotional video for future use. Also, during the season, several media events (on-site press conferences) were conducted.

Pressure rinsing was promoted as the most effective rinsing method. To promote the practice, mechanical pressure rinsing probes, along with instruction for installation and use, were supplied to over 600 Washington County farmers. Pressure rinsing is quicker and much more effective than triple rinsing.

Mississippi aerial applicators offered eight landing strip sites for "in-County" container collection. Special container wagons were positioned at each site - one labeled plastic and the other labeled metal. Farmers or applicators were able to deposit properly rinsed containers as soon as emptied; such collection took empty containers off of the farm.

Tons of plastic and metal containers were collected and processed for recycling. The Washington County Board of Supervisors utilized County-owned trucks, trailers and personnel to collect and transport all plastic containers from the eight collection sites to one central site for baling and shipment to a recycling company. Before baling, containers from forty different pesticide products were identified, separated into small samples and shipped to a laboratory to be processed for chemical residue analysis. The analytical program is now being completed by cooperating manufacturers.

An unused cotton gin and press was renovated to bale the plastic containers. Approximately 1200 plastic containers were required to form a 500 pound bale. Metal containers were collected separately and sold for scrap to a local metal recycler. Funds received from metal sales were used to underwrite the County cost for transportation.

The Mississippi Department of Natural Resources provided inspection and certification of collected containers so that they would be acceptable for recycling. The Mississippi State University Extension Service managed educational efforts. The Mississippi State Farm Bureau prepared and aired promotional messages over their state TV network. Local TV and radio stations provided local coverage. One manufacturer provided 700 pressure rinsing probes. Another manufacturer supervised and implemented the plastic container recycling and residue analysis programs. Other farm organizations, state agencies, state associations, government, dealers and crop protection chemical manufacturing companies provided full cooperation and resources to make the program work. It was truly a voluntary, well-organized effort.

Summary. The two pilot programs were extremely successful in accomplishing set objectives. They were very complicated first-time projects requiring very detailed planning and execution. Much was learned - good and bad. The lessons learned can go far to help others in future efforts. Collection and recycling of properly rinsed pesticide containers has great potential.

The agricultural industry, with the help of the farm community and regulatory agencies, must handle its products and containers in an environmentally satisfactory and safe manner. In the future, other states are or will be considering similar programs.

Society is encouraging recycling of waste instead of open disposal or having it fill up rapidly disappearing county landfills. Recycling pesticide containers into other useful products or for resource energy recovery is a step in the right direction.

LISA: WHERE DO WEED SCIENTISTS FIT IN? Philip Westra, Assistant Professor, Weed Science, Dept. of Plant Pathology & Weed Science, Colorado State University, Ft. Collins, CO 80523.

Abstract. An analysis of the debate over North American farming systems shows a wide range of positions on the use of chemical inputs ranging from high level pesticide users to organic, zero pesticide users. These polar opposites are engaged in a fierce debate which encompasses politics, federal research dollars, consumer food quality issues, and environmental issues. As agriculture in North America becomes increasingly industrialized, new players (consumers, environmentalists, pro-organic groups) are increasingly demanding access to the inner circle of decision makers in American agriculture. Several ways for weed scientists to contribute to the resolution of this debate are offered in this article.

The LISA Debate

LISA is an acronym for Low Input Sustainable Agriculture, a new phenomenon in American agriculture which has stirred considerable debate since its arrival on the stage of food and fiber production in America. In its strictest sense, agricultural sustainability is defined by the Wisconsin Rural Development Center as "those methods which use less commercial fertilizer, herbicides, and pesticides". Other movements are closely allayed with LISA concepts and include organic farming, regenerative agriculture, biodynamic farming, French-intensive methods, and CIRA (Controlled Input Responsible Agriculture). Although these movements may differ in their tolerance of chemical inputs, all are motivated by a desire to reduce or eliminate chemical inputs in farming systems.

A dialectical analysis of the current debate over North American farming systems shows a widely divergent range of positions on the use of chemical inputs. The pro-chemical proponents advocate the use of any and all synthetic fertilizers herbicides, and pesticides in a decision making environment which primarily emphasizes economic considerations. The pro-organic proponents advocate food and fiber production without the use of any chemical fertilizers, herbicides, or pesticides. Other farmers may practice farming methods that use varying degrees of both of these positions. These polar opposites are engaged in a fierce debate which encompass politics, federal research dollars, consumer food quality issues, and environmental issues.

Herbicide use in the United States, based on pounds of active ingredient, increased six-fold from 1964 to 1986. Insecticide, fungicide, and use of other pesticides remained fairly constant over the same period. Herbicides represent by far the greatest volume of pesticides used in modern North American food and fiber production. This represents a disturbing trend in the eyes of some people, who would argue that we do not yet have adequate yardsticks to measure the environmental and health impacts of such quantities of herbicides entering the environment.

Additional considerations fuel the controversy over the use of chemicals in food and fiber production. By the year 2020, agricultural production worldwide will need to increase 90 to 140% to feed an anticipated world population of 10 to 11 billion. Estimates of current energy conversion ratios for conventional farming suggest that we extract only 1 unit of food energy for every 10 units of fossil energy input. Contemporary food and fiber production is based on relatively cheap fossil fuel, which has been used to replace high cost labor.

Modern agriculture has been dominated primarily by economic decisions, but increasingly is influenced by political decisions. People involved in agriculture are increasingly forced to consider environmental and food quality aspects of contemporary food and fiber production systems. Decisions affecting agriculture used to be the exclusive domain of farmers, bankers, and members of the ag chemical industry. As agriculture in North America becomes increasingly industrialized, new players (consumers, environmentalists, pro-organic groups) are increasingly demanding access to the inner circle of decision makers in American agriculture. For some weed scientists, this pressure to consider new impacts (beyond economic impacts) of our weed control systems is unwelcome, and viewed as perhaps an intrusion on our operating turf. Whatever our immediate response may be, it is clear that weed scientists will be called on by society to increasingly monitor and address new impacts of the weed control technologies we develop. This will call for a new integration of our multifaceted discipline to deal with political, environmental, and ethical issues. The industrialization of agriculture not only put the stamp of science and technology on agriculture, but also transformed agriculture's connection with economic and political powers.

Several key points and accusations are made by pro-chemical proponents.

1. We enjoy access to the best quality, cheapest food supply the world or any civilization has ever seen; this is due in no small part to scientific and technological revolutions in food production i.e. chemical fertilizers, pesticides, and new crop varieties.
2. Synthetic fertilizers and pesticides have minor health and environmental consequences compared to other aspects of our society such as smoking, industrial pollution, drugs, and alcoholism.
3. Our world is laden with many "natural, organic" toxins, many of which are far more toxic than man made pesticides.
4. Anti-pesticide people are not involved in a major way in food production, and do not understand the constraints to food production.
5. We will be non-competitive with foreign food producers who have access to banned North American technology (i.e. imported foods have high pesticide residue levels).
6. There is an obvious hypocrisy to organic farming proponents who then make other life decisions which place the health of themselves or their children at risk.

Several key points and accusations are also made by pro-organic proponents.

1. Current farming practices poison the land, pollute streams, contaminate groundwater, and waste renewable resources.
2. Modern farmers have grown accustomed to chemical dependency in their farming practices, and require an annual fix to keep their systems going.
3. Current farming systems do not make good long term economic sense.
4. There are "substantial hidden costs" (i.e. health, environmental, food quality) to our current "cheap" system of North American food and fiber production.

5. Going organic requires several years to rid the system of the shock of chemical poisons and fertilizers.
6. The "earth" (i.e. Mother Earth) possesses self-healing, regenerative powers which can be harnessed by organic farming methods.

Pro-chemical proponents tend to emphasize scientific research and tests which "prove" the efficacy of the modern farming system. Generally, they are quite well funded for their research activities. Pro-organic proponents tend to base their appeal on what I would term "religious type appeal" rather than on scientific evidence. They often are long on beliefs, but short on facts. Until the recent creation of the LISA competitive grants funding program, they have tended to be poorly funded, and still receive proportionately few of the total research dollars expended for North American agriculture.

Some might say of the pro-organic position "where's the beef?". Support for this position often is anecdotal, based on testimonials, and non-scientific in nature. Attendance at their meetings may be likened to a religious revival meeting, where the admission price for involvement is almost a spiritual requirement, i.e. "have you got the spirit to be one with us in this organic movement?". Sometimes the pro-organic people are referred to as "myth keepers" who guard some very real spiritual knowledge of an alternative form of agriculture that is essential to the heart and core of what American agriculture should be like.

Pro-chemical proponents may feel overwhelmed by the onslaught of publicity attacking their position, and often counter with a position that says "leave us alone, and we will provide you with a cheap, bountiful supply of food and fiber". Society increasingly is questioning the total cost, and the actual quality of this supply of food and fiber. Critics of the current system of agricultural production say "that mainstream agricultural institutions not only have not been able to grasp the essence of sustainable agriculture, but do not even want to .... mainstream agricultural institutions are too committed to the status quo to mount such a challenge". Although this may be a somewhat radical position, there is mounting sentiment that mainstream agricultural institutions have not risen to support sustainable agriculture in an appropriate fashion, and that the movement has its origins and motivation primarily from sources outside mainstream institutions.

For weed scientists the crucial question is "do we want to be part of the solution to the current debate about sustainable agriculture, or do we want to be part of the problem?". How do we remain part of the problem? By refusing to think about how we think about the science of weed control. When we allow our presuppositions and biases to color our response to weed science challenges, we affect our ability to conduct sustainable agriculture research.

Suppose for the sake of argument that society gives us a mandate to produce weed control strategies utilizing all existing and new herbicides currently available in the arsenal of weed control tools. If this makes us feel comfortable and self congratulatory on our past efforts as weed scientists, we need to look at scenario two that society presents us. Suppose that society gives us a mandate to produce weed control strategies that use no herbicides or synthetic chemicals. If this mandate makes our blood pressure rise, then perhaps we need to ask ourselves if we are "weed" scientists, or are we "chemical, herbicide" scientists. What intrinsic difference does it make to us, if we are objective and unbiased in our scientific, research endeavors, of we can use, or cannot use herbicides?

Part of the problem in American agriculture has been the shift in paradigms which rule our activities. For several decades, the ruling paradigm was the desire to provide food sufficiency for our country, and perhaps to help feed other people in the world. Recently, the paradigm of sustainability as influenced by land, energy, groundwater, and ecosystem conservation has come to influence the value system and discussion about American agriculture. Even more recent has been the arrival of the paradigm of rural community, along with discussions of the value of small family farms, the erosion of small rural communities in North America, and the way of rural American life has come to influence the debate over American agriculture.

One message seems to be coming through loud and clear today. Society is saying "read my lips; use less fertilizer and pesticides." Part of the dilemma is that our society expects "microwave solutions" to every problem. It is my conviction that if LISA is to be widely adopted, there will be no microwave solutions to support it. LISA research will require well funded, well planned, well executed long term research (5 to 10 years minimum) to provide the reliable data base to support LISA concepts in agricultural productions. What LISA proponents fail to realize is that once guns and bullets were invented, swords became irrelevant. Although fertilizer and pesticide can and will decrease in North America, the cultural unfolding of these technologies in the hands of North American farmers will preclude a total return the bucolic, idyllic ways of farming of the 1930's and 1940's in North America.

No-till pro-chemical farmers may be able to achieve excellent weed control with a preemergence soil applied and a single postemergence herbicide strategy. An organic farmer may have to make 5-7 mechanical tillage passes over a field in the same time frame to achieve comparable control. What will the economic costs be of such organic strategies? What will the environmental impacts be of additional tractors tilling weeds across North America? What will the effects be on carbon dioxide levels in the atmosphere, soil erosion, and soil compaction problems? Such issues will require an environmental balance sheet that will apply to the pro-organic strategy as well as the pro-chemical strategy. To do less will be to unleash the thoughtless pogroms of thoughtless bureaucratic decisions on a system that result in more harm than benefits. Such issues will require careful research and investigation by all parties involved in the debate.

We need to ask if the pro-chemical and pro-organic proponents approach weed control from radically different positions, or if there are common areas of overlap and congruence where meaningful cooperative research and dialogue can occur. I believe there are issues involving economics, food distribution (so that all people, including the poor and outcast of our society can eat), justice (so that all who want to eat can afford an adequate supply of good quality food), and environmental factors. Would we all not like to pass on to our children an agricultural production system as good as, or better than the one we inherited from our ancestors?

A frustrating problem faced by weed scientists (and other scientists) is that many people in our society are scientifically illiterate; they make decisions based on emotions rather than on facts. People ask less "what can science do for me?" but are inclined to ask more "what is science doing to me?" This subtle distinction is critical to the current mistrust of weed scientists and our ability to provide clean, safe systems of weed control.

With the expected peace dividend after the recent thaw in east-west relations, are we weed scientists being called to help beat the swords of our cultures into plowshares to feed the world? Should we look at LISA as an obstacle to advances in our science, or as an opportunity to help numerous disenfranchised farmers on our globe? Should we help head the move to rediscover plants as a source of nourishment for our bodies, our families, our communities and our country, or are we going to assist the move to view plants as biochemical factories to be manipulated and altered as powerful poker chips in a growing international poker game of economics and politics? We will need to work to change the current system of rewards for scientist who devote major portions of their careers to long term sustainable agricultural research.

There are specific ways in which weed science can fit into LISA projects.

1. We can be involved in meaningful dialogue with all players in the current agricultural systems debate.
2. We can lend the power of our scientific, logic oriented minds to sustainable weed control research. Pro-organic proponents need us to help design and conduct sustainable agriculture research.
3. We can increase our involvement in multi-disciplinary, systems research that deals with multi-faceted research topics.
4. We need to help lobby for additional state and federal dollars to fund long-term, integrated sustainable weed control research topics.
5. We need to help educate society and our children on the proper role of science in our world.
6. We can provide leadership in discovering innovative new ways to best manage weeds in sustainable farming systems.

All we ask of modern weed scientists is that you spend 10% of your time meaningfully involved in sustainable agriculture weed research to help resolve the debate about sustainable agriculture weed control strategies.

PESTICIDE RESIDUES AND CANCER RISKS. Carl K. Winter, Extension Toxicologist, Department of Entomology, University of California, Riverside, CA 92521.

The issue of pesticide residues in the human food chain is of considerable interest to consumers, consumer advocates, food producers, processors, retailers, the chemical industry, and government agencies. It is a highly controversial and extremely complicated subject. This report highlights the value of information in assessing potential carcinogenic risks from pesticide residues and recommends changes that could improve the accuracy of scientific data used in risk assessment. Of particular note are our recalculations of the National Research Council's dietary cancer risk estimates for several pesticides and selected foods, using alternative assumptions about exposure. The results differ markedly, calling into question the value of many current assumptions that generally underlie the risk assessment used in guiding regulatory decisions.

Risk assessment-quantification of the potential adverse effects of pesticides--is a critical component of our present regulatory system. Estimates of dietary risks from pesticide residues for selected pesticides and crops depend on (1) sound toxicology, to assess the potential for adverse health effects of specific pesticides; (2) information on pesticide use patterns, specifically to determine which materials may result in residues on food crops; (3) good data on the levels, if any, of residues that can be expected to occur; and (4) up-to-date estimates of the foods people eat, sufficiently identified by age, sex, ethnicity, and location to determine likely exposure levels. As greater reliance on risk assessments to guide regulatory poilicy develops, complete and accurate information concerning these variables is critical to effective and economically efficient regulation.

Although regulatory agencies use quantitative risk assessment methodology to estimate human health effects from exposure to toxic substances such as pesticides, it is an evolving science. Risk assessment suffers from many sources of uncertainty; knowledge of how chemicals cause cancer is far from complete. Uncertainty arises from the need to extrapolate from the high doses necessary to induce tumors in animals to the lower doses to which humans are likely to be exposed. Data from cancer studies of many pesticides are limited, and data on both pesticide use and residues on raw crops and in processed foods are insufficient to conduct aggregate risk analyses. Up-to-date information on dietary patterns of various population groups is also lacking.

To compensate for these uncertainties, risk assessment employs what have been termed worst-case or upper-bound statistical approaches in determining dietary risk. Basically, all components of the risk analysis are taken at their most conservative value to ensure that risk estimates are appropriately conservative. As such, carcinogenic risk estimates may be useful for regulatory purposes and, when adequate information is available, for comparing risks associated with various pesticides and other manufactured or natural chemicals. But the estimates do not predict actual human cancer incidence. This approach to risk assessment has been justified by these many uncertainties. It is quite possible, however, that priorities established on the basis of such analysis could result in a misallocation of resources.

NRC study. Concern over the degree to which pestitcide residues in the food chain pose risks to consumers has prompted studies by consumer groups, research units, and government agencies. The most comprehensive study was performed by the National Research Council (NRC) of the National Academy of Sciences in 1987. The NRC study was requested by the U.S. Environmental Protection Agency (EPA) to examine the existing statutory basis for establishing legal levels (tolerances) for pesticide residues in food and assess the operation of the tolerance-setting process in practice. The NRC development estimates of dietary cancer risks from pesticides currently in use and explored alternative regulatory approaches, evaluating the effects of these alternatives on health risks and pesticide use patterns. The NRC study has been critical in reforming existing pesticide policy.

The NRC risk analysis relied largely on the baseline of pesticides that have food tolerances using EPA's existing pesticide data base. The analysis largely followed EPA's current risk assessment techniques, employing the two-stage linear dose-response model and "potency factors" (slopes of the dose-response model estimated from animal studies) developed by EPA. These currently exist for 28 of the 53 pesticides identified by the EPA as suspected carcinogens. Assumed pesticide residue levels in foods were set equal to legal tolerance levels, with estimates of dietary exposure to residues derived from aggregate estimates of food consumption in the United

States. Because of this approach, the NRC estimates are considered "legally allowable risk," which is quite different from actual risk. Risk was thus characterized as a person's probability of additional risk of cancer from a lifetime exposure to pesticide residues at levels legally allowed in food products under existing regulations.

Results of the NRC risk assessment indicate that the total legally allowable risk (the additional risk of cancer from 70 years of exposure to these 28 potentially carcinogenic pesticides at tolerance levels in food) was slightly less than 0.006 or 5.84×10^{-3}. (This is in addition to the current general cancer risk for the U.S. population of 0.25, or one in four.) The risk estimates were also separated into categories of pesticides. Fungicides made up the largest proportion (nearly 60%) of estimated risk; herbicides' share of the total was greater than that for insecticides (approximately 27% and 14%, respectively). Older (pre-1978) pesticides appeared to generate a larger share of risk.

Results suggest that in the case of both herbicides and insecticides, one or two chemicals explained a large portion of estimated risk, yet risk appeared to be more uniformly distributed among fungicide compounds. Twelve pesticides were identified by the NRC as contributing 96% of estimated dietary risk. According to the NRC, greater risk was associated with raw than with processed food products (80% and 20%, respectively). Fifteen foods accounted for nearly 80% of total dietary risk from pesticide residues with the greatest risks calculated from exposure to tomatoes, followed by beef, potatoes, oranges, lettuce, apples, peaches, pork, wheat, soybeans, beans, carrots, chicken, corn, and grapes. From this analysis, the NRC concluded that exposure to potentially carcinogenic pesticides was likely to be concentrated in a few foods and be derived from a relatively small number of pesticides, many of which were registered before 1978.

Bias in cancer risk estimates. Given the known gaps in the data and the compensating assumptions made in developing dietary risk estimates, the NRC figures are likely to be biased estimates of real risks. Therefore, the specific risk-benefit estimates and rankings of foods and pesticides presented in the NRC report should be viewed with considerable caution, rather than immediately used to guide regulatory action.

For example, in the absence of data on actual pesticide use patterns and residue levels, the NRC assumed that all material registered for use on a specific crop are always used at maximum levels allowed and are always present on that crop at levels equal to the legal tolerance limit. This assumption surely leads to substantial upward bias in risk estimates.

Use varies by region and within a crop cycle in any given region. In California, for example, many pesticides are not used on specific commodities, although they may be registered for use. (See Fig. 1 , which compares registered and actual uses of 9 of the 12 riskiest pesticides identified by the NRC.) When pesticides are used on specific commodities, pesticides may not be applied to all of the commodity acreage (Table 1), therefore, the assumption that all materials registered for a crop are actually used may greatly overstate pesticide use. The assumption also can bias the ranking of foods by associated dietary risk, since more materials are registered for crops whose high value and market size provide economic incentives to pesticide manufacturers. If the 26 most frequently consumed fruits and vegetables are ranked by the number of pesticides registered for use on each, the list is almost identical to the NRC list of the 15 foods with the greatest dietary risk.

Setting residues at tolerance levels because it is difficult to obtain data on actual residue levels leads to additional upward bias. Despite a lack of consensus on estimates of actual food residues, historical data from the Food and Drug Administration (FDA) and the California Department of Food and Agriculture (CDFA) over the past two decades consistently show that residues in excess of established tolerance levels are encountered infrequently (generally in less than 1% of the samples). In California in 1987, for example, 1,839 lettuce samples and 259 tomato samples were analyzed by CDFA for residues of over 100 pesticides. No residues were detected in 78% of the lettuce samples and 81% of the tomato samples. In the majority of lettuce and tomato samples in which residues were detected, residue levels were within 10% of the established tolerances. These results are not surprising, considering that tolerances are established to exceed the maximum residues determined from field studies using the most severe application conditions, including maximum application rate, maximum number of applications per growing season, and minimum preharvest intervals. Typical, legal application of pesticides should therefore not result in residues approaching tolerance levels. The NRC's assumption that residues would

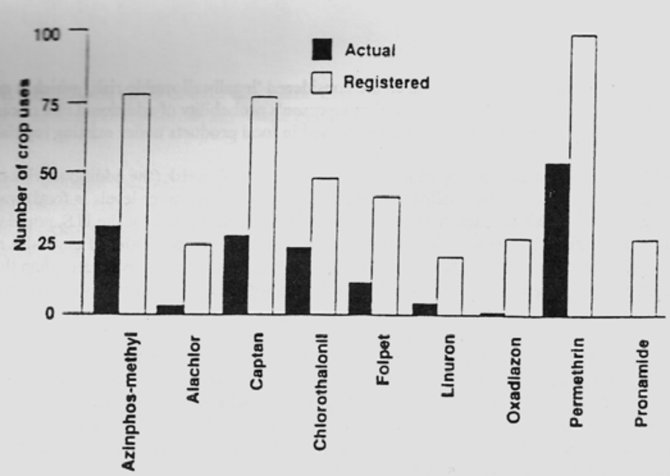


Fig. 1. Number of actual uses of selected pesticides in California in 1986, compared with their registered crop uses. (Sources: California Department of Food and Agriculture and National Research Council, 1987)

always be present at tolerance levels biases risk estimates significantly upward, leading to distortions in risk rankings.

Other assumptions used in the analysis, however, may bias risk estimates downward, lending even greater uncertainty to the estimates. Risk estimates were based on data for only 28 of 53 suspected carcinogenic pesticides accounting for less than 10% of food-use pesticides. A second source of underestimation derives from the fact that many tolerances were set for pesticides with incomplete toxicological data. Of the active pesticide ingredients registered for use on food, most were registered before 1972. Also, estimates of dietary exposure to residues were based on the 1977 to 78 U.S. Department of Agriculture (USDA) Food Consumption Survey. Food consumption patterns have changed significantly over the past decade, with noticeable decreases in the quantities of processed foods consumed and increases in consumption of raw fruits and vegetables. Furthermore, NRC's use of aggregate averages ignores significant differences in dietary patterns in children, women, and the elderly, as well as regional differences. Average consumption estimates imply that the "average" American would have to consume less than 7.5 ounces per year of 74 different foods, when many may consume more than this quantity of some foods such as almonds or mushrooms.

Recalculations of cancer risk. To highlight difficulties with NRC's underlying assumptions in their cancer risk estimates, we recalculated dietary risk in two ways. In both we held constant the cancer potency factor but used exposure estimates that differ from NRC's.

The first method recalculated the dietary risk of selected pesticides by basing exposure on results from FDA's 1987 Total Diet Study, in which inspectors purchased "market baskets" of selected food items, including meat and poultry, and had the food prepared "ready-to-eat" in institutional kitchens before analyzing for residue. A total of 234 food items were selected to represent the 5,000 foods identified in the 1977 to 78 USDA Nationwide Food Consumption Survey and the 1976 to 80 National Health and Nutrition Examination Survey. Samples of each food were purchased from retail stores in three cities in each of four U.S. geographical areas (northeastern, southern, north central, and western). This approach more accurately documents actual human exposure to pesticide residues, since it reflect the changes in residue levels that may result from transportation, handling, preparation, and processing, all of which have been shown to have the potential to dramatically alter pesticide residue levels.

Table 1. Percentages of lettuce and tomato acreage treated with selected pesticides in Calfornia.

Commodity, pesticide	Percent treated
LETTUCE	
Acephate	95.92
Captan	5.48
Dinoseb	33.79
Folpet	18.29
Mancozeb	1.64
Maneb	13.53
Methomyl	223.29*
Parathion	21.53
Permethrin	212.21
Zineb	<1.00
TOMATOES	
Benomyl	1.86
Captafol	1.13
Chlorothalonil	26.42
Dicofol	2.28
Folpet	<1.00
Glyphosate	15.09
Lindane	1.17
Mancozeb	4.44
Maneb	4.16
Parathion	5.62
Permethrin	3.84
Trifluralin	9.53

*Percentages greater than 100 indicate that some acreage is treated more than once.

Table 2. Comparison of estimated cancer risks from selected pesticides under alternative exposure assumptions.

Chemical	NCR estimates	6-11 months old	14-16 years males	60-65 years females
Acephate	37.3	0.01725	0.02139	0.03243
Linuron	1520	0.328	0.0984	0.1312
Captan	474	0.04462	0.02024	0.05612
Permethrin	421	2.13	0.9	1.215
Chlorothalonil	237	<0.0024	<0.0024	0.0024
Parathion	14.7	0.01116	0.00126	0.00288
Folpet	324	0.0273	0.01015	0.0336

Table 3. Comparison of estimated cancer risks under alternative residue assumptions.

Commodity, pesticide	NCR tolerance	FDA residue data*
TOMATOES		
Acephate	14	0.0017
Azinphos-methyl	0.00015	$1.5x10^{-8}$
Captafol	191	0.0033
Captan	29	0.0026
Chlordimeform	479	0
Chlorothalonil	61	0.23
Folpet	45	0.00017
o-Phenylphenol	8	0
Parathion	0.92	0.0002
Permethrin	31	0.088
Total	859	0.33
LETTUCE		
Acephate	16	0.025
Captan	55	0.011
Folpet	42	0.054
Parathion	0.43	0.00025
Permethrin	143.4	0.8
Pronamide	3.8	0.0044
Total	261	0.89

*Authors' recalculations are based on residue data from FDA Los Angeles laboratory, 1982-86.

The second method recalculated the dietary risk from pesticides on tomatoes and lettuce, basing exposure on actual residues found by FDA's Los Angeles laboratory.

First recalculation. Table 2 presents the NRC estimates of cancer risk for 7 pesticides (for which data were available) of the 28 analyzed by NRC. In the recalculation, instead of using NRC exposure estimates, we used data from the 1987 FDA Total Diet Study for population subgroups.

The risks calculated by the NRC for these seven pesticides ranged from 14.7 to 1,520 excess cancers per million. Five of the pesticides (linuron, captan, permethrin, folpet, and chlorothalonil) were ranked among the top 10 pesticides contributing to dietary cancer risk by the NRC. With our recalculation, these risks dropped by several orders of magnitude. Only one pesticide, permethrin, exceeded the EPA's "negligible risk standard" of one excess cancer per million. Risks posed by the other six pesticides were from 4,600 to nearly 100,000 times lower than NRC estimates. Although different results are obtained for the three population subgroups due to differences in food consumption patterns, more realistic calculations of cancer risk would require that the age-group data be combined, since risks are calculated assuming 70 years of exposure. It is not valid to consider that the risks of the 6- to 11 -month-old subgroup are accurate for lifetime estimates, because this assumes that consumption patterns and body weight would remain constant for 70 years.

Even though we did not obtain data necessary to evaluate the other 21 potentially carcinogenic pesticides analyzed by NRC, monitoring data provide evidence about actual residue levels for many of these pesticides. We know that the FDA detected no residues of six potentially carcinogenic pesticides--chlordimeform, oxadiazon, alachlor, diclofop-methyl, metolachlor, and ortho-phenylphenol--and that residues were well below tolerances in other cases.

Second recalculation. The NRC assumption that all residues were always present at tolerance levels may also have severely distorted the estimated aggregate cancer risks from consumption of specific commodities. More pesticides are registered for use on high-value, high-volume commodities. Therefore, the assumption that all pesticides registered for use on a crop are actually used overstates pesticide use on these crops and the cancer risk these pesticides pose. Such logic does not take into account actual pesticide use practices on specific commodities.

Alternatively estimated cancer risks from pesticides used on tomatoes (the riskiest food identified by the NRC) and on lettuce (the fifth riskiest food) are shown in Table 3. Risks reported by the NRC are compared with our recalculation using FDA residue data from its Los Angeles laboratory from 1982 to 1986. During this period, 3,179 tomato and 2,139 lettuce samples were analyzed for residues of over 200 pesticides, including all of the pesticides shown in Table 3.

Large differences exist between NRC's calculated cancer risks using tolerance levels and ours using actual residue findings. The NRC, for example, found the major contributor to cancer risk for tomatoes was chlordimeform, but chlordimeform was not detected by the Los Angeles laboratory. Both the NRC and our recalculation found the main contributor to cancer risk on lettuce was permethrin, but the risks calculated using actual residue data were considerably lower.

Conclusions. Estimates of carcinogenic risk from the presence of pesticide residues have been provided. Such estimates differ greatly depending on the assumptions used in calculating them. The assumption by the NRC that all residues will always be present at the tolerance levels results in estimates of carcinogenic risk several orders of magnitude greater than the risks calculated using residue data. Our analysis clearly shows that tolerances do not equal exposure and demonstrates that the use of tolerance values to calculate risk is not appropriate. Such calculations should be used only as guides to more in-depth analysis. Even then, it may be critical to obtain more information on actual use and probability of exposure to ensure that relative risk rankings are accurate.

Additional uncertainty is associated with gaps in toxicological data for a large number of pesticides. Toxicology is an evolving science, and information that meets today's standards may be considered inadequate within a few years. If risk assessments are to guide regulatory policy, toxicology must be current and complete.

Concerns about the cancer risks posed by pesticides in the food chain have triggered calls for regulatory action and legislative reform. The choice of methods used to evaluate cancer risks and the criteria for establishing which risks are excessive should be made on the basis of the best scientific data available. Our analysis shows that lack of accurate data can impart great imprecision to the estimates of dietary risk. Probable risks based on likely pesticide use patterns and residues in foods indicate that the carcinogenic risks from pesticides may be well below earlier estimates. At the same time, it may be difficult to assess the effects on agriculture of modifying the use of specific pesticides. Eliminating a specific pesticide may increase pesticide expenditures by an estimated amount, as more expensive substitutes are employed, and yields and quality may be reduced, affecting supply and demand in a complex manner. In cases where no substitute chemicals are available, economic costs of use withdrawals would be higher. Economic impacts will depend on actual pesticide use patterns, benefits--including quality effects--from specific materials, and substitution possibilities.

Consideration should also be given to alternative risks to public health following removal of a specific pesticide. Elimination of specific fungicides, for example, could decrease the safety of the food supply by allowing the production of greater levels of naturally occurring fungal carcinogens. Better understanding of use patterns, benefits, and substitution possibilities remains critical to any reliable estimation of economic and health costs of pesticide withdrawals. Absence of actual data to estimate both risk and benefits of pesticides complicates and compromises the use of quantitative risk assessment as a regulatory tool.

THE SANDOZ COMMITMENT TO BIOLOGICALLY DERIVED PESTICIDES. Dan Hess, Sandoz Crop Protection, Zoecon Research Institute, Pulo Alto, CA.

Paper not submitted for publication.

POSTER SESSION

MONITORING THE OCCURRENCE OF SULFONYLUREA RESISTANT PRICKLY LETTUCE.
Mauricio Alcocer-Ruthling and Donald C. Thill, Graduate Assistant and Associate Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83843.

Abstract. Sulfonylurea herbicides control broadleaf weeds effectively and economically in several crops. However, it has been observed recently that these herbicides no longer control prickly lettuce in wheat fields where it was controlled previously. The objective of this survey was to determine the spread of sulfonylurea-resistant prickly lettuce beyond the original resistance point. Prickly lettuce seeds were collected in September, 1988 and October 1989 from plants growing in fields of wheat stubble and along roadsides within a 4 km radius of the original resistance point. The seeds were germinated in potting mix at 20 C in a growth chamber. The plants were sprayed at the one to two leaf stage with 4.2 g/ha of metsulfuron. In 1988, one site within the original point of herbicide resistance and another site 1.8 km along the roadside southeast and downwind from the original site had plants that survived the treatment. In 1989, three sites had resistant biotypes; 2.5 km north, 2.3 km southeast, and 2.3 km east from the original resistance point. One site from the 1989 survey was on the edge of a highway that had been sprayed with sulfometuron for 2 yr consecutively and may be an independent occurrence of resistance.

SPURRED ANODA INTERFERENCE IN CHILE PEPPERS. Jill Schroeder, Assistant Professor, New Mexico State University, Box 30003, Department 3BE, Las Cruces, N.M. 88003.

Abstract. Chile peppers (Capsicum annuum L.) are planted in New Mexico during March, thinned (15 cm height) in late May, and harvested for green and/or red pods in August and October, respectively. The thinning and harvest procedures require hand labor. Chile peppers emerge and grow slowly and are poor competitors with weeds. Herbicides are available which provide grass control; however, large seeded broadleaf weeds which emerge after thinning are a major problem. Spurred anoda is common throughout the chile growing region and is not controlled by registered herbicides. Spurred anoda emerges, beginning in mid-May, throughout the season. Hand labor has been utilized for late season weed control; however, immigration legislation has made hand labor expensive and scarce. Therefore, research was initiated in 1989 to determine if spurred anoda interference is detrimental to chile pepper yield, quality and ease of harvest. Chile was planted March 22, 1989 and thinned to one plant per 10 cm on June 5. Acid scarified spurred anoda seed was planted to provide densities of 0, 3, 6, 12, 24 and 48 plants per 9 m of row alone and 10 cm from the row of chile (spurred anoda emergence - June 12). Plots were four rows (100 cm spacing) by 9 m in length. Spurred anoda was established only in the middle two rows of each plot. One center row was harvested by hand in August and October for green and red pods, respectively. Time to harvest each plot, chile yield, percent marketable pods (green chile only), and spurred anoda number and weight per plot were measured. Spurred anoda at 48 plants per 9 m reduced the yield of green pods but not the time required for harvest compared to the control. Red yield and time required to harvest were not affected by spurred anoda density. Spurred anoda did not mature until October. Spurred anoda weight (average) was not affected by density. However, mean spurred anoda weight at green harvest was 0.17 and 0.65 kg growing in competition with chile and alone, respectively. Mean spurred anoda weight at red harvest was 0.45 and 0.97 kg growing in competition with chile and alone, respectively.

DOSE-RESPONSE OF PEAS, LENTILS, POTATOES, SUGARBEETS, AND ALFALFA TO SULFOMETURON. L. W. Lass and R. H. Callihan, University of Idaho, Moscow, ID 83843 and L. K. Hiller, Washington State University, Pullman, WA 99164.

Abstract. This study used logarithmic dose treatments of sulfometuron to enable development of dose-response

curves and to identify the nature of injury induced. Pre-emergence applications were made with a tractor-mounted sprayer to 3 by 30 m paired-plots in a randomized complete block design with 4 replications. The logarithmic dose curve was established prior to application by spectrophotometric measurement of dye applied through the log sprayer. Crop responses to sulfometuron at rates of 2.19, 1.64, 1.09, 0.55, 0.27, 0.14, and 0.07 g/ha were measured. Average pea height during pod fill was reduced 93% by 2.19 g/ha, 87% by 1.64 g/ha, 73% by 1.09 g/ha, 66% by 0.55 g/ha, and 25% by 0.27 g/ha sulfometuron. The number of pea pods were reduced by 100% at 2.19 and 1.64 g/ha, 99% at 1.09 and 0.55 g/ha, 93% at 0.27 g/ha, 57% at 0.14 g/ha and 56% at 0.07 g/ha. Lentil height at pod set was reduced 66% at 2.19 g/ha, 59% at 1.64 g/ha, 45% at 1.09 g/ha, 48% at 0.55 g/ha, 36% at 0.27 g/ha, 18% at 0.14 g/ha and 13% at 0.07 g/ha. Alfalfa height at bloom was reduced 80% or more at 2.19, 1.69, and 1.09 g/ha, 72% at 0.55 g/ha, 61% at 0.27 g/ha, and 44% at 0.14 g/ha. Sugarbeet height was reduced 92% at 2.19 g/ha, 88% at 1.64 g/ha, 75% at 1.09 and 0.55 h/ha, 60% at 0.27 g/ha, and 32% at 0.14 g/ha. Potato height and shoot size were not reduced by the treatments; typical sulfonylurea malformations of tubers were severe at 2.19 g/ha, grading to light at 0.27 g/ha.

ARE WEED PROBLEMS CAUSED BY COMPETITION OR DISPERSION? Claudio M. Ghersa. Visiting Professor. Crop Science Department, Oregon State University, Corvallis, OR 97331.

Abstract. It is proposed that understanding competitiveness of weeds and effects of competition in crop-weed stands is a prerequisite for measuring effects of weeds on crops. In addition crop competition may be an integral part of weed control systems. In this paper, I present information derived from models of the population ecology of Datura ferox (L.) (Chinese thornapple) and Johnsongrass suggesting that dispersion of propagules can be more important than competition process in dealing with weed problems. The model outputs show that yield reductions are more sensitive to changes in the dispersion rates than to changes in the relative ability of the crop to compete with the weeds. Thus, more attention should focuse on dispersion, and such studies should look for the capacity of the whole cropping systems to disperse propagules, rather than for the plant species adaptations to disperse its seeds.

INCREASING THE EFFICACY IN CONTROLLING JOHNSONGRASS (Sorghum halepense (L.) Pers). Claudio M. Ghersa and Miguel Van Esso. Visiting Professor. Crop Science Dept. Oregon State University and Teaching Assistant. Dept. of Ecology. University of Buenos Aires, Argentina

Abstract. Knowledge of population ecology of weeds can allow improvements in current cropping systems and could effectivelly reduce weed abundance. Studies with Johnsongrass indicate that it has a crucial period for its perpetuation (CPWP), which occurs when rhizome biomass is at a minimum. We hypothesized that traditional control practices (e.g. soil tillages and presowing or postemergence herbicide application) performed during the CPWP would substantially improve the efficacy of these tools. Results showed that relatively small but precise changes in the cropping system (which included soybean and sunflower crops) yielded tremendous reductions in the persistance of the weed population. In one growing season weed infested areas were reduced over 80% in comparisons of precise vs. the traditional control practices in soybean crops. In sunflower cropping systems, greater reductions were obtained in one year when precise control was performed. We propose that threshold criteria should be revised to include the perpetuation of the species as well as competition relationships. Knowledge about weed perpetuation, obtained from population ecology studies, are usefull to develop weed reduction strategies.

EFFECT OF EARLY POSTEMERGENCE HERBICIDES ON SEEDLING ALFALFA. Larry S. Jeffery, Professor, Department of Agronomy and Horticulture, Brigham Young University, Provo, UT 84602.

Abstract. Four herbicides in various combinations were evaluated for their effects on seedling alfalfa in 1988 and

1989. Alfalfa was seeded during the second week of April each year. Herbicides were applied when seedling alfalfa was 15 to 25 cm tall. Herbicides and rates used were: fluazifop at 0.3 kg/ha; sethoxydim at 0.3 kg/ha; bromoxynil at 0.3 kg/ha; and 2,4-DB at 0.8 kg/ha. Fluazifop and sethoxydim were applied in combination with either a nonphytotoxic crop oil or adjuvant. Bromoxynil reduced alfalfa yield each year and sethoxydim reduced yield in 1989. Fluazifop combined with nonphytotoxic crop oil had no effect on alfalfa yield in either year but in combination with an adjuvant reduced yield in 1988. 2,4-DB had no effect on alfalfa yield in either year. A mixture of fluazifop plus 2,4-DB reduced alfalfa yield in 1988 but not in 1989. A mixture of sethoxydim plus 2,4-DB reduced alfalfa yield each year.

INTRODUCTION

Alfalfa is the most productive forage grown in the irrigated areas of the western United States. It is often seeded separately in the fall or with a nurse crop such as barley or oats in the spring or fall. When planted separately in the spring, alfalfa seedings often fail because many annual broadleaf weeds and weedy grasses germinate at approximately the same time and offer heavy competition to the fragile, slow establishing, noncompetitive alfalfa seedlings. If left uncontrolled, weeds reduce forage quality and yields and weaken or reduce the alfalfa stand. Herbicides are necessary to reduce weed interference in spring seeded alfalfa stands. Benefin and EPTC have been applied as preplant incorporated herbicides to reduce weed interference. At times when these herbicides have not been applied or when weeds escape their action, a post emergence herbicide is needed. Until recently 2,4-DB was the only postemergence herbicide labeled to control annual broadleaf weeds in seedling alfalfa. In 1989 bromoxynil was also cleared for this purpose. Sethoxydim is currently labeled for postemergence control of grasses in alfalfa and some research is being conducted to evaluate for weedy grass and alfalfa tolerance with fluazifop. Most of the research with fluazifop and sethoxydim has been conducted on established alfalfa.

The objectives of this study were to measure seedling alfalfa response to 2,4-DB, bromoxynil, fluazifop and sethoxydim applied singly and in various combinations and to determine if th use of a surfactant in place of the nonphytotoxic crop oil concentrate normally added to fluazifop and sethoxydim would reduce phytotoxicity to seedling alfalfa.

MATERIALS AND METHODS

A field study was conducted in both 1988 and 1989 at the Brigham Young University Agricultural Experiment Station to evaluate four foliar-applied herbicides, bromoxynil, 2,4-DB, fluazifop, and sethoxydim, singly and in various combinations for phytotoxicity to seedling alfalfa. Either a surfactant or a nonphytotoxic crop oil concentrate was mixed with each fluazifop and sethoxydim containing treatment. For comparative purposes, two preplant herbicides, benefin and EPTC, and a non-herbicide treated control were also included. Herbicide treatments and rates are shown in Table 1. The experiment was established on a Timpanogos loam, (Calcic Argixerolls fine loamy, mixed mesic). 'WL 312' alfalfa was seeded April 13, 1988 and April 17, 1989. EPTC and benefin were applied preplant incorporated on April 12, 1988 and April 13, 1989 using a power-driven rototiller set to cut 7.5 cm deep. Alfalfa seed was dropped on the soil surface from the legume seeding attachment mounted on a grain drill and pressed into the soil surface with a cultipacker. After planting the plot area was sprinkle irrigated as needed. Postemergence herbicides were applied on June 16, 1988 and June 7, 1989. Alfalfa was 20 to 25 cm in heighth at the time the postemergence herbicides were applied in 1988 and 15 to 20 cm tall in 1989. All herbicides were applied using a hand-carried, CO_2-powered sprayer delivering 190 L aqueous spray/ha. Herbicides were applied to 2.4 x 9 m plots arranged in a randomized complete block design and replicated 3 times. Data were obtained for alfalfa vigor reduction on June 14, 1989 and for height at the time of the first cutting 1988 and 1989. Yield data from the first cutting were obtained on July 6 each year and for the second cutting on August 14, 1989. No data were obtained for the second cutting in 1988 or for the third cutting in either year. Data means were separated using an analysis of variance.

RESULTS AND DISCUSSION

Excellent stands of virtually weed-free alfalfa were obtained each year, thus differences in alfalfa vigor, height

Table 1. Effect of overtop herbicides on seedling alfalfa. Brigham Young University Agricultural Experiment Station, Provo, UT.

Herbicide	Rate	Vigor reduc.[1] 1989	Height 1988	Height 1989	Alfalfa yield 1988 1st cut	Alfalfa yield 1989 1st cut	Alfalfa yield 1989 2nd cut
	kg ae/ha	(%)	----(cm)----		-----------(kg/ha)----------		
Bromoxynil	0.3	12	51	56	3258 b-d[4]	3631 cd[4]	4200
2,4-DB	0.8	2	55	61	3476 a-d	4782 ab	4139
Fluazifop+OC[2]	0.3	0	47*[5]	60	3246 b-d	4907 ab	4529
Fluazifop+Surf[3]	0.3	0	49*	56	2718 de	4361 a-c	4217
Fluazifop+bromoxynil+OC	0.3+0.3	3	50	56	3252 b-d	3793 cd	4343
Fluazifop+bromoxynil+Surf	0.3+0.3	8	47*	58	2938 c-e	4118 a-d	4440
Fluazifop+2,4-DB+OC	0.3+0.8	12	37*	54*	2225 e	3736 cd	4179
Fluazifop+2,4-DB+Surf	0.3+0.8	0	44*	60	2212 e	4492 a-c	4465
Sethoxydim+OC	0.3	2	54	60	3776 a-c	4005 b-d	4283
Sethoxydim+Surf	0.3	2	--	53*	--- ---	3720 cd	4080
Sethoxydim+bromoxynil+OC	0.3+0.3	8	50	53*	2992 c-e	3922 b-d	4160
Sethoxydim+bromoxynil+Surf	0.3+0.3	15	51	56	3295 a-d	4014 a-d	3993
Sethoxydim+2,4-DB+OC	0.3+0.8	17	55	53*	3314 a-d	3690 cd	4187
Sethoxydim+2,4-DB+Surf	0.3+0.8	17	49*	53*	2875 de	2836 d	4342
Benefin	1.7	0	58	60	4021 ab	3986 b-d	3892
EPTC	3.4	2	58	53*	3903 a	4775 ab	4221
Control	---	0	57	61	4021 ab	5042 a	4124
Control+OC	---	-	--	60	---- --	4321 a-c	4538
Control+Surf	---	0	--	60	---- --	4900 ab	4239
LSD			7.0[6]	7.0[6]			NS[7]

[1]Vigor reduction is a visual estimate where 0 = no injury and 100 = complete kill.
[2]O.C. = Oil concentrate applied @ 2.3 l/ha.
[3]Surf. = surfactant applied @ 2.3 l/ha.
[4]Values followed by the same letters within columns not significantly different at the 5% level according to Duncan's multiple range test.
[5]* = Significantly lower than the control.
[6]LSD for height in 1988 at 0.05 level and in 1989 at 0.1 level.
[7]Differences in second cutting alfalfa yield in 1989 are not significant.

and yield among herbicide treatments and the nonherbicide-treated control are attributed to herbicide action.

First Crop. Several herbicides caused a slight reduction in alfalfa vigor (Table 1). Vigor reduction was in the form of leaf spotting and height reduction. Most fluazifop treatments reduced alfalfa height in 1988 but not in 1989. Several of the sethoxydim treatments reduced alfalfa height in 1988 (significant at the 10% level) and in 1989 (significant at the 5% level).

No alfalfa yield reductions occurred on plots treated with 2,4-DB. Bromoxynil significantly reduced seedling alfalfa yields in 1989 but not in 1988. Fluazifop plus crop oil concentrate had no effect on seedling alfalfa yield in either year; however, when a surfactant was substituted for oil concentrate, fluazifop reduced alfalfa yield in 1988 but not in 1989. In 1988, sethoxydim plus crop oil concentrate did not reduce alfalfa yield; but in 1989 sethoxydim with either crop oil concentrate or surfactant reduced seedling alfalfa yield.

In most cases the combination of either bromoxynil or 2,4-DB with either fluazifop or sethoxydim reduced seedling alfalfa yields. The effect of crop oil concentrate or surfactant on these combination treatments is unclear although sethoxydim plus bromoxynil plus surfactant did not significantly reduce seedling alfalfa yield in either year. The preplant herbicide applications of benefin and EPTC had no effect on seedling alfalfa yield in 1988 although benefin treated alfalfa plots yielded less than the nonherbicide treated control in 1989.

Crop oil concentrate and surfactant applied without a herbicide had no effect on seedling alfalfa yield.

Second Crop. Seedling alfalfa recovered after first cutting and none of the herbicide treatments had an effect on vigor, height or yield obtained for the second crop of alfalfa in its seedling year.

CONCLUSION

Some postemergence herbicides reduce the first crop yield of seedling alfalfa. In this experiment 2,4-DB (0.8 kg/ha), fluazifop plus crop oil concentrate (0.3 kg/ha plus 2.3 L/ha) and sethoxydim plus bromoxynil plus surfactant (0.3 plus 0.3 kg/ha plus 2.3 L/ha) did not significantly reduce first crop seedling alfalfa yield. Bromoxynil applied separately and all other treatments containing bromoxynil, 2,4-DB, fluazifop and sethoxydim reduced first crop seedling alfalfa yield. Seedling alfalfa recovered after first cutting and none of the herbicide treatments affected second crop alfalfa yield. The differences in phytotoxicity due to crop oil concentrate and surfactant is unclear.

PHOTOGRAPHIC TECHNIQUES IN WEED SCIENCE. Jack Schlesselman, Research and Development Representative, Rohm and Haas Company, 726 E. Kip Patrick, Reedley, CA 93654.

INTRODUCTION

Photography can be a useful "tool" in weed science. This has little to do with "weed science" per se, but one that is based on education. The end result for those of us in weed science is to disseminate information we have acquired. Most of us are "educators"; whether a university professor, weed scientist, industry R&D representative, etc. Getting our point across is of the utmost importance, if we are to be successful. Photography can be used to add interest, a better understanding, and perspective to publications and presentations. Some of the areas where photography can be used might be in weed identification, herbicide symptoms, documenting research trials, and efficacy of a product or an innovative weed control technique.

The following are some photographic "tips" or suggestions which should be helpful in obtaining the desired effect. They are not the only way to use photography in weed science, but are some methods or techniques that I use and have worked for me. No matter how long a person has been interested in photography, there is always something new to learn, or some different technique that might work better.

CAMERA AND LENSES

The most widely used camera is the 35mm single lens reflex (SLR). This camera allows you to look directly through the lens at what you're going to photograph. The other popular camera used in the field is the 35mm viewfinder which has a viewing area separate from the lens. A viewfinder camera is useful for most field situations, but is extremely limiting the closer you get to the subject. Of course when using an SLR, there's no problem with close-ups since you're looking directly through the lens at the subject. There is a definite cost advantage with the 35mm viewfinder camera, but that doesn't offset the versatility advantage with the 35mm SLR.

There are numerous 35mm SLRs on the market today. The past several years have spawned the "auto-everything" camera that does just that; everything automatically in terms of exposure and focusing. Generally the automatic mode will give satisfactory results, but sometimes can be fooled by unusual light conditions and/or lack of sharpness due to subject position. Therefore I would not recommend an automatic 35mm SLR that does not have a manual override; which allows for a little creativity on the part of the photographer.

One of the greatest advantages with using a 35mm SLR is the selection of lenses available for every need. The standard or normal lens that usually comes with the camera body is the 50mm. This lens "sees" subjects as our eyes do, with very little distortion. This is the lens that will be used in most situations in the field and will focus down to about 18 inches from the subject.

When photographing plotwork at close range, a wide angle lens such as 28mm or 35mm is useful to encompass a large area of foreground. To get the same area in a normal lens, you would have to back up a considerable distance out of the plot area.

A third useful lens is the zoom telephoto, which generally ranges from 80-200mm. This type of lens allows you to compose the shot by bringing distant subjects closer for more detail. There are zoom lenses which cover the complete range from wideangle to telephoto (ie: 28-200mm). This may be alright for the photographer who wants to shoot everything with one lens, but will generally not be as sharp as other lenses (depending on the brand and price).

FILM

Selecting the right film to use can be as confusing as deciding on the appropriate camera. For anyone who has gone into a camera shop and observed the wall covered with endless brands, film types and speeds, it can be a nightmare. All films have an exposure speed, usually expressed in "ASA". The higher the ASA, the more light-sensitive the film will be, and less light will be necessary for proper exposure (compared to "slower" film or lower ASA film). There are trade-offs with fast (high ASA) verses slow (low ASA) film. The fast films (with ASA of 400+) are great for low light conditions or when photographing fast moving objects. However, fast film can be grainy (less sharp), and does not always give the correct color reproduction (example of the blue tinge with Ektachrome 400). Slow film (25-100 ASA) will result in the sharpest image and best color, but does require more light. For most conditions, the film with 64-100 ASA will give the best results, and is the choice of most photographers. However, always carry some fast film for those special low-light situations.

TRIPODS

A tripod can be a very useful piece of equipment in photography. There is a great debate among photographers on their practicality. I generally don't use a tripod in the field. I find them very cumbersome and difficult to use when composing a photograph (especially close-up work). For other photographers, a tripod is a necessity and they wouldn't be caught without one. The bottom line is whatever works for you. A tripod definitely eliminates movement by the photographer and does allow for a slower film to be used. There is a rule-of-thumb if you are handholding a camera (especially with a telephoto lens): Handholding a camera is only recommended when the shutter speed is equal to or faster than the focal length of the lens (ie: 200mm lens, use at least 1/250 second or faster shutter speed). Otherwise the photograph might be blurred since a telephoto lens amplifies movement.

COMPOSITION

In photography, composition refers to the organization of the pictorial elements. In other words, composition is based on how a photographer puts the subject into the photograph in order to communicate the intent as he perceives it. A photograph with good composition should be balanced and the subject easily understood. There are many pitfalls to a well-composed photograph that we all have to understand. For example, unless you're taking photographs from a crop duster, keep the horizon level. Few things are more distracting than a diagonal line where it shouldn't be. Also don't put too much sky in the picture, unless that's the intent. Just remember to evaluate not only the subject, but everything in the viewfinder before releasing the shutter.

SHADOWS

Shadows can add to or take away from the effect of a photograph. A shadow cutting across the subject can be very distracting and will make proper exposure extremely difficult. A shadow correctly placed can add depth and enhance the perspective of the subject. For example, time of day can be important in obtaining the proper perspective when using shadows to accentuate soil texture or define the shape of seedbeds. Morning and late afternoon are best for shadows, whereas noon can result in a "flat" photograph.

COMPARISON PHOTOGRAPHS

Comparison shots such as TREATED verses UNTREATED are very effective, and will add validity to the results of a trial. Side-by-side views in the same photograph can be more convincing than two separate photographs.

DEPTH-OF-FIELD

The "depth-of-field" is the distance range from the camera where everything will be in sharp focus. This is directly related to two factors; the lens aperture and the focal length of the lens. The lens aperture is also known as the lens opening or the "f-stop". The general rule of thumb is the smaller the aperture, the greater the depth-of-field. For example, f2.8 is considered a large aperture and f22 is a small aperture. If the camera is focused on a subject 10 feet away, the depth-of-field for an f2.8 aperture will be from 9 to 12 feet (everything between 9 and

12 feet from the camera will be in sharp focus). An f22 aperture lens focused on a subject 10 feet away will result in a depth-of-field from 5 feet to infinity. Table 1 shows the various depth-of-field ranges based on lens aperture.

The focal length of a lens also influences depth-of-field. For a given aperture (f-stop), a wider angle lens offers a greater depth-of-field than a standard or telephoto lens. For example, with an f4 aperture, a standard 50mm lens will result in sharp focus from 30 feet to infinity, whereas a 28mm (wide angle) lens will be in sharp focus from 10 feet to infinity. Table 2 shows a comparison of depth-of-field ranges based on various lenses.

Understanding the concept of maximizing depth-of-field is essential for obtaining photographs that are in sharp focus.

Table 1. Depth-of-field ranges based on aperture with normal 55mm lens focused on object 10 feet away.

APERTURE:	f2	f2.8	f4	f5.6
D-O-F Range:	9 1/2'-11 1/2'	9'-12'	8 1/2'-13'	8'-15'
(Total)	(2')	(3')	(4 1/2')	(7')
APERTURE:	f8	f11	f16	f22
D-O-F Range:	7 1/2'-17'	7'-23'	6'-45'	5'-Infinity
(Total)	(9 1/2')	(16')	(39')	

Table 2. Depth-of-field based on various focal length lenses.

	DEPTH-OF-FIELD RANGE (feet from camera to infinity)			
	Focal length of lens			
APERTURE	135mm	50mm	35mm	28mm
f4	Inf. Only	30'-Inf.	15'-Inf.	10'-Inf.
f8	100'-Inf.	15'-Inf.	8'-Inf.	6'-Inf.
f11	80'-Inf.	12'-Inf.	6'-Inf.	4'-Inf.
f16	50'-Inf.	8'-Inf.	4'-Inf.	3'-Inf.

CLOSE-UP OR "MACRO" PHOTOGRAPHY

When photographing small subjects like weed seedlings and flowers for plant identification, specialized close-up equipment will be necessary to obtain the desired magnification. This usually requires a modification to the standard lens, such as extension tubes, diopters, or bellows. However, the most common article for magnification of a subject is the "macro" lens. These lenses can magnify small objects up to lifesize (1X) to photograph considerable detail of very small subjects. The term lifesize magnification means that the object on the slide or negative will be the same size as the actual object. Just for a point of reference, the standard 50mm lens only focuses down to a magnification of about 1/6 lifesize (0.17X).

There are two primary problems to consider when using close-up photographic equipment. First of all, as the magnification increases, the depth-of-field necessary for sharp focus decreases. The result can be a flower part in focus, with everything else somewhat fuzzy. Table 3 shows the effect magnification plays on what willbe in sharp focus. For example,using an f16 aperture at 0.1X magnification, the total depth-of-field is 104 mm, whereas at lifesize (1.0X), total depth-of-field is less than 2 mm.

Another problem associated with close-up photography is that there is a reduction of light as magnification increases. To compensate for this, a slower shutter speed must be used (increasing the chance of movement), or the aperture should be opened to allow for more light (reducing the critical depth-of-field). Table 4 shows the corrections necessary to obtain more light as a result of increasing the magnification.

Table 3. The effect of magnification on depth-of-field.

	TOTAL DEPTH-OF-FIELD (mm)			
	Aperture			
Magnification	f2	f4	f8	f16
0.10X	13.0	26.0	52.0	104.0
0.25X	2.4	4.8	9.6	19.2
0.50X	0.72	1.44	2.88	5.76
1.00X	0.24	0.48	0.96	1.92

Table 4. Exposure increase factors resulting from loss of light when subjects are magnified.

	EXPOSURE INCREASE FACTOR		
Magnification	Multiply Shutter Speed By:	OR	Increase Aperture By (f-stops):
0.10X	1.21		0.25
0.25X	1.57		0.63
0.50X	2.25		1.25
1.00X	4.00		2.00

In close-up photography, the best results will be obtained if small strobes or flashes are used on the subject. Two flashes are recommended for best distribution of light. Since working distances from strobe-to-subject will generally be short (6 to 18 inches), low power, manual flashes work the best. The strobes will make up for the loss of light due to magnification and therefore a smaller aperture can be used (usually f16 with 64 ASA film). The net result will be a dramatically sharp image, with excellent color and contrast qualities. One of the greatest advantages with using strobes is that no clumsy tripod is needed, since the shutter speed will be set on "flash sync" (usually 1/60-1/125 second) and with the speed of the strobes (around 1/2000 second), no movement will be picked up in the photograph.

Backgrounds are always important in photography, especially when doing close-up work. Shade will generally result in the best contrast. Blue sky will give a pleasing background, but is not always possible unless the plant is picked and held up to the sky. Background colors the same as the subject will usually add confusion to the photograph and can cause detail to "run together". Watch out for stray grass and twigs that can interfere with the subject and ruin an otherwise good photograph. Light soil backgrounds can wash out a photograph. However, if the soil is wet, the contrast is usually increased, and the result is much more pleasing.

CONCLUSION

Field photography in weed science can be very rewarding. It can also be extremely frustrating,especially if the slides or photographs turn out poorly. Other than the basic understanding of photographic techniques, the most important factor for successful photography is time! A person can't just snap away with several rolls of film and hope for some great results. It takes time to decide what you want to photograph and what thought or idea you're trying to convey. It takes time to compose the subject so the end result is correctly perceived as the photographer intended it to be. It takes time at the end of a tiring day, after establishing or evaluating a trial, to visually document what went on and what weed species were present. The difference between a photographer and a person taking pictures is not necessarily in the equipment. It's the motivation of trying to understand what and how to capture that subject or idea on film and realizing that it takes time to do it right.

MON 15151 - TURF HERBICIDE: EXPERIMENTAL USE PERMIT UPDATE. Nelroy E. Jackson, Karen E. Kackley, Domingo C. Riego, Timothy E. Dutt and Sarah H. Bundschuh, Product Development Associates, Monsanto Company, Corona, CA 91719.

Abstract. The performance of MON 15151 1EC for pre- and postemergence control of crabgrass was evaluated in 1989 under a United States Environmental Protection Agency (EPA)-approved Experimental Use Permit (EUP). MON 15151 is a formulation of dithiopyr (3,5-pyridinedicarbothioic acid, 2-(difluoromethyl) -4- (2 methylpropyl)-6-(trifluromethyl)-S, S-dimethyl ester). The trade name for turf uses is Dimension herbicide.

Trials were established, under commercial use conditions, throughout the United States on both warm and cool-season turfgrasses. (Total EPA-approved EUP allocations for the United States were 3785 L of product and 540 ha treated.) MON 15151 1EC was distributed to selected golf courses, lawncare companies, landscape companies as well as municipal and industrial organizations and was applied through commercial equipment. Performance was evaluated on sites up to one-half hectare in size.

MON-15151 provided excellent season-long preemergence control of crabgrass. Rates required for season-long control with a single spring application were 0.43 to 0.56 kg/ha for the Northeast, Midwest and CA and 0.56 to 0.84 kg/ha for the South and Southeast.

Rates of MON 15151 required to provide postemergence control of crabgrass in the 1 to 3 leaf stage are 0.28 to 0.43 kg/ha in CA, 0.43 to 0.56 kg/ha in the Northeast and Midwest and 0.56 to 0.84 kg/ha in the South and Southeast. Control of plants with 1 to 3 tillers was improved with the addition of MSMA. Effective rates are 0.28 kg/ha MON-15151 plus 0.56 to 1.12 kg/ha MSMA for the Northeast, Midwest and CA, and 0.56 kg/ha MON 15151 plus 1.12 to 2.24 kg/ha MSMA for the South and Southeast.

Excellent turf safety was demonstrated on both cool-season and warm-season turfgrasses (Table 1). MON 15151 also provides preemergence control or suppression of a number of other annual grass and broadleaf weeds (Table 2).

The EPA has granted an EUP extension for MON 15151 1EC and MON 15104 1EC, an alternate formulation, for expanded evaluation in 1990. Total allocations approved under the extension are 5981 L of product and 1603 ha treated.

Table 1. Turf species demonstrating tolerance to MON 15151 1EC at rates recommended for crabgrass control.

Common Name	Scientific Name
Cool-Season	
Bentgrass	Agrostis spp.
Kentucky bluegrass	Poa pratensis
Tall Fescue	Festuca arundinacea
Perennial ryegrass	Lolium perenne
Fine fescues**	Festuca rubra
	Festuca ovina
	Festuca longifolia
Warm-Season	
Bahiagrass	Paspalum notatum
Bermudagrass	Cynodon dactylon
Buffalograss	Buchloe dactyloides
Centipedegrass	Eremochloa ophiuroides
Kikuyugrass	Pennisetum clandestinum
St. Augustinegrass	Stenotaphrum secundatum
Zoysiagrass	Zoysia japonica

** Certain subspecies and cultivars of fine fescues have shown tolerance to MON 15151, while others have not.

Table 2. Annual grass and broadleaf weeds controlled or suppressed by MON 15151 1EC.

Common Name	Scientific Name
Annual bluegrass	Poa annua
Crabgrass	Digitaria spp.
Foxtail	Setaria spp.
Goosegrass	Eleusine indica
Chickweed	Stellaria spp.
Spurge	Euphorbia spp.
Lespedeza	Lespedeza spp.
Oxalis	Oxalis spp.
Purslane	Portulaca oleracea

EFFECT OF ALS-INHIBITOR HERBICIDES ON SULFONYL UREA-RESISTANT WEEDS. W. F. Smith, J. C. Cotterman, and L. L. Saari, E. I. du Pont de Nemours and Company, Inc., Wilmington, DE 19898.

Abstract. Repeated applications of chlorsulfuron to cereals grown in monoculture in the U.S. and Canada have resulted in the development of resistant biotypes of kochia, Russian thistle, and common chickweed. Repeated applications of sulfometuron-methyl to roadside, railroad, or industrial sites have resulted in the development of

sulfometuron methyl-resistant biotypes of kochia, Russian thistle, and perennial ryegrass. Resistance in these biotypes is due to selection for an enzyme, acetolactate synthase (ALS), which is less sensitive to inhibition by the herbicides chlorsulfuron or sulfometuron methyl. Resistance is not due to differences in metabolic inactivation between resistant and sensitive biotypes. The efficacy of other ALS-inhibitor herbicides has been evaluated on these resistant biotypes in the greenhouse. Metsulfuron methyl and triasulfuron were less active on chlorsulfuron-resistant biotypes of kochia, Russian thistle, and common chickweed, than on sensitive biotypes. Chlorsulfuron, CGA-131036, and imazapyr were less active on a sulfometuron methyl-resistant biotype of perennial ryegrass than on the sensitive biotype. These results suggest that chlorsulfuron- and sulfometuron methyl-resistant biotypes may be cross resistant to other ALS-inhibitor herbicides which have utility for weed control in cereals or noncrop areas.

PERSISTENCE AND PERFORMANCE OF THREE HERBICIDES IN DRIP IRRIGATED GRAPES.

Rick A. Boydston, Plant Physiologist, USDA-Agricultural Research Service, Irrigated Agriculture Research and Extension Center, Prosser, WA 99350.

INTRODUCTION

Weed control with preemergence applied herbicides is often poor in drip-irrigated crops due to frequently wetted soil under drip emitters. Herbicides tend to dissipate rapidly in the wet zone under drip emitters. This study was conducted to determine the efficacy and persistence of diuron, norflurazon, and prodiamine in a drip irrigated vineyard. The effect of irrigation frequency and duration on herbicide efficacy was also investigated.

MATERIALS AND METHODS

Diuron, norflurazon, and prodiamine were applied preemergence at 2.2 kg/ha in April of 1988 and 1989 in a Concord grape vineyard. Plots were sprinkler irrigated with 1.3 cm of water immediately after herbicide application. Grapes were drip irrigated the remainder of the growing season starting at 2 weeks after herbicide application.

Two drip irrigation regimes were imposed: frequently irrigated (3 to 5 times per week) with sets of 4 to 16 h and less frequently irrigated (2 to 3 times per week) with sets of 10 to 36 h. In both cases the total amount of water applied was identical and based on weekly pan evaporation and appropriate crop use coefficients.

Weeds were counted and above ground biomass measured from two emitters in each plot in August of 1988 and 1989. Soil was sampled with a 2.5 cm diameter plastic lined corer to a depth of 45 cm at 5, 10, 20, 30, and 40 cm from the center of the wet zone. Soil was sampled at 0, 2, 4, 8, 16, and 24 weeks after herbicide application. Two cores were combined from each distance and cores were divided into depths of 0 to 15, 15 to 30, and 30 to 45 cm. Parent herbicides were extracted from soil cores and quantified by gas chromatography or by barley bioassays.

Each plot contained four vines and eight drip emitters. The experiment was an RCB with a factorial arrangement of treatments (watering frequency and herbicides). Each treatment was replicated six times and the experiment was repeated.

RESULTS AND DISCUSSION

Length and frequency of irrigation sets did not affect weed control in both years. The total amount of water applied was identical under both irrigation regimes.

In 1988, common mallow density in the entire wet zone under drip emitters was reduced by prodiamine. Norflurazon and diuron significantly reduced mallow density in the outer region of the wet zone, but not in the inner 20 cm radius. In 1989 all three herbicides reduced common mallow density in the entire wet zone under drip emitters.

Prodiamine and diuron controlled redroot pigweed well in the wet zone under drip emitters in both 1988 and 1989. Norflurazon tended to reduce the density of redroot pigweed under drip emitters in 1988, but differences were not significant from the untreated check. Norflurazon reduced redroot pigweed density in 1989, but control was not as great as with prodiamine and diuron. Norflurazon controlled redroot pigweed poorly in the inner 20 cm radius of the wet zone in both years.

In 1988, none of the herbicides significantly reduced the density of lambsquarters in the inner 20 cm radius of the wet zone. However, in 1989 all three herbicides reduced the density of common lambsquarters in the inner 20 cm radius of the wet zone. The density of lambsquarters was greater and less variable in 1989 than in 1988 and may explain why herbicides had a significant effect on lambsquarters in 1989. Prodiamine and diuron controlled lambsquarters in the inner 20 cm radius of the wet zone better than norflurazon. In 1989, all three herbicides reduced lambsquarters density in the outer area of the wet zone with diuron being the most effective.

Green foxtail density was reduced by all three herbicides in the entire wet zone under drip emitters in 1989. In 1988, green foxtail density was low even in untreated check plots and was not reduced further by herbicides.

All herbicides effectively reduced annual weed populations in the wet zone under drip emitters early in the growing season. Later emerging weeds tended to be spindly and heavily shaded by the grape canopy, but many plants were still able to produce seeds.

In 1988, herbicide concentrations were greatest in the 0 to 15 cm depth. Only traces less than 0.06 ppm of norflurazon and 0.02 ppm of prodiamine were detected below 15 cm in the soil profile. Herbicides tended to degrade more rapidly in the inner 10 cm radius of the wet zone than in the outer regions. Norflurazon dissipated faster than diuron and prodiamine and was not detected at 8 weeks after application in the inner 10 cm radius of the wet zone. Diuron and prodiamine were still detected at 24 weeks after application in all areas of the wet zone with the lowest concentrations near the center.

SUMMARY

1) Frequency and length of irrigation sets did not affect control of four annual weeds with diuron, norflurazon, and prodiamine in drip-irrigated grapes.

2) Preemergence applied diuron, norflurazon, and prodiamine reduced the density and biomass of common mallow, redroot pigweed, lambsquarters, and green foxtail in August under drip emitters. Prodiamine and diuron controlled redroot pigweed and lambsquarters in the inner 20 cm radius of the wet zone under drip emitters for a longer period than norflurazon.

3) Preemergence applied herbicides dissipated faster in the center of the wet zone under drip emitters than in the outer regions of the wet zone. Norflurazon dissipated more rapidly in the center of the wet zone than diuron and prodiamine.

4) Limited amounts of parent herbicides were detected lower than 15 cm in the soil profile under drip emitters.

LANDIS INTERNATIONAL - RESEARCH AND DEVELOPMENT MANAGEMENT. Thomas Mester and Kandy Walker, Landis International, Placerville, CA 95667.

Paper not submitted for publication.

PICLORAM ABSORPTION BY BROOM SNAKEWEED AND PICLORAM-INDUCED ETHYLENE PRODUCTION. Tracy M. Sterling and Norman K. Lownds, Assistant Professor and Assistant Professor, Entomology, Plant Pathology and Weed Science Department and Department of Agronomy and Horticulture, New Mexico State University, Las Cruces, NM 88003.

Abstract. Broom snakeweed is a suffrutescent shrub widely distributed in the western United States. This weed is a problem in rangeland production areas because it interferes with forage growth and is potentially poisonous to livestock. An estimated 60% of New Mexico rangeland is infested with broom snakeweed. Picloram is the major herbicide used for broom snakeweed control. Adequate control can be achieved at recommended rates; however, potential does exist for lower use rates. Research was conducted to characterize broom snakeweed leaf surfaces, define picloram uptake by broom snakeweed foliar tissue and measure picloram-induced ethylene production. Leaf surfaces were examined using Scanning Electron Microscopy. Trichomes and stomata were randomly distributed over both the abaxial and adaxial leaf surfaces. Epicuticular wax was a discontinuous amorphous layer with very little fine structure. Picloram uptake was determined by applying droplets (0.25 µL) of ^{14}C-picloram to leaves, stems, or axillary buds of greenhouse-grown broom snakeweed plants. The droplets contained ca. 9 nCi of uniformly ring-labelled ^{14}C-picloram (16.3 µCi/µmol) and ^{12}C-picloram with equimolar KOH to achieve a total picloram rate of 0.28 kg/ha in 187 L/ha. Following treatment, plants were placed in a growth chamber (11 h photoperiod; 25/15 C day/night; 80% relative humidity) and ^{14}C-picloram uptake was determined over time (0 to 48 h). Surface ^{14}C-picloram residue was removed by rinsing with 50% aqueous methanol. Tissue fractions were oxidized and radioactivity in each sample quantitated using liquid scintillation spectrometry. Recovery of radiolabel was > 96% of applied. Broom snakeweed leaves absorbed approximately 7% of applied ^{14}C-picloram within 5 minutes and 15% of applied within 15 minutes with no additional absorption through 48 h. Picloram uptake by leaf, stem and axillary bud tissue was similar. Less than 5% of absorbed ^{14}C-picloram was translocated from treated leaves. Ethylene production by treated shoots increased from linearly between 0 and 72 h.

Coronopus squamatus (FORSKAL)ASCHERSON; IDENTIFICATION, DISTRIBUTION, BIOLOGY, AND CONTROL. Carl E. Bell, Jim C. Hitchcock, and Miguel Monroy, Farm Advisor, University of California Cooperative Extension, Holtville, CA 92250, Biologist, State of California Department of Food and Agriculture, Riverside, CA 92504, and Deputy, Imperial County Agricultural Commissioner, El Centro, CA 92243.

IDENTIFICATION

Coronopus squamatus (Forskal)Ascherson is in the Mustard Family (Brassicaceae). Cotyledon leaves are lanceolate, approximately one cm long (3). The first true leaves are also lanceolate,occasionally with lateral lobes. Later leaves are pinnatifid, with a broad, flattened petiole. Leaf outline is narrowly oblong (obovate) and are from 5 to 20 cm long. Early growth is as a rosette, but later becomes freely branched. Stems stay appressed to the ground and obtain a maximum length of 30 cm. Stem leaves are numerous, but generally shorter then rosette leaves. The leaves and stems are glabrous, light green in color, and odorfree. C. didymus (L)Sm, a related species in California has a distinctive, skunk-like odor (2). A single, stout taproot is produced, 15 mm in cross section and 30 cm long.

Cruciform flowers are small (ca 2 mm), white, and produced in leaf axils. Inflorescenses are compact racemes. Fruit is an indehiscent silicle, reniform, tuberculate, and flattened contrary to the narrow partition, approximately 4 mm broad and 2.5 mm long. Seeds are yellow-brown and 2 to 2.5 mm long (3, 8).

C. squamatus (Forskal)Ascherson has synonyms of C. procumbens Gilib (3, 8), C. ruelli All, and Senebiera coronopus (L)Poiret (3). The WSSA common name is creeping wartcress under the synonym C. procumbens in the Composite List of Weeds (6), but the species is not listed in later revisions (9, 10). The common name used in Europe is swinecress, with the five letter Bayer Ag List code of COPSQ (3). C. didymus is refered to as lesser swinecress, but is swinecress according to the WSSA (9), with a code name of COPDI.

DISTRIBUTION

C. squamatus is native to Europe, probably the Mediterranean region. It is well distributed throughout Europe. Herbarium specimens exist in California, collected by J. S. Blowski in Berkeley in 1922 and by B. Crampton in Yolo County in 1955 (5). It is cited by Munz (8) as being reported in San Francisco, no date, under the synonym C. procumbens. The population in Yolo County is still present (5).

In the Imperial Valley of southeastern California, specimens were first collected and identified in 1982 (5). Infestations occured in two, 70 A onion fields being grown for seed production. Since that time, the weed has spread considerably. A survey conducted in 1986 (5) found the weed in 9 locations. A more extensive survey, conducted in 1987 (4), found this weed in 54 fields, totaling 3715 A. Of these 54 fields, 16 had infestations throughout the field, 16 had localized infestaions, and 22 fields had very limited infestations.

BIOLOGY

In the Imperial Valley, seed germination begins in September and continues throughout the winter. Although it is listed as an occasional biennial (1, 3), we have not seen any plants survive more then one season. Plants grow initially as rosettes from fall through February. Stems with flowers begin to grow in March. Flowering may be induced to start in late February by a photoperiod.

The weed is reported in Europe to prefer heavy, compacted soil, periodically damp and nitrogenous (1, 3). It also prefers warm conditions. The Imperial Valley of California is very warm, mean January temperature is 54 degrees F (12 C) (7). The valley has 460,000 A of farmland, many with heavy soil, and is fertilized and irrigated regularly. Environmental conditions in the Imperial Valley are well suited to the survival and spread of C. squamatus.

CONTROL

Cultivation and hoeing are successful means of killing small plants. Large plants with well developed taproots are more difficult to kill. Uprooted plants have been observed to resist dehydration and will survive if re-buried. Vertical cultivating implements, such as a disk or a harrow, do not kill 100% of the large weeds in a field. Cutting off the plant below the crown is more effective.

No natural enemies of this weed have been observed. This is probably because the weed is a recent arrival in the western USA and the related species, C. didymus is not present in the Imperial Valley.

Herbicides have been tested for control of C. squamatus. Glyphosate is effective at 2 lb/A (Table 1). Bromoxynil will kill small plants (2 to 4 leaf stage) at 0.5 lb/A. When the plant has 6 to 8 leaves, bromoxynil at 0.375 lb/A does not kill this weed (Table 2). Imazethypyr has been partially effective in controlling C. squamatus, but results have been variable (Tables 2, 3, 4). Oxyfluorfen, 2,4-D amine, and 2,4-DB amine are not effective (Tables 1, 2, 3). Linuron applied to an infested carrot field was effective, but did not kill plants with 6 to 8 leaves or larger. Phenoxy herbicides tested before 1972 in Europe had a range of activity on this weed. C. squamatus is reported as susceptible to mecoprop-salt, moderately susceptible todichlorprop salt, and moderately resistant to MCPA-salt, 2,4-D amine, MCPB-salt, and 2,4-DB salt (1).

Table 1. *Coronopus squamatus* control at 2 to 4 leaf stage.

Herbicide	Rate	Control 8 DAT[a]	Control 15 DAT
	(lb/A)	----------(%)----------	
Glyphosate	2	99	100
Bromoxynil	0.5	100	100
2,4-D	0.5	91	54
Oxyfluorfen	0.5	97	95

[a]DAT = days after treatment

Table 2. *C. squamatus* control at 6 to 8 leaf stage.

Herbicide	Rate	Control 48 DAT
	(lb/A)	(%)
Bromoxynil	0.125	2
Bromoxynil	0.25	5
Bromoxynil	0.375	24
Imazethypyr + COC[a]	0.063	76
Imazethypyr + COC	0.125	94
Imazethypyr + bromoxynil	0.063 + 0.125	79
Imazethypyr + bromoxynil	0.063 + 0.25	73
Imazethypyr + 2,4-DB	0.063 + 1.0	96
2,4-DB	1.0	31
Untreated control		0

[a]COC = crop oil concentrate surfactant at 1 quart/A

Table 3. *C. squamatus* control at 4 to 8 leaf stage.

Herbicide[a]	Rate	Control 76 DAT[b]	Weight[c]	Number[d]
	(lb/A)	(%)		
Imazethypyr	0.063	79	18.7	19.8
Imazethypyr	0.094	90	10.6	9.5
Imaz + COC	0.063	90	5.2	10.0
Imaz + COC	0.094	93	9.1	8.8
Imaz + NIS	0.063	88	17.9	27.8
Imaz + NIS	0.094	94	3.8	13.2
Imaz + 2,4-DB	0.063 + 1.0	90	5.8	7.2
Imaz + 2,4-DB	0.094 + 1.0	97	2.2	2.2
2,4-DB	1.0	0	53.7	18.2
Untreated control		0	57.0	26.3
			NS	NS

[a]Imaz = imazethypyr, COC = crop oil concentrate surfactant at 1 quart/A, NIS = nonionic surfactant at .5%(v/v)
[b]DAT = days after treatment
[c]Weight - in grams from line quadrat 3 meters long in each plot average of four replications
[d]Number - number of plants from the same line quadrats

Table 4. C. squamatus control when flowering

Herbicide	Rate	Control 11 DAT
	(lb/A)	(%)
Imazethypyr	0.125	42
Imazethypyr	0.25	62
Untreated control		0

DISCUSSION

C. squamatus has become established in the Imperial Valley of California. It is a troublesome weed in many of the fall planted vegetable crops grown in the Valley. It is also very competitive in new planting of alfalfa sown in the fall. One alfalfa field was disked under before the first harvest because of this weed. Rotational practices in one infested field resulted in the decrease of the population of the weed to very low levels. This field was rotated for three years with carrots, wheat, and sudangrass. Alfalfa was planted in October, 1989. Although the weed population is diminished, it will increase in alfalfa because of the lack of control and the movement of seed by harvesting equipment. Management of this weed with rotations requires further study. The weed thrives in this area because of the suitable climate and edaphic conditions. Control has been difficult because of the weeds resistance to cultivation and to many herbicides. Since the weed exists throughout Europe and an infestation is known from northern California, the weed could spread with time to many areas of North America.

LITERATURE CITED

1. Bulcke, R. 1987. Personal Communication. Faculty of Agricultural Sciences, State University Gent, Belgium.

2. Fischer, B. B., J. McCaskill, and J. McReynolds. Growers Weed Identification Handbook. University of California, Division of Agrcultural Sciences, Plate WI-190.

3. Hanf, M. 1983. The Arable Weeds of Europe. BASF United Kingdom Limited. pp 39,299.

4. Hitchcock, J. C. 1987. Coronopus squamatus, Swinecress in the Imperial Valley. Special Report to the California Department of Food and Agriculture.

5. Hitchcock, J. C. and J. Troutwine. 1986. Coronopus squamatus in Imperial County, Report of a Survey. Special Report to the California Department of Food and Agriculture.

6. Holstun, J. T., Chair. 1971. Composite List of Weeds. Weed Sci. 19:442.

7. Mayberry, K. S. 1980. Agricultural Visitors Guide. Imperial County Cooperative Extension. Circular 111.

8. Munz, P. A. and D. D. Keck. 1968. A California Flora. University of California Press, pg. 230.

9. Patterson, D. T., Chair. 1984. Composite List of Weeds. Weed Sci. 32(suppl 2):16.

10. Patterson, D. T., Chair. 1988. Supplement to WSSA Composite List of Weeds. Weed Sci. 36:850-851.

FEEDING LEAFY SPURGE HAY TO CATTLE. Brad Muller, Peter K. Fay and Mark K. Petersen, Research Assistant and Professor, Department of Plant and Soil Science, Associate Professor of Animal Nutrition, Department of Animal Science, Montana State University, Bozeman, MT 59717.

Abstract. Leafy spurge is reported to be unacceptable and toxic to cattle. Two feeding experiments were conducted to determine if cows would eat leafy spurge hay, and to determine if it was toxic to cows. In the first experiment,four cows received increasing proportions of leafy spurge hay while control cows received only barley straw. While cows ate leafy spurge hay, they consumed less of the ration than the control cows. In a second experiment, nine pounds of leafy spurge hay was added directly to the rumen of cannulated cows. The rumen cannulated-cows consumed more total forage than uncannulated cows suggesting that leafy spurge hay consumption was reduced in the initial trial because of palatibility problems. None of the animals fed leafy spurge hay showed any signs of toxicity.

INTRODUCTION

Leafy spurge is a deep rooted perennial weed of rangeland that infests over 1 million A in Montana. Leafy spurge is reported to contain substances which cause scours and death in cattle (2, 6). Lym and Kirby (5) conducted research to determine the foraging behavior of cattle on leafy spurge. They found that cattle would graze leafy spurge after plant senescence. The objectives of this research was to determine a) if cows consume leafy spurge hay and b) if leafy spurge hay was toxic to the animals.

MATERIALS AND METHODS

Stair step feeding experiment. A five-week feeding experiment was conducted at the Oscar Thomas Nutrition Center, Montana State University, Bozeman, MT from November 6 to December 12, 1989. Eight black angus cows ranging from 7 to 9 yr were placed in pairs in four 10 foot by 30 foot pens. Control animals in pens 1 and 3 received 18 lb of chopped barley straw daily. Cows in pens 2 and 4 received 18 lb of a chopped ration of barley straw and increasing amounts of leafy spurge hay that was cut and baled in mid-September 1989. The cows were weighed and tail bled at the beginning and end of the experiment. The ration of the cows fed leafy spurge hay began with 18 pounds of barley straw. After one week the ration was adjusted to contain 20% leafy spurge hay and 80% barley straw. The leafy spurge content was increased 10% weekly until it reached 50%.

Cannulated-cow experiment. A 16 day experiment was conducted during December, 1989. The cow and pen arrangement described above was used. The cows were also weighed and tail bled at the beginning and end of this experiment. Cows in pens were rumen-cannulated to permit direct placement of leafy spurge hay into the rumen. The soft, rubber cannula plug was removed and nine pounds of leafy spurge hay was added to the rumen of four cows daily in an attempt to determine if the reduced oral consumption of hay containing leafy spurge was due to lowered palatability or metabolic disruption. Each control and cannulated cow received 25 lb of barley straw daily. Forage intake and body temperature were measured daily.

RESULTS AND DISCUSSION

Stair step feeding experiment. Cows fed a ration containing leafy spurge hay did not consume the entire daily ration (Figure 1). The control cows consumed the entire 18 lb barley straw ration. While the control cows gained an average of 1% of initial body weight, the spurge-fed cows lost an average of 5% body weight. The analysis of the blood samples taken at the beginning and end of the stair step feeding experiment were analyzed to measure the internal condition of the animals. Consumption of leafy spurge hays appeared to have no deleterious effects since none of the blood test results were abnormal.

Cannulated cow experiment. Each control cow consumed the entire 25 lb barley straw ration daily. The cannulated-cows consumed an average of 21 lb of barley straw per day in addition to the 9 pounds of leafy spurge hay added daily to the rumen (Figure 2). It is possible that the cannulated-cows were unable to consume the entire 25 pound ration because of the limited holding capacity of the rumen.

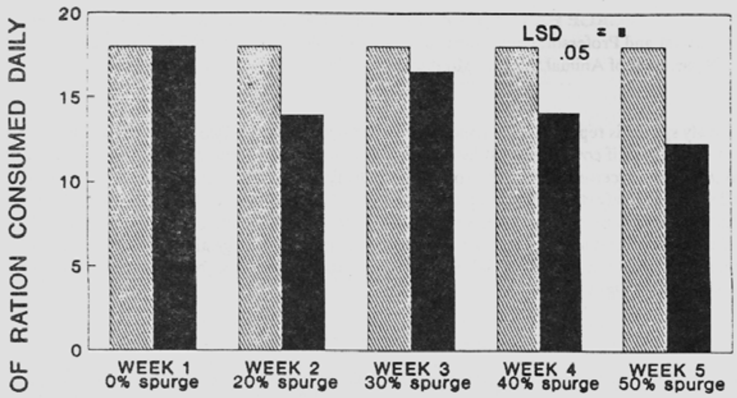


Figure 1. The average daily intake of cows fed 18 pounds of barley straw ▬ or hay containing leafy spurge ▨.

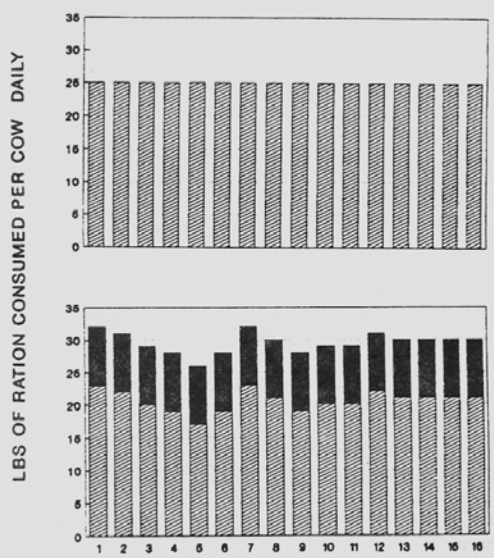


Figure 2. The amount of ration consumed daily by cows fed barley straw only ▨ and cows fed barley straw and force-fed leafy spurge ▬.

The body temperature of the cannulated-cows was recorded daily. The normal body temperature range for cows is 100.5 to 102.5 F (3). Leafy spurge hay added to the rumen of the cannulated-cows did not affect body temperature indicating that leafy spurge hay was not toxic. A significant fluctuation in body temperature is normally the first indication of a metabolic disorder in cattle (3). The control and cannulated-cows receiving leafy spurge hay gained the same amount of weight during the experiment (unpublished results).

In conclusion, cows consumed leafy spurge hay mixed in a barley straw ration however leafy spurge hay was not as acceptable as barley straw. We cannot make a conclusion regarding toxicity after just two short-term feeding studies, however no deleterious effects were observed in the cows fed leafy spurge hay.

LITERATURE CITED

1. Bakke, A. L. 1936. Leafy Spurge, Euphorbia esula L. Iowa Agric. Exp. Sta. Res. Bull. 198:209-245.

2. Bartik, M. and A. Piskac. 1981. Veterinary Toxicology. Elsevier Scientific Publishing Co., New York. 346pp.

3. Fraser, C. M. (Editor). 1986. The Merck Veterinary Manual 6th Edition. Merck and Co., Inc. Rahway, NJ. 1677 pp.

4. Landgraf, B. K., P. K. Fay, and K. M. Havstad. 1984. Utilization of leafy spurge (Euphorbia esula) by Sheep. Weed Sci. 32:348-353.

5. Lym, R. G. and D. R. Kirby. 1987. Cattle foraging behavior in leafy spurge (Euphorbia esula) Infested Rangeland. Weed Technol. 1:314-318.

6. Selleck, G. W., R. T. Coupland, and C. Frankton. 1962. Leafy spurge in saskatchewan. Ecol. Monogr. 32:1-29.

THE FUEL VALUE OF LEAFY SPURGE PELLETS. Edward S. Davis, Peter K. Fay and Rodney G. Lym, Research Associate, Professor and Associate Professor, Plant and Soil Science Department, Montana State University, Bozeman, MT 59717 and Crop and Weed Sciences Department, North Dakota State University, Fargo, ND 58105.

INTRODUCTION

Leafy spurge is a deep rooted perennial weed with widespread distribution throughout the Northern Great Plains (1, 2). The extensive root system of leafy spurge makes herbicidal control difficult, often requiring multiple applications to achieve acceptable long term control (3, 6). Established infestations of leafy spurge are very competitive, producing near monoculture stands capable of reducing carrying capacity of pasture and rangeland to almost zero (4).

Interest in utilizing leafy spurge has increased because it is uneconomical to control, thrives on marginal land, and has no significant insect or disease pests. Leafy spurge has many qualities which make it an ideal candidate for utilization as a renewable fuel resource (5). Hay from leafy spurge contains 7 to 9% oil depending on harvest date. The caloric value of the hay is comparable to wood and unlike timber spurge can be harvested annually. Leafy spurge is very responsive to cultivation, in one instance tonnage was doubled when leafy spurge was fertilized and irrigated (5). The extensive root system makes it an ideal, long lived perennial plant for potential exploitation.

The objective of this research was to compare the performance of pelletized leafy spurge hay with wood pellets for use in heating homes with commercial pellet stoves.

MATERIALS AND METHODS

The BTU (British Thermal Unit) potential of several pelletized plant materials and anthracite coal was measured by combustion in an adiabatic bomb calorimeter. Percent noncombustible ash was determined by combustion in a muffle furnace at 600 F for 12 h.

Leafy spurge hay was harvested at Bozeman in July using conventional haying equipment. Bales were transported to a commercial alfalfa pellet mill to produce 2000 lb of leafy spurge pellets. Bags containing 40 lb of pellets were distributed to six residential pellet stove owners and two commercial pellet stove retailers for evaluation. Each participant in the survey received four 40 lb bags of leafy spurge pellets (4 to 5 days of fuel). While several different pellet stove manufacturers and models were represented in the survey, the basic design and function of the stoves was similar.

The productivity of leafy spurge at two sites in North Dakota was measured on a dry wt basis. The sites, located in Valley City and Dickinson, represent high and low production potential sites respectively. In both infestations the leafy spurge comprised 80 percent of total vegetation.

RESULTS AND DISCUSSION

Leafy spurge pellets produced significantly more heat than pellets made from barley straw or alfalfa (Table 1). The BTU value of leafy spurge was slightly lower than wood. Anthracite coal (a nonrenewable fuel) produced 12,880 BTU/lb.

Percent noncombustible ash is an important factor in evaluating fuel material since pellet stoves are designed to burn wood pellets that produce less than one percent ash. Although leafy spurge pellets produced significantly less ash than alfalfa pellets, barley straw pellets and coal, they produced 19 times more ash than wood pellets (Table 2).

Leafy spurge pellets manufactured at a commercial alfalfa pellet mill resembled wood fuel pellets in size and shape without modifying the die setup for alfalfa pellets. Survey results showed that leafy spurge pellets were dense enough to be augered from the stove hopper to the firebox without crumbling. Leafy spurge pellets burned hot and didn't produce odors or excessive smoke. The one negative observation reported by users was the accumulation of excessive ash.

Pellet stoves utilize a very small firebox which concentrates pellets resulting in a hotter blaze and more efficient combustion. High ash containing materials fill the firebox faster than the combustion fan can disperse the ash, resulting in less efficient burn. One manufacturer developed a pellet stove that is capable of burning high ash containing fuel pellets by modifying the design of the firebox. In this stove an auger like agitator is built into the bottom of the fire box. The agitator slowly turns while the pellets are burning thereby dispersing the ash which falls through small holes in the bottom of the firebox and accumulates in a large ash pan. This type of stove was not tested in the survey but appears promising for efficiently utilizing pellets made of leafy spurge and other plant materials.

Harvesting leafy spurge in a timely manner to obtain optimum yields and at the same time conserve carbohydrate reserves would allow annual production of hay. Productivity of noncultivated leafy spurge was 4.6 and 1.7 T/A at Valley City and Dickinson, ND, respectively. The energy requirement to heat an average size house (3000 sq ft) for one year in Montana is 106 million BTU (5). It would take 6.8 T of leafy spurge pellets to provide this amount of heat, and could be produced from an infestation of just 1 to 4 A assuming an average productivity of 3 T/A.

SUMMARY

Leafy spurge is a noxious perennial weed that is difficult to control. The plant contains 7 to 9% oil and produces nearly as much energy as wood when combusted. Leafy spurge has few endemic pests and thrives on

marginal land. A farm or ranch owner who has leafy spurge could utilize a small portion of an infestation to produce a renewable source of fuel for heating and thereby become less reliant on fossil fuels.

Table 1. BTU production of potential biofuel materials.

Fuel source	BTU/lb[†]
Anthracite coal (5)	12,880 a
Wood pellet	8,066 b
Leafy spurge pellet	7,758 c
Alfalfa pellet	7,115 d
Barley straw pellet	6,839 e

[†] Means followed by the same letter are not significantly different at the 5% level using the LSD test.

Table 2. Percent noncombustible ash of potential biofuel materials.

Fuel source	% Ash[†]
Wood pellet	0.3 a
Leafy Spurge pellet	5.7 b
Alfalfa pellet	7.4 c
Barley Straw pellet	7.4 c
Anthracite coal	8.4 c

[†] Means followed by the same letter are not significantly different at the 5% level using the LSD test.

LITERATURE CITED

1. Dunn, P. H. 1979. The distribution of leafy spurge (Euphorbia esula) and other weedy Euphorbia spp. in the United States. Weed Sci. 27:509-516

2. Lacey, C. A., P. K. Fay, R. G. Lym, C. G. Messersmith, B. Maxwell and H. P. Alley. 1985. Leafy spurge: distribution, biology and control. Circ. 309. Coop. Ext. Serv., MSU, Bozeman, MT.

3. Lym, R. G., and C. G. Messersmith. 1984. Leafy spurge control with herbicides in North Dakota: 20 year summary. J. Range Manage. 38:149- 154.

4. Lym, R. G., and C. G. Messersmith. 1983. Economics of leafy spurge (Euphorbia esula L.) in pasture and rangeland. Proc. West. Soc. Weed Sci. 36:94-96.

5. Maxwell, B. W., S. M. Wiatr, and P. K. Fay. 1985. Energy potential of leafy spurge. Econ. Bot. 39:150-156.

6. Messersmith, C. G. 1983. The leafy spurge plant. North Dakota Farm Res. 40(5):3-7.

PREDICTING YIELD LOSS IN COTTON DUE TO VELVETLEAF INTERFERENCE. Brenda S. Smith and Don S. Murray, Lecturer, Crop Science Department, California Polytechnic State University, San Luis Obispo, CA 93407 and Professor, Department of Agronomy, Oklahoma State University, Stillwater, OK 74078.

Abstract. Field experiments were conducted for 2 years to evaluate velvetleaf growth parameters as a method to predict cotton lint yield loss due velvetleaf interference. Data were collected on velvetleaf at a density of 32 plants/10 m every 15 days during the growing season. Parameters included plant height, main-stem nodes, and dry weights. A linear relationship existed between increasing velvetleaf dry weight and decreasing cotton lint yield. However, the relationship between the number of main-stem nodes or plant height was best described by quadratic regression equations. Weed dry weight appeared to most accurately predict yield loss, followed by plant height and main-stem nodes. A nonlinear equation was utilized to describe percent yield loss as a function of critical-period interference intervals. The results indicated that weed measurements can be used to predict cotton lint yield loss and have potential for practical weed management.

GLYPHOSATE FORMULATIONS FOR CONTROL OF LEAFY SPURGE (*Euphorbia esula* L.). David G. Hanson, Neal R. Hageman and Douglas K. Ryerson, Development Associates, Monsanto Agricultural Company, An Operating Unit of Monsanto Company, West Fargo, ND 58078, Kearney, NE 68847 and Great Falls, MT 59405.

Abstract. Glyphosate formulations were applied to leafy spurge to evaluate efficacy and selectivity to grass species present at each location. Glyphosate has been most effective for control of leafy spurge when applied at 0.75 lb a.e./A in the fall. Glyphosate provides excellent burndown control with regrowth or seedling establishment occurring the following year. Glyphosate at 0.75 lb/A can cause unacceptable injury to desirable grass species in the treatment area.

Three glyphosate package mixes, including either 2,4-D or dicamba, have been tested on leafy spurge both early season prior to seed set and in the fall prior to frost. These products were: Landmaster BW(TM) herbicide (0.9 plus 1.5 lb, glyphosate plus 2,4-D), Landmaster II(TM) herbicide (0.9 plus 0.8 lb, glyphosate plus 2,4-D) and Fallow Master(TM) herbicide (1.1 plus 0.5 lb, glyphosate plus dicamba). Fall applications of these products at 0.38 lb/A glyphosate equivalent and 2,4-D or dicamba were found to be more effective than glyphosate at 0.75 lb/A. Grass selectivity was also improved with the lower application rates of these products. Landmaster II and Landmaster BW provided fall burndown ratings over 90% and Fallow Master provided fall burndown of about 70%. Leafy spurge control one year after treatment was above 90% for all three products.

Since it is desirable to prevent leafy spurge from going to seed, applications of the glyphosate products were made to leafy spurge in full bloom. Landmaster II and Landmaster BW at 0.38 lb/A glyphosate equivalent provided burndown of above 90%, while Fallow Master was more variable, ranging from 60 to 90% burndown. Control from Landmaster II one year after treatment dropped 10% and control 450 days after treatment dropped another 10% to around 70%. Glyphosate equivalent of 0.38 lb/A applied to leafy spurge in full bloom in May or June caused injury to smooth bromegrass of 30 to 40% from Landmaster II, Landmaster BW and Fallow Master. Applications made at 0.28 lb/A glyphosate equivalent did not reduce injury from Landmaster II or Landmaster BW, but injury was reduced from Fallow Master.

Fall applications of Landmaster BW and glyphosate plus 2,4-D tank mix have been made at 0.19, 0.28 and 0.38 lb/A glyphosate equivalent plus 0.5 lb/A 2,4-D in the tank mix. All rates provided excellent burndown of leafy spurge 30 days after treatment. These trials will be evaluated in 1990 for long-term control and grass selectivity.

(TM) Landmaster and Fallow Master are registered trademarks of Monsanto Company.

FOREST, RANGE, AND PASTURE

LEAFY SPURGE (*Euphorbia esula* L.) CONTROL WITH VARIOUS ADJUVANTS COMBINED WITH PICLORAM AND FLUROXYPYR. Tom D. Whitson and N. R. Adam, Associate Professor and Research Associate, Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Leafy spurge control is often erratic with picloram and fluroxypyr when applied at low rates. A field study was initiated to compare 11 different adjuvants applied with 0.5 lb/A picloram and 0.25 lb/A fluroxypyr. Treatments were applied on June 6, 1988 to leafy spurge in early bract, and July 6, 1988 when leafy spurge was in full seed development. Surfactants compared in the study included: X-77, Surphtac, Sprayfuse 90, Activator 90, Access Penetrator, Sulfac DG, Amway APSA-80, Crop Oil Concentrate, LI-700, ammonium sulfate and Aquamate II.

When picloram at 0.5 lb/A was applied May 18, 1988 in combination with Surphtac at 2 qt/A, Sprayfuse 90 at 1 qt/A and Sulfac DG at 2 lb/A, and evaluated June 8, 1989, significantly higher leafy spurge control occurred than picloram applied alone. When picloram at 0.5 lb/A was applied July 6, 1988 in combination with Access Penetrator at 1 qt/A and Sulfac DG at 2.0 lb/A and evaluated June 8, 1989, significant increases in leafy spurge control occurred compared to picloram applied alone. No control differences were found at the latter evaluation date (August 9, 1989). Neither the addition of adjuvants nor the time of application had any effect on leafy spurge control with fluroxypyr.

EFFICACY OF DIFFERENT HERBICIDES ON BIGLEAF MAPLE SPROUT CLUMPS. Elizabeth C. Cole and Michael Newton, Senior Research Assistant and Professor, Department of Forest Science, Oregon State University, Corvallis, OR 97331.

INTRODUCTION

Sprouting species of hardwoods have been considered problems for young conifers in plantations, especially in the first years of a plantation. Due to rapid juvenile growth, these species can quickly outgrow conifer seedlings, causing early overtopping and suppression which results in growth losses for the conifers. One such sprouting species is bigleaf maple, which can grow over three meters in height the first year after cutting. In order to insure conifer dominance around bigleaf maple clumps, control during the first few years of a plantation are critical.

Several herbicides were tested to determine efficacy for controlling bigleaf maple sprout clumps. The site selected was approximately five miles southwest of Burnt Woods, Oregon in the Oregon Coast Range. The site was a mixed hardwood/Douglas-fir stand that was clearcut in early 1987 and planted with Douglas-fir seedlings in early spring of the same year. Predominant vegetation consisted of bigleaf maple sprout clumps from 3 to 10 feet tall, sword fern, trailing blackberry, scattered sprout clumps of red alder and cherry, thistle, stinging nettle, and several species of grass.

TREATMENT PROCEDURES

Individual bigleaf maple sprout clumps were the treatment units. Each treatment was randomly assigned to two groups of four clumps, for a total of eight clumps in each treatment. In addition, eight clumps were left untreated to serve as controls. Treatments are shown in Table 1 and included applications of fluroxypyr, glyphosate, imazapyr, and triclopyr ester.

Different treatment procedures were used for the fluroxypyr and triclopyr ester treatments than for the imazapyr and glyphosate treatments. For the fluroxypyr and triclopyr ester treatments, all treatments were applied by basally spraying the stems of the clumps. Except for the thinline treatment, carrier was diesel and treatments utilized the streamline technique. Concentrations are based on percent of product. Treatments were applied on April 8 and June 30, 1988. Total volume applied was estimated by timing spraying through a calibrated nozzle.

For the imazapyr and glyphosate treatments, only foliar applications were made on June 30, 1988. Carrier was water, and clumps were sprayed to mist with total volume calibrated at 10 gpa.

Table 1. Treatments for bigleaf maple clumps.

Treatment	Formulation	Concentration	Month
	(ai)	------%------	
Fluroxypyr	200 g/l	12, 24, 48	April, June
Triclopyr ester	4 lb/gal	3, 5, 10, 20 30, 100	April, June
Glyphosate	4 lb/gal	5	June (foliar)
Imazapyr	4 lb/gal	1.25	June (foliar)
Untreated			

RESULTS

Each clump was evaluated for percent crown recovery in summer 1989, approximately 14 and 12 months after treatment. Crown recovery is expressed as percent of previous year's (year of treatment) leaf area. Some of the clumps had been inadvertently included in an operational hexazinone spray in spring 1989. Clumps showing symptoms of hexazinone treatment were separated from the other clumps for the original analyses. The only treatment for which the hexazinone treatments showed a difference was the control. Control clumps treated with hexazinone had slightly less leaf area (relative to last year) then those that were not sprayed with hexazinone. However, this difference was not important in terms of the overall analysis, and data from all clumps were used.

Several treatments resulted in complete or almost complete crown reduction (0 to 1% crown recovery) (Table 2). These treatments included fluroxypyr at 48% treated in June, triclopyr ester at 20, 30 and 100% treated in April, and triclopyr ester at 30% treated in June.

Triclopyr ester at 100% treated in June resulted in 14 percent crown recovery after severe top dieback. This was greater recovery than predicted and did not follow the pattern of response for the other concentrations, nor for the April application. One explanation would be the difficulty of application of the thinline technique when substantial foliage is present, due to visibility of the stems and interception by the foliage. Applications were calibrated for a certain delivery rate per unit of crown diameter. During the June applications, some of the chemical was deflected by foliage and did not reach the stems. This was most critical with the thinline treatment, since the number of ml per unit diameter was less than for the other treatments. With the loss of material to the foliage, some of the stems were not adequately covered.

Several treatments significantly reduced the competitive ability of the clumps. These included fluroxypyr at 48% in April (14% of original crown), 12% in June (16%), and 24% in June (4%); triclopyr ester at 10% in April (18%), 5% in June (16%), 10% in June (14%), 20% in June (5%), and 100% in June (14%); and imazapyr 1.25% foliar in June (11%).

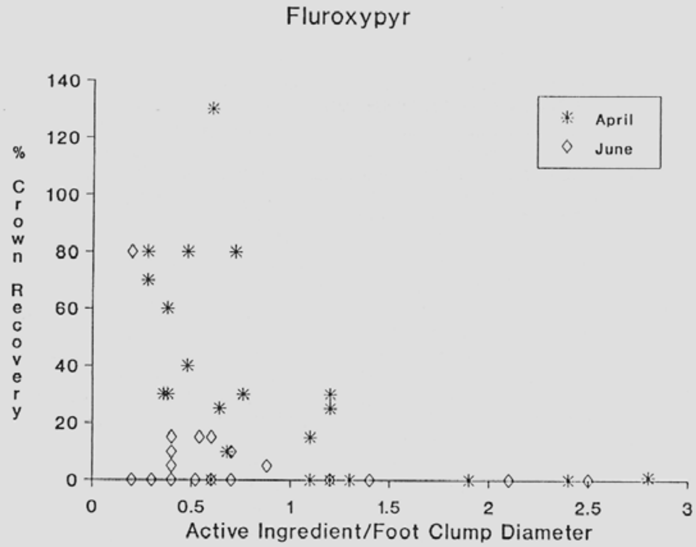


Fig. 1a. Crown recovery and active ingredient/foot diameter comparisons by season.

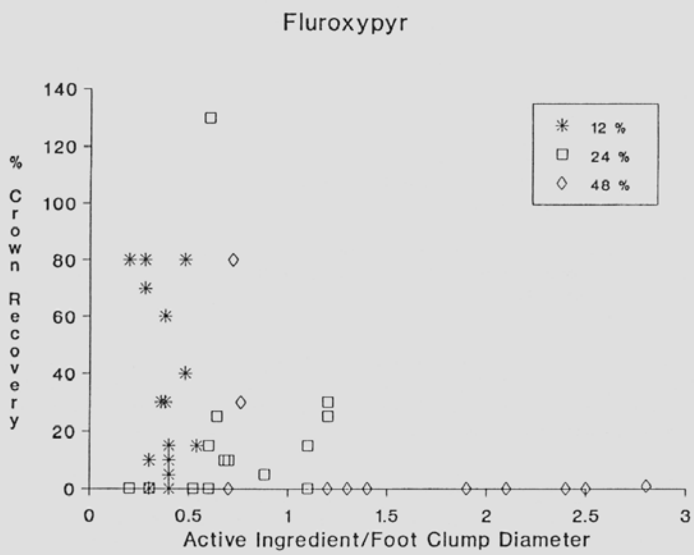


Fig. 1b. Crown recovery and active ingredient/foot diameter comparisons by concentration.

Table 2. Percent crown recovery.[1]

Treatment	% Conc.	Month	% Crown Recovery
Fluroxypyr	12	April	58 bc[2]
	24		29 cd
	48		14 d
	12	June	16 d
	24		4 d
	48		0 d
Triclopyr ester	3	April	71 ab
	5		39 bcd
	10		18 cd
	20		0 d
	30		1 d
	100		1 d
	3	June	24 cd
	5		16 d
	10		14 d
	20		5 d
	30		0 d
	100		14 d
Glyphosate	5	June	78 ab
Imazapyr	1.25	June	11 d
Untreated	0		110 a

[1]Percent crown recovery is percent of pretreatment leaf area 12 and 14 months after treatment.

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

Although some of the remaining treatments were significantly different from the untreated control clumps, the amount of recovery (greater than 20% of the original) indicated that these clumps would recover too rapidly from the treatments to give economic benefits. The herbicide treatments had an effect on the short-term growth of the clumps, but these clumps would probably recover faster than the Douglas-fir could outgrow them.

For the fluroxypyr treatments, June treatments resulted in less overall crown recovery than the April treatments (6% compared to 34%) (Table 3). This was a seasonal effect rather than an application effect, because when the amount of active ingredient (a.i. grams) per foot of crown diameter of the clump was compared, there was no significant difference between seasons (0.8 g/foot diameter June, 1.0 g/foot diameter April). There were significant differences among the concentrations for both crown recovery and a.i./foot diameter. For the 12% treatment, crown recovery was 37% and a.i. was 0.4 g/foot diameter. For the 24%, crown recovery was 17% and a.i. 0.7 g/foot diameter. And, for the 48%, crown recovery was 7% and a.i. 1.6 g/foot diameter. Crown recovery was significantly different for the 12% and 48% treatments. The 24% treatment was not significantly different from either. When crown recovery was plotted against active ingredient/foot diameter, it can be seen that all clumps receiving greater than 1.25 g/foot diameter had 0 crown recovery (Fig. 1a and b).

For the triclopyr ester treatments, the June treatments were significantly better overall than the April treatments in terms of crown recovery (12% compared to 22%) (Table 4). This was primarily due to the lower concentrations being more effective during June (Table 2). As with the fluroxypyr treatments, the difference in active ingredient/foot diameter was not significant between the months (1.2 g June compared to 1.1 g April). Concentrations varied significantly in both crown recovery and a.i./foot diameter. For the 3% mix, recovery was 48% and a.i. 0.2 g/foot diameter. For 5%, recovery was 27% and a.i. 0.4 g/foot diameter. The 10% clumps had 16% crown recovery and 0.8 g/foot diameter a.i. For 20%, crown recovery averaged 2% and a.i. 1.5 g/foot diameter. For 30%, recovery was 0.4 and a.i. 2.2 g/foot diameter. For the thinline treatment, recovery was 8%, and a.i. 1.8 g/foot diameter. When a.i./foot diameter is at least 1 g, then crown recovery is less than 20% (Fig. 2a and b).

Table 3. Fluroxypyr comparisons.

Month	Crown recovery (%)	Clump diameter g A.I./foot
April	34 a[1]	1.0 a[1]
June	6 b	0.8 a
Concentration	**Crown recovery (%)**	**Clump diameter g A.I./foot**
12	37 a[1]	0.4 b[1]
24	17 ab	0.7 b
48	7 b	1.6 a

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

Table 4. Triclopyr ester comparisons.

Month	Crown recovery (%)	Clump diameter g A.I./foot
April	22 a[1]	1.1 [1]
June	12 b	1.2 a
Concentration	**Crown recovery (%)**	**Clump diameter g A.I./foot**
3	48 a[1]	0.2 d[1]
5	27 b	0.4 d
10	16 bc	0.8 c
20	2 c	1.5 b
30	0.4 c	2.2 a
100	8 c	1.8 ab

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

CONCLUSIONS

Several treatments offered excellent possibilities for controlling bigleaf maple sprout clumps. In general, concentrations greater than 20% of triclopyr ester resulted in less than 10% crown recovery of maple in both active (June) and dormant (April) seasons. With the thinline treatment, care must be taken to insure adequate stem coverage due to foliage blocking the stems. High concentrations of fluroxypyr (greater then 24%) in June and imazapyr as a summer foliar spray also resulted in less than 11% crown recovery.

It appears that application of 1.5 g a.i. to maple stems will give excellent control with either fluroxypyr or

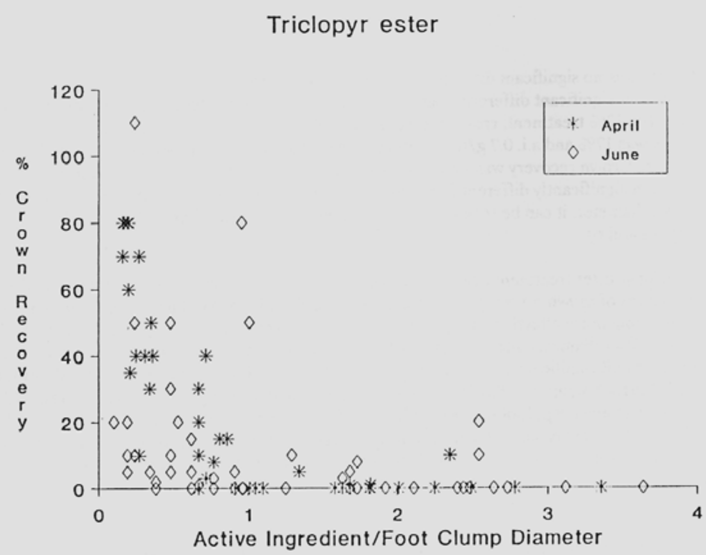


Fig. 2a. Crown recovery and active ingredient/foot diameter comparisons by season.

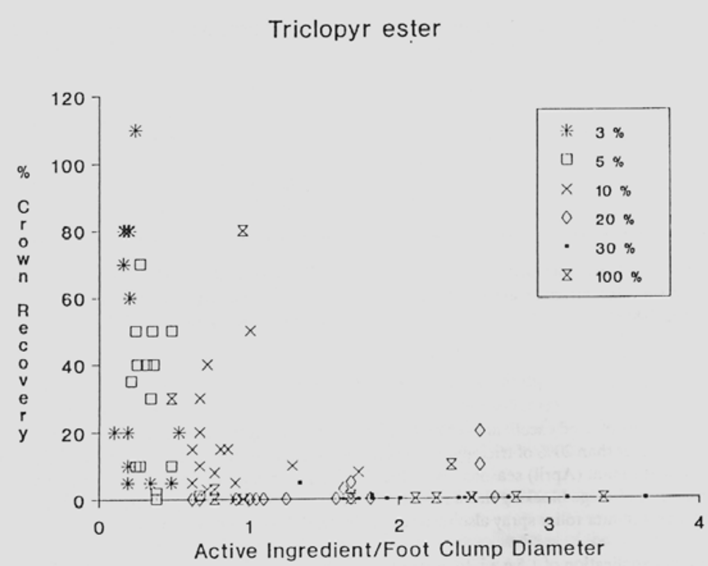


Fig. 2b. Crown recovery and active ingredient/foot diameter comparisons by concentration.

triclopyr ester and that the products are roughly equivalent. Dilution with diesel fuel appears to have some advantage over thinline when foliage is in full leaf. The 1:3 dilution should be applied to result in 1 to 1.5 g a.i./foot diameter. We recommend kicking away leaves and debris from the base of the sprouts before spraying to insure adequate coverage.

GROWING CONIFERS UNDER CHANGING RESOURCE GOALS. Michael Newton, Professor, Department of Forest Science, Oregon State University, Corvallis, OR 97331.

Conifers, especially Pacific Coast species, have among the world's highest rates of primary production. Recent studies have shown that such growth is not achieved until stands have fully occupied their sites and that this takes 13 to 20+ yr.

Conifers are limited by their genetic potential in the rate at which they can be pushed in growth. They appear to achieve maximum growth on weed-free sites in which they are able to grow for two or more yr before competitors are allowed to develop. If given this freedom, survival is nearly perfect, and damage from biotic and physical sources is light. This seems to be the optimum environment for conifers in terms of nearly all published work.

Forests are areas dominated by trees, but many organisms other than trees flourish there. The kind of forest determines what smaller plants and wildlife can prosper. Today, there is increased pressure to grow forests with maximum plant and habitat diversity. There is also recognition that considerations of long-term productivity must be addressed. Indeed, there are many areas in which it is becoming less clear what people want from forests, and what kind of forest will support various sets of commodity and intangible values. Those who regenerate forests are having to prepare stands so that they can meet a host of future criteria in a kaleidoscope of changing goals.

The advent of modern vegetation management and other reforestation tools has led to unprecedented success in production silviculture. The use of fire and herbicides, in particular, have played major roles in this. In general, efficient use of these tools has been associated with clearcut harvesting in units of reasonable size (20+ acres).

It has become a popular belief that "sloppy" clearcuts are more desirable for wildlife. This approach leaves snags and scattered residual trees for perches and nesting habitat. An abundance of down logs is thought to be important for amphibians and other small vertebrates. Pockets of hardwoods and brush are regarded as useful examples of habitat diversity. There is widespread feeling that herbicides harm wildlife.

Most of the reasons for leaving snags and green trees are legitimate. Reasons for leaving brush and hardwoods may be more hypothetical. Nevertheless, tall objects standing in clearcuts and residual brush and down logs often pose serious problems for vegetation management. Tall objects are serious flying hazards for helicopters. Down logs are havens for burrowing animals that damage conifers (mountain beavers) and patches of brush are usually not reforestable. Residual hardwoods and hardwood buffers along streams not only cause aircraft hazards, but they scatter progeny throughout the plantation and thus intensify future weeding needs.

There is excellent evidence that judicious weeding in conifer site preparation and release can improve habitats for a variety of wildlife species. Minor adjustments in prescription can favor one group of habitats or another. In this respect, herbicides are extremely valuable. The density and distribution of planted conifers have profound effects on product quality and also habitat.

It is almost certainly possible to meet a multiplicity of goals in forestry without seriously jeopardizing even a few in forests designated for management. To do this, we must first clearly articulate what that forest is to deliver, and when. A clearly stated set of goals releases managers to set about achieving them.

Once the goals are clarified, the specifics that give trouble can usually be handled creatively. For example,

- Residual green trees can be left in clumps that pilots can avoid easily.
- Tall snags.
- Snags may be cut short where they create a flying hazard on side slopes, and removed altogether on ridges.
- Avoid reliance on hardwoods for tree cover in clearcuts, and if possible, stream margins.
- Consult with wildlife specialists about how the habitat needs to develop in the first two decades after harvesting. Prescribe vegetation management to help achieve habitat as well as reforestation goals. Program tree spacing accordingly.
- Reforest with the types of planting stock that have the maximum tolerance of both animal damage and competition. Large trees, just by themselves, are an excellent biological control of some brush types.
- Care for the planted trees in the first yr or two with enough intensity so that replanting and later tending are not needed.
- Use ground-applied herbicides near streams and flying hazards.

These are planning and operational tactics of the sort that help meet a multiplicity of objectives. If there is agreement on what the forest is to deliver and we plan with creativity and inspiration, the forest can be an attractive place not only for conifers, but for all its other inhabitants.

SUSCEPTIBILITY OF BRUSH SPECIES TO A BASALLY APPLIED FORMULATION OF IMAZAPYR.
M. A. Risley, American Cyanamid Company, Princeton, NJ 08540, and T. E. Nishimura, American Cyanamid Company, Lake Oswego, OR 97034.

Abstract. An imazapyr formulation developed for basal application was evaluated for the control of brush. Treatments were applied to the entire stem from the ground to 18 inches. Stem diameters ranged from 0.5 to 4 inches. Control responses based upon defoliation and resprouting were recorded over a two-year period. Results indicate the formulation provides effective control of Bigleaf Maple, Red Alder, Cottonwood, Russian olive, Saltcedar, Black Cherry, Willow and Oak species.

CONTROL OF TALL LARKSPURS ON MOUNTAIN RANGELANDS. Michael H. Ralphs, Larry V. Mickelsen, John O. Evans and Steven A. Dewey, USDA/ARS Poisonous Plant Lab., Logan UT 84321, and Plant Science Dept., Utah State Univ., Logan UT 84322.

Abstract. Larkspur kills more cattle on mountain rangelands than any other plant or disease. Losses can be reduced if dense patches can be controlled. The following herbicides were evaluated for control of duncecap and tall larkspur: picloram and clopyralid each applied at 1.1, 2.2 and 4.5 kg/ha; triclopyr at 2.2, 4.5 and 9 kg/ha; glyphosate at 0.6, 1.1 and 2.2 kg/ha; and metsulfuron at 8.6, 13.8 and 27.4 g/ha. Glyphosate at 1.1 to 2.2 kg/ha was most effective in killing larkspur plants (>90% reduction of both species). However, it is non-selective and killed all other perennial vegetation. Picloram at 2.2 to 4.5 kg/ha killed > 80% of larkspur plants but prevented an increase in grass cover. Triclopyr and metsulfuron provided variable control (6 to 98%). They were not detrimental to grasses. Clopyralid was ineffective. Two repeated annual applications of picloram, triclopyr or metsulfuron at the middle rate were more effective than a single application at the high rate, and less detrimental

to associated vegetation. Selective application of glyphosate as a spot spray or with a wiper killed larkspur plants without adversely affecting associated grasses and forbs. The spot spray took half the time (2.0 vs 3.9 sec/plant) and required less effort than the wiper.

WESTERN RED CEDAR RESPONSE TO SPRING GRASS CONTROL HERBICIDES. Bruce R. Kelpsas and Fred W. Pfund, Northwest Chemical Corporation, Salem, OR 97303 and Starker Forests, Inc., Corvallis, OR 97339.

Abstract. Western red cedar (Thuja plicata Donn.) is a valuable commercial timber species often planted in mixture with other conifers in forest plantations or in a monoculture because of its resistance to root rots. Herbaceous weed control chemicals often used over other conifers in plantation management regimes however, have not been widely tested over red cedar. This study focuses on red cedar tolerance to several herbicides used for herb control in conifer plantations.

Two field trials, one over newly planted cedar and the other over established seedlings, were instigated in the spring of 1989 to test the impacts of several herbicides. Individual seedlings were sprayed over the top with a gas-operated back pack sprayer delivering 10 gallons per acre. The following herbicides and rates were used: hexazinone 2 lb/A, sulfometuron 3 oz/A, atrazine 4 lb/A, 2,4-D 1 lb/A, and glyphosate 1 lb/A. All plots were sprayed the first week of April. In addition, glyphosate with two surfactant concentrations was also tested at one (established trees) or two (planted trees) other timings. Both trials were established as randomized complete block designs with four replications. Six months after application the established seedlings were visually evaluated for crown kill and growth reduction. Total height of these seedlings also was measured, as was herb cover remaining around each tree. Mortality in both trials also was evaluated at this time.

The results of these trials indicate that red cedar can be damaged by several herbicides. Established seedlings were severely damaged by hexazinone (60% crown kill), and less so by 2,4-D combined with atrazine (25% crown kill). Atrazine alone injured crowns the least (<5%), with sulfometuron and all glyphosate treatments near 10 percent injury. Visual ratings of growth reduction presented a different picture however, where hexazinone, sulfometuron, and 2,4-D plus atrazine had ratings of 60, 40 and 35 percent, respectively. All glyphosate treatments varied near 25 percent growth reduction. Atrazine was the least stunting with a rating of less than 10 percent. Total seedling height also followed this trend, although the differences between treatments were not as great.

Herb control following treatment also varied by herbicide. Herb cover remaining around hexazinone treated seedlings was the least of all methods (less than 10%) followed atrazine plus glyphosate (12%) and sulfometuron (14%). Trees treated with atrazine alone had an average herb cover rating of 18 percent while all glyphosate applications varied between 25 and 30% cover.

These results suggest that although hexazinone and sulfometuron provided better weed control than other treatments, they can be damaging over red cedar. Atrazine alone may be the best treatment for both avoiding injury and controlling herbaceous vegetation.

SENSITIVITY OF ACTIVELY GROWING DOUGLAS-FIR TO SELECTED HERBICIDE FORMULATIONS. P.F. Figueroa, Weyerhaeuser Company, Centralia, WA 98531, R.C. Heald, Blodgett Forest Research Station, Georgetown, CA 95634, and S.R. Radosevich, Oregon State University, Corvallis, OR 97331.

INTRODUCTION

Aerial herbicide treatments are routinely applied to red alder when densities of alder are at a level that will impact Douglas-fir survival or growth. Proper herbicide application timing, with respect to red alder shoot development, is critical to obtain effective red alder control and minimize resprouting. Dougherty (2) determined that there is an optimum window for herbicide application that begins after red alder leaves have grown to at least 65% of their previous yr full size.

A second and equally important aspect with the optimum herbicide spray window is that application should be done prior to Douglas-fir shoot elongation. Graham (3) reported reductions in height growth due to late applications of 2,4-D, when Douglas-fir had shoot elongation in excess of 6 inches. She reported non-sprayed trees from non-treated plots grew 6.9 feet in three yr. The most severely damaged trees in the herbicide sprayed plots grew only 2 feet during the same period. Conard (1) reported similar affects using glyphosate for vegetation control. She found herbicide damage reduced growth up to 3.2 feet in one yrdue to applying herbicides when the shoots were actively growing.

Herbicide damage due to improper spray timing can produce damage ranging from very slight tip curling or foliage loss, up to and including tree mortality. When casual observations of spray damaged trees are made a few yr after application, the impression that damaged trees damaged can recover is sometimes made. Many conifers with spray damaged appear to achieve similar annual growth rates and rebuild their foliage mass. This suggests that they have fully recovered from the effects of herbicide spray damage and "catch up" to the undamaged trees.

To understand the effects of herbicide spray damage on Douglas-fir, two studies were summarized. These studies both had long-term growth data from trees sprayed outside the normal herbicide spray window.

An experiment had been established in Washington State to test efficacy of several rates and product types of granular hexazinone. This test included an operational treatment that used a mixture of 2,4-D and triclopyr ester. This 2,4-D/triclopyr treatment was to be used as a benchmark of the vegetation control that would be obtained with standard herbicide prescriptions. At the time of the 2,4-D/triclopyr treatment, Douglas-fir shoots were actively growing and had elongated and grown past the optimum timing for herbicide spray. The treatment was applied knowing conifers would be damaged.

A separate experiment had been established in California to examine the phytotoxicity of various herbicides applied to the foliage of six conifer species. Application was made during three different growth periods during the yr using herbicides at or near label maximum rates. This test also would be used to evaluate whether initial survival and foliage damage could be used to forecast future tree growth. This study included applications of 2,4-D and triclopyr ester as separate treatments. Treatment timing was done prior to bud break, mid-growing season, and at the end of the growing season to examine the sensitivity of conifers during various growth phases.

STUDY LOCATIONS

The Washington study was on Weyerhaeuser ownership in the western slopes of the Cascade Range approximately 25 miles east of Seattle. Elevation at this site is 1000 feet. The residual Douglas-fir stand was tractor-logged in the fall of 1981. The site was tractor-scarified for site preparation and 2+0 Douglas-fir stock was shovel planted in April 1982. The conifer stand had an understory dominated by red alder, blackberries, salmonberry and vine maple. Soils are from the Klaus series that are deep well drained, coarse textured soils developed from glacial drift and outwash material. Soils are gravely sandy loams.

The California study was conducted at the University of California Blodgett Forest Research Station near Georgetown in the central Sierra Nevada Range. Elevation at the site was 4400 feet. The nearly level, mid-slope bench was cleared of brush in 1975 by a rake-equipped tractor, then disked in two directions. Before being cleared, the site was dominated by greenleaf manzanita, brush chinquapin, and bracken fern. The soil is a Holland sandy loam developing in place from granodiorite parent material. Depth to bedrock was approximately 6.6 feet. Douglas-fir 1+0 bareroot stock was planted in mid-April, 1976. Seed came from a slightly lower elevation in a seed zone adjacent to the Blodgett Forest.

At the Washington study site, the herbicide treatment consisted of a 15 acre non-sprayed check area and a 10 acre herbicide treatment area. The treatment area was given an aerial application of 2,4-D plus triclopyr ester at 1.2 + 0.5 lb/A in water for a 10 gal/A mix. Treatment was applied on May 21, 1985.

Red alder height averaged 6.9 feet and leaf development was greater than 75% of its previous full leaf size. The Douglas-fir averaged 3.7 feet tall and from visual estimates, bud elongation at time of spraying was greater than 3 inches in length.

Twenty plots were established in each block at 100 feet intervals on a systematic grid. Plot center was a randomly selected Douglas-fir. Conifer vigor was assessed with diameter at breast height, basal caliper (1 inch above the ground), and total height. Measurements were taken before treatment, then annually for five yr in the fall.

Treatment means were tested using Tukey's t-test (4). Means were considered different when the p-value exceeded a 0.05 probability level.

At the California site, herbicide treatments were applied on April 14, July 7, and September 23, 1977. The trees were dormant during the April application, actively growing during the July treatment, and had ceased seasonal growth before the September application. Nine herbicides were tested, although this report will deal with the 2,4-D and triclopyr treatments. The 2,4-D and triclopyr treatments were both applied as separate treatments at 4 lb/A each which is at maximum label rate. Both treatments were applied in a solution with water at 20 gallons/A.

Plots were 1200 ft^2 and contained 30 trees for each of six species for a total of 180 seedlings. However, only survival data for Douglas-fir plots will be reported in this paper.

The experimental design was a split plot design with 10 treatments and five replicates. Herbicide was considered as the main plot effect and times of application as subplots. Herbicide and specie rows were randomly assigned in each replication. Treatments were analyzed using a least significant difference test at p=0.05.

RESULTS

At the Washington site, no conifers died on either treatment over the 5-yr period. As a result of the herbicide application when the trees were actively growing, 100% of the trees on the sprayed plots received herbicide injury. Injury included varying degrees of top leader kill, tip curl and foliage loss. Virtually all trees on the non-sprayed treatment were in higher vigor classes for the 5 yr of the study. As shown in Table 1, the distribution of trees in the various vigor classes in the sprayed plots were impacted by the spray treatment. After 5 yr, the total population of damaged trees had not fully recovered to the pre-treatment levels and 30% of the trees continued to have low or very low vigor.

At the California site, survival was reduced by both the 2,4-D and triclopyr treatments. As shown in Table 1A, all herbicide timing applications had lower survival than the untreated check plots. The treatment least affected by herbicide spray was the September application after the Douglas-fir had become dormant after the growing season.

Douglas-fir survival on the 2,4-D mid-summer treatment was 12% when the trees were at their most active growing period. Survival for the April treatment was at 38% while the September dormant application was at 59% survival. The triclopyr treatments had a similar impact on Douglas-fir with the exception of the mid-summer treatment.

The levels of 2,4-D and triclopyr were at maximum dosage rates for conifer release. The survival data for the California site showed significant increases in conifer mortality with the increased dosages over the rates used in the Washington study. The herbicide rates in the Washington study were at operational application levels.

Table 1. Washington site: distribution of Douglas-fir by vigor class and year for non-treated and plots sprayed with 2,4-D/triclopyr.

Plant-ation Age (yr)	Year after treatment	Non-sprayed Vigor class 1	2	3	4	Herbicide sprayed Vigor class 1	2	3	4
		(% of population)							
3	0	55	45	0	0	45	50	5	0
4	1	45	55	0	0	0	20	55	25
5	2	15	45	40	0	0	10	35	55
6	3	55	45	0	0	5	40	35	20
7	4	65	35	0	0	20	35	30	15
8	5	60	40	0	0	20	50	20	10

* Vigor codes are as follows: code 1, 100% foliage retention with green color foliage; code 2, greater than 75% foliage retention with green color; code 3, 50% foliage retention with some chlorosis; code 4, less than 25% foliage remaining, very chlorotic

Table 1A. California site: percent survival of Douglas-fir after six growing seasons.

Plant-ation Age (yr)	Year after treatment	Non-sprayed check plot	Application date Apr 14	Jul 7	Sep 23
		(% survival)			
2,4-D treatment (4 lb)					
7	6	74	38	12	59
Triclopyr treatment (4 lb)					
7	6	74	44	44	56

At the Washington site, tree growth was measured for 5 yr. There were no differences in ground-line basal calipers between treatments prior to treatment and after the first growing season. Significant herbicide effects on basal caliper occurred in the second growing season. There were significant differences between the sprayed and non-sprayed trees for the next 5 yr as shown in Table 2. After 5 yr basal caliper of sprayed trees averaged 28% smaller than the non-sprayed trees.

Annual basal caliper increment was affected in a similar manner. Caliper increment decreased sharply after treatment. There were four yr of reduced growth before the caliper growth returned to the same level as the non-sprayed trees as shown in Table 2A.

Table 2. Washington site: comparison of Douglas-fir basal caliper at ground line by year after treatment for non-sprayed and sprayed (2,4-D/triclopyr) plots.

Plant-ation age (yr)	Year after treatment	Basal caliper Non-sprayed in.	(SE)	Sprayed in.	(SE)	p-value
3	0	0.7	(0.1)	0.6	(0.1)	0.165
4	1	0.9	(0.1)	0.7	(0.1)	0.125
5	2	1.3	(0.1)	0.9	(0.1)	<0.001
6	3	1.7	(0.1)	1.1	(0.1)	<0.001
7	4	2.2	(0.1)	1.5	(0.1)	<0.001
8	5	2.9	(0.2)	2.1	(0.2)	0.002

Table 2A. Washington site: Douglas-fir annual basal caliper growth on non-sprayed and sprayed (2,4-D/triclopyr) plots.

Plant-ation age (yr)	Year after treatment	Annual basal caliper growth increment Non-sprayed in.	(SE)	Sprayed in.	(SE)	p-value
4	1	0.16	(0.02)	0.12	(0.02)	0.259
5	2	0.45	(0.04)	0.15	(0.03)	<0.001
6	3	0.42	(0.03)	0.24	(0.03)	<0.001
7	4	0.51	(0.04)	0.36	(0.05)	0.012
8	5	0.69	(0.05)	0.60	(0.06)	0.245

There were no significant differences in the breast height diameter between treatments for the first 2 yr. By the third yr, mean tree diameter of the sprayed trees continued to diverge from the non-sprayed trees (Table 3). After 5 yr the mean diameter of sprayed trees was 33% lower than the non-sprayed trees.

Annual diameter growth of sprayed trees began to decrease immediately after treatment. As shown on Table 3A, there were annual diameter growth increment differences between treated and non-treated plots. Growth diverged over time and continued out for the 5 yr of this study.

Mean tree height followed a similar diverging growth trend between treatments as did caliper and diameter. Sprayed trees initially were comparable to non-sprayed trees. Yet, after the first yr the mean height of sprayed trees were significantly shorter and by the 5 yr they were 26% shorter as shown in Table 4.

Annual height increment has not recovered from the herbicide spray after 5 yr. As shown in Table 4A, height increment has maintained a lower growth trajectory for sprayed trees.

Mean tree volume was calculated assuming a cone form for trees less than 4.5 feet, using the basal caliper and total height. Volume for trees taller than 4.5 feet the volume of a truncated cone for the section from ground-line to 4.5 feet and adding the volume of the above 4.5 feet section, assuming the top had the volume of a cone. As shown in Table 5, mean tree volume was still diverging due to treatment after 5 yr. After 5 yr, sprayed trees had 48% less volume than non-sprayed trees. The volume of sprayed trees at 5 yr after treatment was equivalent to the volume of non-sprayed trees four yr after treatment.

Table 5A shows annual total volume growth over the 5 yr. These data show damaged trees are at least one yr behind the non-sprayed trees and do not show evidence that they will "catch up" to the growth of the non-sprayed trees.

Table 3. Washington site: comparison of Douglas-fir diameter at breast height on non-sprayed and sprayed (2,4-D/triclopyr) plots.

Plantation age (yr)	Year after treatment	Diameter breast height: Non-sprayed in.	(SE)	Sprayed in.	(SE)	p-value
3	0	0.1	(0.1)	0.1	(0.1)	0.885
4	1	0.2	(0.1)	0.1	(0.1)	0.644
5	2	0.4	(0.1)	0.3	(0.1)	0.082
6	3	0.8	(0.1)	0.5	(0.1)	0.006
7	4	1.3	(0.1)	0.8	(0.1)	0.003
8	5	1.8	(0.1)	1.2	(0.2)	0.004

Table 3A. Washington site: Douglas-fir annual diameter breast height growth on non-sprayed and sprayed (2,4-D/triclopyr) plots.

Plantation age (yr)	Year after treatment	Diameter breast height annual growth: Non-sprayed in.	(SE)	Sprayed in.	(SE)	p-value
4	1	0.09	(0.02)	0.06	(0.02)	0.644
5	2	0.27	(0.10)	0.15	(0.03)	0.082
6	3	0.42	(0.15)	0.22	(0.03)	0.006
7	4	0.46	(0.12)	0.30	(0.04)	0.003
8	5	0.50	(0.11)	0.40	(0.04)	0.004

Table 4. Washington site: comparison of Douglas-fir height on non-sprayed trees and sprayed (2,4-D/triclopyr) plots.

Plantation age	Year after treatment	Mean tree height: Non-sprayed		Mean tree height: Sprayed		p-value
(yr)		ft.	(SE)	ft.	(SE)	
3	0	3.7	(0.2)	3.8	(0.2)	0.837
4	1	4.8	(0.2)	4.2	(0.3)	0.055
5	2	5.8	(0.2)	4.8	(0.4)	0.027
6	3	8.3	(0.3)	6.2	(0.5)	0.001
7	4	10.6	(0.5)	7.6	(0.6)	0.001
8	5	13.4	(0.6)	9.9	(0.8)	0.002

Table 4A. Washington site: comparison of Douglas-fir annual height growth on non-sprayed and sprayed (2,4-D/triclopyr) plots.

Plantation age	Year after treatment	Mean tree height annual growth: Non-sprayed		Mean tree height annual growth: Sprayed		p-value
(yr)		ft.	(SE)	ft.	(SE)	
4	1	1.1	(0.1)	0.4	(0.1)	_0.001
5	2	1.0	(0.1)	0.8	(0.1)	0.196
6	3	2.4	(0.1)	1.3	(0.2)	_0.001
7	4	2.4	(0.2)	1.6	(0.2)	0.010
8	5	2.7	(0.2)	2.1	(0.2)	0.031

Table 5. Washington site: comparison of Douglas-fir mean tree volume on non-sprayed and sprayed (2,4-D/triclopyr) plots.

Plantation Age	Year after treatment	Mean tree volume: Non-sprayed		Mean tree volume: Sprayed		p-value
(yr)		ft^3	(SE)	ft^3	(SE)	
3	0	0.005	(0.001)	0.004	(0.001)	0.389
4	1	0.009	(0.002)	0.007	(0.001)	0.187
5	2	0.027	(0.004)	0.013	(0.002)	0.006
6	3	0.056	(0.008)	0.025	(0.005)	0.002
7	4	0.114	(0.016)	0.053	(0.010)	0.003
8	5	0.221	(0.029)	0.114	(0.021)	0.005

Table 5A. Washington site: comparison of Douglas-fir mean tree volume growth on non-sprayed and sprayed (2,4-D/triclopyr) plots.

Plant-ation age (yr)	Year after treatment	Mean tree volume annual growth: Non-sprayed ft^3	(SE)	Sprayed ft^3	(SE)	p-value
4	1	0.004	(0.001)	0.003	(0.001)	0.072
5	2	0.017	(0.003)	0.006	(0.001)	0.001
6	3	0.030	(0.004)	0.013	(0.003)	0.001
7	4	0.058	(0.008)	0.027	(0.006)	0.005
8	5	0.107	(0.011)	0.062	(0.011)	0.012

SUMMARY/DISCUSSION

Aerial foliar herbicide treatments using 2,4-D or triclopyr, separately or in combinations, can cause significant reduction in Douglas-fir survival and growth if applied during periods of active conifer growth. In the Washington study, 100% of trees in the sprayed plots were damaged by this herbicide treatment. After 5 yr, no mortality occurred, but tree vigor, basal caliper, diameter and volume growth reductions were still evident. There was no evidence after 5 yr that the damaged trees would recover completely from the effects of the spray.

In the Washington study, 30% of the trees in the sprayed plots had less than 50% foliage compared with 100% of non-sprayed trees having greater than 50% crown foliage. In the California study all treatments caused reductions in Douglas-fir survival after 6 yr.

In both studies the conifers have not fully recovered from the impact of herbicide spray during active growth periods. Damaged trees are at least one yr behind in growth from the non-damaged trees. There is no indication that those damaged trees will be able to "catch up" to the size of the undamaged trees.

Herbicide applications of either 2,4-D or triclopyr should be made during periods when conifers are dormant. Application of lower herbicide rates have less impact as trees begin active growth.

The maximum herbicide rates used at the California site shows that higher herbicide rates can cause significant mortality when compared to the lower rates used at the Washington site where only vigor and growth were reduced. Normal herbicide application rates would be lower than those in the California study, but the risk of accidental double passes due to pilot error are always possible. When overlap occurs, the effects of herbicides on actively growing trees would be significantly increased.

If the competitive effects of the weeds being treated are less than the loss associated with herbicide damage, there will be a net loss to the growth and value of a stand. If the competitive effects of the weeds are greater than those from herbicide damage, the operator can consider delaying treatment for one yr to treat during the optimum window the next yr. This can reduce the overall impact of both the competing vegetation and herbicide damage and increase the stand value.

LITERATURE CITED

1. Conard, S.G. 1982. A preliminary study of the influence of environment, phenology and application variables on the response of major conifers and brush species to glyphosate. Weyerhaeuser Technical Report 050-1504/2.

2. Dougherty, P.M. 1980. Factors influencing the effectiveness and selectivity of early season LV-4 broadcast foliar sprays for controlling red alder. Weyerhaeuser Technical Report 042-4505/80/38.

3. Graham, R.L. 1986. 1985-1986 Summaries of vegetation management competition trials in the Northwest. Weyerhaeuser Technical Report 050-3910.

4. Steel, R.G.D, J.H. Torrie, 1980. Principles and procedures of statistics. 2nd edition, New York: McGraw-Hill Book Company.

CONTROL OF ANNUAL GOLDENEYE ON RANGELAND. M. Coburn Williams, Plant Physiologist, Poisonous Plant Research Laboratory, ARS, USDA, Logan, UT 84321.

Abstract. Annual goldeneye accumulates toxic levels of nitrate when rooted on soils near water tanks, ponds, corrals, trails, or other sites where an abundance of animal excreta provides an adequate source of available nitrogen. Control of the plant on these sites would reduce livestock losses from nitrate poisoning.

Foliar sprays of the dimethylamine salt of dicamba butoxyethyl ester of triclopyr, and the butyl ester of 2,4-D were applied to vegetative annual goldeneye at 0.56, 1.1, and 2.2 kg/ha on rangeland near Buckhorn, New Mexico, in July 1988. Plots were evaluated 4 weeks after treatment for control of annual goldeneye, changes in foliar cover, and nitrate concentration in treated and untreated annual goldeneye.

Mortality of annual goldeneye was 47% and 64%, respectively, after treatment with triclopyr and 2,4-D at 2.2 kg/ha. These herbicides provided less than 30% control when applied at 0.56 and 1.1 kg/ha. The 2.2 kg/ha rate of triclopyr produced a noticeable burning on tobosagrass, an effect not observed on plots treated with 2,4-D or dicamba. Mortality of annual goldeneye was 54%, 93%, and 100%, respectively, on plots treated with dicamba at 0.56, 1.1, and 2.2 kg/ha. Foliar cover of tobosagrass increased 119% and 92%, respectively, on plots treated with dicamba at 1.1 and 2.2 kg/ha. Nitrate concentration was nontoxic (0.03% to 0.05%) in both treated and untreated annual goldeneye. Dicamba, applied at 2.2 kg/ha, is recommended for control of annual goldeneye as a poisonous plant near water tanks, ponds, corrals, and along frequently used trails. Control of annual goldeneye elsewhere, except for range improvement, is not practical since the plant rarely accumulates toxic levels of nitrate on less frequently used range. (Published with the approval of the Agricultural Research Service, U. S. Department of Agriculture).

CONTROL OF (COMPOSITAE) PERENNIAL WEEDS ON ARIZONA RANGES. John H. Brock, School of Agribusiness and Environmental Resources, Arizona State University, Tempe, AZ 85287.

Abstract. Burroweed, turpentine weed (Happlopappus larcifolius Grey), and broom snakeweed were more effectively controlled by autumn versus spring herbicide applications. Twelve months following herbicide applications, metsulfuron at rates of 0.017 to 0.07 kg/ha caused mortalities ranging from 60 to 100% for autumn treatments. Picloram at rates of 0.5 and 1 kg/ha provided mortalities ranging from 30 to 97% for spring treatments and 67 to 97% for autumn treatments.

VIABILITY OF ALFOMBRILLA SEED. Howard L. Morton and Alfonso Sanchez-Munoz,
Plant Physiologist, United States Department of Agriculture, Agricultural Research Service, 2000 East Allen Road, Tucson, AZ 85719; and Professor, Universidad Autonoma de Chihuahua, Facultad de Zootecnica, Division Posgrado, Km 6.5 Carretera Cuauhtemoc, Chihuahua, Chihuahua, Mexico 31000.

Abstract. Alfombrilla, a poisonous, perennial plant native to Mexico, has caused severe damage to the cattle industry in the states of Chihuahua and Sonora. Although alfombrilla is not currently found in the United States, it has been found growing near the Chihuahua- New Mexico and Sonora-Arizona borders, and American ranchers are aware of the potential livestock losses if alfombrilla spreads across these borders. We buried alfombrilla seed in soil at four locations and at four depths in northern Mexico. Seed were collected over a 10-yr period. Seed buried at 2 cm were viable after 10 yr at all locations. No seed buried at 0, 6, or 12 cm germinated after 10 yr. While only a few seed (5 to 10 out of 400) were recovered from each location after 10 yr, the fact that viable seed were recovered at all locations indicates that eradication of alfombrilla would take many yr at sites where seed production had taken place.

INTRODUCTION

Alfombrilla, a poisonous, perennial plant native to Mexico, has caused severe damage to the cattle industry in the states of Chihuahua and Sonora. This member of the Caryophyllaceae family contains saponins which are highly toxic to cattle, sheep, and goats (2). Animals show toxic symptoms when fed the plant at doses of 0.1% of body weight, and it is uniformly lethal when fed at 0.5% of body weight (7, 9).

Alfombrilla is associated with the Bouteloua-Aristida plant community in northern Mexico. It is widely distributed in Chihuahua and Sonora, and grows in the states of Durango, Zacatecas, San Luis Potosi, and Hidalgo (4). Although alfombrilla is not currently in the United States, American ranchers are aware of the potential death losses if alfombrilla spreads across the border (1, 3, 5). Alfombrilla has been found growing within 11 km of Antelope Wells, New Mexico (El Berrendo, Chihuahua); within 1.6 km of the Sonora-Arizona border near La Bota, Sonora[1]; and at a point 24 km south of the Sonora-Arizona border near Lukeville, Arizona.

Weaver (8) found soil pH had little effect on alfombrilla germination. Sanchez-Munoz and Morton (6) found only about 2% of freshly harvested alfombrilla seed germinated, but with time after harvest germination increased to more than 80% after 26 months. Optimum temperature for germination of alfombrilla was 14 to 25 C, with no germination below 11 or above 37 C. In experiments to determine seedling emergence from sand, vermiculite, and silt, maximum emergence was from sand and vermiculite and no seedlings emerged from planting depth of 2.0 cm or more. This study was conducted to determine the viability and germination of alfombrilla seed as affected by location, time, and depth of burial.

MATERIALS AND METHODS

Ripe alfombrilla seeds were gathered at Rancho San Francisco, Janos, Chihuahua, in late November 1976. After harvest, seeds were cleaned and sewed in separate lots of 100 in a 5- by 5-cm, 52-mesh, Saran screen packet. Each 100-seed packet served as an experimental unit. Packets were buried in a 17.7- by 17.7-mm (3/8- by 3/8-inch) hardware cloth box. The box consisted of compartments 20 cm deep by 30 cm wide by 60 cm long designated at random for a burial period. A removable lid permitted access to the packets and when closed ensured that packets placed in the compartment remained in place. Boxes were buried in soil and seed packets placed at depths of 0, 2, 6, and 12 cm below the soil surface in late December 1976 and early January 1977. Boxes were placed at the following locations in the indicated plant communities and elevations in Mexico: Centro de Investigaciones Pecuarias del Estado de Sonora, Carbo, Sonora, Matorral Arbosufrutescente

---

[1] Personal communication, T. G. Flanagan, USDA-APHIS, January 8, 1986.

(CIPES), 470 m; Rancho Experimental "La Campana," Chihuahua, Chihuahua, Bouteloua-Aristida, (RELC-BA), 1600 m; Rancho Experimental "La Campana," Chihuahua, Chihuahua, Bouteloua-Quercus (RELC-BQ), 1700 m; and Rancho San Francisco, Janos, Chihuahua, Bouteloua-Aristida (RSFO), 1500 m. The design at each location was a split-plot with burial periods of 1, 4, 8, and 10 yr as main plots and burial depths of 0, 2, 6, and 16 cm as sub-plots. Four seed packets were buried at each depth providing four samples for germination at each depth, 16 samples at each location, and 64 samples at all depths and the four locations each yr. Cleaned seeds were also stored in opaque vials in the dark at room temperature in the laboratory.

Packets were collected at each location in early January of the appropriate yr. Sound seeds in each packet were counted and placed on Whatman #1 filter paper. Six 100-seed lots were removed from vials stored in the laboratory at the same time buried seed packets were collected in the field and placed on filter paper. Seeds from buried packets and the laboratory were moistened with distilled water in 9-cm petri dishes, and held for 21 days at 25q2 C for germination. Seeds with emerged radicles 5 mm long were counted as germinated and removed. The sample standard deviations for average number of sound seeds and percentage of recovered seeds that germinated were calculated.

RESULTS AND DISCUSSION

Average number of seeds recovered after 1 yr when held on the surface ranged from 46 at CIPES to 90 at RELC-BA, and when buried at 2, 6, or 12 cm the averages were similar or greater than those at the surface (Table 1). Alfombrilla seeds recovered after 1 yr of burial were mostly dormant. Only seeds collected from the surface germinated. They germinated at about the same rates as freshly harvested seeds; whereas, germination of seeds stored in vials in an air conditioned laboratory (temperature ca. 20 C) was 16% after 12 months (Table 5).

After 4 yr, average number of seeds recovered from the surface ranged from 0 at CIPES to 19 at RELC-BA (Table 2). These values are considerably lower than those for seeds recovered after 1 yr (Table 1). Numbers of seeds recovered after 4 yr of burial at 2 and 6 cm were lower at all locations than after 1 yr, and seeds recovered after 4 yr burial at 12 cm were similar or lower than after 1 yr. After 8 yr, average number of alfombrilla seeds recovered from the surface ranged from 0 at RELC-BQ and RELC-BA to 12 at CIPES (Table 3). Average numbers of seeds recovered from 2, 6, and 12 cm were lower than after 4 yr. After 10 yr, no seeds were recovered from the surface or 12 cm (Table 4). Average number of seeds recovered from 2 and 6 cm ranged from 0 to 8.

Table 1. Number of alfombrilla seed recovered after one year and germination of recovered seed as affected by depth and location.

Burial	Number of recovered seed Location[a]				Germination of recovered seed Location[a]			
depth	CIPES	RELC-BQ	RELC-BA	RSFO	CIPES	RELC-BQ	RELC-BA	RSFO
(cm)	(number)				(%)			
0	46 (8)[b]	67(15)	90 (4)	76(21)	1 (1)	4 (2)	0 (0)	1 (1)
2	82(20)	95 (2)	85(13)	99 (2)	0 (0)	0 (0)	0 (0)	0 (0)
6	74 (6)	85(14)	93 (5)	92 (5)	0 (0)	0 (0)	0 (0)	0 (0)
12	44(12)	91 (6)	90 (3)	68(11)	0 (0)	0 (0)	0 (0)	0 (0)

[a]Location abbreviations are:
CIPES = Centro de Investigaciones Pecuarias del Estado de Sonora, Mattorral Arbosufrutescente.
RELC-BQ = Rancho Experimental La Campana, Bouteloua-Quercus.
RELC-BA = Rancho Experimental La Campana, Bouteloua-Aristida.
RSFO = Rancho San Francisco, Bouteloua-Aristida.
[b]Values between parentheses are sample standard deviations.

Table 2. Number of alfombrilla seed recovered after four years and germination of recovered seed as affected by depth and location.

Burial depth (cm)	Number of recovered seed Location[a] (number)				Germination of recovered seed Location[a] (%)			
	CIPES	RELC-BQ	RELC-BA	RSFO	CIPES	RELC-BQ	RELC-BA	RSFO
0	0 (0)[b]	7 (3)	19 (6)	1 (1)	0 (0)	10(13)	0 (0)	0 (0)
2	64(16)	45(15)	45(10)	36(20)	2(10)	12(10)	18 (8)	39(23)
6	67(15)	26 (6)	47 (6)	50(13)	2 (2)	14(11)	3 (1)	1 (2)
12	58(11)	19 (4)	46(11)	65 (7)	0 (0)	0(0)	0 (0)	0 (0)

[a]Location abbreviations are:

CIPES = Centro de Investigaciones Pecuarias del Estado de Sonora, Mattorral Arbosufrutescente.

RELC-BQ = Rancho Experimental La Campana, Bouteloua-Quercus.

RELC-BA = Rancho Experimental La Campana, Bouteloua-Aristida.

RSFO = Rancho San Francisco, Bouteloua-Aristida.

[b]Values between parentheses are sample standard deviations.

Table 3. Number of alfombrilla seed recovered after eight years and germination of recovered seed as affected by depth and location.

Burial depth (cm)	Number of recovered seed Location[a] (number)				Germination of recovered seed Location[a] (%)			
	CIPES	RELC-BQ	RELC-BA	RSFO	CIPES	RELC-BQ	RELC-BA	RSFO
0	12(12)[b]	0 (0)	0 (0)	T (T)[c]	6(10)	0(0)	0 (0)	0 (0)
2	52(17)	4 (7)	26(18)	6 (5)	2 (4)	2(4)	23(18)	12(25)
6	2 (2)	5 (3)	10 (6)	T (T)	0 (0)	0(0)	6 (8)	0 (0)
12	T (T)	0 (0)	1 (1)	0 (0)	0 (0)	0(0)	0 (0)	0 (0)

[a]Location abbreviations are:

CIPES = Centro de Investigaciones Pecuarias del Estado de Sonora, Mattorral Arbosufrutescente.

RELC-BQ = Rancho Experimental La Campana, Bouteloua-Quercus.

RELC-BA = Rancho Experimental La Campana, Bouteloua-Aristida.

RSFO = Rancho San Francisco, Bouteloua-Aristida.

[b]Values between parentheses are sample standard deviations.

[c]T = Less than 0.5.

Table 4. Number of alfombrilla seed recovered after ten years and germination of recovered seed as affected by depth and location.

Burial depth	Number of recovered seed, Location[a]				Germination of recovered seed, Location[a]			
	CIPES	RELC-BQ	RELC-BA	RSFO	CIPES	RELC-BQ	RELC-BA	RSFO
(cm)	(number)				(%)			
0	0 (0)[b]	0 (0)	0 (0)	0 (0)	0 (0)	0(0)	0 (0)	0 (0)
2	2 (2)	8 (9)	4 (7)	8 (2)	17(29)	23(31)	3 (6)	7 (9)
6	3 (5)	2 (2)	1 (1)	0 (0)	0 (0)	0(0)	0 (0)	0 (0)
12	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0(0)	0 (0)	0 (0)

[a]Location abbreviations are:
CIPES = Centro de Investigaciones Pecuarias del Estado de Sonora, Mattorral Arbosufrutescente.
RELC-BQ = Rancho Experimental La Campana, Bouteloua-Quercus.
RELC-BA = Rancho Experimental La Campana, Bouteloua-Aristida.
RSFO = Rancho San Francisco, Bouteloua-Aristida.

[b]Values between parentheses are sample standard deviations.

Table 5. Germination of alfombrilla seed stored at room temperature for seven periods after harvest.

Length of storage (months)	Germination (%)
2	2 (1)
12	16(10)
26	81(12)
50	80(20)
98	74(15)
122	63 (7)
146	56 (4)

[a]Values between parentheses are sample standard deviations.

Alfombrilla seeds removed from soil after 4, 8, and 10 years of burial germinated at rates ranging from 0 to 39%, 0 to 23%, and 0 to 23%, respectively (Tables 2, 3, and 4). It is of interest that no seeds recovered from 12 cm at any location or in any year germinated, and only seeds recovered from 2 cm germinated after 10 years.

When alfombrilla seeds were buried and placed in vials in the laboratory they were about 2 months old and mostly dormant (Table 5). Seeds stored in the laboratory increased germination over time and a peak of 81% was achieved after 26 months. After 50 and 98 months germination decreased slightly but not significantly. Seed germination continued to decrease with time and slightly more than half germinated after 146 months. This is considerably higher than the germination achieved by alfombrilla seeds buried for 10 years in the soil. Not only did the climate and soil environment destroy alfombrilla seeds, their germinability was also diminished.

Because alfombrilla is extremely toxic to most classes of livestock (2, 9), it is important that this plant not become widespread on rangelands in the United States. While only a few alfombrilla seeds (2 to 8) were recovered from each location after 10 years of burial (Table 4), there were enough available germinable seeds at each location to establish an alfombrilla stand. The fact that viable seeds were recovered from each location indicates that eradication of alfombrilla would take many years at a site where seed production had taken place. It is important that any infestations of alfombrilla in Texas, New Mexico, or Arizona be discovered, the plants killed, and the sites monitored for at least 10 years if seed production has occurred.

LITERATURE CITED

1. Allison, C. D. 1977. Dymaria: A poisonous genus. Rangeman's Journal. 4:140-141.

2. Dollahite, J. W. 1959. Toxicity of Drymaria arenarioides for cattle, sheep, and goats. J. Amer. Vet. Med. Ass. 135:125-127.

3. Jacoby, P. W., Jr., and H. L. Morton. 1974. Alfombrilla. Univ. of Arizona Coop. Ext. Serv. Agr-File Q-352. 2 pp.

4. Martinez, M. F. 1960. Distribucion y habitat de la alfombrilla en Mexico. Agricultura Tecnica en Mexico. 10:49-51.

5. Reed, C. F. 1977. Economically important foreign weeds--Potential problems in the United States. Agric. Handbook No. 498. ARS-APHIS-USDA. Washington, D.C. 746 pp.

6. Sanchez-Munoz, A. and H. L. Morton. 1979. Autecologia dalfombrilla. Pastizales 10:2-8.

7. Sperry, O. E., J. W. Dollahite, G. O. Hoffman, and B. J. Camp. 1964. Texas Plants poisonous to livestock. Texas A&M University B-1028. 57 pp.

8. Weaver, J. W. 1964. Effects of pH, osmotic pressure and buffer solutions on germination of Drymaria pachyphylla and Drymaria arenarioides. M.S. Thesis, New Mexico State Univ. 66 pp.

9. Williams, M. C. 1978. Toxicity of saponins in alfombrilla Drymaria arenarioides. J. Range Manage. 31:182-184.

YELLOW MIGNONETTE BIOLOGY AND CONTROL. D. M. Wichman, Central Research Center, Montana State University, Moccasin, MT 59462.

Abstract. Yellow mignonette (Reseda lutea L.) is a tap rooted perennial which is invading alfalfa meadows, public road right-of-ways, and some cereal grain fields in central Montana. Yellow mignonette is of great concern to area cattlemen because of its high nitrate content. Nitrate contents as high as 2.5 percent have been recorded and the average nitrate content of thirty plants was 1.16 percent on an air dry basis. Yellow mignonette has been designated a noxious weed in Judith Basin county. The current goal is to eradicate yellow mignonette.

Yellow mignonette along public roads has been tolerant of repeated applications of spring applied 2,4-D, 2,4-D plus picloram and 2,4-D plus dicamba. Fall and spring herbicide plots were established in yellow mignonette infested barley stubble. Fall and spring applications of phenoxy herbicides provided partial control of established yellow mignonette. Fall and spring applications of chlorsulfuron and metsulfuron at 0.25 and 0.24 oz/A, respectively, controlled seedling and established yellow mignonette.

Table 1. Fall control of yellow mignonette.

Applied: 9-22-1988 Herbicide	Rate	Plants/m seedlings 6-1-89	Control Mature plants[1] 6-1-89	7-28-89
	(oz/A)	(No.)	(%)	(%)
Glyphosate+2,4-D	(7.2+12.8)	36	87	11
Metsulfuron+2,4-D	0.24+16	0	99	96
2,4-D (638)	16	25	75	4
Chlorsulfuron+2,4-D	0.25+16	0	100	89
Glyphosate	16	31	98	14
Dicamba+2,4-D	16+16	50	70	11
2,4-DP	16	27	69	4
Picloram+2,4-D	4+16	72	38	14
Clopyralid+2,4-D	(3+16)	32	61	0
Check	untreated	44.3	0	0
Mean		31.97	70	24
C.V.		54.21	54.4	4.9
LSD (0.05)		51.5	48.5	11.0

[1]Spring 89 seedlings included in 7-28-89 mature plants.

Table 2. Spring control of yellow mignonette.

Herbicide	Rate	Control[1] 6-19-89	7-28-89
	(oz/A)	(%)	(%)
Glyphosate+2,4-D	(7.2+12.8)	70	52
Metsulfuron+2,4-D	0.24+16	73	100
2,4-D (638)	16	57	55
Chlorsulfuron+2,4-D	0.25+16	67	100
Glyphosate	16	83	70
Dicamba+2,4-D	16+16	50	67
2,4-DP	16	27	63
Picloram+2,4-D	4+16	65	67
Clopyralid+2,4-D	(3+16)	65	78
Check	untreated	0	0
Mean		53.3	62.2
C.V.		14.7	13.5
LSD (0.05)		20.4	14.9

[1]Control rating includes both seedlings and mature plants.

EPIDEMIOLOGY AND 2,4-D. Wendell R. Mullison, Herbicide Consultant, 1412 North Parkway, Midland, MI 48640.

Questions regarding the safety of pesticides are very much in the mind of the public today. Although 2,4-D has been in extensive world wide usage for over 40 yr and while documented medical records of its causing ill health in humans are few, questions still continue to be raised about its safety.

Some of the recent questions about the safety of 2,4-D have been raised as a result of the publicity given the Kansas Farm Worker Study (19). Furthermore two other studies of a similar nature will be published soon, so it is a cinch that there will be many more such questions.

The purpose of this talk is to to discuss these epidemiological studies and to give an exceedingly brief summary of the toxicology of 2,4-D. The chief question about the toxicity of 2,4-D has been whether or not it is a carcinogen. The opinions of most scientists who have studied this question have been 2,4-D is not a carcinogen, or if so it is a very weak one.

There is some other interesting new toxicological data on this compound. Rat studies (27, 28) have shown that dermal or oral administration of 2,4-D did not cause toxic neuropathological effects to the nervous system. Also toxicological studies (2, 3) with mice have shown that whether administered dermally or orally, 2,4-D did not cause adverse immunotoxicological effects.

In the USA, 2,4-D is currently in the re-registration process. EPA has said certain studies must be repeated. The 2,4-D Industry Task Force II is having these tests done but it will be three or four years before they are completed. This delay is unfortunate but in the meantime it is comforting to note that a review on the possible carcinogenic effects of 2,4-D by the Council for Agricultural Science and Technology (7) concluded that "In summary, evidence that feeding 2,4-D to laboratory animals causes cancer remains very weak. It is also reassuring that recent data, when assessed together with earlier toxicological animal studies, do not provide sufficient evidence to warrant serious concern that 2,4-D is an animal carcinogen."

Time does not permit a lengthy discussion of applicator exposure to 2,4-D. To summarize, there are a number of excellent studies (9, 12, 21, 22, 23, 30, 40) showing applicators will not suffer ill health as a result of exposure to 2,4-D. One very interesting statement was made in a USDA paper (30) on this subject. Namely, a worker's absorption of 2,4-D over a lifetime would be about double the single ingested experimental dosage with human volunteers that had no harmful effects. Questions regarding exposure of the average human to 2,4-D may be best answered with this quotation from the World Health brochure "Environmental Health Criteria 29--2,4-Dichlorophenoxyacetic Acid (2,4-D) (39) "As far as the general population is concerned, 2,4-D intake from any source, is negligible".

Epidemiology is the science that studies the distribution of a disease and its causes in human populations. This is done by obtaining data, both environmental and human, that is thought to be pertinent to the disease being researched. Epidemiology is one way to obtain information about causes of human diseases without actual human experimentation.

The strength of epidemiology is its direct relationship to humans and to real life situations. Its weakness is that epidemiology is an observational science, not an experimental one. Thus epidemiological studies are complicated by the fact the conditions of the experiment are not under control of the researcher. Humans are extremely variable genetically, in educational background, as well as work and general living experiences.

Therefore, with extremely rare exceptions, epidemiologists do not consider an association found in any single study proves a cause and effect relationship, and before an association found in any one study can be considered as showing a true cause and effect relationship, it is mandatory that there be consistent evidence found repeatedly from a number of studies using different methods by different investigators. This is even more true if there are several well designed and conducted epidemiology studies that disagree with each other. A causal interpretation is much more likely to be valid if the findings are consistent with those of other similar studies. Epidemiologists also need to integrate their findings with other evidence from human or animal studies before concluding that a certain finding in their research shows causation. The causal interpretation is also strengthened if there is evidence of a dose-response relationship.

Findings also need to be evaluated for the possibility that they arose from chance alone. Tests for statistical significance are helpful in this regard, but it must be recognized that statistical significance does not necessarily equate to biological significance, and a lack of statistical significance does not necessarily mean the hypothesis being tested is wrong. There have been plenty of examples found of absurd associations that were statistically significant, but which lacked any biological meaning.

The first epidemiological study on 2,4-D was done by Dr. Hardell in Sweden. This was followed by a series he and his associates (8, 13, 14, 15, 16, 17, 18) published in the late 1970,s and early 1980's. The merit of these Swedish studies is the subject of much controversy because of methodological problems. Some say the results cannot be totally discounted. Others such as the world recognized cancer authority Sir Richard Doll say this work should no longer be cited as scientific evidence.

Although The Kansas Farm Worker Study (19) has also been much criticized, it is generally agreed that the methodology used was improved over that used in the Swedish Studies. This Kansas paper is the epidemiological study that has had the most publicity in this country and it is likely the one you will get questioned about, therefore it will be discussed in some detail.

Kansas had been targeted for this study because it is a major site of wheat production and herbicides are commonly used to control weeds in wheat. Discussions of this research with the investigators has brought out that they had been interested in testing the hypothesis that three types of cancer: soft tissue sarcoma (STS); Hodgkin's disease (HD) and non-Hodgkin's lymphoma (NHL) were associated with the various types of crops grown and the number of acres under cultivation. Ironically, they had set-up their data gathering in this way because they did not have confidence that they would be able to get valid information regarding exposure to specific herbicides.

Their findings did not support the original hypothesis and they found no association between the number of acres and types of crops grown and these three kinds of cancer. Looking further at their data, they found no associations between the use of phenoxy herbicides and soft tissue sarcoma or Hodgkin's disease. This is important because the Swedish work prompting the Kansas study had reported large risk ratios for all three types of cancer at comparable levels of exposure. Therefore in this respect the Kansas study conflicted with the Swedish work and provides further evidence for dismissal of the Hardell studies. The authors then focused on non-Hodgkin's lymphoma.

Their major finding was that the odds ratio increased from a baseline of 1.3 for farmers never using herbicides to 6.0 for farmers using herbicides more than 20 days a yr. But data from only one group of farmers, those reporting they had used 2,4-D more than 20 days/yr was statistically significant. Further, this was based upon only 7 cases. Misclassification of exposure among only a few cases could have had a dramatic impact on the statistical significance of their results.

There were some Kansas findings that supported their idea. There was a trend toward an increased risk of NHL as the number of yr increased after the first use of herbicides; there was a higher risk among farmers who reported mixing and applying the herbicides themselves; there was a higher risk among farmers who used backpack or hand-held sprayers; and there was a lower risk among farmers who reported using any protective clothing.

Not all the Kansas Data supported a herbicide-NHL association. There was no association with total yr of herbicide use. There was no association with the number of acres treated with herbicides.

A very important point in discussing the Kansas results is that their data was collected refering to herbicides in general not specifically to 2,4-D. This is because the authors did not collect sufficient information to evaluate frequency, duration, latency and other factors in relation to specific herbicides. Only one opened ended question was asked which was: did you use a herbicide? Since 2,4-D was most often mentioned, it was assumed the generic reported herbicide use was synonymous with the use of 2,4-D which is not correct. This very important point is often overlooked.

In fact, the Kansas data showed statistically increased risks of getting non-Hodgkin's lymphoma for farmers using every type of herbicide reported: for example the triazines, trifluralin and a group of non-specified herbicides. All these herbicides showed an association with non-Hodgkin's lymphoma with an odds ratio (OR) that was statistically significant and sometimes greater than that obtained for 2,4-D and other phenoxys.

A major criticism is the accuracy of the exposure data. Intuitively one recognizes this flaw in the Kansas data. It clearly is difficult to recall with any degree of accuracy details regarding one's exposure to the use of a pesticide over a lifetime. Moreover more than 50% of the patients and controls had died so this information came from next of kin, and obviously, then its accuracy is even more questionable. In a lighter vein, the difficulty of accurate recall of past events is well illustrated in a play entitled "The Night of January 16th". In this play in which the audience takes part, an important question was "Where were you on the night of January the 16th?" Then imagine you had to answer the question "Where was Dad on the night of January 16?" Probably you can think of many better examples.

There are several other rather odd things about this Kansas data that suggest a need for cautious interpretation of the results.

First, more than 70% of the farmers reported never having used herbicides.

Historical knowledge of farm practices in Kansas suggest this figure is too low. Thus there may well have been an under-reporting of herbicide use by the controls.

The highest odds ratio was for farmers who reported more than 20 days of herbicide use per yr. It would be unusual for a farmer to spray this many or more times a yr.

Finally a time analysis showed that the greatest risk for herbicide use and non-Hodgkin's lymphoma was among persons who reported spraying herbicides before 1946. Herbicides were not generally used on wheat before the advent of 2,4-D and 2,4-D was not marketed extensively until after 1946.

EPA and other governmental regulatory agencies naturally have been most interested in knowing the public health implications of this information. Therefore, a number of reviews of this Kansas study have been obtained from academic epidemiologists.

Dr. Brian MacMahon, Professor and Chairman of the Department of Epidemiology at Harvard (26), concluded that: "In my opinion, the weight of the evidence does not support the conclusion that there is an association between exposure to 2,4-D and NHL. Taken as a whole, I believe that 2,4-D and NHL remains a hypothesis that is still to be tested."

Dr. Martha Linet (24), formerly with Johns Hopkins and now with the National Cancer Institute said: " In the opinion of this reviewer, the weight of the scientific evidence is beginning to lean towards possible causation between herbicide exposure, particularly 2,4-D, and development of non-Hodgkin's lymphomas in farmers." This disagrees with Dr. MacMahon, although with qualifications, but she certainly did not take the position that the Kansas study shows a cause and effect relationship.

Dr. A. B. Miller of the University of Toronto (29) reviewed the epidemiological papers on 2,4-D as part of the expert panel convened at the request of the Ontario government. He said " Overall, the epidemiological evidence indicates that a relationship between an increased risk of soft-tissue sarcoma and non-Hodgkin's lymphoma with phenoxy herbicide exposure is tenable: however in regard specifically to 2,4-D, the evidence for human carcinogenicity must be considered as inadequate." Thus none of the reviewers thought the Kansas study's conclusion was the final word on showing an association of 2,4-D and NHL.

You will remember that as emphasized earlier no epidemiological study stands alone but must be interpreted with all the other epidemiological and toxicological results. Therefore, let's briefly review the results from other epidemiological studies on this subject.

Pearce et al (31) published a case-control study of NHL in New Zealand. Earlier studies (34,35) by these workers on phenoxy herbicide use did not show any association of NHL with 2,4-D or 2,4,5-T. Prompted by the Kansas paper, Pearce (32) recently reanalyzed his data looking for such a trend with increasing herbicide use but reported finding none.

Woods et al (38), after the Kansas study, published a case-control study on non-Hodgkin's lymphoma and soft-tissue sarcoma with special emphasis on the use of phenoxys and chlorophenols in the state of Washington. They found no increased risk for non-Hodgkin's lymphoma or soft-tissue sarcoma from past exposure to phenoxy herbicides.

The National Cancer Institute is expected shortly to publish two papers known as the Iowa-Minnesota and the Nebraska study that have been under way for a number of years. Preliminary results have been reported at scientific meetings so the general thrust of these papers is known. The design of these two studies is very similar to that of the Kansas one.

The Nebraska (41) study design was improved over the Kansas study since it asked about the duration and frequency of use of specific types of herbicides. This Nebraska study dealt with several kinds of cancer. They found no association between any measure of herbicide use and Hodgkin's disease, multiple myeloma and chronic lymphocytic leukemia.

They did find a slight increased odds ratio of 1.5 for NHL. The odds ratios increased along with an increased number of use days per year. The highest odds ratio found was 3.3 with farmers using 2.4-D more than 20 days per year. None of these results were statistically significant. Moreover, there was no increased risk for farmers reporting that they had used 2,4-D at some time versus farmers who had never used it. Along the same line, the odds ratio for getting NHL for farmers in general was unchanged when compared with farmers reporting that they had personally handled 2,4-D.

Additional analyses of the Nebraska findings were made. Some were positive, such as that there was a slightly higher risk when using a hand-held sprayer vs. a tractor mounted sprayer. Others were negative. For instance, the use of personal protective clothing was found to be associated with a higher risk of NHL rather than a lower risk.

The authors have interpreted these Nebraska results as strongly supporting their earlier Kansas study. This belief is based largely on their findings of an an increased odds ratio of 3.3 for Nebraska farmers who used 2,4-D for more than 20 days per year. However, this ratio was not statistically significantly, was based on only three exposed cases and four controls and finally was only half the odds ratio found in their Kansas work. So it would seem to raise doubt as to the validity of this proposed association. Nonetheless, the authors say that it shows a trend.

In the Iowa-Minnesota epidemiological study, the use of herbicides and other agricultural practices was studied in relation to leukemia and NHL (6). No statistical significant association was found with the use of 2,4-D. In contrast, statistically significant associations were found between NHL and the use of several other pesticides.

Unfortunately data was not collected in this Iowa-Minnesota study regarding the frequency of herbicide use as this was the variable that showed the strongest association with NHL in the Kansas study. A sample of the subjects from the Iowa portion of the study have been reinterviewed in an attempt to get this information. It is important to test the suggestions raised in the Kansas study but reinterviewing these subjects after all the publicity on the Kansas study creates a substantial opportunity for recall bias. In any case, the results of this effort have not yet been published (3/13/90).

There have been a number of epidemiological studies among manufacturing and applicator workers (1, 4, 11, 20, 25, 33). The strength of such studies is the accuracy of the exposure data and the elimination of recall errors. A criticism is their inability to detect statistically significant small to modest increases in risk of getting rare diseases owing to the small number of workers in these situations. However, the results in all these studies gave no evidence to support a cause and effect relationship between 2,4-D exposure and mortality from any disease.

Bond et al (5) in an attempt to get rid of the criticism of small numbers, combined the data from these studies and still the conclusions were the same no association.

Dr. Wiklund (36 ,37) was able to overcome the problem of small numbers of workers in a study in Sweden. She identified 20,245 Swedish pesticide applicators of which 72% were estimated to have used phenoxy herbicides. This large group was linked to the Swedish central cancer registry. The incidence of soft tissue sarcoma and NHL among these applicators was found to be at or below that occurring in the general Swedish population. These findings are particularly important since much of the present epidemiological studies have come about because of the early work of Dr. Hardell in Sweden. The major limitation of Wiklund's work is the lack of specific individual exposure data. However since the numbers involved are so large, this study should be able to detect effects of the magnitude suggested originally by Hardell.

There is one more important point. You will remember that we talked about the fact that in an epidemiological study the hypothesis being tested should agree with the biological data known about the problem. In animal toxicological experiments, NHL is not diagnosed per se but lymphomas are, and an increased incidence of lymphomas has not been found in the animal chronic long term toxicological studies with 2,4-D.

There has been a very recent review on this question of whether or not 2,4-D is carcinogenic. In January 1990, The Harvard School of Public Health published a report "The Weight of the Evidence on the Human Carcinogenicity of 2,4-D (10)." This study was sponsored by the National Association of Wheat Growers Foundation through a grant from the Industry Task Force II on 2,4-D Research Data. In summary this report says there is little reason to expect that 2,4-D causes cancer in humans, and while some epidemiological studies suggest a possible link between people occupationally exposed to 2,4-D and NHL, such a cause and effect relationship has not been established.

In conclusion, recently completed toxicological studies support the conclusions of earlier studies namely: 2,4-D may be used without undue risk to man, wildlife, or the environment. After considering all the toxicological and epidemiological evidence, it has not been established that the use of 2,4-D causes non-Hodgkins lymphoma or any other type of cancer. This is the opinion shared by most scientific experts that have carefully examined the data.

LITERATURE CITED

1. Axelson, O., L. Sundell, K. Anderson and et al. 1980. Herbicide Exposure and Tumor Mortality. An updated Epidemiologic Investigation on Swedish Railroad Workers. Scandinavian Journal Workers and Environmental Health 6:73-79.

2. Blakley, B. R. 1986. The Effect of Oral Exposure to the N-Butyl ester of 2.4-Dichlorophenoxyacetic Acid on the Immune Response in Mice. Int. J. Immunopharmaco. 8:93-99.

3. Blakley, B. R., and B. H. Schiefer. 1986. The Effect of Topically Applied N-Butyl Ester of 2,4-Dichlorophenoxyacetic Acid on the Immune Response in Mice. J. Appl. Toxicol. 6:291-295.

4. Bond, G.G., N. H. Wetterstrom and G. I. Roush. 1988. Cause-specific Mortality Among Employees Engaged in the Manufacture, Formulation or Packaging of 2,4-Dichlorophenoxyacetic Acid and Related Salts. British Journal of Industrial Medicine 45:98-105.

5. Bond, G. G., K. M. Bodner and R. R. Cook. 1989. Phenoxy Herbicides and Cancer: Insufficient Epidemiological Evidence for a Causal Relationship. Fundamental and Applied Toxicology 12:172-188.

6. Cantor, K. P. and A. Blair. 1986. Agricultural Chemicals, Drinking Water, and Public Health: An Epidemiologic Overview. Soil Science Society Workshop. Paper No. 2. Soil Science Society of America, Madison, Wisconsin.

7. CAST. 1987. Perspectives on the Safety of 2,4-D. Council for Agricultural Science and Technology. pp. 16.

8. Eriksson, M. L. Hardell.O.N. Berg et al. 1981. Soft-tissue Sarcomas and Exposure to Chemical Substances. A Case-referent Study. British Journal Industrial Medicine 38:27-33.

9. Frank, R., R. A. Campbell and G. J. Sirons. 1985. Forestry Workers Involved in Aerial Application of 2,4-Dichlorophenoxyacetic Acid(2,4-D): Exposure and Urinary Excretion. Archives of Environmental Contamination and Toxicology. 14:427-435.

10. Graham, J.D. et al. 1990. The Weight of the Evidence on the Human Carcinogenicity of 2.4-D. pp 65. Harvard School of Public Health, l677 Huntington Avenue, Boston, MA 02115.

11. Green, L. M. 1986. Mortality Analysis of Ontario Hydro Forestry Tradesmen Cohort 1950-1982. Health Services Department, Health and Safety Division, Ontario Hydro, Toronto Ontario, Canada.

12. Grover, R., A. J. Cessna, N. I. Muir, D. Riedel, C. A. Franklin and K. Yoshida. 1986. Factors Affecting the Exposure of Ground-rig Applicators to 2,4-D Dimethylamine Salt. Archives of Environmental Contamination and Toxicology. 15:677-686.

13. Hardell, L. 1977. Soft-tissue Sarcomas and Exposure to Phenoxy Acids: A Clinical Observation. Lancet 74:2753-2754.

14. Hardell, L. 1979. Malignant Lymphomas of Histiocytic Type and Exposure to Phenoxyacetic Acids or Chlorophenols. Lancet 1:55-56.

15. Hardell, L. 1980. Cross-examination Before the Environmental Protection Agency. FIFRA Docket Nos. 4115ff Exhibit 773. September 29.

16. Hardell, L. 1981. Relation of Soft-tissue Sarcomas, Malignant Lymphoma and Colon Cancer to Phenoxy Acids, Chlorophenols and Other Agents. Scandinavian Journal of Work and Environmental Health. 7:119-130.

17. Hardell, L., and A. Sandstrom. 1979. Case-control Study: Soft Tissue Sarcomas and Exposure to Phenoxyacetic Acids or Chlorophenols. British Journal of Cancer. 39:711-717.

18. Hardell, L., M. Eriksson, P. Lenner.and E. Lundgreen. 1981. Malignant Lymphoma and Exposure to Chemicals Especially Organic Solvents, Chlorophenols and Phenoxy Acids: A Case-control Study. British Journal of Cancer. 43:169-176.

19. Hoar, S. K., A. Blair, F.F. Holmes, C.D. Boysen, R. J. Robel, R. Hoover. and J. F.Fraumeni. 1986. Agricultural Herbicide Use and Risk of Lymphomas and Soft Tissue Sarcoma. Journal of the American Medical Association. 256:1141-1147.

20. Hogstedt, C. and B. Westerlund. 1980. Cohort Studies of Cause of Death of Forest Workers With and Without Exposure to Phenoxy Acid Preparations. Lakartidningen 77:1828-1831.

21. Lavy, T. L., J. D. Walstad, R. R. Flynn and J. D. Mattice. 1982. (2,4-Dichorophenoxy) acetic Acid Exposure Received by Aerial Application Crews during Forest Spray Operations. Journal Agricultural Food Chemistry. 30:375-381.

22. Lavy, T. L., L. A. Norris, J. D. Mattice and D. B. Marx. 1987. Exposure of Forestry Ground Workers to 2,4-D, Picloram and Dichlorprop. Environmental Toxicology and Chemistry 6:209-224.

23. Libich, S., J. C. To, R. Frank and G. J. Sirons. 1984. Occupational Exposure of Herbicide Applicators to Herbicides Used Along Electric Power Transmission Line Right-of-Way. American Industrial Hygiene Association Journal. 45:56-62.

24. Linet, M. S. 1986. Review of "Agricultural Herbicide Use and Risk of Lymphoma and Soft Tissue Sarcoma" by S. K. Hoar, A. Blair, F. F. Holmes, et al. and Other Epidemiologic Studies Examining the Association Between the Herbicide 2,4-D, Herbicides in General, Farming and Malignant Lymphoma. Prepared for the Environmental Protection Agency October 17.

25. Lynge, E. 1985. A Follow-up Study of Cancer Incidence Among Workers in Manufacture of Phenoxy Herbicides in Denmark. British Journal Cancer 52:259-270.

26. MacMahon B. 1986. Review of Hoar et al and Related Literature for EPA P.D. # 6W-3948-NASA. September 29,1986.

27. Mattsson, J. L., R. R. Albee, K. A. Johnson, and J. F. Quast. 1986a. Neurotoxicologic Examination of Rats Dermally Exposed to 2,4-D Amine for Three Weeks. Neurobehavioral Toxicology and Teratology. 8:255-263.

28. Mattsson, J. L., K. A. Johnson. and R. R. Albee. 1986b. Lack of Neuropathologic Consequences of Repeated Dermal Exposure to 2,4-Dichlorophenoxyacetic Acid in Rats. Fundamental and Applied Toxicology 6:175-181.

29. Munro I. C. et al. 1987. Expert Panel Report on Carcinogenicity of 2,4-D. Canadian Centre for Toxicology, Guelph, Ontario, Canada.

30. Nash, R. G., P. C. Kearney, J. C. Maitlen, C. R. Sell and S. N. Fertig. 1982. Agricultural Applicators Exposure to 2,4-Dichlorophenoxyacetic Acid. In Pesticide Residues and Exposure A. C. S. Symposium Series J. R. Plimmer, Ed. 182, pp119-132.

31. Pearce, N E., A. H. Smith, R. A. Sheppard et al. 1986. Non-Hodgkin's Lymphoma and Exposure to Phenoxyherbicides, Chlorophenols, Fencing Work, and Meat Works Employment: A Case-control Study. British Journal Industrial Medicine.43:75-83.

32. Pearce, N. E. 1989. Phenoxy Herbicides and Non-Hodgkin's Lymphoma In New Zealand: Frequency and Duration of Herbicide Use. British Journal of Industrial Medicine 46:143-144.

33. Riihimaki, V., S. Asp and S. Hernberg. 1982. Mortality of 2,4-Dichlorophenoxyacetic Acid and 2,4,5-Trichlorophenoxyacetic Acid Herbicide Applicators in Finland. Scandinavian Journal Work Environmental Health 8:37-42.

34. Smith, A. H. and N. E. Pearce. 1986. Update on Soft-tissue Sarcoma and phenoxyherbicides in New Zealand. Chemosphere 15:1795-1798.

35. Smith, A. H., N. E. Pearce, O. D.Fisher et al. 1984. Soft-tissue Sarcoma and Exposure to Phenoxyherbicides and Chlorophenols in New Zealand. Journal National Cancer Institute 73:1111-1117.

36. Wiklund, K., J. Dich and L. Holm. 1987. Risk of Malignant Lymphoma in Swedish Applicators. British Journal of Cancer. 56:505-508.

37. Wiklund, K., J. Dich and L. Holm. 1988. Soft Tissue Sarcoma Risk in Swedish Licensed Pesticide Applicators. Journal Occupational Medicine. 30:801-804.

38. Woods, J. S., L. Polissar, R. K. Severson. 1987. Soft Tissue Sarcoma and Non-Hodgkin's Lymphoma in Relation to Phenoxy Herbicide and Chlorophenol Exposure in Western Washington. Journal National Cancer Institute 78:899-910.

39. World Health Organization. 1984. Environmental Health Criteria 29 - 2,4-Dichlorophenoxyacetic Acid (2,4-D) World Health Organization, Geneva, Switzerland. pp.151.

40. Yeary, R. A. 1986. Urinary Excretion of 2,4-D in Commercial Lawn Specialists. Applied Industrial Hygiene. 1:119-1201.

41. Zahm, S. H., et al. 1988. A Case-control Study of non-Hodkin's Lymphoma and Agricultural Factors in Eastern Nebraska. American Journal of Epidemiology 128 (4) 901 (abstract).

WILD OAT AND BARLEY NITROGEN UTILIZATION AFFECTED BY INTERROW SPACING AND NITROGEN PLACEMENT. Joan Lish and Donald Thill, Research Associate and Associate Professor, Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83843.

Abstract. Nitrogen fertilizer placement may affect weed-crop competitive interactions. The effects of band and broadcast nitrogen placements, 20 and 38 cm interrows between 15 cm paired barley rows, and five wild oat densities were determined for spring barley and wild oat growing together at Moscow, Idaho. Wild oat plants were sampled from the middle of the interrow, from the interrow adjacent to paired barley rows, and from within the paired barley row, and barley plants were sampled from the paired rows. Samples were frozen in the field, dried, and analyzed for nitrogen content. Wild oat growing in the broadcast nitrogen plots was shorter and was chlorotic compared to the band nitrogen plots. Nitrogen utilization by wild oat was inversely related between fertilizer placement and the area sampled. Nitrogen content of wild oat was 5.2, 4.6, and 3.8% in the band placement plots and 4.8, 5.1, and 5.2% in the broadcast placement plots from within the paired barley row, adjacent to the paired row, and the center of the interrow, respectively (LSD 0.05 = 0.3). Overall, wild oat plants had higher nitrogen content in broadcast fertilized plots (5.1%) than band fertilized plots (4.6%). Barley utilized nitrogen similarly in both band (5.0%) and broadcast (4.8%) fertilized plots, when no wild oat was present. However, when wild oat was present, barley nitrogen content was higher in band fertilized plots (4.8%) compared to broadcast (4.4%). Interrow spacing and wild oat density had no effect on nitrogen utilization per wild oat plant. Barley grain yield was higher in band (4606 kg/ha) than broadcast (4020 kg/ha) fertilized plots.

QUINCLORAC CONTROL OF GRASSY WEEDS IN CALIFORNIA RICE. Duke C. Wiley and John O. Pearson, BASF Corporation - Field Development P.O. Box 13528, Research Triangle Park, NC 27709.

Abstract. Quinclorac (BAS 514 00H) has been field tested for the last three years as a new grass control herbicide for California rice production. Quinclorac has been tested under the code number BAS 514 00H, and has recently been assigned the commercial name Facet.

Testing of quinclorac included rates and timing, water management, crop safety and additives. Tests were conducted in several geographic locations throughout California rice producing areas. Quinclorac has controlled Echinochloa species very well under low water regime. Rates from 0.25 to 1.0 lb/A have been tested. A maximum application rate has been established at 0.5 lb/A. The 0.5 lb/A rate will be required under California conditions. The application timing is postemergence to the rice and grass. The one- to two-leaf stage of the grass appears to be the best time to apply quinclorac. A surfactant improves efficacy. No broadleaf weed activity has been noticed. Crop safety is excellent. Quinclorac has little effect on Leptochloa species. In 1989, BASF conducted several air and ground studies where the water level was lowered to a two-inch depth then quinclorac was applied. After 72 hr, the water level was returned to the standard four-inch depth. Control of Echinochloa species was very satisfactory. Studies will be established in 1990, testing to see if the low water holding period can be shortened to 24 or 48 hr. Average yields from four air trials, applied in 1989, are listed. Each treatment was three to eight acres in size. Londax or MCPA was used as a broadleaf treatment. Water volume of 10 gpa was applied by commercial aircraft.

AVERAGE YIELD FROM FOUR AIR TRIALS

Untreated	Facet	Ordram
5539	8344	8177

Figures in lb/A, dry weight corrected to 13% moisture.

Results indicate very comparable control with quinclorac compared to the label rate of Ordram. Testing 1990 will continue with Quinclorac in rice in California. Additives, holding time, combinations and timing of applications will be major target areas for study.

BASF is expecting a Federal registration in 1991 or early 1992. California registration would follow as soon as possible.

FIELD BINDWEED (Convolvulus arvensis L.) CONTROL BETWEEN CROPS OF SMALL GRAINS USING PICLORAM AND OTHER HERBICIDES. Michael J. Barton and Philip Westra, DowElanco, Shawnee Mission, KS 66210 and Colorado State University, Fort Collins, CO 80523.

Abstract. Control of perennial weeds using multi-year, repeat application of low rates of herbicides is replacing the practice of one time applications using extremely high rates of herbicides. This programmed approach to perennial weed control provides equivalent weed control at less cost to the producer and lessens the possibility of environmental risk.

One such system is the control of field bindweed using picloram herbicide in combination with 2,4-D. The objective of this paper was to review research collected in Kansas and Colorado and 1) determine the efficacy of picloram 2,4-D combinations in comparisons to other herbicides 2) determine differences in the length of residual control from 0.13 and 0.28 kg/ha picloram in combination with 2,4-D and 3) to determine the effect of substituting the 2,4-D component of the tank mix with other herbicides.

Results indicate that one year after application, treatments of picloram plus 2,4-D provided superior bindweed control to dicamba, dicamba plus 2,4-D or glyphosate, clopyralid, clopyralid plus 2,4-D, glyphosate, glyphosate plus 2,4-D, 2,4-D or fluroxypyr.

Under the environmental conditions of eastern Colorado and western Kansas it was determined that the 0.13 kg/ha and the 0.28 kg/ha rate of picloram applied in combination with 2,4-D provided equivalent residual control of field bindweed until early summer the year following application. By mid summer, 9 to 12 months after application, control from picloram at 0.13 kg/ha declined.

It was also determined that replacement of the 2,4-D component in the picloram plus 2,4-D tank mix by fluroxypyr, dicamba, glyphosate plus 2,4-D, atrazine or clomazone did not effect control of field bindweed provided the amount of picloram was held constant. If needed, the spectrum of weed control could be increased by substituting these compounds for the 2,4-D component of the tank-mix. These substitutions will, however, increase the cost of the tank-mix.

WEED SEED ANALYSES FROM FOUR DECADES OF UTAH SMALL-GRAIN DRILLBOX SURVEYS. Steven A. Dewey and Ralph E. Whitesides, Associate Professors, Department of Plant, Soil, and Biometeorology, Utah State University, Logan, UT 84322-4820.

Abstract. Wheat, barley, and oat seed samples collected from farmers in all Utah counties during the spring and fall of 1988 were analyzed for weed seed content as part of an ongoing statewide small-grains drillbox survey program. Of 450 grain samples collected, 141 (31.3%) were infested with weeds, averaging 313 seeds/lb of grain. The most heavily infested lot contained 11,118 weed seeds/lb. Non-noxious weeds were found in 107 samples (23.8%); while weeds designated as noxious, according to the Utah Seed Law, were detected in 76 (16.9%) of the samples. The number of noxious weed seeds/lb of infested grain was as high as 1537, with an average of 58/lb. Wild oat was the most common noxious weed species, occurring in 13.8% of samples at an average of 47 seeds/lb. Jointed goatgrass was found in 26 samples (5.8%); making it the second most common noxious weed species encountered in 1988. Quackgrass was the third most common noxious weed (4%), averaging 11

seeds/lb; followed by field bindweed at 3%, and averaging 7 seeds/lb. There were no weeds of any kind found in any Utah Certified seed samples in 1988. Weed contamination data from similar Utah drillbox surveys conducted in 1958, 1968, and 1978 indicate a general improvement in several categories (Table). The percentage of samples infested with weeds of any kind declined steadily from 52% in 1958, to 31% in 1988. Incidence and level of wild oat contamination also declined over the past 4 decades. Jointed goatgrass appeared for the first time in the 1988 Utah survey.

Table. Weed seed contamination in Utah small-grain drillbox surveys conducted from 1958 to 1988.

	Year			
	1958	1968	1978	1988
Total No. of samples	1232	450	274	450
Counties surveyed	25	25	20	29
Samples w/ any weeds (%)	52	39	37	31
Samples w/ nox. weeds (%)	40	25	26	17
Samples w/ wild oats (%)	36	23	24	14
Samples w/ quackgrass (%)	3	0	4	4
Samples w/ bindweed (%)	5	5	5	3
Samples w/ goatgrass (%)	0	0	0	6

HERBICIDE AND SUGARBEET VARIETY INTERACTIONS. K. James Fornstrom and Stephen D. Miller, Professors, Agricultural Engineering and Weed Science, University of Wyoming, Laramie, WY 82071.

Abstract. Planting sugarbeets to stand requires a uniform, predictable and preferable high emergence rate. However, emergence rates are often highly variable even with one set of cultural practices and climatic conditions. The objective of this research was to compare sugarbeet stand establishment as influenced by herbicide treatment and variety.

The studies were conducted at the Powell Research and Extension Center in 1988 and 1989 and at a cooperator location near Powell, WY in 1989. Four replications were arranged in a split plot arrangement to compare sugarbeet variety response to preplant incorporated applications of cycloate plus ethofumesate or, ethofumesate plus diethatyl. The plots were conventionally tilled and planted in 22-inch rows. Preplant herbicides were applied in a seven-inch band and incorporated with a rotary power incorporator. Sugarbeets were planted at the rate of 56,000 seeds/A and approximately 0.75-inch deep. Desmedipham plus phenmedipham was applied postemergence to all plots in a seven-inch band when the sugarbeets were in the two to four leaf staged. The Powell-88 sugarbeets had poor emergence due to crusting, which resulted from a heavy rain and were replanted.

There were no significant differences in sugarbeet populations or yields according to herbicide treatment, although there was a tendency for sugarbeets treated with cycloate plus ethofumesate to have lower populations (Table). Holly Hybrid 50 sugarbeets had the highest and MonoHy R-2 the lowest initial populations. Yield differences according to variety were not related to initial population differences. There were no herbicide-variety interactions at any of the locations. It thus appears that herbicides and variety influences on sugarbeet stand establishment can be studied separately, without being concerned about their interaction.

Table. Plant populations and yields of five varieties of sugarbeets treated with preplant incorporated and postemergence herbicides.

Comparison	Population Initial	Population Harvest	Yield	Sucrose
	------(1,000 pl/A)-------		(T/A)	(%)
Location				
Powell REC-88	31.6	19.4	18.8	15.8
Powell REC-89	26.4	29.3	20.1	15.3
Cooperator-89	21.1	21.3	20.1	16.6
LSD (0.05)	4.6	2.0	NS	0.4
Herbicide[a]				
Cycloate + ethofumesate	24.3	22.5	19.2	15.8
Ethofumesate + diethatyl	27.4	24.3	19.4	16.0
Check	27.5	23.2	20.5	15.9
LSD (0.05)	NS	NS	NS	NS
Variety				
Holly Hybrid 50	29.7	25.4	18.8	15.9
MonoHy D-2	24.9	24.0	20.9	15.9
American Crysta Hybrid 164	27.5	23.0	18.1	16.2
MonoHy 5891	27.3	23.0	19.5	15.8
MonoHy R-2	22.4	21.4	21.0	15.7
LSD (0.05)	4.1	NS	2.2	0.3
Mean	26.4	23.3	19.7	15.9

[a]Herbicide rates (lb ai/A): cycloate (1.5) + ethofumesate(1.5); ethofumesate (2.0) + diethatyl (2.0); desmedipham(0.5) + phenmedipham(0.5) applied postemergence to all treatments.

PREHARVEST WEED CONTROL IN COTTON. S. D. Wright and E. S. Saches, Farm Advisor, University of California Cooperative Extension Service, Visalia, CA 93921 and Monsanto Agricultural Products, Fresno, CA 93710.

Abstract. Cotton is a major crop in California comprising about 1.5 million A. Occasionally weeds can be a major problem at harvest because other weed control techniques both cultural and chemical either have not provided adequate control or have not been implemented. These weeds present at harvest may have already lowered yields, reduces the effectiveness of defoliation, reduces harvest efficiency, lower cotton grades, and contaminate the following crop.

After growers have tried other weed control measures for the control of several weeds there remains one last chance to obtain control using glyphosate just prior to harvest. Glyphosate can be tank mixed with defoliants butifos (Def) or tribuphos (Folex). It can also be applied alone, followed 7 to 10 days later by sodium chlorate. Glyphosate can be applied by air using a maximum of 1.0 lb/A. which is usually adequate for control of annuals and johnsongrass during the fall of the year. Higher rates can be applied by ground for control of bermudagrass or field bindweed.

Glyphosate or tank mixtures containing glyphosate can be applied when 60% or more of the bolls are open. There must be enough residual soil moisture for herbicide uptake and weeds must not be senesced for successful control. If these conditions are met this application should result in a cleaner field the following season.

In 1985 a test was conducted to evaluate the effect of glyphosate applied preharvest. Unfortunately the conditions for the cotton was not the best because cotton varied in height from 12 to 38 inches but had several weeds present for a test. A conventional high clearance sprayer was used. Plot size was 550 by 12.66 feet replicated three times.

Glyphosate was applied at defoliation to a weed infested field having bermudagrass, purple nutsedge, johnsongrass, and Chinese thornapple. Glyphosate was applied at rates varying from 0.75 to 3.0 lb/A in combination with butifos. Treatments were compared to DEF plus paraquat and sodium chlorate.

Weed control was fair but inconclusive since weeds were partly senesced and drought stressed at the time of application. Using percent cotton leaf damage as an indication of desiccation, sodium chlorate and butifos plus paraquat treatments had slightly more cotton leaf damage than glyphosate treatments at this site.

During the 1986 season similar studies were conducted at two locations. At the first site tall morningglory was heavy in scattered portions of the field. Prometryn had been applied preplant for morningglory control. Cyanazine was applied at layby for tall morningglory.

Plots were 31.66 by 1320 feet replicated four times. Cotton was 60 to 80% boll open at the time of application. All treatments were applied on September 30, 1986. Sodium chlorate plus paraquat was applied on October 6, 1986 to the treatment previously treated with glyphosate.

A windmill electrostatic sprayer was used delivering 10 gpa. With electrostatic spraying each droplet as it passes through the spray nozzle is electrically charged and is automatically attracted to the leaves being sprayed. A more uniform coverage to all sides of the leaves is expected with this type of application.

All treatments gave equal burndown of tall morningglory leaves, however, treatments containing glyphosate dried the stems more. There were no differences in cotton leaf damage or percent open bolls at this location.

The second location was heavily infested with johnsongrass. The field had not been summer fallowed for some time and the grower did not want to spend money on sethxoxydim or fluazifop. Glyphosate had been used once on the field as a rope wick application. Other weeds included tall morningglory, bermudagrass, purple nutsedge, citron and American black nightshade . Cotton was non-uniform in height and maturity with a range of 20 to 70% boll open at time of application. Plots were 31.66 by 3960 feet and replicated four times. The electrostatic sprayer was again used at 10 gpa. The glyphosate treatment was applied on October 10, 1986. Sodium chlorate was applied over the glyphosate treatment and the other treatments were applied on October 20, 1986.

Treatments containing glyphosate gave good control of johnsongrass and fair burndown of tall morningglory. The glyphosate followed with a later sodium chlorate application gave the most effective control of johnsongrass and better stem drydown of tall morningglory. All herbicide treatments gave poor control of citron and American black nightshade. Glyphosate followed by sodium chlorate gave the greatest control of nightshade. None of the treatments showed any visual effect on bermudagrass or purple nutsedge with these rates.

Treatments containing glyphosate gave 10 to 15% more cotton leaf damage than the butifos or sodium chlorate. The butifos treatment without glyphosate resulted in the lowest percent open bolls.

In Fresno County glyphosate has been applied commercially as a preharvest application principally for field bindweed control. Infested fields are first treated with glyphosate early in the season using shielded sprayers. Then at defoliation glyphosate is applied in a auxiliary sprayer system. With this system as a defoliant butifos or tribuphos is applied, the operator is able to turn on a switch so that qlyphosate is also being applied in infested spots. The extra spray boom has nozzles set up depending on the height of the weed.

It has been observed that the harvest aid ethephon (Prep) has enhanced control of tall morningglory and made cotton harvest easier. It has also been observed that ethephon applied 7 days prior to a glyphosate application improves control of field bindweed. Researchers with Monsanto and growers have been experimenting with an ethephon plus glyphosate tank mix and also ethephon plus butifos or tribuphos with glyphosate applied in an auxiliary tank.

In summary, glyphosate when applied preharvest 1) can give a last chance for controlling problem weeds, 2) allows an easier harvest, 3) may enhance defoliation, 4) is possible to combine the application with an existing trip, and 5) should leave the field cleaner for the next crop.

WINTER ANNUAL GRASS CONTROL IN SEEDLING ALFALFA. Steve B. Orloff and David W. Cudney, Farm Advisor and Weed Science Specialist, University of California Cooperative Extension, 335-A East Ave K-6, Lancaster, CA 93535 and University of California, Riverside, CA 92521.

Abstract. Winter annual grasses, such as foxtail barley and volunteer cereals, are a serious problem during alfalfa stand establishment in the high desert. Not only is the quality of the first harvest reduced, but alfalfa stand and vigor can be reduced as well. In a trial conducted in 1989, alfalfa stand density was 21.9 plants/ft^2 where foxtail barley was controlled and only 0.4 in the untreated plots.

Over 20 yr ago, propham was introduced for weed control in seedling alfalfa. It was commonly used, but grass control was often erratic. Its use has now been discontinued. Although effective, pronamide has not been widely used because the recommended use rates have made it too costly. More recently, postemergence grass herbicides have been introduced. Of the six postemergence grass herbicide tested in three trials, was the least effective on winter annual grasses. However, sethoxydim is the only one presently registered for use in alfalfa. Trials were conducted to study methods to enhance the performance of sethoxydim on winter annual grasses using adjuvents and application timing. A recently introduced crop oil concentrate (Dash), and the use of a non-ionic surfactant plus liquid fertilizer improved foxtail barley control with sethoxydim compared to a standard crop oil concentrate or a non-ionic surfactant alone. When using sethoxydim, control is normally considered best when applications are made at the early seedling stage. However, a timing study showed an interaction between alfalfa canopy growth and timing of sethoxydim application, indicating that delaying applications to when the alfalfa had approximately four to six trifoliate leaves improved control. Pronamide was also re-evaluated at lower rates and compared to several grass herbicides. When used at 0.75 lb/A, pronamide controlled foxtail barley as well or better than any of the grass herbicides. All studies showed significant stand reduction from winter annual grasses, emphasizing the necessity of controlling these species.

WEED CONTROL IN SEEDLING ALFALFA WITH BROMOXYNIL. A. W. Dalrymple and S. D. Miller, Research Associate and Professor, Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Seedling alfalfa requires effective broad spectrum weed control for successful establishment; however, few herbicides are registered for postemergence broadleaf weed control. Since bromoxynil was recently labeled for broadleaf weed control in seedling alfalfa, field trials were conducted at the Research and Extension Center, Torrington, Wyoming to evaluate weed control and alfalfa tolerance with bromoxynil, alone and in combination with other herbicides. Common lambsquarters, kochia, wild buckwheat and Russian thistle control was excellent (≥95%) at the 0.38 lb/A rate; however, crop injury averaged 15%. Further, alfalfa yields tended to be reduced at the 0.38 lb/A rate.

Growth chamber experiments were initiated in 1988 and repeated in 1989 to evaluate the influence of temperature on bromoxynil phytotoxicity to seedling alfalfa. Two alfalfa varieties (Apollo II and Ranger) were treated with five rates of bromoxynil (0.25 to 2.0 lb/A) at three temperatures (10, 20 and 30 C). Alfalfa injury with bromoxynil increased as temperature increased, regardless of variety or rate. The greatest phytotoxicity occurred at 30 C, with injury ranging from 15 to 67% at the 0.25 and 2.0 lb/A rates, respectively. Alfalfa dry weight reductions (as a percentage of the untreated check) showed similar trends.

BREEDING FOR GLYPHOSATE TOLERANCE IN BIRDSFOOT TREFOIL. Chris M. Boerboom, Donald L. Wyse, Nancy J. Ehlke, and David A. Somers, Assistant Professor, Department of Agronomy and Soils, Washington State University, Pullman, WA 99164, Professor, Assistant Professor, and Associate Professor, Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN 55108.

Abstract. The dense stands of Canada thistle that often develop in the certified seed production fields of birdsfoot trefoil in northern Minnesota cannot be controlled because selective herbicides are not available. If the glyphosate tolerance of birdsfoot trefoil was increased, Canada thistle could be selectively controlled with glyphosate without crop injury. A breeding program was initiated to increase the glyphosate tolerance of birdsfoot trefoil. Two cycles of recurrent selection for glyphosate tolerance were practiced on three birdsfoot trefoil populations, Leo, Noreen, and MU-81. Plants were selected for glyphosate tolerance by treating seedlings with 0.56 kg/ha glyphosate plus 0.5% surfactant. Selected plants were intercrossed within the source population to form the subsequent cycle. The tolerance of the parental (C0), first cycle (C1), and second cycle (C2) populations was evaluated in the greenhouse by treating 7 cm tall seedlings with 0.56 kg/ha glyphosate plus 0.5% surfactant. Untreated and treated shoot fresh weights were measured 14 days after treatment (DAT) and regrowth was measured at 35 DAT. Improved glyphosate tolerance was observed in the selected populations, which had lower injury ratings and higher treated shoot fresh weights. Treated shoot fresh weights of the three C2 populations were from 44 to 85% greater than their C0 populations. The evaluation of regrowth showed a similar response to selection with treated shoots of C2 populations weighing 44 to 127% more than their unselected parents. Differences in treated fresh weights reflect differences in glyphosate tolerance because untreated shoot fresh weights were not substantially affected by selection. Established plants of the C0 and C2 populations of Leo, Noreen, and MU-81 were evaluated for glyphosate tolerance at two field locations. Three months after planting, plant rows were treated with 0.56 kg/ha glyphosate plus 0.5% suractant, 1.12 kg/ha glyphosate plus 0.5% surfactant, or left untreated. The selected C2 populations also had greater glyphosate tolerance under field conditions with the treated shoot fresh weights averaging 28% greater than the C0 populations following the high glyphosate rate. The two cycles of selection imposed upon these heterogeneous, synthetic populations increased the frequency of tolerant plants in the C2 populations. Tolerant and susceptible plants were assayed for 5-enolpyruvylshikimate 3-phosphate (EPSP) synthase activity. EPSP synthase specific activity of tolerant plants averaged 45% greater than susceptible plants and indicated that tolerance resulted from increased EPSP synthase activity. Further selection for glyphosate tolerance will be made on these populations to create a glyphosate tolerant birdsfoot trefoil germplasm.

COMPUTER SIMULATION OF LIGHT, WATER AND NITROGEN COMPETITION BETWEEN CORN AND REDROOT PIGWEED. Daniel A. Ball and Marvin J. Shaffer, Research Agronomist and Supervisory Soil Scientist, USDA-ARS, Great Plains Systems Research, 1701 Center Ave., Ft. Collins, CO 80526.

INTRODUCTION

In late 1979, work began on a comprehensive computer simulation model to assess the potential influence of nitrogen fertilization, tillage practices and crop residue management on the soil environment and crop growth. The product of this effort is known as the NTRM (Nitrogen-Tillage-Residue Management) simulation model (1).

Within the realm of computer modeling in agriculture, NTRM is a mechanistic, simulation model with applications in research, crop and soil management and teaching. The model is designed to simulate various processes in the soil environment including: unsaturated water flow, nitrogen transformations and movement, changes in soil physical properties, and organic matter dynamics. A plant growth submodel interfaces with the soil component to simulate the interaction between plants and the chemical, physical and moisture status of the soil.

The plant growth submodel of NTRM acts as a producer and consumer of carbohydrates. Processes simulated by the model include: photosynthesis, respiration, dry matter production and leaf area development.

A one-dimensional root growth model is interactive with crop growth and is designed to simulate root penetration, branching and root death. Root growth is controlled by soil moisture potential, soil physical properties, soil temperature, soil salinity and soil nitrogen.

More recently, an emphasis has been placed on the development of sustainable cropping systems. In these types of cropping systems, multiple species including weeds become an important component, especially in reduced tillage and/or herbicide input systems. Because of this, a project was initiated to expand the NTRM model with the objective to simulate the simultaneous growth and development of several plant species competing for light, water and nitrogen and to model the effects of interacting species on resource removal and changes in the soil environment. This expanded model version will be referred to as NTRM-SA (NTRM-Sustainable Agriculture).

MODELING APPROACH

Light competition. It is commonly recognized that competition for sunlight is an important interaction between species in agricultural plant communities. Because of this, several workers have modeled light partitioning between competing species (2,3). The basic approach has been to calculate the extinction of light through the canopy as a function of canopy leaf area distribution. For the expanded NTRM model, horizontal layers through the plant canopy are defined and leaf area in each layer calculated once per day. Plants are assumed to exhibit a cylindrical growth form with leaf area uniformly distributed through the cylinder. Plant height and diameter are a function of aboveground dry matter accumulation.

Available solar radiation in each canopy layer, after attenuation for time of day, is computed based on the total leaf area in the preceding layer. Light extinction in a canopy layer is based on the equation:

$$S_1 = S_0 * e^{(-EK * LAI)}$$

Where: S_1 - resulting direct, short-wave solar radiation
S_0 - incoming direct, short-wave solar radiation
EK - extinction coefficient
LAI - leaf area index

This approach assumes random leaf distribution and orientation in the canopy, cylindrical growth form of component species, and ignores diffuse and reflected radiation in the canopy.

Water and nitrogen competition. An ability to simulate competition for water and nitrogen requires an understanding of root growth rates and rooting patterns. The root growth submodel of NTRM is a one-dimensional model designed to simulate root elongation, branching and root death through a layered soil profile. This root growth submodel was expanded to compute the root growth for up to ten species growing simultaneously. Several soil parameters affect the root growth simulation including: soil temperature, soil bulk density, soil aeration, soil water potential, soil salinity and soil nitrogen availability in each soil layer. If necessary, the model redistributes root growth to exploit more favorable conditions. Each soil layer will allow a maximum root density which acts to limit growth of competing species. Water and nitrogen uptake between competing root systems is dependent on root density, root distribution in the soil layers, plant transpiration rates, soil water status, soil hydraulic properties, and soil nitrogen content. Water and nitrogen are extracted from each soil layer based on soil water and nitrogen availability and the root density of each species present in that layer. The species with the greatest proportion of roots in a given soil layer will receive a proportionally greater amount of available soil resources.

RESULTS AND DISCUSSION

In a sensitivity analysis of the light interception submodel, it became evident that several important factors were involved in simulating light competition. Plant competitive interactions were sensitive to emergence time of plants, rate of early leaf area development and plant height development. Changes in canopy density (i.e.

increases in EK or LAI) also have a large effect on competitive interactions, with the understory species exhibiting the greatest effect.

Limited data pertaining to plant rooting distribution and canopy transpiration in mixed plant communities makes it difficult to evaluate the adequacy of simulated competition between species for soil water and nitrogen. This lack of data has slowed model development efforts, and points to the need for studies concerning root system response to interspecific competition. Rooting characteristics for corn growing free from interference have been adequately documented. Rooting characteristics for pigweed species have also been evaluated. However, the response of root systems of these, and other, species growing in competition have received little attention. It has also been recognized that individual plant transpiration rates will differ according to population density, and according to the plant position in the canopy, but further data are necessary to adequately model canopy transpiration and subsequent water use of crops and weeds growing in mixtures. Preliminary testing of the water and nitrogen competition algorthims indicates that corn and pigweed are relatively insensitive to a mixed planting as long as water and nitrogen are in adequate supply.

Additional key words: maize, Amaranthus retroflexus, models

LITERATURE CITED

1. Shaffer, M.J. and W.E. Larson (eds.). 1987. NTRM, a soil-crop simulation model for nitrogen, tillage, and crop-residue management. U.S. Dept. of Agriculture, ARS, Cons. Res. Rep. 34-1. 103 pp.

2. Spitters, C.J.T. and R. Aerts. 1983. Simulation of competition for light and water in crop-weed associations. Aspects of Appl. Biol. 4:467-483.

3. Wiles, L.J. and G.G. Wilkerson. 1989. A simple model of light competition between broadleaf weeds and soybeans. WSSA Abst. 29:11.

CORN PRODUCTION IN ALFALFA SOD FOLLOWING NO-TILL AND PLOW-BASED FIELD PREPARATION. J.M. Krall and S.D. Miller, Assistant Professor and Professor, Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Corn follows alfalfa in many local rotations. With the transition comes soil erosion when conventional plow-based seedbed preparation is used. The purpose of this research was to examine the no-till alternative to conventional practices for removal of alfalfa prior to corn production. In 1987, 1988, and 1989 areas of established alfalfa on a sandy loam soil with 1.1% organic matter and a pH of 7.6 were chosen as study sites at the Torrington Research and Extension Center. A split plot in a randomized complete block design was used with 4 replications. The main plots were management systems, no-till and plow, with 2 primary herbicide systems respectively. Early-preplant systems for the no-till comprised treatments of cyanizine, atrazine, and dicamba at 2.2, 1.1, and 0.6 kg/ha respectively and metolachlor, atrazine, and dicamba at 1.7, 1.3 and 0.6 kg/ha respectively, applied not less than 18 days prior to seeding. The plow-based system, which consisted of moldboard plow then 2 roller harrow operations employed at planting, herbicide systems of cyanizine and atrazine at 1.6 and 0.8 kg/ha, respectively, and metolachlor and atrazine at 1.3 and 1.1 kg/ha, respectively. The split was cultivation with a minimum-till cultivator. Dicamba at 0.3 kg/ha was applied to all treatments for control of alfalfa escapes when corn and alfalfa were 20 to 25 and 15 to 30 cm tall, respectively. Herbicide treatments were applied broadcast with a tractor-mounted sprayer delivering 187 L/ha. All 3 by 27 m plots were fertilized according to soil test and sprinkler irrigated.

Corn populations were similar for both primary management systems in 1987 and 1989 and lower, but within recommended population limits, for the plowed system in 1988. Alfalfa counts were always higher in the no-till plots, for 1988 and 1989 counts averaged 3,594 and 55,153 pl/ha for the plow and no-till respectively, but did not seem to impact yield. In fact, grain yields were 17% higher 2 of the 3 yr in the no-till plots, with 3 yr means of

203 and 187 kg/ha for no-till and plow, respectively. Silage yields were comparable with the exception of 1989 when both silage and grain yields were lower in the no-till plots. High weed counts in 1989 confirm herbicide application error with greatly elevated weed populations in the no-till plots. No consistent yield differences could be attributed to cultivation or primary herbicide treatment. No-till production of corn into alfalfa sod using early preplant herbicides is a viable alternative to plow-based field preparation.

DPX-V9360 FOR WEED CONTROL IN CORN. Stephen D. Miller, Professor, Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. DPX-V9360 is a sulfonyl urea herbicide that has shown considerable promise for postemergence grass control in corn. Field experiments were conducted at several locations in Wyoming during 1988 and 1989 to evaluate weed control and corn tolerance with postemergence applications of DPX-V9360 alone and in combination with other herbicides. Wild proso millet and yellow foxtail control was good with 2- and 5-leaf applications of DPX-V9360 at 0.047 lb/A or higher. Grass control with DPX-V9360 was influenced by additive. DM-710 was the least effective and oil concentrate plus aqueous nitrogen (28% w/w) the most effective. Broadleaf weed control with DPX-V9360 was variable and influenced by species. DPX-V9360 combinations with atrazine, bromoxynil, cyanazine and dicamba have provided excellent broad spectrum weed control. Corn tolerance to DPX-V9360 at rates as high as 0.094 lb/A was good at all stages of application; however, rates above 0.094 lb/A reduced weed free corn yields 26 and 17 bu/A at the 2- and 8-leaf stages of application, respectively. Corn tolerance to DPX-V9360 was not influenced by cultivar. (Published with the approval of the Wyoming Agricultural Experiment Station).

RESIDUAL EFFECTS OF DPX-R9674 ON FIELD CORN, PINTO BEANS, AND FIELD POTATOES.
R.N. Arnold, E.J. Gregory, and M.W. Murray, Pest Management Specialist, Professor of Agronomy, and Research Assistant, Agricultural Science Center, New Mexico State University, Farmington, NM 87499.

Abstract. DPX-R9674 (DPX-L5300 plus DPX-M6316) is a new sulfonylurea short residual herbicide developed by Dupont and other university researchers over the past six years for control of annual broadleaf weeds in wheat. In 1988, DPX-R9674 was applied early postemergence with a crop oil concentrate to broadleaf weeds at rates of 0.225, 0.45, 0.9, and 1.35 oz ai/A. This product provided excellent control in 1988 of kochia, prostrate pigweed, redroot pigweed, and Russian thistle. In 1989 these research plots were planted to field corn, pinto beans, and field potatoes. Results indicated that there were no significant differences among yield of field corn, pinto beans, and field potatoes. Field corn averaged 202 bu/A, pinto beans, 4484 lb/A, and field potatoes, 590 cwt/A during the 1989 growing season.

DIFFERENTIAL RESPONSE OF CORN GENOTYPES TO CGA-136872. Charlotte V. Eberlein, Kathleen M. Rosow, and Paul R. Viger, Associate Professor, Assistant Scientist, and Graduate Research Assistant, University of Idaho, Aberdeen Research and Extension Center, Aberdeen, ID 83210 and University of Minnesota, St Paul, MN 55108.

Abstract. CGA-136872 is a sulfonylurea herbicide that has shown potential for grass control in corn. Field studies with ten inbred corn lines that represented widely used germplasm families were conducted at Rosemount, MN. CGA-136872 plus surfactant at 80 g/ha plus 0.25% was applied when inbreds were at the four- to five-leaf stage. Injury ranged from 0 to 89% among inbreds, and yields were reduced 0 to 91% when compared to the untreated controls. Two inbreds, A641 and A619, were highly susceptible to CGA-136872, and six inbreds, A632, A654, A671, B73, CM105, and MO17, were tolerant. Two inbreds, ND246 and W153R, were intermediate in tolerance. Laboratory studies to determine the basis for differential tolerance were conducted using susceptible A641 and tolerant A671. Acetolactate synthase (ALS) extracted from both tolerant A671 and

susceptible A641 was highly susceptible to inhibition by CGA-136872. I_{50} values for ALS inhibition by CGA-136872 were 4.2 nM for A671 and 4.5 nM for A641. There was little difference in absorption of CGA-136872 by A641 and A671 over a 72 h uptake period. CGA-136872 was metabolized more rapidly in leaf tissue of A671 than A641. By 4 h after treatment, A671 had metabolized 89% of the absorbed CGA-136872 while A641 had metabolized only 55%. Metabolism rate appeared to be the primary mechanism responsible for the tolerance of A671 and the susceptibility of A641 to CGA-136872. Preliminary studies suggested that CGA-136872 may be metabolized by a microsomal cytochrome P450 monooxygenase system.

WEED CONTROL IN DRY BEANS WITH IMAZETHAPYR. A. W. Dalrymple and S. D. Miller, Research Associate and Professor, Department of Plant, Soil and Insect Sciences, University of Wyoming, Laramie, WY 82071.

Abstract. Imazethapyr is currently under development for weed control in dry edible beans at rates of 0.032 to 0.063 lb/A. Field experiments were conducted at the Research and Extension Center, Torrington, Wyoming from 1985 to 1989 to evaluate weed control and dry bean tolerance with preplant incorporated, preemergence and postemergence applications of imazethapyr alone and in combination with other herbicides. Broadleaf weed control with imazethapyr has been good to excellent (88 to 98%) with preplant incorporated and preemergence applications, and fair to good (79 to 91%) with postemergence applications. Grass control with imazethapyr has been variable and influenced by species. Imazethapyr combinations with pendimethalin, metolachlor or alachlor have provided excellent (93 to 100%) broad spectrum weed control, whether applied as a tank mix or sequential treatment. Dry bean tolerance to imazethapyr has been better with preemergence or early postemergence applications than with preplant incorporated applications. In addition, imazethapyr combinations with metolachlor or alachlor have been safer on dry beans than combinations with pendimethalin, whether tank mixed or applied sequentially. UI-111 pinto beans appear to be one of the most susceptible, and UI-126 pinto beans one of the most resistant cultivars to imazethapyr.

THE INTRODUCTION OF A MINIMUM TILLAGE CROP PRODUCTION SYSTEM TO DRYLAND SORGHUM PRODUCTION IN TAMAULIPAS, MEXICO. Michael V. Hickman, Marvin D. Heilman and Leticia A. Salinas, Research Agronomist, Soil Scientist, USDA-Argicultural Research Service, Weslaco, TX 78596-8344, and SARH, San Fernando, Tamaulipas, Mexico.

Abstract. A minimum tillage production system for dryland grain sorghum has been developed in South Texas. The system is built around a wing-chisel plow coupled to lister bedders to give a single pass seed bed preparation. Winter weed control is accomplished with single fall applications of atrazine at 1.4 kg/ha in combination with metsulfuron at 1.7 g/ha. The wing-chisel plow system has resulted in reduced wind erosion, improved soil water conditions, reduced soil compaction and greater economic return. Demonstration fields were established at 6 locations near San Fernando, Tamaulipas, Mexico in July 1988. Each consisted of 1 ha wing-chisel plots located within conventionally tilled grain sorghum fields. Due to drought conditions only 3 sites yielded harvestable grain. The wing-chisel treatments averaged 1420 kg/ha versus 1280 kg/ha from the conventional systems. A second yr of demonstration plot work is underway at 10 sites in Tamaulipas. The agencies in charge of Tamaulipas agriculture have contracted for 20 modified chisel plows and are currently in the initial stages of adopting the wing-chisel system for dryland grain sorghum production in Tamaulipas.

SULFONYLUREA-RESISTANT WEEDS: AN UPDATE OF DISTRIBUTION AND CONTROL. Michael G. King, Wayne J. Schumacher, Norman D. McKinley, John Saladini, and Leonard L. Saari. E. I. Du Pont De Nemours & Co., Inc., Wilmington, DE 19898.

Abstract. Since the first confirmation of a weed developing resistance to an herbicide, scientists have struggled with the dilemma it posed to the weed science discipline. Currently over 100 weed biotypes have evolved resistance to at least 15 classes of herbicides. In 1987, the first case of sulfonylurea-resistant kochia and prickly lettuce were discovered, and in 1988, sulfonylurea-resistant Russian thistle and common chickweed had also occurred.

In 1989, field tests were conducted in the western half of the United States on populations of sulfonylurea-resistant kochia and Russian thistle. Results from these tests revealed that metsulfuron-methyl in combination with 2,4-D ester and dicamba offered the highest level of efficacy on Russian thistle and kochia, respectively. These results also concluded that the tankmix strategy employed by DuPont in 1989 could effectively control these resistant biotypes and slow the development of resistance.

Also this same year, a survey was conducted of cereal growers to measure their level of awareness and belief in weeds developing resistance to cereal herbicides and their compliance in using tankmixes with chlorsulfuron and metsulfuron-methyl. Of the farmers surveyed, over 80% are aware that weeds can develop resistance to cereal herbicides and that it can happen on their farm. Over 80% are using tankmixes with metsulfuron-methyl, and approximately 60% are using tankmixes with chlorsulfuron.

WHOLE PLANT STUDIES ON WEED RESISTANCE TO ALS/AHAS INHIBITING HERBICIDES. Jose de Castro and Cletus D. Youmans, Biologist and Product Manager, American Cyanamid Company, Princeton, NJ 08540.

Abstract. Duplicate whole plant studies were conducted at the American Cyanamid Agricultural Research Center in Princeton, NJ in 1988 and 1989 to evaluate cross-resistance within and between the sulfonyl urea and imidazolinone herbicide families with weed biotypes suspected of being resistant to certain sulfonyl ureas.

Seeds were collected from locations where sulfonylurea resistance was reported. Four kochia bioytpes, three reportedly resistant to chlorsulfuron and one to sulfometuron, one common chickweed biotype and one Russian thistle biotype both reportedly resistant to chlorsulfuron along with seeds from common chickweed and kochia susceptible to ALS/AHAS (acetolactate synthase or acetohydroxyacid synthase) inhibiting herbicides were tested. Herbicides from both the sulfonylurea and imidazolinone families were applied postemergence (plants 2.5 cm tall) at 1, 5 and 10X rates. The herbicides tested (1X rates) were: chlorsulfuron (14 g/ha), imazaquin (140 g/ha), imazapyr (560 g/ha), imazethapyr (70 g/ha), metsulfuron-methyl (4 g/ha), sulfometuron (64 g/ha) and thifensulfuron (14 g/ha).

The Russian thistle biotype showed growth reduction of 11% with chlorsulfuron at 14 g/ha. It was cross-resistant to metsulfuron (55% reduction), sulfometuron (37% reduction), and thifensulfuron (41% reduction), but not resistant to any of the imidazolinones (100% reduction).

The suceptible common chickweed was controlled by all herbicide treatments (100% growth reduction). At the 1X rates, none of the sulfonylurea herbicides controlled the resistant biotype: chlorsulfuron (8% reduction), metsulfuron (14% reduction), sulfometuron (3% reduction) and thifensulfuron (5% reduction), but all three imidazolinones provided excellent control (100% reduction).

Kochia biotypes from the four locations suspected of sulfonyl urea resistance, showed growth reductions of 13, 44, 51, and 26%, respectively, with chlorsulfuron at 1X rate. Cross-resistance within and between herbicide families was different for each biotype tested. All four biotypes showed cross-resistance to thifensulfuron (25,

26, 62, and 22% reduction). One of the four kochia biotypes was cross-resistant to sulfonylureas [metsulfuron (41% reduction) and sulfometuron (66% reduction)] and imidazolinones [imazethapyr (47% reduction), imazaquin (56% reduction) and imazapyr (77% reduction)]. The susceptible kochia biotype showed growth reductions of 95% to 100% to all herbicides at their 1X rates.

These data indicate that cross-resistance within or between chemical families with the same mode of action has to be evaluated for each biotype in question before concluding cross-resistance occurs.

EFFECTS OF ALS INHIBITING HERBICIDES ON POTATOES FOLLOWING FOLIAR MISAPPLICATION OR SOIL CARRYOVER. Philip Westra, Assistant Professor, Department of Plant Pathology and Weed Science, Colorado State University, Ft. Collins, CO 80523.

Abstract. Sulfometuron applied preplant incorporated (PPI) at 100 to 500 parts per trillion (ppt) in the soil reduced the number of Russet Burbank normal tubers, increased the number of abnormal tubers, and reduced tuber weight. Sulfometuron did not affect the number of shoots per pot, the plant height, nor shoot or root dry weight. Sulfometuron applied PPI did very little damage to Centennial Russet or Russet Norkotah potatoes, except for reduced tuber weight at 100 ppt. When sulfometuron at 10 to 100 ppt was banded around the seed piece, it had no major effects on all 3 potato varieties except to significantly increase the number of Russet Burbank abnormal tubers. Sulfometuron applied preemerge at 300 ppt to the soil surface significantly decreased the number of Russet Burbank normal tubers per pot, and significantly decreased tuber weight for Russet Burbank and Russet Norkotah potatoes. Depending on the study, detectable potato damage, especially with Russet Burbank, was obvious beginning at 100 ppt [0.1 part per billion (ppb)]. In some pots damage was obvious at 10 and 20 ppt, but this was not consistent across replications. When 1988 tubers from the sulfometuron, harmony extra, and assert treated plots were planted in 1989, the sulfometuron at 4 ppb treatment caused a significant reduction in the number of shoots per 10 plants, but did not affect tuber germination. Sulfometuron at 4 ppb tubers produced significantly fewer tubers, and less tuber weight. All of the herbicide treated tubers produced more abnormal tubers than the untreated check plot tubers. However, the vast majority of 1989 tubers were normal and of a marketable quality. When barley was planted back into a portion of each 1988 research plot, sulfometuron caused visible barley injury (11 to 40%) early in the season, but this did not translate into yield reduction. Slightly more potato damage occurred on early treated 1988 plots vs. late treated plots, perhaps because early treated plots had more bare soil exposed; the early 1988 application of sulfometuron reduced the number and weight of Russet Burbank potatoes. The other herbicides, when applied at low rates in 1988, did not cause significant carryover damage to Russet Burbank or Centennial Russet potatoes. When sulfometuron was applied at 2.5 to 500 ppt PPI in the SLV in a 1989 field experiment, the 200 and 500 ppt rates caused a significant reduction in the number and weight of potato tubers, while simultaneously increasing the number of abnormal tubers. Rates below this tended to produce little or no potato tuber damage. Russet Burbank yielded the most tubers per plot (but was also the variety most easily damaged by sulfometuron), followed by Sangre, then Russet Norkotah, and finally Centennial Russet. Improved redroot pigweed control was also obvious in plots with 200 and 500 ppt of sulfometuron. In Summary, this research has shown that sulfometuron has moderate to high carryover potential in SLV soils (as measured by its biological activity on potatoes, particularly the Russet Burbank variety). Carryover injury from sulfometuron becomes most obvious and most consistent at 100 to 200 ppt (0.1 to 0.2 ppb). Russet Burbank is the potato variety most sensitive to sulfometuron presence in the soil. Barley was unaffected by herbicide soil carryover. Finally, every herbicide user in the SLV must realize that herbicides with very high biological activity need to be used with extreme caution in the valley.

POTATO RESPONSE TO SIMULATED DRIFT OF IMIDAZOLINONE HERBICIDES. Charlotte V. Eberlein and William C. Schaffers, Associate Professor and Research Associate, University of Idaho, Aberdeen Research and Extension Center, Aberdeen, ID 83210.

INTRODUCTION

Imazamethabenz, imazapyr, and imazethapyr are members of a new family of herbicides called the imidazolinones. Imazamethabenz and imazethapyr are used to control weeds in certain crops, and imazapyr is used to control weeds in non-crop land. The relatively high activity of the imidazolinones may increase their potential to damage susceptible crops when spray drift occurs. However, little information is available on potato yield and quality losses due to drift of imidazolinone herbicides. Therefore, the objectives of this study were to determine the effects of simulated drift of imazamethabenz, imazapyr, and imazethapyr at three potato growth stages on foliar injury, tuber yield, and quality.

MATERIALS AND METHODS

Experiments were conducted at the Aberdeen Research and Extension Center in Aberdeen, ID. 'Russet Burbank' potatoes were seeded in early May and were maintained weed-free throughout the growing season with a preemergence application of pendimethalin plus metribuzin at 0.84 plus 0.28 kg/ha, respectively. Imazamethabenz at 11.2, 56, and 280 g/ha, imazapyr at 22.4, 112, and 560 g/ha, and imazethapyr at 1.4, 7, and 35 g/ha were applied at emergence, tuber initiation or tuber bulking. Simulated drift rates corresponded to 2, 10, and 50% of the typical use rate for each herbicide. The experimental design was a split-split plot arrangement of a randomized complete block with four replications. Main plots were potato growth stages, subplots were herbicides and sub-subplots were herbicide rates. Sub-subplot size was 3.7 by 12 m. Foliar injury symptoms were evaluated visually 2, 4, and 6 weeks after treatment and tuber yield and quality were measured at harvest.

RESULTS AND DISCUSSION

Foliar injury symptoms ranged from slight yellowing to plant death depending on herbicide, rate, and stage of growth. Imazamethabenz at 11.2 and 56 g/ha caused less than 10% visual injury regardless of time of application and yield of US #1 potatoes was not reduced. Imazamethabenz at 280 g/ha caused 12 to 27% injury and reduced yield of US #1 potatoes 25, 84, and 78% when applied at emergence, tuber initiation, or tuber bulking, respectively. Malformed tubers were often cracked and folded, and were sometimes knobby. Imazethapyr at 1.4 g/ha caused 10% or less visual injury regardless of growth stage, but yield of US #1 potatoes was reduced 0, 44, and 28% by application at emergence, tuber initiation and tuber bulking, respectively. Higher rates of imazethapyr caused moderate to severe injury, depending on stage of growth. Yield of US #1s was reduced 50% by imazethapyr at 35 g/ha applied at emergence; imazethapyr at 7 or 35 g/ha at tuber initiation or tuber bulking reduced US #1 yield 86 to 100%. Malformed tubers displayed moderate to severe cracking, folding, and knobbiness. Simulated drift of imazapyr caused moderate to severe foliar injury initially, and injury became even more severe as the season progressed. Imazapyr at 22.4 g/ha at emergence reduced yield of US #1s 64%; all other imazapyr treatments reduced US #1 yield 99 to 100%. In addition to moderate to severe cracking, folding, and knobbiness, imazapyr also caused severe elephant hide on tubers produced by plants treated at the tuber bulking stage.

EFFECTS OF RUSSIAN KNAPWEED AQUEOUS EXTRACTS ON GRASS GERMINATION AND SEEDLING GROWTH. D. Eric Hanson and K. George Beck, Graduate Research Assistant and Assistant Professor, Department of Plant Pathology and Weed Science, Colorado State University, Fort Collins, CO 80523.

Abstract. Russian knapweed is an herbaceous, creeping perennial weed that is prevalent in the western United States and is spreading at an estimated annual rate of 8%. Russian knapweed forms single-species stands, that

in part is caused by allelopathy. Fletcher and Renney isolated an unidentified growth inhibitor from Russian knapweed and Stevens isolated phytotoxic sesquiterpene lactones and polyacetylenes. Germination, shoot growth, and/or root growth of various crops are reduced by Russian knapweed aqueous extracts. There are no data on allelopathic effects of Russian knapweed on rangeland grasses. Experiments were established to determine Russian knapweed aqueous extract effects on rangeland grass germination, and seedling growth.

The aqueous extract stock solution was prepared as outlined by Wilson and Rice, using 100 g fresh weight of leaves per 1000 ml of distilled water. Treatments were 0% (distilled water control), 10%, 50% and 100% aqueous extract; 10% and 50% treatments were made by diluting with the stock solution with distilled water. Western wheatgrass and smooth brome were used in seedling growth and germination experiments.

Germination experiments followed the American Association of Official Seed Analysts procedures with 10 ml of treatment applied. Grasses in the seedling growth experiments were allowed 7 days establishment after emergence, then were irrigated with 25 ml of respective treatments every 2 days. Grasses were harvested at weekly intervals over 4 weeks. Germination data were arcsine square root transformed, whereas, primary root length and root and shoot dry weight were log transformed. All means were separated with Duncan's Multiple Range Test.

Germination of two-year old western wheatgrass seed was lower with all extract treatments relative to the control 21 days after treatment began, however, germination of one-year old seed was lower only with the 100% extract treatment. Germination of smooth brome decreased with increasing extract percentage 15 days after treatments began and germination with 100% extract, 7 days after treatments began, was lower than the control. Corn germination was reduced with the 100% extract, 2 days after initial treatment, but there were no differences at 3 and 7 days. Polyethylene glycol (PEG), at 0.17 MPa osmotic potential (same osmotic potential as 100% extract), reduced germination more than all other treatments at 2, 3, and 7 days. Smooth brome primary roots were shorter with 50%, 100% and PEG treatments than the other treatments. Corn primary root length decreased as percent extract increased. PEG also reduced corn primary root length.

Western wheatgrass shoots without added fertilizer, increased in dry weight with 50% and 100% treatments relative to the 10% extract treatment. With added fertilizer, smooth brome roots and shoots and western wheatgrass shoots decreased in dry weight as percent extract increased.

EVALUATION OF DPX-V9360 AND OTHER POSTEMERGENCE HERBICIDES FOR WILD PROSO MILLET CONTROL IN FIELD CORN. Brian M. Jenks and John O. Evans, Research Assistant and Professor, Plant Science Department, Utah State University, Logan, UT 84322-4820.

Abstract. Wild proso millet is an extremely competitive annual grass that has rapidly spread throughout the corn belt states and is now a problem for corn growers in Cache County, Utah. Many consider it to be the greatest threat to corn production today. Wild proso millet is morphologically similar to corn in early growth stages. Some infested fields in Cache County have over 1,000 plants/m^2.

DPX-V9360 is an experimental sulfonylurea herbicide being developed by Dupont for grass control in corn. DPX-V9360 was applied at three rates (17.5, 35, and 70 g/ha) at two sites for wild proso millet control in field corn. Other postemergence herbicides evaluated were tridiphane (0.84 kg/ha), tridiphane plus cyanazine (0.84 plus 1.41 kg/ha), tridiphane plus atrazine (0.84 plus 1.41 kg/ha), and pendimethalin plus cyanazine (1.12 plus 1.41 kg/ha).

None of the treatments caused any visual crop injury. DPX-V9360 provided 83 to 94%, 77 to 88%, and 64 to 82% wild proso millet control at 70, 35, and 17.5 kg/ha, respectively. No other treatment provided acceptable season-long control. DPX-V9360 increased grain yields by as much as 229% at the highest rate, whereas standard treatments increased yields only as much as 55%.

CULTURAL AND CHEMICAL CONTROL OF WILD OAT IN SPRING BARLEY. David L. Barton and Donald C. Thill, Graduate Assistant and Associate Professor, Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83843.

Abstract. Most arable lands in Idaho are infested with wild oat. It is estimated that these infestations cost Idaho crop producers over $45 million annually. Barley producers alone spend an estimated $14 million each yr to control wild oat. An experiment was established to determine the optimum barley seed rate, barley row spacing, and herbicide-rate combination for wild oat control. The design was a factorial, randomized complete block split-plot. Two row spacings and three seeding rates were the main plots. Sub-plots were three herbicides and three herbicide rates. Spring barley was seeded at 67, 134, and 201 kg/ha on 9 and 18 cm row spacings near Twin Falls (irrigated), Moscow (dryland), and Bonners Ferry (dryland), ID using varieties NK 560, Steptoe, and Morex, respectively. Triallate, diclofop, and difenzoquat were applied preplant incorporated (0, 0.7, and 1.4 kg/ha), to three leaf wild oat (0, 0.6, and 1.1 kg/ha), and to five leaf wild oat (0, 0.6 and 1.1 kg/ha), respectively. Barley and wild oat plant number were counted and biomass was harvested at barley soft dough stage. Barley grain was harvested at maturity with a small plot combine. Average wild oat densities at Twin Falls, Moscow, and Bonners Ferry were 0, 325, and 293 plants/m^2, respectively. Only data from Bonners Ferry will be presented. Row spacing had no effect on barley grain yield, barley quality, or wild oat biomass, but wild oat plant number was 20% less in 18 cm wide rows compared to 9 cm wide rows. Grain yield was greatest when barley was seeded at 134 and 202 kg/ha (4000 kg/ha) compared to 67 kg/ha (3500 kg/ha). Barley grain quality was greatest when barley was seeded at 67 and 134 kg/ha, compared to 201 kg/ha. The number of wild oat plants/m^2 was 33% less at the highest seed rate compared to the medium and low seed rates. Wild oat biomass and density decreased with increased seeding rates. Averaged over herbicide rates, barley grain yield was greatest and wild oat biomass was least for diclofop and difenzoquat treatments compared to triallate. Diclofop reduced wild oat plant number more than triallate. Averaged over herbicides, barley grain yield was equal between the half and full herbicide rates. However, the full herbicide rate reduced wild oat plant number 44% and biomass 47% more than the half rate.

EFFECTS OF BROADLEAF HERBICIDES ON SEEDLING ALFALFA. Dennis M. Tonks and Larry S. Jeffery, Graduate Research Assistant and Professor, Department of Agronomy and Horticulture, Brigham Young University, Provo, UT 84602.

Abstract. Field experiments were performed in 1988 and 1989 at the Brigham Young University Agricultural Research Station to compare the effects of four herbicides used to control broadleaf weeds on seedling alfalfa growth. Bentazon, bromoxynil, and 2,4-DB amine, and 2,4-DB ester were applied at the 2nd, 4th, and 8th trifoliate leaf stages using a CO_2-powered handheld sprayer calibrated to deliver 190 L/ha. Rates of application were 1.12 kg/ha for 2,4-DB amine and ester, 0.84 kg/ha for bentazon, and 0.56 kg/ha bromoxynil. Bentazon had no negative effects on alfalfa in either 1988 or 1989 regardless of the stage at which it was applied. Bromoxynil reduced yield in 1989 but did not affect yield in 1988. 2,4-DB amine did not reduce height regardless of stage of application but reduced yield in 1988. 2,4-DB amine did not reduce height regardless of stage of application but reduced yield in 1988. 2,4-DB ester reduced yield in 1988 and 1989 but only reduced height in 1988.

CONTROL OF PERENNIAL RYEGRASS IN ESTABLISHED ALFALFA. Bryan C. Leavitt and Larry S. Jeffery, Graduate Student and Professor, Department of Agronomy and Horticulture, Brigham Young University, Provo, UT 84602.

Abstract. Alfalfa is grown extensively throughout the western United States as a high protein forage crop. Perennial ryegrass is also used as a forage and at times is grown with alfalfa. This practice is used in areas when cattle are allowed to graze alfalfa to reduce the bloat potential. Ryegrass in alfalfa reduces protein content of the forage and shortens alfalfa stand life. Climatic conditions in the intermountain area are favorable to perennial

ryegrass growth. Field experiments were conducted in 1988 and 1989 at the Brigham Young University Agricultural Research Station to evaluate six herbicides for control of perennial ryegrass in established alfalfa. Diuron (2.2 and 2.7 kg/ha), hexazinone (1.1 and 1.7 kg/ha), metribuzin (0.8 and 1.1 kg/ha), norflurazon (1.7 and 2.2 kg/ha), pronamide (0.8 and 1.1 kg/ha) and terbacil (1.1 and 1.3 kg/ha) were applied at or slightly before alfalfa broke dormancy in the spring. Hexazinone, metribuzin and terbacil effectively controlled or reduced perennial ryegrass at each rate. Diuron, norflurazon and pronamide did not provide satisfactory control.

PREDICTING WEED COMPETITION IN WHEAT UNDER IRRIGATED FIELD CONDITIONS.
Emmanuel M. Pomela, J. O. Evans, and S. A. Dewey, Reasearch assistant and professors, Plant, Soil, and Biometeorology Department, Utah State University, Logan, UT 84322-4820.

Abstract. Weed populations vary in response to soil moisture. Therefore weed competition under variable irrigation levels must also be variable. This research was conducted at Huntington and Logan, Utah to ascertain the influence of irrigation on frequency and density distributions of weeds and subsequent competition with wheat.

The experimental design was a continuous variable design of the line-source with three replications. The six irrigation levels were provided by a line-source sprinkler irrigation system. When the system is operating at about 270 kPa, it provides a water application gradient pattern which is uniform along the length of the experimental plot, and uniformly variable across the width of the experimental plot. The irrigation water applied by the system is highest near the line and lowest away from the line.

Weed frequency and density distribution and drymatter harvests for both crops and weeds were determined on June 20, July 11, and August 10, 1989 at Logan and June 8, July 20, and September 5, 1989 at Huntington.

Wild oat, kochia and green foxtail were the prevalent weeds. The frequency distributions of wild oat were low at Logan. The density distributions of wild oat and green foxtail increased with increasing irrigation level. Contrarily, the density distribution of kochia decreased with increasing irrigation level.

Weed competition was severe in low irrigation levels and less severe in high irrigation levels. A crop yield prediction model which is based on wheat water use (evapotranspiration) measurements and competitive indexes of each weed at all irrigation levels was developed. (Published with the approval of the Utah Agricultural Experiment Station, Logan, UT. 84322-4810).

Table. Frequency and density distributions of six weeds in response to irrigation in alfalfa and wheat at Logan and Huntington, Utah.[a]

Irrigation		Density of weeds[b]											
		SETVI		KCHSC		LACSE		CHEAL		AMARE		AVEFA	
Level	Amount	L	H	L	H	L	H	L	H	L	H	L	H
	-(mm)-	(Numbers/m^2)											
1	540	448	0	0	912	0	0	24	0	0	48	0	4
2	1578	708	8	0	300	0	0	20	3	0	45	0	12
3	3457	1128	28	0	180	0	4	14	4	0	66	0	30
4	5905	1292	44	0	120	0	8	8	8	0	80	0	205
5	6893	1492	20	0	20	0	20	4	32	0	36	0	580
6	8142	1804	20	0	8	0	22	6	44	0	32	0	612

[a]Data are the average of three harvests per season in both crops.

[b]SETVI = green foxtail, KCHSC = kochia, LACSE = prickly lettuce, CHEAL = common lambsquarters, AMARE = redroot pigweed, AVEFA = wild oat, L = Logan, H = Huntington.

HORTICULTURE

MON 15100 - A NEW HERBICIDE FOR ANNUAL GRASS AND BROADLEAF WEED CONTROL IN ORNAMENTALS. Nelroy E. Jackson, Timothy E. Dutt, Sarah H. Bundschuh, Domingo C. Riego and Karen E. Kackley, Product Development Associates, Monsanto Company, Corona, CA 91719.

Abstract. MON 15100, a formulation of dithiopyr, is a new preemergence herbicide that provides broadspectrum weed control in ornamentals. MON 15100 rates of 1.12 to 2.24 kg/ha gave control of annual summer and winter grasses and broadleaves in container, field-grown and transplanted ornamentals. Weeds controlled include annual bluegrass, bittercress, common chickweed, common purslane, oxalis, pearlwort and spotted spurge.

Safety studies have demonstrated that many ornamental species grown in containers have tolerance to MON 15100 applied as a granule. A partial list of tolerant species includes agapanthus, azalea, bougainvillea, coleus, cotoneaster, crepe myrtle, daffodil, daylily, English ivy, euonymus, gazania, gardenia, hibiscus, holly, ice plant, impatiens, iris, juniper, oleander, photinia, pittosporum, pyracantha, raphiolepsis, rhododendron, viburnum, vinca, wax myrtle and zinnia.

HERBICIDE EVALUATION IN ORNAMENTAL BULBS. Stott Howard, Carl Libbey, and Eric Hall, Assistant Weed Scientist and Agricultural Research Technologists, Washington State University, Research and Extension Unit, Mount Vernon, WA 98273.

Abstract. Bentazon, bromoxynil, cinmethylin, DCPA, dithiopyr, linuron, oryzalin, and pyrazon were applied in late fall 1988 prior to bulb emergence. Paraquat was included in the spray with all treatments, except bentazon and bromoxynil, to kill actively growing weeds. Plots treated with bentazon and bromoxynil received a second application in spring 1989. Bulb injury was determined by noting changes in the bulb-size distribution when compared to the industry standard oryzalin. For example bentazon and bromoxynil significantly decreased the number of tulips size 9 through 13 (bulb circumference in cm). In addition, there were fewer tulips of size 3 through 5. However, there was a significant increase in bulb sizes 6 and 7. Similar effects were observed in daffodils and iris treated with bromoxynil. These effects are evident in total yield of daffodils, iris, and tulip. The remaining treatments did not significantly alter the bulb-size distribution. Many treatments showed slight injury in late-season subjective evaluations, however, this did not appear to reduce yields or crop quality. The most effective, long-term control was in plots treated with cinmethylin, dithiopyr, and oryzalin. Common chickweed, annual bluegrass, shepherdspurse, common groundsel, pineappleweed, little bittercress, and hedgemustard were effectively controlled by these three herbicides for the duration of the bulb growing season.

RESPONSE OF PURPLE NUTSEDGE TO TURFGRASS COMPETITION AND IMAZAQUIN HERBICIDE. D. M. Kopec, E. S. Heathman, C. F. Mancino, A. K. Dobrenz, and H. N. Moharram, Associate Extension Specialist, Weed Control Specialist, Assistant Professor, Professor, and Graduate Student, Plant Science Department, University of Arizona, Tucson, AZ 85721.

Abstract. Purple nutsedge is a persistent weed in lower elevation turfs in Arizona. Its high elongation rate, coarse leaf texture, and light green color are objectionable in turfgrass stands. This study was conducted to determine the effects of turfgrass cultivar, mowing height and imazaquin herbicide on purple nutsedge suppression over the 1988 and 1989 growing seasons.

Nutsedge infestations were monitored after three applications in 1988 and 1989, totalling six applications, each at the 0.56 kg/ha rate. During both years, 'Midiron' bermuda was not as competitive as 'Tifway' bermudagrass when no herbicide was applied. 'Midiron' was influenced by mowing, allowing for 60 cm2 infestation levels at the low (1.9 cm) mowing height during midsummer of both years. With repeat applications,

purple nutsedge was greatly reduced during the first yr (1988), and essentially eliminated in the more aggressive 'Tifway' turf after an early summer application in yr two (1989). Mowing height was not significant when the herbicide was applied. This data shows that both competitive (grass type and mowing height) and herbicide effects are effective in reducing purple nutsedge infestation levels in turfgrass stands under conditions of this test.

INTRODUCTION

Purple nutsedge is a persistent perennial weed in low desert turfs. Control is problematic, due to the competitiveness of this weed and the subsequent regrowth from tubers. Previous research on 100% stands of purple nutsedge treated with imazaquin showed that repeat applications were required more frequently than those casually observed in mixed turf swards. Therefore, an experiment was designed to assess turfgrass competition (cultivar and mowing height) and herbicidal effects on suppression of purple nutsedge.

MATERIALS AND METHODS

In early May 1988, three actively (sprouted) growing nutlets were placed in 8 oz styrofoam cups and filled with a mixture of 34% loamy sand, and 66% fine sand (v/v). After 4 weeks of growth, the entire surface of the cups were uniformly filled with purple nutsedge. One cup was introduced into the center of each experimental unit, being either 'Midiron' or 'Tifway' bermudagrass turf established in 7.6 L white nursery containers. Drainage was enhanced by drilling four 3.8 cm drain holes in the bottom of each container. Turfs were mowed three times weekly at either 1.9 or 3.8 cm, starting on June 10, 1988. Applications of imazaquin were made at 0.56 kg/ha with 0.5 (v/v) X-77 surfactant using a hand sprayer operated at 40 psi with 8006 nozzles. Applications were made during 1988 on 1 July, 21 July, and 11 September, while nutsedge infestation was measured on 15 July, 12 August, and 20 October, 1988. Applications during the second growing season were made on 6 July, 16 August, and 14 October 1989. Infestation was measured on 5 July (to measure early summer infestation levels before respraying), 10 August, 25 September, and 21 October 1989. Treatment dates were determined by visual suppression release of the nutsedge foliage, prompting retreatment.

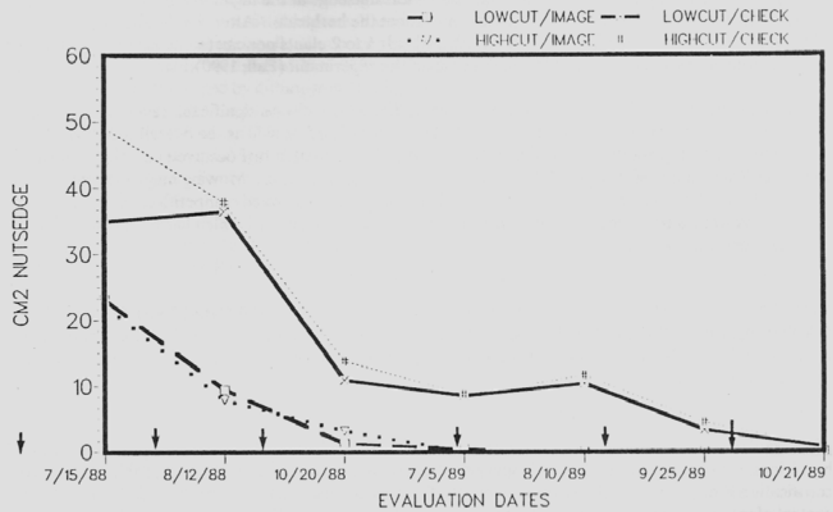
Nutsedge infestation was determined in cm^2 by tracing and shading the surface area of each experimental unit occupied by the weed, quantified by use of a leaf area meter. The experimental design was split plot design with grass cultivar and mowing height in main plots, with chemical applications (imazaquin or control) in subplots. Whole plots were replicated eight times.

RESULTS AND DISCUSSION

During both years, 'Midiron' bermudagrass was not as competitive with 'Tifway' bermudagrass when no herbicide was applied. 'Midiron' was also influenced by mowing height, allowing for 60 cm^2 of nutsedge infestation by midseason, during both years (Figure 1). Initially, 'Tifway' allowed for a greater amount of weed infestation at the high mowing height, but increased competitive effects of the 'Tifway' by midseason of 1988 resulted in uniform suppression (no mowing height response) when no chemical was applied (Figure 2). During 1988, nutsedge suppression was enhanced by two applications of the herbicide to 10 to 12 cm^2, regardless of mowing height for each of the two cultivars (Figures 1 and 2). A third application resulted is further suppression, with 'Tifway' having 2 to 3 cm^2 of nutsedge left before the season's end. Natural reductions occurred during the early fall in both yr, due to short day length and cooler temperatures.

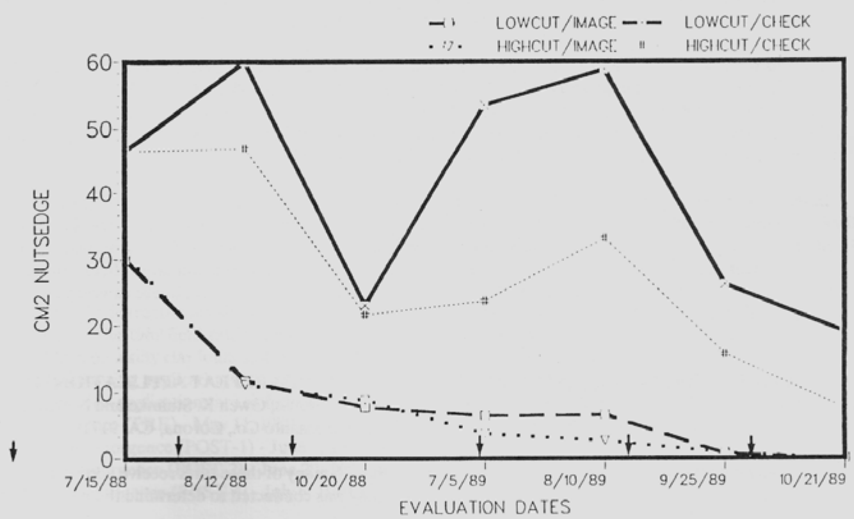
Following early and midsummer growth during yr two, turf infestation levels increased to 60 and 32 cm^2 for 'Midiron' at the low and high mowing heights, respectively, when no herbicide was applied, again demonstrating the inability of 'Midiron' to compete, especially under the increased mowing stress (Figure 1). Alternatively, the untreated 'Tifway' had approximately a 20 cm^2 infestation, regardless of mowing heights during July and August, further decreasing to 5 and 1 cm mean infestations in late September and August, respectively (Figure 2). When imazaquin was applied in 1989, nutsedge was essentially eliminated in 'Tifway' by 10 August, regardless of mowing height.

RESPONSE of PURPLE NUTSEDGE to
TIFWAY BERMUDAGRASS COMPETITION and IMAGE



** (ARROWS INDICATE IMAGE APPLICATIONS) **

RESPONSE of PURPLE NUTSEDGE to
MIDIRON BERMUDAGRASS COMPETITION and IMAGE



** (ARROWS INDICATE IMAGE APPLICATIONS) **

After the fourth application 'Midiron' had slightly less nutsedge at the high mowing height, showing a similar response to mowing height exhibited by 'Midiron' without the herbicide. After the fifth application, lower levels of infestation were observed for 'Midiron', which had only 1 to 2 plants per c.u. (< 1.0 cm^2 area). Further seasonal reductions were observed during the close of the experiment (Fall, 1990).

Throughout the experiment, chemical and cultivar effects were always significant, resulting from the increased innate competition of the 'Tifway' over the 'Midiron' turf, as well as the overall reduction due to the imazaquin. Visual elimination of purple nutsedge in the Tifway-treated turf occurred early in the second season, [resulting from 4 applications (3 + 1)], under the conditions of these tests. Mowing height was not a factor alone, but caused significant interactions with cultivar, since increased weed competition occurred under the increased mowing stress from the low mowing height for the 'Midiron' turf, which has a growth habit similar to common bermudagrass.

VOLUNTEER SEEDLING GRASS CONTROL AND TOLERANCE OF GRASS SEED VARIETIES TO OXYFLUORFEN. Thomas J. Neidlinger and George Mueller-Warrant, Research and Development Representative and Research Agronomist, Rohm and Haas Company, Clackamas, OR 97015 and USDA/ARS, Corvallis, OR 97331.

Abstract. With increased restrictions on open field burning and the loss of previously registered triazine herbicides, volunteer seedling grasses in grass seed fields have become a serious weed problem where seed certification is desired. The objectives of these studies were to evaluate the degree of activity of oxyfluorfen for control of volunteer grasses in established grass seed fields and determine crop tolerance. Grass species included in these studies were: perennial ryegrass, tall fescue, orchardgrass, Kentucky bluegrass, creeping bentgrass, and fine-leaved fescue.

Two field tests were established in each of the above grass species, one to evaluate weed control and the other to determine crop tolerance by obtaining seed yields. Rates of oxyfluorfen ranged from 0.0625 to 0.50 lb/A. Oxyfluorfen plus diuron was included in all tests except the fine fescues. The diuron rate was 1.6 lb/A. Treatments were applied in the fall when the crops were semi-dormant and volunteer seedlings were in the one to three leaf stage of growth. Visual weed control and crop injury ratings were taken throughout the winter and seed yields were obtained at normal harvest periods the following summer.

Oxyfluorfen alone gave 81 and 86% control of seedling tall fescue and orchardgrass, respectively, at 0.125 lb/A, and 91% control of each at 0.25 lb/A. The tank mixture of oxyfluorfen plus diuron at 0.125 plus 1.6 lb/A increased control to 86 and 94%, respectively. Seedling perennial ryegrass appeared slightly less susceptible to oxyfluorfen than did tall fescue or orchardgrass. Control was 64 and 73% at 0.125 and 0.25 lb/A, respectively. Addition of diuron to oxyfluorfen increased control of volunteer perennial ryegrass to 81%.

Initial crop injury, expressed as leaf chlorosis, ranged from 18% (ryegrass) to 41% (fine fescue), from 0.125 lb/A oxyfluorfen. Addition of diuron did not increase injury over oxyfluorfen alone, except in creeping bentgrass. In all grasses except fine fescue full crop recovery was confirmed by yield data which indicated no significant yield differences between any oxyfluorfen or oxyfluorfen/diuron treatment and the untreated check. In fine fescue oxyfluorfen at 0.25 and 0.50 lb/A resulted in season-long crop injury but no treatment caused yields significantly different from the untreated check.

ANNUAL BLUEGRASS (Poa annua) POPULATION DECLINE WITH REPEAT APPLICATIONS OF DITHIOPYR TO BENTGRASS TURF. Stanton E. Brauen, Roy L. Goss, Gwen K. Stahnke and Nelroy E. Jackson. Washington State University, Puyallup, WA 98371 and Monsanto Co., Corona, CA 91719.

Abstract. Annual bluegrass is a strong invader of turfs even though many of these turfs receive accepted cultural management best suited for the desired turf species. A 4 yr study was conducted to determine the potential of dithiopyr herbicide to control established annual bluegrass and prevent further invasion of germinating annual bluegrass into a mixed 'Highland' colonial bentgrass/'Penncross' creeping bentgrass turf. Dithiopyr was evaluated for pre- and postemergence application prior to expected germination of annual bluegrass during the fall and spring. The turf initially consisted of 20 to 30% established annual bluegrass. Established annual bluegrass was selectively suppressed by dithiopyr at 1.12 kg/ha and above annually over 3 yr to less than 50% of original population as compared to untreated turf. Annual bluegrass was controlled during preemergence or early postgermination stage at 0.28 to 0.56 kg/ha. Dithiopyr produced significant thinning and discoloration of bentgrass 2 to 10 weeks following fall application of 2.24 and 4.48 kg/ha and reduced root pegging of daughter plants. No significant bentgrass injury was observed following spring applications of dithiopyr at rates below 2.24 kg/ha. No significant loss of total root mass was observed with rates below 1.12 kg/ha annually. Slight reduction in percent turf cover was present where repeat applications totalling 34.85 kg/ha were applied over 3.5 yr, but bentgrass turf was poorly rooted to the soil. (Published with the approval of the Washington State University, College of Agriculture and Home Economics.)

INFLUENCE OF CULTIVATION AND REDUCED RATE HERBICIDE APPLICATION ON FOUR VEGETABLE CROPS. W. Thomas Lanini and Michelle Le Strange, Cooperative Extension Specialist and Farm Advisor, Department of Botany, University of California, Davis 95616 and Visalia, CA 93291.

Abstract. Vegetable growers typically use herbicides for weed control and cultivate escaped weeds. Guidelines on how long weeds need be excluded from particular vegetable crops to preserve yield and quality and to prevent excessive weed seed production, may reduce unnecessary weed control operations. Additionally, with concern over food safety, growers would like to reduce their herbicide use. The objective of this research was to assess weed control and yield of vegetables as influenced by weed free duration and reduced herbicide treatments in combination with cultivation. Vegetable crops evaluated were pickling cucumber, bell pepper, head lettuce, and cauliflower. Studies were conducted each yr at Five Points and Davis, California, from 1986 to 1989. Pickling cucumbers required four to six weeks of weed free conditions to achieve full yield. Reducing the rate of a combination of naptalam and bensulide from 4.5 kg/ha each to 2.25 kg/ha resulted in a 20% reduction in yield, however, when reduced rate treatments were combined with a single cultivation, yields increased by 11%. Bell peppers required eight weeks weed free after emergence to achieve full yield. Using full rates of napropamide (2.25 kg/ha) without cultivation resulted in a 75% yield reduction. Reducing the rate of napropamide and cultivating a single time did not increase yield relative to the full use rate. Lettuce required 10 weeks weed free to achieve full yield potential but maintaining plots free of weeds for 2 weeks or more yielded 90% of full yields. Full rates of pronamide (2.25 kg/ha) yielded 88% of maximum while reducing the rate to 1.12 kg/ha yielded 76% of maximum. Cauliflower required a 2 week weed free period to maintain full yields and a single application of DCPA at 11.25 kg/ha or 4.5 kg/ha also resulted in full yields. Yield losses associated with weed competition (0 weeks weed free) were 62, 99, 65, and 20% for cucumbers, bell peppers, lettuce and cauliflower, respectively.

WEED CONTROL IN CARROTS. Dan Curtis and Garvin Crabtree, Research Assistant and Professor, Department of Horticulture, Oregon State University, Corvallis, OR 97331.

Abstract. Herbicide treatments showing promise in 1988 and combinations of herbicides suggested by that test were included in the 1989 field study. This work was carried out at the Oregon State University Horticulture Research Farm on a silty clay loam soil. Carrots, cv. Royal Chantenay, were seeded on May 10, 1989 immediately following application and soil incorporation of preplant (PPI) herbicide treatments. The schedule for other herbicide applications are as follows:

Preemergence (PRE) - May 11, 1989
Early postemergence (POST-1) - June 7, 1989, when carrots were in the 3-leaf stage
Mid postemergence (POST-2) - June 20, 1989, when carrots were in the 5-leaf stage
Late postemergence (POST-3) - July 6, 1989

Herbicide treatments were broadcast applied using a single wheel, compressed air, small plot sprayer deliviering 23 gpa. Plot size was 8 by 30 feet. Carrots were sown in 24-inch rows, with 4 rows per plot. Weed control was evaluated on July 13, 1989. Plots were harvested (10 feet of center row for each plot) on October 10, 1989. Treatment list and results are shown in the Table.

Treatments providing the best selective weed control with the weed species present in this study included combinations of trifluralin/clomazone, clomazone/metribuzin and clomazone/ SMY-1500 and pendimethalin alone. (Oregon State University Extension Service).

Table. Weed control in carrots - 1989.

Treatment			Weed Control					
Herbicide	Rate	Timing	SOLSA	AMARE	SENVU	CHEAL	Root	Yield
	(lb/A)		------------(%)------------				(No.)	Tons/A
Clomazone	0.25	PPI	79	0	99	48	112	14.5
Clomazone	0.50	PPI	95	15	100	90	115	25.7
Clomazone	1.00	PPI	97	70	100	100	84	21.5
Trifluralin	0.75	PPI	40	90	13	88	122	9.3
Trifluralin/	0.75	PPI	80	100	100	100	112	32.4
clomazone	0.50	PPI						
Pendimethalin	1.00	PRE	75	95	0	100	104	24.6
Pendimethalin	2.00	PRE	88	100	13	100	113	29.9
Pendimethalin/	1.00	PRE	95	99	99	100	123	36.6
clomazone	0.50	PPI						
Metribuzin	0.25	POST-1	0	100	96	100	102	8.4
Metribuzin	0.25	POST-2	22	51	59	69	112	6.7
Metribuzin	0.50	POST-2	0	70	81	80	104	3.7
Metribuzin/	0.25	POST-2	20	93	80	83	140	7.0
metribuzin	0.25	POST-3						
Metribuzin/	0.25	POST-2	90	66	100	100	108	31.7
clomazone	0.50	PPI						
SMY-1500	1.00	PRE	15	100	56	100	118	16.2
SMY-1500	2.00	PRE	50	100	99	100	122	24.2
SMY-1500/	1.00	PRE	100	100	100	100	83	34.6
clomazone	0.50	PPI						
Linuron/	0.75	POST-1	71	100	25	98	138	18.8
linuron	0.75	POST-2						
Weeded check			75	75	75	75	116	9.8
Unweeded check			0	0	0	0	107	3.7
LSD (0.05)			29	30	22	27	33	8.7

EVALUATION OF CALCIUM CYANAMIDE FOR PREPLANT WEED CONTROL IN HORTICULTURAL CROPS. Harry S. Agamalian, Farm Advisor - Weed Science, U. C. Cooperative Extension, 118 Wilgart Way, Salinas, CA 9390l.

INTRODUCTION

The continuous cancellation of selective herbicides for horticultural crops has stimulated research with alernative products such as calcium cyanamide. The product is manufactured by SKW, Trostberg, West Germany. The broad spectrum biocide potential of this compound may provide weed and disease control and nutrient benefits to the crop. This research concentrated only on the weed control phase.

MATERIALS AND METHODS

Field experiments were conducted during a 3 yr period on broccoli, cauliflower and strawberries. The granular cyanamide was applied topically to preshaped beds at 250, 500, 750 and 1,000 lb/A. Applications were made during the summer and fall periods in the Salinas Valley of California and in October at Irvine, California.

Following application, sprinkler irrigation of 0.75 inches was applied to the treatments. The broccoli experiments were seeded at 0, 3, 7 and 10 days after treatment (DAT). The strawberries were planted 10, 14 and 21 DAT. Cauliflower was transplanted 10 DAT.

All crops were planted into undisturbed soil following the DAT periods. Subsequent irrigation was applied immediately following seeding and transplanting. The initial irrigaton was 0.5 to 0.75 inches/A depending upon soil texture. Weed control, crop phytotoxicity and vigor evaluations were made by visual ratings. Numerical data was obtained on stand counts and crop yields, compared to a weeded control.

Weed control data obtained from the two sites included shepherd's purse, little mallow, hairy nightshade, Indian sweetclover, burning nettle, annual sowthistle, henbit, Nettleleaf goosefoot, and redroot pigweed.

RESULTS AND CONCLUSIONS

Optimum weed control was obtained at the 500 and 750 lb/A rates. Little mallow was the most resistant species evaluated in these experiments. The 750 lb/A rate provided 80% control of the above weeds.

Broccoli selectivity from the fall experiments required a minimum of 10 DAT. When soil (15 cm depth) temperatures were above 20 C, 7 DAT were adequate for crop safety.

Strawberry selectivity was best at 14 DAT or longer with the 750 lb/A rate of calcium cyanamide. The 1,000 lb/A rate required 21 DAT. One experiment, using 500 and 750 lb/A and planted 10 DAT, caused initial crop phytotoxicity, but didn't affect strawberry yields.

Calcium cyanamide yields from the Salinas strawberry experiment were significantly better than the hand-weeded control. Since weed competition was not a factor with the crop, it appears that calcium cyanamide may give other benefits beside weed control.

SUMMARY

The results from these experiments indicate that calcium cyanamide will effectively control several annual weeds common in horticultural crops. Selectivity as a preplant treatment is dependent upon the proper DAT. Cooler soil temperatures in the range of 10 to 14 C required a longer DAT interval than temperatures above 20 C. Depending on soil texture, application rates of 500 to 750 lb/A provided acceptable weed control.

Table 1. Strawberry evaluation at two locations

Location	Rate	Weed Control Meuin	Weed Control Malpa	Weed Control Amare	Strawberry Evaluation (11/19) Phyto	Strawberry Evaluation (1/29) Vigor
Irvine	lb/A	--------(%)--------			(%)	(%)
Calcium cyanamide	500	94	100	100	20	90
Calcium cyanamide	750	96	97	100	35	75
Metham	238	94	97	100	11	98

Location	Rate	Weed Control Meuin	Weed Control Malpa	Weed Control Amare	Strawberry Evaluation (1/26) Phyto	Strawberry Evaluation (4/20) Vigor
Salinas	lb/A	--------(%)--------			(%)	(%)
Calcium cyanamide	500	80	70	62	12	95
Calcium cyanamide	750	95	67	72	15	100
Calcium cyanamide	1000	92	84	91	22	88
Metham	160	95	74	86	5	92
Control	-	0	0	0	5	82

Table 2. Average yield of strawberry plot - Salinas.

Treatment	Rate	Yield
	lb/A	(g/100 ft^2)
Calcium cyanamide	500	7718.5 a
Calcium cyanamide	750	6907.3 ab
Metham	50 ga	5718.8 abc
Control	0	3961.3 c

Table 3. Average weed control.

Treatment	Rate	Shep. purse	Little mallow	Sweet clover	Chick-weed
	lb/A	--------------(%)---------------			
Calcium cyanamide	500	62	70	80	92
Calcium cyanamide	750	72	67	95	96
Metham	50 gal	86	74	95	97
Control	0	0	0	0	75

Table 4. Broccoli - winter experiment.

Treatment	Rate	Weed Control				
		Shep. purse	Chick-weed	Burning nettle	Pine apple	Blue grass
	lb/A	(%)				
Calcium cyanamide	500	77	90	97	75	72
Calcium cyanamide	750	90	95	82	70	75
Control	0	0	0	12	22	25

Soil Texture: Clay - 22%, Silt - 35%, Sand - 43%, O.M. - 2.8%

Table 5. Broccoli - winter stand per 50 foot row.

Treatment	Rate	Days after treatment			
		0	3	7	10
	lb/A				
Control	0	131 a	152 a	142 a	142 a
Calcium cyanamide	500	45 b	133 b	124 b	131 a
Calcium cyanamide	750	17 c	122 b	116 b	126 a

Means values followed by same letter are not significantly different (P. = 0.05)

Table 6. Broccoli - winter yield lb/165 feet^2.

Treatment	Rate	Days after treatment			
		0	3	7	10
	lb/A				
Control	0	11.7 a	14.0 a	14.8 a	15.8 a
Calcium cyanamide	500	5.0 b	11.4 b	15.3 a	16.7 a
Calcium cyanamide	750	2.8 c	10.0 b	14.0 a	14.4 a

Means values followed by same letter are not significantly different (P. = 0.05)

Table 7. Winter mean soil temperature (6 in. Depth).

	Nov.	Dec.	Jan.	Feb.
High	51.7	47.2	54.6	56.4
Low	59.9	53.6	45.8	48.1

Table 8. Summer broccoli stand count per 20 foot row.

Treatment	Rate	Days after Treatment 0	3	7
	lb/A			
Control	0	23.5	23.7	25.5
Calcium cyanamide	250	22.7	22.0	23.7
Calcium cyanamdde	500	16.0	23.0	25.0
Calcium cyanamide	750	11.0	25.2	25.0

Table 9. Summer broccoli yield per lb/43 ft^2.

Treatment	Rate	Days after Treatment 0	3	7
	lb/A			
Control	0	9.3 a	7.8 a	9.0 a
Calcium cyanamide	250	9.3 a	9.8 a	10.5 a
Calcium cyanamide	500	7.0 a	9.3 a	9.6 a
Calcium cyanamide	750	4.6 b	5.4 b	10.3 a

Mean values followed by same letter are not significantly different (P = 0.05)

Table 10. Summer broccoli weed control.

Treatment	Rate	Shep purse	Harry nightshade	Little mallow
	lb/A	(%)		
Calcium cyanamide	250	61.3	22	14
Calcium cyanamide	500	98.0	69	40
Calcium cyanamide	750	99.0	82	46
Control	0	0	0	0

Table 11. Irvine - broccoli evaluations.

Treatment	Rate	Phyto.	Head wt	Harvest
	lb/A	(%)	(g)	(%)
DCPA	10	0	105	85
Calcium cyanamide	500	0	131	89
Calcium cyanamide	750	0	115	92
Control (Weeded)	0	0	102	87

Table 12. Irvine - cauliflower evaluations.

Treatment	Rate lb/A	Phyto. (%)	Head wt (g)	Harvest (%)
DCPA	10	2	613	97.3
Calcium cyanamide	500	27	642	90.7
Calcium cyanamide	750	32	654	89.0
Control (Weeded)	0	0	570	93.6

Table 13. Irvine - cauliflower weed control.

Treatment	Rate	London rocket	Henbit	Sow thistle	Lambs quarters
	lb/A	(%)			
DCPA	10	77	45	95	100
Calcium cyanamide	500	100	100	100	100
Calcium cyanamide	750	100	100	100	100
Control (Weeded)	0	0	0	0	0

Soil: clay - 12.2%, silt - 17%, sand - 70.8%, O.M. - 39%

OPTIMIZING PERENNIAL WEED MANAGEMENT WITH REPEATED LOW RATES OF DICHLOBENIL IN HORTICULTURAL CROPS. R.D. William, W.A. Sheets, W.S. Braunworth Jr., G.D. Crabtree, and D.J. Burkhart, Oregon State University, Corvallis, OR 97331.

INTRODUCTION

Horticultural berries and tree fruits often are infested with patches of perennial weeds such as Canada thistle, field horsetail, yellow nutsedge, perennial ryegrass, and others. Standard weed control practices such as mowing, herbicides, or cultivation have failed to control or suppress these weeds. Dichlobenil controls these weeds, but growers express concern about cost, possible crop injury, and erratic weed control. Based on knowledge of the chemical and physical properties of dichlobenil, we conducted a series of demonstration trials in growers' caneberry and pear orchards to optimize performance while suppressing perennial weeds.

METHODS

Established caneberries and pears planted by growers at standard spacings for the Pacific Northwest, and infested with one or more perennial weeds, were used in this study. Growers attempted to maintain a weed) free strip representing half or a third of the area for berries and pears, respectively. Plots were established in winter and contained 3 to 12 berry plants (15 to 20 feet long) or a single pear tree (6 by 6 feet). Dichlobenil was premeasured for each plot and distributed from a hand) held shaker (quart jar with holes punched in lid) to ensure uniformity by sprinkling half the material in two perpendicular passes. Selected application dates were characterized by cold, inclement weather conditions followed by moderate to intense rainfall to minimize volatilization and loss of the herbicide (see tables for details).

Table 1. Canada thistle control with winter or spring applications of dichlobenil in caneberries, Washington County, OR and Clark County, WA 1980 (winter) and growing season of 1981.

Herbicide treatment and time	Rate	Site and crop[a] Washington County, OR R. raspb.	Marion b.	Th.bl.b.[b]	Clark Co. WA Evgn. bl.b.	Mean
	lb/A					
Winter		(No. thistle/plot)				
Control	--	82	80	142	28	83
Dichlobenil	4	13	16	20	7	14
Dichlobenil	6	7	4	2	9	6
Dichlobenil	12	4	1	2	0	2
Spring						
Control	--	44	64	122	59	72
Dichlobenil	4	16	9	1	18	11
Dichlobenil	6	15	0	0	16	8
Dichlobenil	12	2	0	0	4	2

Date applied:	12/22;3/18	12/22;3/18	12/22;3/18	1/5;4/15
Air Temperature F:	56;60	56;60	--	55;--
Rainfall:[c]	Yes*;Yes	Yes;Yes	--	7 days;Yes
Date evaluated:	6/29	6/29	6/29	6/29
Days elapsed:	119;103	199;103	199;103	175;75

[a] Crops included red raspberry, Marion blackberry, thornless blackberry, and Evergreen blackberry, respectively.
[b] Observation plot only (2 replications).
[c] YES = rainfall occurred either during or immediately following application.

RESULTS

Initial results suggested that winter or spring applications controlled Canada thistle similarly (Table 1). Cane length for evergreen blackberry was reduced by the two highest rates applied during spring (data not included). A yr later, we observed residual suppression or control at the 4 lb/A rate. Subsequent trials included single treatments during yr 1 or 2 and a consecutive treatment over two years.

Volatile losses of dichlobenil were demonstrated when the herbicide was applied preemergence in spring compared to either winter preemergence under colder temperatures or spring preplant incorporated (Table 2). Additionally, consecutive treatments over 2 yr dramatically reduced yellow nutsedge infestations (Tables 2 and 3). Results from consecutive treatments began to suggest the possibility of reduced rates during subsequent yr.

Consecutive applications at rates of 3 lb/A controlled Equisetum after 2 yr in both trials (Tables 4 & 5), whereas 2 lb/A eliminated the weed in two years when temperatures and rainfall were ideal (Table 5). Perennial ryegrass was eliminated at all rates of dichlobenil (Table 5).

Red raspberries, Marion blackberries, blueberries, and pears tolerated all rates and repeat applications of dichlobenil. Evergreen blackberries grew normally with winter applications of dichlobenil not exceeding 4 lb/A.

DISCUSSION AND CONCLUSION

Current suggestions regarding perennial weed management in permanent horticultural cropping systems include consideration of dichlobenil applied at 4 lb/A during cold, inclement weather in mid-winter, followed immediately by moderate to intense rainfall. Subsequent applications during the second yr may be reduced to 2 or 3 lb/A depending on weed survival following the first application. Following two or perhaps three consecutive applications, other weed management strategies should be considered to avoid shifts toward resistent species such as field bindweed. Inevitably, perennial weeds will reestablish or encroach from row middles, thereby requiring another cycle.

We conclude that the wonderful world of weeds represents a challenging struggle between monitoring, predicting, and learning to live with low weed thresholds when conditions prevent picture perfect weed control. Meanwhile, these data suggest appropriate conditions and management strategies to achieve optimum supression of perennial weeds within perennial horticultural cropping systems.

Table 2. Yellow nutsedge control during yr of application and 2 consecutive yr using dichlobenil in pears, Hood River County, OR 1983 and 1984[a].

Herbicide treatment	Rate	Time and method of appli.	Air temp.	Yellow nutsedge: Within season Year-1 1983	Yellow nutsedge: Within season Year-2 1984	Yellow nutsedge: Consecutive seasons Year 1+2	Yellow nutsedge: Subsequent season Year-3 (no herb.)
	(lb/A)		F	-------------(No. tubers/plot)-------------			
Control	--		--	537	------------478------------		
Dichlobenil	6	Winter (Pre)	40;46	205[b]	145	57	198
Dichlobenil	6	Spring (Pre)	52;61	452[b]	279	215	415
Dichlobenil	6	Spring (PPI)	52;61	286[b]	109	106	285
Date applied:				1/18;3/21	1/26;3/31		
Date evaluated:				Sept.	Sept.		
Days elapsed:				226;163	218;153		

[a]Grower participation trial conducted by W. Pereira, previously Graduate Res. Assistant on study leave from EMBRAPA, Brazil.

[b]Average of first yr infestation for both Year-1 and Year 1+2 plots.

Table 3. Canada thistle and yellow nutsedge control during yr of application and two consecutive yr using dichlobenil in red raspberries, Clackamas and Multnomah Counties, OR 1984 and 1985[a].

Herbicide treatment	Rate	Canada thistle: Within seasons Year-1 1984	Canada thistle: Within seasons Year-2 1985	Canada thistle: Consecutive seasons Years 1+2	Yellow nutsedge: Within seasons Year-1 1985	Yellow nutsedge: Within seasons Year-2 1985	Yellow nutsedge: Consecutive seasons Years 1+2
	(lb/A)	---------------------(% control)---------------------					
Control	--	0	0	0	0	0	0
Dichlobenil	4	45	89	98	88	100	100
Dichlobenil	6	94	40	98	97	100	100
Date applied:		3/27	2/25		2/14	3/14	
Air temp. F:		--	55		--	60	
Rainfall:		--	2 days		--	day	
Date evaluated:		7/3	5/28		7/3	5/28	
Days elapsed:		98	93		140	75	

[a]Grower participation trials conducted by E. Ross, previously Clackamas County Extension agent.

Table 4. Equisetum control during year of application, subsequent yr without additional herbicide, and two consecutive yr using dichlobenil in 'Marion' blackberries, Washington County, OR 1984 and 1985.

Herbicide treatment	Rate	Within season Year -1* 1984	Within season Year-2 1985	Consecutive seasons Years 1+2	Subsequent season (no herb. Year-2)
	(lb/A)	(No. Equisetum/plot)			
Control (est)	--	200-300	200-300	200-300	200-300
Dichlobenil	2	34	60	47	88
Dichlobenil	3	20	3	8	61
Dichlobenil	4	10	0	0.3	19
Dichlobenil	6	9	0	0.5	14

Date applied:	2/16	2/12
Air Temp. F.:	50	40
Rainfall:	Moist surfaces	Two days
Date Evaluated:	5/21	4/25
Days Elapsed:	94	72

[a]Average of first yr infestation for both Year-1 and Years 1+2 plots; Granules fell on cane and leaf debris.

Table 5. Equisetum control with repeated applications over 3 yr using dichlobenil in blueberries, Washington County, OR, 1986 to 1988.

Herbicide treatment	Rate	Equisetum control Year-1 1986	Equisetum control Year-2 1987	Equisetum control Year-3 1988	Perennial ryegrass 1988 only
	(lb/A)	(% control)			
Control	--	0	0	0	0
Dichlobenil	2	43	93	100	78
Dichlobenil	3	59	99	100	97
Dichlobenil	4	80	98	99	100
Dichlobenil	6	92	100	100	99

Date applied:	3/10	2/16	2/18
Air Temp. F.:	60	45	46
Rainfall:	3 hours	during	14 days
Date evaluated:	6/6	6/29	5/15
Days elapsed:	88	133	86

RESPONSE OF TOMATO AND ZUCCHINI TO MULTIPLE EXPOSURES OF LOW RATES OF ATRAZINE AND GLYPHOSATE. Philip S. Motooka and Guy Nagai, Extension Specialist in Weed Science and Noxious Weed Specialist, University of Hawaii at Manoa, P.O. Box 208, Kealakekua, HI 96750 and State of Hawaii Department of Agriculture, Captain Cook, HI 96704.

INTRODUCTION

Some farmers on the island of Maui have suffered inexplicable injury to their vegetable crops. The symptoms have been diverse: phenoxy-like curling, formation of spindly leaves, premature tomato fruit drop, and sudden death of seedlings. Herbicide drift from sugar plantations was suspected as the cause of the injuries despite consistent evidence that aerial drift was not likely to cause injury beyond 400 m (1, 2, 8). Moreover, the symptoms observed were atypical of the commonly used plantation herbicides, i.e. atrazine and glyphosate (3, 4, 5, 6, 7). The latter is used as a ripener to increase sugar yield. However, it was speculated that frequent drift episodes of doses individually too low to elicit plant injury symptoms were the cause of the atypical symptoms observed although no credible evidence or hypothesis was offered in support of this notion. This study was conducted to determine if repeated exposures to sub-toxic rates of atrazine and glyphosate would cause tomato and zucchini to develop symptoms atypical of the applied herbicide.

MATERIALS AND METHODS

Pot trials - NOEL Determinations. Preliminary to the field trials, no effect levels (NOEL) were determined for the test crop species. The NOEL for the purposes of this investigation was the highest single dose of herbicide applied to the plants that did not produce visible injury symptoms.

Tomatoes and zucchinis were planted in a 50:50 peat: perlite media in 125 mm diameter plastic pots. Three seeds were planted and thinned to one plant upon germination. When the seedlings were in the 4-leaf stage, they were sprayed with a logarithm sprayer to achieve 0.16, 0.12, 0.08, 0.06, 0.05, 0.04, 0.03, 0.02, 0.01 and 0 kg/ha of atrazine on tomatoes and zucchini and glyphosate on tomatoes. For glyphosate on zucchini the rates applied were equivalent to 0.30, 0.24, 0.20, 0.19, 0113, 0110, 0.07, 0.06, 0.05, and 0 kg/ha. There were four replicates. Plants were observed at 1 or 2 weeks after treatment when symptoms were most pronounced to determine the NOEL.

Field Trials. Field trials were conducted at the Maui Agricultural Park at Kula and at the University of Hawaii Kona Experiment Station. The soil at the Maui site was a Keahua stony silty clay (Typic Torrox); that at the Kona site was a Honuaulu very stony silty clay loam (Hydric Dystrandepts). All field trials were arranged in randomized complete blocks in six replicates. Herbicide applications were made with a CO_2 sprayer at 1.44 kPa with a flat fan stainless steel 8002 nozzle. Each plot consisted of seven treated plants of which the five middle plants were observed and harvested. Guard rows were maintained between plot rows. Visual ratings of plant injury were made biweekly using a 0-10 scale with 0 = no effect and 10 = kill. Tomatoes were harvested at maturity in four weekly harvests, segregated into "number 1", "number 2", "off-grade", or "unmarketable" grades and weighed. Zucchinis were harvested at two-day intervals over two weeks, graded as above and weighed.

Trial A. Impact of atrazine on tomatoes, Maui. Tomatoes were started in flats and transplanted to the field six weeks later on September 22, 1987. The plants were spaced at 1.52 m between rows and 0.61 m between plants. The treatments imposed were 0, 0.004, 0.02, and 0.04 kg atrazine/ha corresponding to 0, 0.1, 0.5 and 1.0 NOEL, respectively, and were applied 2 weeks after transplant and biweekly thereafter for a total of six treatments. The land was fumigated with dichloropropene pre-planting. Insecticide and fungicide treatments were made weekly according to manufacturers' recommendation and on advice of the farm manager and the county extension agent. The chemicals used as necessary were: copper hydroxide, azinphos-methyl, endosulfan, methomyl, chlorothalonil, maneb, and fenvalerate.

At transplanting, 896 kg/ha of a 10-30-10 (N-P_2O_5-K_2O) fertilizer was applied. Supplemental fertilization was made via drip irrigation with a 12-26-26 soluble formulation twice a week at 43 to 78 kg/ha as needed.

Trial C. Impact of atrazine on tomato, Kona. Trial 3 was conducted at the Kona Experiment Station. Treatments imposed were identical to that in experiment A. The field was fertilized prior to planting with 280 kg superphosphate and 280 kg 16-16-16/ha. This was supplemented by biweekly side dressings of 12-27-7 at 179 kg/ha. The tomatoes were trellised in the Kona trials. Insecticide and fungicide treatments consisted of malathion weekly and benlate and mancozeb applied alternately and biweekly.

Trial G. Impact of atrazine on tomato, 2nd Maui trail. In Trial G, the plants were spaced at 0.91 m between plants and 1.52 m between rows. Prior to transplanting, a windbreak of Sudex (Sorghum sudanese x S. vulgare) was planted around the experimental area to prevent invasion of thrips that vectored the spotted wilt virus. The pesticide used for disease and insect control were: chlorothalonil, azinphos-methyl, dimethoate, copper hydroxide, diazinon, methomyl, fenvalerate, kelthane, and mancozeb, applied as needed. Otherwise, the cultural practices employed were identical to that in Trial A, as were the experimental procedures.

Trial B. Impact of glyphosate on tomatoes, Maui. Cultural practices in trial B were identical to that in Trial A as were the experimental procedures except for the treatment applied. Glyphosate was applied biweekly at 0, 0.004, 0.02, and 0.04 kg/ha corresponding to 0, 0.1, 0.5 and 1.0 NOEL respectively.

Trial D. Impact of glyphosate on tomatoes, Kona. Cultural practices and experimental procedures in Trial D were the same as in Trial C except that glyphosate was the experimental variable.

Trial H. Impact of glyphosate on tomatoes, 2nd Maui trial. The treatments imposed in Trial H were: 0, 0.004, 0.008, 0.016, and 0.032 kg/ha corresponding to 0, 0.1, 0.2, 0.4, and 0.8 NOEL. Otherwise, cultural practices and experimental procedures were identical to that in trial G.

Trial E. Impact of atrazine on zucchini, Maui. In Trial E, zucchinis were planted in the field and later thinned to 1 plant per 0.61 m. There were 1.52 m between rows. The plot consisted of 7 plants with the middle 5 plants observed and harvested. Prior to planting the field was fertilized with 10-30-10 at 896 kg/ha with twice weekly applications of 19 kg/ha of soluble 12-26-26 with irrigation. Atrazine was applied at 0, 0.004, 0.02, and 0.04 kg/ha, equivalent to 0, 0.1, 0.5, and 1.0 NOEL respectively, at weekly intervals for 5 weeks. Insecticides and fungicides were applied weekly. The pesticides used, as necessary, were maneb, diazinon, carbaryl, methomyl, endosulfan, and copper hydroxide.

Trial F. Impact of glyphosate on zucchinis, Maui. Cultural practices and experimental procedures in Trial F were identical to Trial E except the experimental variable was glyphosate at 0, 0.01, 0.02, 0.1,and 0.2 kg/ha, corresponding to 0, 0.05, 0.1, 0.5, and 1.0 NOEL.

RESULTS AND DISCUSSION

Pot Trials - NOEL Determinations - Tomato. The highest single dose of atrazine at which no visible symptoms occurred in tomato was 0.04 kg/ha. Likewise, for glyphosate, the highest no effect level was 0.04 kg/ha.

Zucchini. The highest no effect level for atrazine on zucchini was 0.04 kg/ha. However, the highest no effect rate for glyphosate on zucchini was considerably higher, 0.2 kg/ha. Because of the startling differences in NOEL, this test was repeated with the same result.

Field Trials. Ironically, Trials A and B (Maui) were damaged by glyphosate drift from a nearby unrelated experiment. Two replicates of Trial A and three replicates of Trial B were discarded because of visible glyphosate injury. The entire replicate was discarded where any plant within that replicate was injured. Because the inadvertent glyphosate drift may have affected the results of the Maui tomato trials, the trials were repeated (Trials G and H).

Trials C and D (Kona) were injured by overtop metribuzin applications. Apparently the tolerance of tomatoes to metribuzin was marginal and the humid, cloudy weather in Kona resulted in succulent plants and hence, increased metribuzin absorption and consequent injury. Plants in Trials A and B on Maui, where the weather was dry and sunny, did not display injury to metribuzin.

The metribuzin injury to the young tomatoes in Kona undoubtedly contributed to the lower yields in Kona. However, the shallow soil in Kona, which was underlain by an impervious basalt formation, created both waterlogged and dry spots within the field and that probably also contributed to suppressed yields. This problem led to the termination of further work at that site.

Serious virus problems, especially spotted wilt in tomatoes, in all the trials probably suppressed yields and increased variability. None of the trials produced significant shifts in fruit grades nor in the numbers of zucchinis due to treatment. Therefore, total yields only were reported.

Atrazine on tomato. Although the initial pot studies had indicated that 0.04 kg/ha was the no effect level for atrazine on tomato, the plants of Trials A and G on Maui displayed no injury to repeated atrazine applications at the NOEL rate. This was also reflected in the yields where no significant difference was apparent (Tables 1, 4).

In contrast, Trial C in Kona did demonstrate early injury at the higher rates of atrazine which the plants partly outgrew (Table 2). The atrazine injury at the Kona site was complicated by metribuzin injury. The atrazine injury symptom was the typical chlorosis, frequently at the leaf margins, that diminished as the plant matured, despite continuing atrazine applications. The greater response of the Kona plants to both the maintenance application of metribuzin and the experimental treatments of atrazine (and glyphosate) was consistent with the hypothesis of "softer" cuticles on the Kona plants because of the more humid and cloudy weather in Kona, in contrast to the hot sunny weather of the Maui Agricultural Park.

In both Maui trials (Tables 1, 4) atrazine did not elicit any response in yields of tomatoes. However, in the Kona trial there was a downward trend in yields with increasing atrazine rate but the difference was significant only at the highest rate of 0.04 kg/ha/application (Table 3).

Table 1. Yield response of tomato to six bi-weekly applications of atrazine on Maui. on Maui. Trial A, Maui.

Rate	Application (kg/ha)	Total atrazine (kg/ha)	Yield[1] (kg/plot)
0		0	26.36
0.004	(0.1N)[2]	0.02	29.57
0.02	(0.5N)	0.12	23.10
0.04	(N)	0.24	23.81

[1] Nonsignificant

[2] N = no effect level for a single application determined in a pot study.

Table 2. Injury ratings of tomato treated six times at bi-weekly intervals with low rates of atrazine. Trial C, Kona.

Rate	Application (kg/ha)	Injury ratings[1] by dates 10/30	11/13	11/27	12/1	12/24
0		1.8	1.8	0.7	0.7	0.7
0.004	(1/10 N)[2]	1.7	0.9	0.7	0.3	0.3
0.02	(1/2 N)	3.1	2.5	1.7	1.3	1.3
0.04	(N)	3.2	2.6	2.8	2.0	1.3

[1] Rating scale: 0 = no effect, 1-3 = minor effects, 4-5 = moderate injury, 7-9 = severe injury, 10 = all plants dead.

[2] N = no effect level.

Table 3. Yield response of tomato to six bi-weekly applications of low rates of atrazine. Trial C, Kona.

Rate (kg/ha)	Appli- cation	Total atrazine (kg/ha)	Yield[1] (kg/plot)
0		0	14.43[a]
0.004	(0.IN)[2]	0.02	13.18[ab]
0.02	(0.5N)	0.12	12.02[ab]
0.04	(N)	0.24	7.80[b]

[1]Duncan's new multiple range test. Different letters indicate significant differences (P = 0.05).

[2]N = No effect level

Table 4. Yield response of tomato to five bi-weekly applications of low rates of atrazine. Trial G, Maui.

Rate (kg/ha)	Appli- cation	Total atrazine (kg/ha)	Yield[1] (kg/plot)
0	(0)	0	25.54
0.004	(0.1 N)[2]	0.02	20.50
0.02	(0.5 N)	0.10	24.22
0.04	(N)	0.20	22.32

[1]Non significant.

[2]No effect level.

Glyphosate on tomato. No injury symptom was observed in tomato with the lower rates of glyphosate. However, at the highest rate of 0.04 kg/ha in Trial B (Maui) injury symptoms appeared after the second spraying (Table 5), and in trial D (Kona), injury occurred after the first application at the two highest rates, 0.04 and 0.02 kg/ha (Table 7). The greater response at the Kona site than at the Maui site was consistent with the responses to metribuzin. That two different herbicides produced the differential responses supports the hypothesis of greater uptake at the Kona site because of climate induced succulence of the plants.

Trial H (Maui) produced only mild injury at the highest rate of 0.032 kg/ha (Table 9). However, the response was not consistent between replicate plots or even between plants within the same plots.

The Kona symptoms were: distorted leaves, failure of the leaflets to expand or elongate, crinkling of the leaf blade; chlorosis at the base of the leaf blades progressing to general chlorosis with increasing rates; and at moderate injury levels, the leaves acquired the "strapped" look, a waxy and brittle appearance. Severely injured plants were retarded and chlorotic. Milder symptoms were confined to leaves that were young when sprayed. Injury symptoms decreased in severity as the plants grew (Table 9) presumably because of the increasing biomass and, consequently, diminishing dose (amount herbicide per biomass unit).

Glyphosate depressed yields of tomatoes in both Trials B (Maui) and D (Kona) although only for those treatments that were visibly injured (Tables 6, 8). Both symptoms and yield suppression were more severe in Kona (Tables 7, 8) than on Maui (Tables 5, 6, 9, 10). Trial H (Maui) produced no significant differences in yield (Table 10). Trial H was initiated in the summer whereas Trial D was initiated in the winter. The warmer, drier summer weather would produce a hardier plant than one started in winter.

Table 5. Injury ratings of tomatoes treated six times at bi-weekly intervals with low rates of glyphosate. Trial B, Maui.

Rate (kg/ha)	Application	Injury Ratings[1] by Date 10/19	11/2	11/16	11/1	12/15
0		0	0	0	0	0
0.004	(1/10 N)[2]	0	0	0	0	0
0.02	(1/2 N)[2]	0	0	0	0	0
0.04	(N)[2]	0	0.1	0.1	1.7	1.3

[1] Rating scale: 0 = no effect, 1-3 = minor effects, 4-5 = moderate injury, 7-9 = severe injury, 10 = all plants dead.

[2] N = No effect level.

Table 6. Yield response of tomato to six bi-weekly applications of low rates of glyphosate. Trial B, Maui.

Rate (kg/ha)	Application	Total glyphosate (kg/ha)	Yield[1] (kg/plot)
0		0	24.89[a]
0.004	(0.1N)[2]	0.02	23.02[a]
0.02	(0.5N)	0.12	19.48[ab]
0.04	(N)	0.24	13.41[b]

[1] Duncan's new multiple range test. Different letters indicate significant difference (P = 0.01).

[2] N = No effect level

Table 7. Injury rating of tomato treated six times at bi-weekly intervals with low rates of glyphosate. Trial D, Kona.

Rate (kg/ha)	Application	Injury Ratings[1] by Dates 10/30	11/13	11/27	12/11	12/13
0		1.5	1.0	0.4	0	0
0.004	(1/10N)[2]	0.7	0.8	1.3	0	0
0.02	(1/2N)[2]	1.8	1.9	4.2	5.0	3.0
0.04	(N)[2]	5.4	7.8	7.2	8.0	6.5

[1] Rating scale: 0 = no effect, 1-3 = minor effects, 4-5 = moderate injury, 7-9 = severe injury, 10 = all plants dead.

[2] N = No effect level.

Table 8. Yield response of tomato to six bi-weekly applications of low rates of glyphosate. Trial D, Kona.

Rate (kg/ha)	Application	Total glyphosate (kg/ha)	Yield[1] (lb/plot)
0		0	15.54[a]
0.004	(0.1 N)[2]	0.02	14.09[a]
0.02	(0.5 N)	0.12	6.75[b]
0.04	(N)	0.24	0.28[c]

[1] Duncan's new multiple range test. Different letters indicate significant difference (P = 0.05).

[2] N = No effect level

Table 9. Injury ratings of tomato treated with five biweekly applications of low rates of glyphosate. Trial H, Maui.

Rate	Appli-cation	Injury Ratings[1] by Date 8/22	9/5	9/19	10/3
(kg/ha)					
0	(0)	0	0	0	0
0.004	(0.1N)	0	0	0	0
0.008	(0.2N)	0	0	0	0
0.016	(0.4N)	0	0	0	0
0.032	(0.8N)	1.0	0	0.3	0

[1] Rating scale: 0 = no effect, 1-3 = minor effects, 4-5 = moderate injury, 7-9 = severe injury, 10 = all plants dead.

[2] N = No effect level.

Table 10. Yield response of tomato to five biweekly applications of low rates of glyphosate. Trial H, Maui.

Rate	Appli-cation	Total glyphosate	Yield
(kg/ha)		(kg/ha)	(kg/plot)
0	(0)	0	19.32
0.004	(0.1N)	0.02	23.40
0.008	(0.2N)	0.04	23.22
0.016	(0.4N)	0.08	18.69
0.032	(0.8N)	0.16	18.14

[1] Nonsignificant.

[2] N = No effect level.

Atrazine on zucchini. Atrazine at NOEL (0.04 kg/ha) severely depressed zucchini yields (Table 12). The symptoms were chlorosis and necrosis of leaf margins and interveinal areas, death of leaves young when sprayed, and suppression of growth. Injury symptoms were observed in the 0.02 kg/ha treatments (Table 11) but the yield, though lower, was not significantly different from that of lower atrazine rates.

In contrast to the pot trials, field-grown zucchini plants were sensitive to single applications of atrazine at 0.5 NOEL, even though weather conditions on Maui was expected to develop a more tolerant plant.

Glyphosate on zucchinis. Yields were significantly depressed at the higher rates of treatment: zero at NOEL (0.2 kg/ha) and essentially zero at 0.5 NOEL (Table 14). Visual injury symptoms occurred only in those highest treatments and appeared after the first application. Initial symptoms were: severe chlorosis for the highest glyphosate rate, and mottling of leaves in the 0.1 kg/ha treatment. Severe chlorosis led to necrotic lesions and retardation of plant growth.

As with atrazine (Table 11), zucchini displayed symptoms at the 0.5 NOEL glyphosate treatment (Table 13). Here also, this greater sensitivity in the Maui field trial than in the Kona pot trial was unexpected.

CONCLUSION

Atrazine and glyphosate injury symptoms were each consistent in tomato and zucchini except for differences in severity of response to varying intensity of exposure i.e., the greater the dose, the more severe the injury. Thus this study does not support the notion that repeated exposures of tomato and zucchini to sub-toxic levels of atrazine and glyphosate would elicit atypical injury symptoms.

Table 11. Injury ratings of zucchini treated with five weekly applications of atrazine. Trial E, Maui.

Rate (kg/ha)	Application	Injury Ratings[1] by Date 4/4	4/12	4/19	4/26
0		0	0	0	0
0.004	(0.1 N)[2]	0	0	0	0
0.02	(0.5)	2.3	2.4	0.2	0.2
0.04	(N)	3.5	5.7	3.3	4.0

[1]Rating scale: 0 = no effect, 1-3 = minor effects, 4-6 = moderate injury, 7-9 = severe injury, 10 = all plants dead.

[2]N = No effect level.

Table 12. Yield response of zucchini treated with five weekly applications of atrazine. Trial E, Maui.

Rate (kg/ha)	Application	Total atrazine (kg/ha)	Yield[1] (kg/plot)
0		0	9.72[a]
0.004	(0.1 N)	0.02	9.16[a]
0.02	(0.5 N)	0.10	8.07[a]
0.04	(N)	0.20	2.51[b]

[1]Duncan's new multiple range test: different letters indicate significant difference (P = 0.01).

[2]N = No effect level.

Table 13. Injury ratings[1] of zucchini treated with five weekly applications of glyphosate. Trial F, Maui.

Rate (kg/ha)	Application	Injury Ratings[1] by Dates 1 week	2 weeks	3 weeks	4 weeks
0		0	0	0	0
0.01	(0.05 N)[2]	0	0	0	0.7
0.02	(0.1 N)	0	0	0	0
0.1	(0.5 N)	2.1	2.4	4.2	5.3
0.2	(N)	6.0	7.0	7.2	8.0

[1]Rating scale: 0 = no effect, 1-3 = minor effects, 4-6 = moderate injury, 7-9 = serious injury, 10 = all plants dead.

[2]N = no effect level

Table 14. Yield response of zucchini treated with five weekly applications of glyphosate. Trial F, Maui.

Rate (kg/ha)	Application	Total glyphosate (kg/ha)	Yield[1] (kg/plot)
0		0	11.73[a]
0.01	(0.05 N)[2]	0.05	11.29[a]
0.02	(0.1 N)	0.10	9.97[a]
0.1	(0.5N)	0.50	0.47[b]
0.2	(N)	1.00	0[b]

[1]Duncan's multiple range test: different letters indicate significant difference (P = 0.01).

[2]N = No effect level.

ACKNOWLEDGMENT

Funding was provided by the State of Hawaii Governor's Agricultural Coordinating Committee. Additional resources were provided by the Hawaii Department of Agriculture and the University of Hawaii at Manoa, College of Tropical Agriculture and Human Resources. In addition, the staff of the Hawaii Department of Agriculture and of the College of Tropical Agriculture and Human Resources provided invaluable assistance above and beyond the call of duty.

LITERATURE CITED

1. Akesson, N.B., W.E. Yates, and R.E. Cowden. 1978. Predicting pesticides losses. Agrichemical Age. June p. 26, 28-29E; July-Aug. p22, 24, 25E.

2. DeFrank, J, R.V. Osgood, and S.A. Whalen. 1988. Risk to nontarget tomatoes from ethephon aerial spray drift. Univ. Hawaii Manoa Coll. Trop. Agric. Human Resour. Res. Ser. 053. 12p.

3. Diagnosis of Herbicide Damage to Crops. 1981. Chemical Publishing N.Y. 70 p.

4. Herbicide Injury Symptoms and Diagnosis. 1981. North Carolina State Univ. Agric. Ext. Serv. Raleigh, North Carolina. 31 p.

5. Nishimoto, R.K. l981. Comparative effects of Polado on several horticultural crops. Univ. Hawaii Coll. Trop. Agric. Human Resour. Res. Ser. 004. Honolulu. 11 p.

6. Nishimoto, R.K. and B.H. Zandstra. 1977. Effects of Polaris on several horticultural crops. Univ. Hawaii Agric. Exp. Sta. Res. Bul. 186. Honolulu 11 p.

7. Romanowski, R.R. 1980. Simulated drift studies with herbicides in field-grown tomato. Hort Science 15:793-794.

8. Yates, W.E., N.B. Akesson, and D.E. Bayer. 1978. Drift of glyphosate sprays applied with aerial and ground equipment. Weed Sci. 26:597-604.

BIOLOGY AND PHYSIOLOGY

WINTER-HARDINESS OF LEAFY SPURGE ROOTS. Rodney G. Lym and Calvin G. Messersmith. Associate Professor and Professor, Crop and Weed Sciences Department, North Dakota State University, Fargo, ND 58105.

Abstract. Winter-killing may be an important mechanism of natural weed control in conventional tillage systems. Cold injury is the major environmental stress limiting plant distribution. Infestations of leafy spurge, Canada thistle, field bindweed, and other perennial weeds in cropland are increasing as reduced tillage practices are adopted. Once leafy spurge is established in cropland, few options for control are available because herbicide rates required to control leafy spurge are greater than can be applied to cropland. Manipulation of the leafy spurge root system could result in decreased cold tolerance and reduced regrowth the following season.

The effect of several treatments on winter-hardiness of leafy spurge was evaluated. Leafy spurge, growing in previously untreated cropland, was treated with nitrogen at 200 lb/A (Aug. 15, 1989), cultivation followed by nitrogen applied 30 days later (Aug. 15 and Sept. 13), two cultivations (Aug. 15 and Sept. 13), or picloram plus 2,4-D at 0.5 plus 1 lb/A (Sept. 13). Roots were extracted on Nov. 1 and divided into crown tissue and root tissue from two depths, 0 to 15 and 15 to 30 cm. Root and crown tissues were evaluated for cold-hardiness by freezing the crown or 12-cm long root tissues at 0, -4, -8, -12, -16 or -20 C. An LT_{50}, temperature required to kill 50% of the tissue, and a GR_{50}, temperature required to reduce regrowth by 50%, were determined. Seperate samples were analyzed for carbohydrate content.

The LT_{50} was < -20 C for crown tissue and roots from 0 to 15 cm deep and -16 C for roots from 15 to 30 cm. The GR_{50} was < -20, -18, and -16 C for crown tissue, and roots from 0 to 15 and 15 to 30 cm, respectively. Picloram plus 2,4-D decreased the winter-hardiness of crown tissue and both the herbicide treatment and fertilizer decreased the carbohydrate content. However, no treatment affected the cold hardiness of the root tissue from either depth. Thus, the leafy spurge root system and especially the crown buds, generally can survive over winter in minimum tillage areas and cultivation and nitrogen application did little to decrease the winter-hardiness during the first year of the study. (Published with approval of the North Dakota Agricultural Experiment Station).

DAIRY MANURE REMOVAL SITE EFFECTS ON WEED SEED VIABILITY. David W. Cudney, University of California Cooperative Extension, Riverside, CA 92521, Steven D. Wright, Lancaster, CA 93534, and Thomas A Shultz, Visalia, CA 93291.

Abstract. Dairy manure has been an imortant soil amendment in the San Joaquin Valley of California, particularly when applied to less productive soils. Dairy manure, however, has a poor reputation among growers as a major source of weeds; therefore its use is less popular than chemical fertilizers as a nitrogen and phosphorous source. This study is being conducted to determine which sites of manure collection in the dairy are the greatest source of weeds. The effect of feed quality, composting, and seasonal effects on manure weed seed germination and weed species composition is also being determined. It is hoped that information from this ongoing study could benefit growers by identifying weedy sites so the import of weed seed in manure could be avoided. Dairy manure was sampled from seven dairies in Tulare and Kings counties from corrals of both producing and dry cows and from compost piles and sedimentation ponds. Samples were taken at three-month intervals throughout the yr. Weeds were then germinated in flats where manure was mixed with a peat, sand, vermiculite planter mix. Manure taken from dry cow corrals had a much higher incidence of weed germination than that taken from milking cow corrals. Manure taken from sedimentation ponds had an intermediate weed emergence. Manure taken from compost piles had low weed seed germination. Data thus far indicate that in one ton of dairy manure from lactating cows 14,000 weeds germinated as compared to 230,000 from dry cow manure.

PROTOPLAST ABSORPTION AND THYLAKOID BINDING OF METRIBUZIN AND ITS ETHYLTHIO ANALOG BY WHEAT, DOWNY BROME AND JOINTED GOATGRASS. Buman, R. A., D. R. Gealy, and E. P. Fuerst, Graduate Student, Department of Agronomy and Soils, Washington State University; Plant Physiologist, USDA-ARS; and Assistant Professor, Department of Agronomy and Soils, Washington State University, all Pullman, WA, 99164.

Abstract. Downy brome and jointed goatgrass are two major winter annual weeds in winter wheat production areas of the United States. Only two herbicides, metribuzin and its ethylthio analog (SMY 1500, ethiozine, or ethyl-metribuzin), applied postemergence will control downy brome and jointed goatgrass selectively in winter wheat. However, the activity of these asymmetrical triazines against downy brome and jointed goatgrass has been inconsistent. Earlier studies with both herbicides demonstrated that cool temperatures reduced both inhibition of photosynthesis in protoplasts and absorption by roots. Thus, cool temperatures could contribute to decreased herbicide activity. The purpose of this study was to determine the effect of temperature on protoplast uptake and thylakoid binding of ^{14}C-metribuzin and ^{14}C-ethyl-metribuzin. Binding of metribuzin and ethyl-metribuzin to thylakoid membranes of downy brome, jointed goatgrass, and winter wheat was affected by temperature. In general, binding to thylakoid membranes equilibrated more rapidly with increasing temperature. The quantity of either herbicide bound to thylakoids of each species was similar at 10 and 20 C. However, approximately 20% less herbicide bound at 30 C than at 10 and 20 C. The effect on weed control of decreased binding at 30 C is probably insignificant compared to that of increased uptake of herbicide at 30 C by plants of both species. The average quantity of metribuzin bound to thylakoid membranes was 1.7 times greater than that of ethyl-metribuzin for each species and temperature at concentrations of 0.316 μM or less. The binding constants (K_b) for ethyl-metribuzin were 1.4 to 3.0 times greater than for metribuzin when herbicides were applied to the same species at the same temperature. This indicates that ethyl-metribuzin has lower affinity than metribuzin for the herbicide binding protein. The difference in binding affinity between metribuzin and ethyl-metribuzin partially explains the higher usage rate of ethyl-metribuzin than metribuzin required to obtain the same control of weeds under field conditions. Competitive binding studies indicated that atrazine, metribuzin, and ethyl-metribuzin have a common binding site in jointed goatgrass. The average number of chlorophyll molecules per bound herbicide molecule was estimated to be 890. This value is higher than values of 350 to 500 chlorophyll molecules per bound herbicide molecule published for metribuzin and atrazine in broadleaf plants. Protoplast absorption studies of metribuzin and ethyl-metribuzin utilizing an 8 min. incubation period were conducted at 10, 20 and 30 C in 400 μL microcentrifuge tubes which contained a combination of sugars and silicone oil to produce a density step gradient. There was no consistent effect of temperature, herbicide or species on protoplast absorption of herbicide.

REGULATION OF GENE EXPRESSION DURING IMBIBITION OF DORMANT AND NONDORMANT WILD OAT (*Avena fatua* L.) EMBRYOS. William E. Dyer, Assistant Professor, Plant and Soil Science Department, Montana State University, Bozeman, MT 59717.

Abstract. The locus of dormancy in wild oat seeds is generally thought to reside in the embryo. To test the hypothesis that differential gene expression is responsible for breaking dormancy, proteins were extracted from embryos of dormant and after-ripened (nondormant) inbred wild oat seeds at several times during imbibition and subjected to two-dimensional electrophoresis. The resulting polypeptide patterns revealed subtle differences between the two seed conditions, indicating that the release from seed dormancy is associated with changes in certain proteins. Thus, changes that occur during after-ripening of dormant wild oat seeds may allow derepression of specific genes during imbibition, leading to seed germination.

Intact, dormant wild oat seeds do not germinate under conditions favorable for germination of nondormant seeds. However, excised embryos from dormant seeds readily germinate. Since wounding plant tissues is known to induce ethylene biosynthesis and ethylene stimulates germination of some dormant seeds, the role of ethylene in excised wild oat embryo germination was investigated. Excised embryos were incubated in 2 mM (aminooxy)acetic acid, an inhibitor of ethylene biosynthesis, 5 mM silver thiosulfate, or 5 μl/L norbornadiene,

two competitive inhibitors of ethylene action, at 11 C. Germination (95%) of excised embryos incubated in water occurred within 36 h. However, only 10% of embryos incubated in the ethylene inhibitors germinated during the same period. Germination resumed rapidly when embryos were washed and transferred to water. Thus, wound-induced ethylene may be responsible for the germination of embryos excised from dormant wild oat seeds.

THE MSU SPRAYER PROTECTION KIT. Dawit Mulugeta, B.S. Muller, E.S. Davis, and P.K. Fay. Research Assistants and Professor, Plant and Soil Science Department, Montana State University, Bozeman, MT 59717.

Abstract. Students at Montana State University conducted a survey and determined that most producers were concerned about the long term health risk from using pesticides. In addition, most producers were not using sprayer protection equipment and the equipment was not readily available in most areas of the state. Numerous makes and models of protection items including gloves, goggles, respirators, coveralls, aprons, and foot coverings were assembled for evaluation by a panel of 20 producers. A final kit, the MSU Sprayer Protection Kit, was assembled and contains 2 pairs of neoprene gloves, vented goggles, respirator, 3 pairs of disposable coveralls, a PCV apron and latex foot covers. Attractive order blank brochures were printed and distributed throughout the state by extension specialists, 4-H club members and county agents. The selling rights to the kit were recently transferred to a small firm in Montana and it is being aggressively promoted. (Published with the approval of the Montana Agricultural Experiment Station.)

PROJECT 1: PERENNIAL HERBACEOUS WEEDS

Chairperson: Mike Foster

Subject: A Systems Approach to Weed Control

Leafy spurge- Mark Ferrell, University of Wyoming. Wyoming has 49,000 A of leafy spurge. The size of this infestation has not increased for several yr. The state has an active chemical control program through the state weed law. This weed has been shown to be extremely adaptable in the areas of infestation in the west. Due to increased concern over the use of herbicides, as well as some well contamination found in certain areas of Wyoming, several other management options have been discussed. It was noted that leafy spurge is generally thought to be toxic to cattle. Montana programs have worked well using sheep to graze leafy spurge. A few insect biological control agents are available in some areas. Wyoming researchers are working on development of a program integrating herbicide use with perennial grass competition. Landowner and weed supervisor long-term management of the land infested with leafy spurge is critical management versus control.

Representatives from New Mexico noted that they currently are aware of a very small (2.5 to 3 A) infestation of leafy spurge. They were advised to try to eradicate this small area before it gets well established. Prevention is another important management tool.

The annual leafy spurge symposium will be held July 10 to 12, 1990 in Gillette, Wyoming.

Canada thistle - Gus Foster, Sandoz Crop Protection. A systems approach to Canada thistle control is the same as proper management. Research on timing tillage operations with herbicide applications is underway in cooperation with Bob Zimdahl (Colorado State University). It was noted that discing after a variety of herbicide applications had no effect on control. They are now developing a preconditioning program, using June, July and August pretreatments, followed by a September herbicide application. Pretreatments will include discing, rotary mowing, and herbicide (2,4-D) chemical mowing.

Knapweeds - Bob Callihan, University of Idaho. There are approximately 800 species of knapweeds within this ecological zone in Europe. We currently have 12 in this region. Squarrose knapweed is a perennial as serious as Russian knapweed. Many knapweed infested areas in Idaho were originally infested with downy brome. When the knapweed is controlled, downy brome will then be the first plant back into the area. It is critical to find a grass that will help suppress knapweed that can be used in a rangeland situation.

New weed control methods need to be developed that apply different pressures to weeds and that do not need continual inputs. Another serious concern is the importance of coordination with other agencies working on weed control (SCS, BLM, FS, research needs, range improvement techniques). There are needs to communicate at the local level, especially given the herbicide input needs on farm plans.

Additional information is needed from agricultural economists to justify spending the money needed to control perennial weeds on low value land.

1991 Officers of Project 1:

Chairperson: Barbra Mullin, Weed Coordinator
Montana Department of Agriculture
Capitol Station
Helena, Montana 59620
(406) 444-2944

Chairperson-elect: Bob Callihan
Plant & Soil Science Dept.
University of Idaho
Moscow, Idaho 83843
(208) 885-6617

PROJECT 2: HERBACEOUS WEEDS OF RANGE AND FOREST
Chairperson: K. George Beck
and
PROJECT 3: UNDESIRABLE WOODY PLANTS
Chairperson: Mike Newton

These two research project meetings were held in conjunction because there is a great degree of commonality between these subject matters. The meeting began at 2:30 pm and formally adjourned at 4:30 pm. Discussion continued after adjournment.

Three subjects were presented during the meeting:
1. Use of Forest and Range Vegetation Management to Manage Water Quality, by George Beck
2. Prospects for Industrial Development of Products in Controversial Areas, by Ron Crockett
3. What Vegetation Managers can do for Multiple Species Habitats, by Michael Newton

These discussions centered on the use of herbicides in habitat management, people's perception of herbicide safety, and ways to use herbicides in sensitive areas such as wetlands and riparian habitats. All topics promoted good discussion.

The Herbaceous Weeds and Undesirable Woody Plants Research Projects agreed to meet jointly again in 1991. The general topic for discussion in 1991 will be focused around implementing the team approach used in natural resource management toward vegetation management. Several models for this approach exist. One getting much popular press the past few years has been the Holistic Resources Management model expounded by Allan Savary of Albuquerque, New Mexico.

1991 Officers of Project 2:

Chairperson: Diane E. White
Forest Science Department
Oregon State University
Corvallis, Oregon 97331-5704
(503) 737-2244
Chairperson-elect: Michael Ralphs
USDA/ARS
1150 E. Ircon
Logan, Utah 84321
(801) 752-2941

1991 Officers of Project 3:

Chairperson: John H. Brock
School of Agribus. and Environ. Res.
Arizona State University
Tempe, Arizona 85287-3306
(602) 965-7036
Chairperson-elect: Paul Figueroa
Weyerhauser Co.
505 N. Pearl St.
Centralia, Washington 98531
(206) 736-8241

PROJECT 4: WEEDS IN HORTICULTURAL CROPS

Chairperson: Steve Bowe

Subject: Proper Use of Statistical Analysis in Weed Science

Jack Hills, Extension Biometrician, UC Davis, discussed the "Proper Use of Statistical Analysis in Weed Science." The basics of experimental design were briefly discussed while specific topics such as split-plot designs, mean separation, and visual evaluations were covered in more detail. A panel of weed researchers (Jon Chernicky, Stott Howard, and Tom Lanini) completed the project meeting by answering questions from the audience.

Prerequisite steps that should be completed before designing an experiment are determining the objective, treatments, experimental unit, control, data to be collected, number of replications, analyses, and method of mean separation. A well-planned experiment should be simple, precise, without systematic errors, have conclusions with a wide range of validity, and allow the degree of uncertainty to be calculated.

Several experimental designs were discussed. Split-plot, factorial experiments have restricted randomization that can provide an effective method for examining a potential interaction between factors.

Pair-wise multiple comparisons and orthogonal contrasts were the types of mean separation discussed. LSD is a pair-wise multiple comparison that is once again an acceptable method of mean separation. Orthogonal contrasts are more powerful than LSD's for many comparisons. Class comparisons and trend (regression tests) are types of orthogonal contrasts.

Visual evaluations must be analyzed with caution to avoid making false conclusions. Testing for homogeneity of variances and transformations are methods used to improve interpretation of visual evaluations. Quantitative measurements are favored by some to avoid the subjectivity of visual evaluations. Another viable alternative is arc sine transformation of 0 to 100% evaluations or evaluation using pre-transformed scales.

It was suggested that the WSWS form a committee to investigate standardizing visual evaluations.

Comments and questions elicited by the panel confirmed that visual evaluations and quantitative measurements are a topic of much interest to weed scientists. Other concerns included analysis of check plots, split-plot designs, and perennial weed control and statistics. The number of questions and participants indicated that statistical analysis in weed science is a subject that deserves further discussion in research projects.

1991 Officers of Project 4:

Chairperson: David L. Zamora
American Cyanamid Co.
4525 Cochees
Boise, Idaho 83709
(208) 362-4695

Chairperson-elect: Bob Mullen
UC Cooperative Extension
420 South Wilson Way
Stockton, California 95205
(209) 468-2085

PROJECT 5: WEEDS IN AGRONOMIC CROPS

Chairperson: Charles E. Osgood

Subject: Low-Impact Sustainable Agriculture (LISA)

The topic was introduced by Pat Fuerst. LISA has become a major focus in agriculture as a result of public concern and legislative actions on environmental contamination and food safety issues. Weed scientists need to direct research and educational efforts at minimizing the use of agrichemicals in general, and at shifting to the use of chemicals with reduced risk to the environment and our food. In the opening session of the WSWS, Phil Westra raised the question, "Where is the data about LISA?" This question can be expanded by asking "What is the effect of LISA on 1) environmental contamination, 2) food safety, and 3) economic costs to society and the grower? i.e., what data proves the assumption that LISA will deliver what it is supposed to in terms of significantly improved quality of food and the environment, and what price must be paid for these improvements?

Frank Young delivered a talk entitled, "Short-term results on low input sustainable agriculture in the Palouse". There are few studies that have actually evaluated the relationship between various levels of weed management inputs and the profitability of production systems. The IPM project, which is being directed by Dr. Young, is investigating this relationship in a study that will be conducted through two three-year rotations. A cost analysis of the first three years of data suggested that a moderate weed management level, i.e. using herbicide types and rates recommended by universities, was often more profitable than using reduced herbicide inputs. This study has also yielded valuable information regarding the effect of crop rotation and tillage on weed populations and on the yield of winter wheat, spring wheat, and peas. The downy brome population became especially severe under continuous no-till. Winter wheat in rotation had higher yields than continuous winter wheat, but continuous winter wheat was more profitable.

A discussion followed Dr. Young's presentation. Some opinions were shared: Short term studies of 1 to 2 yr do not answer economic questions, yet this is usually the best information available. Growers must look beyond just the one-year return - they must consider the longer term costs. Is the issue sustainability or flexibility? The effect of moldboard plowing on weed seed longevity was discussed, since the data from Young's study the assumed principle that burying seed would enhance its longevity.

DO YOUR BELIEFS ABOUT LISA AFFECT YOUR ABILITY TO CONDUCT LISA RESEARCH? Philip Westra, Assistant Professor, Weed Science, Dept. of Plant Pathology & Weed Science, Colorado State University, Ft. Collins, CO 80523.

LISA (Low Input Sustainable Agriculture) is a farming systems concept which shares certain philosophical similarities with organic farming, regenerative farming, biodynamic farming, French-intensive farming methods, and CIRA (Controlled Input Responsible Agriculture). Although LISA itself is subject to controversy concerning the appropriateness of low input in conjunction with the concept of sustainability, it does share with these other systems a stated goal of reducing chemical fertilizers and pesticides in North American farming systems. While LISA is an acronym which may disappear over time, the concept of sustainable agriculture is here to stay in the debate over North American agriculture. A definition of sustainable provided by the Wisconsin rural development center states "sustainable methods are those which use less commercial fertilizer, herbicide, and pesticides".

Paradigms in North American agriculture are changing. For several decades, the ruling paradigm defined sustainability as achievement of food sufficiency for our nation. More recently, the paradigm has begun to shift to the concept of sustainability as stewardship of the land and natural production resources. Even more recently, the paradigm of sustainability as maintenance of viable rural communities has entered the debate about North American agriculture. Firmly imbedded in these discussions are the pro-chemical advocates who argue for the use of all chemical fertilizers and pesticides that are currently available to crop producers. They are opposed by the pro-organic advocates who argue for the reduction or elimination of all chemical fertilizers and pesticides that many crop producers currently use.

In a very real sense, the debate about LISA, and the impact of this debate on our ability to conduct LISA weed science research is related to the differences between science and religion and their impacts on our lives. Science operates with the presumption that there are causes to things. Religion operates with the presumption that there are meanings to things. Both causes and meanings share a concept of order. Pro-chemical advocates often cite "scientific research results" to support their point of view, while pro-organic advocates often use a "religious type of zeal" to justify their position.

All human beings hold (consciously or subconsciously) some "worldview" which is a set of presuppositions (or assumptions) about the basic makeup of the world and how it functions. A person's worldview (including those of weed scientists) will color and affect not only the selection of research topics, but also the selection of data to be collected, and data interpretation. No scientist is nearly as "objective" as he or she may profess to be. Scientists are often devoted to reductionist research in which they believe that understanding the parts of the whole will help to finally understand the whole which in itself may defy understanding because of its size or complexity. What scientists often fail to understand is that in reductionist research, they may kill the life of the whole while trying to study the makeup of its parts. Science often tries to function outside of a sense of history, and may even claim that it does not need history. One need only look at modern weed science research to see that we have largely lost sight of the historic roots of mechanical weed control as we research modern weed control systems.

Some advocates of sustainable agriculture claim that not only are mainstream North American agricultural institutions unable to grasp the essence of sustainable agriculture, but they do not even want to work on sustainable agriculture issues. They charge that mainstream agricultural institutions are too committed to the status quo to mount a serious charge in defense of sustainable agriculture. Sustainable agriculture advocates are frequently unimpressed and unswayed by "scientific evidence" which may show that the pro-chemical farming system is more profitable. They may prefer to believe anecdotal and testimonial evidence which suggest that organic farming is the only way to maintain a sustainable agricultural system. The march 1990 issue of The New Farm Magazine features organic weed control systems which exclude all herbicides. This is the natural outcome of a worldview which is radically different from that adhered to by most contemporary North American weed scientists.

While organic weed control may be philosophically and environmentally attractive, we must insist on an ecological and energy balance sheet that applies to all weed control systems. Where a pro-chemical farmer may control weeds with two passes of herbicides over a field, an organic farmer may need to carry out three to five mechanical tillage operations to obtain satisfactory weed control. What will the impact of these additional tillage operations be on soil erosion, soil compaction, and atmospheric carbon dioxide pollution from all the additional tractor trips across fields? Somewhere the impact of tractors on global greenhouse effects must be accounted for.

In some respects, organic weed control in North America will be widely adopted when every Yuppie family spends 2 weeks of their summer vacation (with their children) in the countryside helping to hand-weed the crops that provide our civilization with food and fiber. If they are not willing to contribute to this labor themselves, they must be prepared to pay the price for someone else to carry out such hand-weeding if sustainable agriculture as envisioned by some organic proponents is to succeed in North America.

It is clear, however, that increasingly our society is urging North American farmers to use less chemical fertilizers and pesticides. While we may perceive the rhetoric of some pro-organic advocates to be overly strident, we should not summarily dismiss their arguments, but rather ask "what are the key points they really want to make?" More importantly we need to ask if the pro-chemical and pro-organic advocates approach North American weed control problems from such radically different "worldviews" that they cannot cooperate on any research, or if there are areas of mutual interest in which cooperation could occur. While pro-chemical advocates, backed up by science and technology may say that there are no limits to what we can do, sustainable agriculture advocates, misunderstanding historical developments, may try to set inappropriate limits to scientific endeavors. It may even be that the pro-chemical versus the pro-organic debate is a worn out battle, and that we all need to search for a new worldview to shape future weed control strategies. To a true "weed" scientist, it should make no difference if a social mandate for weed control includes access to all herbicide technology, or if it excludes all herbicide technology. If this difference makes us uncomfortable, then we need to seriously ask ourselves if critics are correct when they accuse us of being "herbicide" scientists rather than "weed" scientists.

We must also understand that the industrialization of agriculture not only put the stamp of science and technology on contemporary agriculture, but it has also transformed agriculture's connection with economic and political powers. We also need to ask whether we should look at plants as sources of food to sustain our bodies, our families, and our rural communities, or should they be viewed as biochemical factories for use as international poker chips in a high stakes political and economic game where food becomes the ultimate weapon. To the extent a society mechanizes and computerizes its activities (including agriculture) life simply moves at an increasingly faster pace, and we may lose contacts with the roots of what agriculture was meant to be. Pro-chemical and pro-organic advocates may be able to find common ground on issues of economics, food distribution, justice in the feeding of the poor, and in environmental concerns. We may need to also consider the concept of rest for our land, the opportunity for the soil to rest from the rigors of modern crop production pressures.

Fundamentally, we need to ask if modern weed scientists are being called to help beat the swords of our cultures into plowshares to feed the world. All agricultural producers need the power and creativity of our minds to develop research projects that will elucidate the merits and demerits of various weed control systems. We need to help educate our society and our children about the importance of weed control to food and fiber production. Our society is challenging us to move North American weed control into the next century. Are we willing to accept this challenge?

1991 Officers of Project 5:

Chairperson: Pat Fuerst
Department of Agronomy and Soils
Washington State University
Pullman, Washington 99164-6420
(509) 335-7484
Chairperson-elect: Rick Arnold
New Mexico State University
Agriculture Science Center
P.O. Box 1018
Farmington, New Mexico 87499
(505) 327-7757

PROJECT 6: AQUATIC, DITCHBANK, AND NONCROP WEEDS

Chairperson: Shafeek Ali

The WSWS Project VI session was attended by 35 people. The discussion centered on the following: properties of a new herbicide for treating aquatic weeds, growth requirements of Hydrilla, new imaging techniques for mapping aquatic plant distributions, and feeding preferences of grass carp.

1991 Officers of Project 6:

Chairperson: David F. Spencer
USDA/ARS Aquatic Weed Research Lab
Botany Department
University of California
Davis, California 95616
(916) 752-1096

Chairperson-elect: Vanelle F. Carrithers
Agricultural Products Department
28884 So. Marshall
Mulino, Oregon 97042
(503) 829-4933

PROJECT 7: CHEMICAL AND PHYSIOLOGICAL STUDIES

Chairperson: Jill Schroeder

Subject: Data Requirements for Field Validation of Herbicide Transport Models

The Project 7 meeting was conducted from 9:30 to 11:30 a.m. on Thursday, March 15, with 20 people in attendance. Tracy Sterling was nominated and unanimously confirmed as chairperson-elect for 1991.

Robert S. Bowman, Dept. of Geoscience, New Mexico Tech, Socorro, led a discussion on prediction of the rate and amount of herbicide leaching using herbicide transport models and validation of model predictions using controlled field experiments. Typical model parameters include herbicide concentration, time, vertical displacement, dispersion coefficient, advective water velocity, retardation factor and degradation coefficient. The input parameters for the model are determined from laboratory experiments or reports from the literature. If the input parameters are appropriate, the model can predict the herbicide distribution in the soil profile as a function of time and distance. Field experiments are needed to validate the model.

Field experimental design was discussed. The importance of working in a multidisciplinary team including a soil physicist was emphasized because one of the major limitations to our ability to predict herbicide movement into groundwater is our poor understanding of water movement in soil. Field experiments determine the distribution of a herbicide and a non-reactive water tracer as a function of depth in the soil. The tracer provides a field measurement of mean advective water velocity, retardation factor, and herbicide degradation (determined from relative recoveries of tracer and herbicide in an experiment where the field is sampled once). Environmental conditions including weather data, heat loss and heat flux should be monitored. The experimental values are then used as input parameters for the model and the results are then compared to the estimates obtained prior to the field experiment.

The impact of spatial variability in the field on experimental results was discussed. Areal variability in herbicide transport is generally large (CV's 30 to 50%). Therefore, a large number of soil samples (as many as 15 to 20 per treatment) are required. Transport properties are not normally distributed and Fisher's statistical analyses are generally not appropriate. The transport properties may also be spatially correlated. Cores analyzed separately rather than composited will give a better indication of herbicide movement. However, the objectives of an experiment will dictate whether soil samples should be analyzed singly or composited. In addition, the number of analyses required will also influence the design of an experiment.

William C. Koskinen, USDA-ARS, St. Paul, MN, led a discussion on techniques for handling soil samples and pesticide analysis. The number of analyses required for a field experiment become prohibitively large when the experiment contains several treatments, replications, sampling dates and depths. In addition to analysis of field samples, additional spiked samples (the addition of a known amount of analyte to sample) must be analyzed prior to the field samples to obtain accuracy and recovery data.

A strict protocol must be followed in all field studies to preserve the pesticide in samples taken in the field until they are analyzed in the laboratory. The researcher must ensure that no cross contamination occurs among samples. Sampling equipment must be cleaned with brushes and solvent between samples. Quality assurance/quality control procedures dictate that, for a percentage of all samples, the equipment must be recleaned and the solvent collected for analysis in order to document that no contamination occurred during sampling. Cross contamination can be avoided by removing potentially contaminated soil from each core. The researcher must also document the amount of herbicide lost between sampling and analysis. A surrogate chemical (a chemical similar to the herbicide in physical and chemical characteristics) is added to each soil sample at a known concentration either in the field or laboratory. Herbicide loss after sampling can be minimized by placing each sample on dry ice in the field and protecting the sample from sunlight. The recovery of the surrogate chemical in the laboratory analysis allows the researcher to document any chemical losses due to handling procedures.

Pesticide analysis in the laboratory consists of several steps including extraction, sample preparation, confirmation of the chemical identity and quantification of the chemical. The extraction and preparation steps should be as simple as possible to ensure the highest recovery and precision possible. Confirmation of chemical identity is accomplished using retention parameters from two column systems, chemical methods and/or instrument systems. If possible, a percentage of samples should be confirmed using mass spectroscopy.

Laboratory procedures are very time consuming and expensive. Robotic systems are available to supplement the laboratory staff. Data was presented which showed that with robotics more samples could be analyzed with greater precision compared to traditional laboratory procedures.

1991 Officers of Project 7:

Chairperson: Charlotte Eberlein
Aberdeen Research and Extension Center
P.O. Box AA
Aberdeen, Idaho 83210
(208) 397-4181

Chairperson-elect: Tracy Sterling
Dept. of Entomol., Plant Path., and Weed Sci.
New Mexico State University
Box 30003, Dept. 3BE
Las Cruces, New Mexico 88003-0003
(505) 646-6177

EDUCATION AND REGULATORY SECTION

Chairperson: Celestine Lacey

The program for the Education and Regulatory Session focused on extension programs and issues in the western states. Three subjects were discussed at the session which will be briefly summarized in this report.

Computers: Creative Uses for Weed Extension Activities. Dr. Steve Dewey, Utah State University, presented information on the use of computers in word processing, developing graphs, and conducting weed inventories. He discussed various software packages including Harvard Graphics and their importance in producing effective graphs and charts that could be utilized in extension and research publications. He also discussed several crop management programs that include control and management information on insects, weeds, and diseases for a specific crop. He is presently working on a program for computerizing a taxonomic "key" for weed identification.

Steve also discussed the importance of geographic information systems in predicting the potential spread and present location of weed infestations. The programs include the use of Landstat data and field inventories in developing computer maps. These maps can be used to gain legislative and public support for weed management programs by showing present and future impact from noxious weeds.

The Effective Use of Video and Other Media Techniques for Weed Extension Programs. Charles Henry, Ag. West Communications, discussed six major points that insure the success of a video production. Each point is summarized below:

Content You must have worthwhile subject matter for your video.

Picture Quality Your audience expectations will be very high because of television. Therefore, you must use the best technology for your video production.

Entertainment Value You must include some entertainment value in your video to hold the interest of your audience. Do not present miscellaneous information but combine facts with entertainment.

Graphics You should include graphics in your video presentation to show results or trends (i.e. weed spread over 10 years). Cost is approximately $160/second for basic animation.

Clear Goals You must have clear goals before initiating a video. Video is limited in its flexibility, therefore overheads or slides may be more appropriate if you need re-emphasize points. If you plan to inspire or motivate an audience, slides will be more effective.

Know Your Audience You should know the education level, job background, sex, and age of your audience before initiating a video. Average length should be from 6 to 12 minutes for adults. Charlie also emphasized that videos are most effective when shown to a small group of people. The optimum size is about 10 with the maximum audience size of 25. He also suggested that a person interact with the group during, before, or after the video to highlight points, clarify the subject, and answer questions. It is important to try and control how a video is presented to most effectively communicate the message.

Charlie briefly discussed the use of overheads and slides. Slides can be used very effectively to inspire or motivate an audience. He recommended that when showing slides its important to remember the inverse square rule: for ever 10 feet you move from the projection source, the level of brightness will drop 10 times.

Coordinating Extension Activities and Ideas in the Western States. Dr. Tom Whitson, University of Wyoming discussed the importance of coordinating extension publications, videos, and other materials in the western states to avoid duplication and conserve funding. Important program needs included: 1) Regional publication on the disposal of pesticide containers; 2) Regional publication on pesticide storage; 3) Current list of extension and industry publications from each state; and 4) Include extension and regulatory information in the Research Progress Report or initiate and new report for this information.

Dr. Robert Parker, Washington State University, will work with the local arrangements committee to have a display area for extension publications, videos, and slide/tape series at the WSWS meeting in 1991. He will also work with the Executive Committee to determine if extension and regulatory material can be included in the Progress Report or if a separate report will be necessary.

MINUTES OF THE BUSINESS MEETING
WESTERN SOCIETY OF WEED SCIENCE
RENO, NEVADA
MARCH 15, 1990

The meeting was called to order by President Sheldon Blank at 7:30 a.m. The minutes of the 1989 Business meeting were approved as published in the Proceedings of the 1989 meeting in Honolulu, Hawaii.

FINANCIAL REPORT-Wanda Graves reported receiving 243 pre-registrations with total registration for the meeting coming to 355. There were 25 graduate students registered and 17 spouses

Rick Arnold reported that the society is in excellent financial condition and the books are in order. We have approximately a two year reserve at the present time. The balance includes Certificates of Deposits in Logan and Newark plus cash in the checking account for a total of $58,228.11.

LOCAL ARRANGEMENTS- Phil Martinelli reported that all arrangements for the meeting went smoothly. The staff at Nugget have been very cooperative and helpful.

Jim McKinley reported that arrangements for the 1991 meeting in Seattle are already underway. Rooms at the Stouffer/ Madison will run $79 for a single and $89 for a double.

PROGRAM COMMITTEE- Pete Fay reported that the number of volunteer papers was down considerably from 1989 (ie. 59 versus 117). There were 41 volunteered papers (only 6 graduate student paper contest entries) and 18 posters scheduled (2 additional posters were also displayed) bringing total participation to 61 volunteer presentations for the 1990 meeting.

RESEARCH SECTION- Jodie Holt reported that the Research Progress Report was completed on schedule. It consisted of 452 printed pages with 208 individual reports from a total of 127 authors. Costs of printing the Progress Report came to $14 per copy. An Ad Hoc committee to evaluate ways to streamline and improve the Progress Report will be appointed by President-Elect Pete Fay. Frank Young will be Chairman of the Research Section and Ed Schweizer is Chairman-Elect. The section chairmen for 1991 are:

Project 1 - Barbra Mullin
Project 2 - Diane White
Project 3 - John Brock
Project 4 - David Zamora
Project 5 - Pat Furst
Project 6 - David Spencer
Project 7 - Charlotte Eberlein

EDUCATION AND REGULATORY- Celestine Lacey reported that excellent discussion took place during the Education and Regulatory meeting. Topics discussed included:

a. Computers: Creative uses for weed extension activities.
b. The effective use of video and other media techniques for weed extension programs.
c. Coordinating extension activities and ideas in the western states.

Celestine reported that in order to help coordinate extension activities between the states a suggestion was made that a room be set up at future meetings so that extension materials could be displayed. This would be one possible way to encourage sharing of information between states. Robert Parker will be chairman and Tom Whitson Chairman-Elect for the Education and Regulatory section during 1990-91.

POSTER COMMITTEE- George Beck reported that 16 posters were listed on the 1990 program. Late requests to show posters brought the total up to 20 posters to be displayed at the poster session. This number was up slightly from 1989 (i.e. 20 versus 19). The poster session continues to be a popular part of the program. David Zamora will be Chairman of the Poster Committee during 1990-1991.

STUDENT PAPER JUDGING COMMITTEE- Jesse Richardson reported that there were six papers in the contest. The papers were presented and judged in a block. The winners were: First place- Emanuel Pomela, USU ($100); second place-David Barton Univ. of Idaho ($75). The judges could not agree on a third place paper. Plaques will be mailed to the winners.

A special award was presented by ICI called the University Recognition Program. The University of California-Riverside and the University of California-Davis will receive a $1000 grant-in-aid in recognition of the training provided to M. K. Balke and S. A. Fennimore who were recently promoted within the ICI Market Development Department.

MEMBER-AT-LARGE REPORT- Bart Brinkman thanked Mobay and Ciba-Giegy for hosting the graduate student breakfasts on Tuesday and Wednesday. Bart indicated that other companies had expressed interest in hosting the graduate student breakfasts if additional sponsors are needed at future meetings.

NOMINATIONS COMMITTEE- Arnold Appleby reported that a strong list of candidates were submitted to the membership for election of officers for 1990-1991. A total of 148 ballots were cast in this election. Results of the election were as follows:

President Elect-Paul Ogg
Secretary-Steve Dewey
Chairman-Elect, Research Section-Ed Schweizer
Chairman-Elect, Ed and Reg-Tom Whitson

George Beck will serve as Chairman of the Nominations Committee during 1990-1991.

FELLOW AND HONORARY MEMBERS COMMITTEE- Alex Ogg reported that Fellows selected for 1990 included Harry Agamalian and Bart Brinkman. Earl Spurrier was selected as Honorary Member of the WSWS. Harvey Tripple will serve as Chairman during 1990-1991.

PUBLIC RELATIONS COMMITTEE- Jack Schlesselman reported that several publications and organizations were notified during the year to publicize WSWS activities and Awards.

SITE SELECTION- John Orr reported that Coeur d'Alene Resort in Coeur d'Alene, Idaho was selected as the site for the 1994 WSWS Annual Meeting. The resort has been notified and contracts have been signed. The meeting will be held March 15-17, 1994. Eric Sachs will serve as Chariman during 1990-1991.

AWARDS COMMITTEE- Jack Evans reported that three nominations were received for the WSWS Outstanding Weed Scientist Award from the public sector. Arnold Appleby was selected by a unanimous vote. No nominations were received for the industry sector award. Jack challenged those in industry to provide nominations from the private sector for next year.

RESOLUTION COMMITTEE- Shaffeek Ali presented one resolution which was passed by the membership. It is printed below:

WHEREAS, The local arrangements for the 1990 annual meeting of the Western Society of Weed Science were of satisfactory quality and well organized; and
WHEREAS, the organization and content of the Program have been of good quality; and
WHEREAS, meeting and sleeping accommodations were excellent; and
WHEREAS, personnel and services provided were outstanding; THEREFORE, BE IT RESOLVED that the Western Society of Weed Science express its appreciation to the members of the 1990 local arrangements committee, to the members of the 1990 WSWS Program Committee and to the management and staff of the Nugget Hotel.

WSSA REPRESENTATIVE- Jack Evans reported that the thirtieth meeting of the WSSA was held in Montreal, Quebec, Canada on February 5-8, 1990. Approximately 800 people attended the meeting with a program consisting of 316 papers, 52 posters and 4 symposium. The WSSA is in excellent financial shape. The 1991 meeting will take place in Louisville, Kentucky and the 1992 meeting will be held in Orlando, Florida. Four western-state cities have been targeted as possible sites for the 1993 meeting (ie. Salt Lake City, Seattle, Reno and Denver).

CAST REPORT- Lowell Jordan presented his final report as CAST representative for the WSWS. Lowell was elected President of CAST for 1991-1992 and will no longer be able to represent the WSWS on the CAST Executive Committee. During 1989 CAST published 6 reports and currently has three additional reports nearing completion. It will address 9 additional areas during 1990. Lowell encouraged the membership to join CAST.

President Blank expressed thanks on behalf of the Society to Lowell for his dedicated service as the WSWS representative to CAST over the last several years.

PLACEMENT COMMITTEE- Dean Gaiser reported good particapation in Placement service this year. As in previous years, the positions available and positions wanted listing from the WSSA meeting were available in the Placement Room. Chariman for 1990-1991 will be Steve Orloff.

LEGISLATIVE COMMITTEE (Ad Hoc)- George Beck reported that the committee consists of Rick Arnold, Bob Callihan, George Hittle and Don Morishita. He indicated a need for additional volunteers so that each western state is represented. The WSWS Legislative Committee was not active in 1989 due largely to increased activities of INWAC. INWAC was very active in 1989. Three weed bills were introduced into Congress in 1989 and 1990. Some INWAC members will travel to Washington D.C. on March 28 to testify before the Senate Sub-committee on Environmental Protection concerning amendments to the Federal Noxious Weed Act.

NECROLOGY COMMITTEE REPORT- Joan Lish reported the deaths of 5 WSWS Members. The membership offered a moment of silent prayer in memory of Glenn P. Hartman, William A. Harvey, Delmar C. Tingey, Loyd Stitt and Alden S. Crafts.

EDITORIAL COMMITTEE- Rod Lym reported that the move to requiring computer disks for all abstracts has gone smoothly. No major problems were encountered and authors adjusted well to the change. Deadline for submission of final copies of abstracts on disk for inclusion in the Proceedings will be Friday, April 13. Rod suggested that the membership review the final copy of the Proceedings and provide recommendations for any needed changes to the 1991 editor.

PUBLICATION COMMITTEE - Tom Whitson reported that progress on "Weeds of the West" was proceeding extremely well. This publication will include 900 color photographs of over 300 weed species common to the Western US. The committee currently has photos of 250 weed species and has completed write-ups for approximately one-half of the weed species. Tom indicated that efforts on remaining weed species would be completed this spring/summer and the publication will be available early in 1991. Tom needs advanced commitments for 12,000 books before the publication can be printed. He currently has commitments for 4500 copies leaving a need for an additional 7500 advance orders. Tom requested the support from the Society to achieve this goal. The WSWS stands to make a substantial profit from this publication.

NEW BUSINESS:

PRESIDENT'S WASHINGTON DC TRIP- Sheldon Blank reported that the presidents (or their representatives) of the WSSA, WSWS, NCWCC, SSWS visited Washington D.C. Sept. 18-22, 1989. This was the fourth annual visit by this group. The group met with personnel from the USDA, EPA and several members of the Congress and the Senate. WSSA position statements and executive summaries were presented for the following issues: Sustainable Agriculture; Water Quality; Food Safety; IR-4 or Minor Crops; Herbicide Resistance; Endangered Species; Noxious Weeds; and Competitive Grants. It was felt that this trip was extremely worthwhile and good progress had been made. Continued participation of the WSWS is recommended.

PAST PRESIDENTS REPORT- Donn Thill introduced the subject of allowing Sustaining Membership to the WSWS. He reported that under current operating procedures the WSWS has almost no liquid assets available prior to the annual meeting each year. This makes it difficult to plan and budget each year. There is also a need to raise additional funds to support the WSWS if it is to remain in good financial condition. Sustaining memberships would be a way to gain a more stable financial base. A lengthy discussion followed Donn's report. A straw vote was taken to determine what the membership felt was the best avenue of increasing funding for the WSWS. Results of this vote are listed below:

1. Increase individual dues/allow Sustaining Members- 73
2. Increase individual dues only-59
3. Sustaining Members only-0

An Ad Hoc Committee will be formed to provide recommendations to the Executive Committee based on the memberships recommendations.

CAST APPOINTMENT- Based on inputs from the Executive Committee and other members of the Society, President Blank approached Dr. Gary Lee to serve as WSWS representative to CAST. Dr. Lee agreed to accept this position.

SUMMER EXECUTIVE COMMITTEE MEETING- Pete Fay indicated that the WSWS Business and Planning Meeting is scheduled for 8:00 a.m., Thursday, June 14, 1990 at the Stouffer/ Madison Hotel in Seattle, Washington.

Pete Fay our new President presented a plaque and the gavel to Sheldon Blank expressing appreciation on behalf of the Society for his dedicated service.

There being no further business, the meeting was adjourned at 8:55 a.m. by President Pete Fay.

Respectfully submitted,

Doug Ryerson
Secretary, WSWS

WESTERN SOCIETY OF WEED SCIENCE FINANCIAL STATEMENT
MARCH 2, 1989 - FEBRUARY 28, 1990

INCOME		
1989 Annual Meeting		
Registration (78 x 45)	$3,510.00	
Spouse Registration (10 x 25)	250.00	
Tour (12 x 15)	180.00	
Membership Dues (not attending annual mtg)	555.00	
1989 Research Progress Report	2,799.61	
1989 Proceedings	3,262.61	
Back Issues	217.30	
Outstanding Invoice Payment	13.50	
Refreshments & tour donations	750.00	
1990 Annual Meeting		
Registration (213 x 40)	8,520.00	
Spouse Reg (14 x 25)	350.00	
Proceedings	2,335.00	
Research Progress Reports	2,064.00	
Interest (Bank Accounts)	2,164.74	
INCOME (YTD)		$26,971.76
EXPENSES		
1989 Annual Meeting		
Audio-Visual Rental	1,314.80	
Refreshment Breaks	859.05	
Luncheon	3,819.88	
Guest Speaker	606.80	
Grad Student Room Subsidy	450.00	
Grad Student Paper Awards	281.05	
Spouse Program	929.53	
Tour	1,801.50	
Misc Expenses	183.00	
Post Office Box Rental (annual)	79.00	
Bulk Mailing Permit ($60-1 time filing/$60 annual)	120.00	
Postage	1,440.83	
Office Supplies	312.48	
Telephone	51.99	
CAST Membership	560.00	
Business Manager (Logan)	1,000.00	
Business Manager (Newark/9 mos)	2,025.00	
Printing		
1989 Proceedings	5,119.68	
1989 Research Progress Reports	4,815.35	
Newsletters, Call For Papers	521.20	
Letterhead, envelopes, invoices	492.02	
Programs	497.50	
Plaques, ribbons	125.48	
Refunds (reg fees)	105.00	
Miscellaneous Exp for 1990 Annual Mtg	352.21	
EXPENSES (YTD)		$27,863.35
CAPITAL		
1989 Balance Forward	$59,119.70	
Current Loss	(891.59)	
		$58,228.11
DISTRIBUTION OF CAPITAL		
Certificate of Deposits (Logan)	$32,347.34	
Certificate of Deposits (Newark)	12,800.00	
Checking Account Balance	13,180.87	
		$58,228.11

1990 OUTSTANDING WEED SCIENTIST AWARD
Western Society of Weed Science

Arnold P. Appleby

Dr. Arnold P. Appleby has been employed at Oregon State University since 1959 with a distinguished professional career in weed science. His superior performance as a teacher and researcher in weed science makes him a deserving recipient of the 1990 WSWS Outstanding Weed Scientist Award. Arnold has served the Society well not only as a member but as chairman of numerous committees; as secretary, as president-elect, and president of WSWS. He was honored in 1976 as an elected Fellow of WSWS.

Dr. Appleby's outstanding contributions to weed science have been recognized by colleagues throughout the world, and as a result, he has been the recipient of numerous awards. The Weed Science Society of America has named him Outstanding Teacher, Outstanding Researcher, and Fellow. Arnold has had numerous committee assignments, has held several offices in WSSA, and would have served as president if illness had not prevented it. The Agronomy Society and the Crop Science Society of America have also elected him as Fellow. In addition, Oregon State University has recognized him on several occasions as an outstandingprofessor.

Arnold's research has been a blend of applied and basic studies with a constant goal of improving crop production. His efforts have been recognized by Oregon producers who have presented him with awards of appreciation. His research in wheat and peppermint weed control alone have resulted in millions of dollars of increased income to Oregon producers.

Although Dr. Appleby has made important contributions to the national and international stature of weed science through the research and extension programs, perhaps his greatest accomplishment has been in education of undergraduate and graduate students. Certainly, his influence is greater than anyone can measure because of the large number of students now working throughout the world who have developed their personal philosophies and ethics based on the example of Dr. Appleby.

Dr. Appleby has served as major professor for over 70 graduate degree recipients, many of whom are members of WSWS and leaders in the profession. He has also taught weed science to hundreds of undergraduate students and participated in numerous grower meetings. Arnold's unique qualities of being one of the world's foremost weed science teachers as well as one of our best researchers makes him truly an obvious choice for WSWS Outstanding Weed Scientist for 1990.

1990 HONORARY MEMBER AWARD
Western Society of Weed Science

Dr. Earl C. Spurrier

Dr. Earl Spurrier has been a strong supporter of agriculture and Weed Science throughout his career. Earl was raised on a dairy farm near Libertytown, Maryland and attended college at the University of Maryland. There he received his B.S. and M.S. in Agriculture. While receiving his Ph.D. in Agriculture from the University of Illinois in 1956, he accepted a position as Extension Agronomist at the University of Illinois, working full-time on weed control. His hard work and enthusiasm were instrumental in the early adoption of chemical weed control by Illinois farmers. In 1958, Dr. Spurrier accepted a position with Monsanto Company as Technical Supervisor for Herbicides. He pioneered the concept of preemergence weed control in corn and was active in the development of Ramrod, Lasso, and Roundup. In 1975, Dr. Spurrier was promoted to Director of Government Relations for Monsanto and in 1980, became Director of Environmental Affairs for Monsanto. In 1982, Dr. Spurrier joined the National Agricultural Chemical Association as Vice-President for Regulatory Affairs and at present serves that organization as Vice-President for State Affairs in Washington, D.C. He is nationally recognized for his skill and work in achieving "fair and just" legislation on pesticide use.

Recently, he helped to establish meetings between the national and regional Weed Science Societies and key officials in Washington, D. C. These meetings have helped tremendously in providing Weed Science a voice in government affairs.

In 1980, Dr. Spurrier was the recipient of the Lea Hitchner Service Award for Outstanding and Dedicated Service to the Agricultural Chemical Industry and in 1989, he was named Fellow of the Weed Science Society of America.

1990 FELLOW AWARD
Western Society of Weed Science

Harry S. Agamalian

Harry Agamalian has been a Farm Advisor with the University of California Cooperative Extension for Monterey and Santa Cruz Counties for the past 35 years, receiving his B.S. Degree in Agronomy at the University of California, Davis, and his M.S. Degree in Weed Science at the University of Arizona. The development of "Weed Control Systems" in vegetables, agronomic, and horticultural crops is only one of the direct results of his far-reaching field research. He has had numerous articles published in various educational journals. His educational programs have emphasized the importance of knowing the "principles of weed control." The use of "Weed Schools" in his educational programs has resulted in extending practical weed control information to pest control advisors, growers, and other agriculturists.

His association with WSWS began in 1962. He has served as Education and Regulatory Section Chairman, Horticultural Section Chairman, Local Arrangements Chairman, and Member-at-large to the Executive Board for which he has served on several committees.

Harry's expertise in vegetable weed control is recognized by his lectures at statewide and regional CAPA meetings, the California Weed Conference, and commodity extension meetings in addition to the WSWS. He has obtained national and international recognition, having lectured in several states and foreign countries. He has served as Weed Science. Vegetable Mechanization Specialist to Hungary, Bulgaria, Yugoslavia, and the Union of South Africa; served as Science Consultant to the Soviet Union Vegetable-Tomato Project in the Ukraine and Moldavia Republic. In addition, he has served as Consultant to the San Jorge Grape and Tree Growers Association in Graneros, Chile. In 1986, by special invitation, he was invited as a Weed Science Expert to the Republic of China where he gave lectures to the Beijing Weed Science Society and vegetable grower cooperatives.

In 1983 he was honored by his Extension colleagues with the Distinguished Service Award in Teaching.

In 1986 he was honored with the Award of Excellence in Education by the California Weed Conference and was a recipient of the USDA/IR-4 Meritorious Service Award.

1990 FELLOW AWARD
Western Society of Weed Science

Bart A. Brinkman

Bart A. Brinkman was born in Hereford, Texas, but spent most of his early years on a potato farm near Melford, Utah. Bart served in the U.S. Army in Viet Nam before attending college at Utah State University. He received his B.S. in Agriculture in 1971. Bart completed his M.S. in Weed Science at South Dakota State University in 1971 and then accepted a position as a Field Representative for Diamond Shamrock in Des Moines, Iowa. In 1976, Bart accepted a position with Velsicol Chemical Company as Field Development

Representative and he and his family moved to Salem, Oregon. In 1980, Bart was promoted to Field Scientist for Velsicol and later made the transition to Sandoz Crop Protection from the merger of Zoecon and Velsicol.

Bart has had extensive experience in the development of herbicides and other pesticides not only in the U.S., but also in Mexico, China, and France. Bart was the lead author for the Product Use Guides for Banvel in small grain in the Pacific Northwest.

Bart has served the Western Society of Weed Science as Secretary, Chairman of the Research Section, Member of the Program Committee, and as Chairman of the Agronomic Crops Section.

Left to Right: Arnold P. Appleby (1990 WSWS Outstanding Weed Scientist), Bart A. Brinkman (1990 WSWS Fellow), Harry S. Agamalian (1990 WSWS Fellow), and Earl C. Spurrier (1990 WSWS Honorary Member).

1990 NECROLOGY REPORT

Submitted by Joan Lish

The committee has five deaths to report.

Glenn P. Hartman, retired Agricultural Research Center Superintendent, Montana State University, Sidney, Montana, passed away on March 21, 1989.

Glenn served as superintendent of the Eastern Agricultural Research Center, Sidney, Montana, from 1951-1989, when he retired. He was responsible for research in weed control, variety improvement, and soil fertility. He was honored by having his name given to Glennman wheat and Hartman safflower.

Mr. William A. Harvey, retired University of California-Davis agriculture expert, passed away on April 4, 1989.

Bill became a faculty member of the University of California-Davis in 1945. After a one-year stint with Monsanto Chemical Company in St. Louis during 1949 to 50, he returned to UC Davis as California's first Extension Weed Control Scientist, a position he held until 1971 when he became the first Extension Environmentalist. He retired on April, 1, 1977. In 1971, Bill was named a Fellow of the Weed Science Society of America and an Honorary Member (now called Fellow) of the Western Society of Weed Science. Bill was on the program of the first WSSA meeting held in New York City in 1956. He helped organize the California Weed Conference and served as its president during 1952 to 1953. He was active in all three organizations and served in many positions for more than 40 years.

Mr. Delmar C. Tingey, retired faculty member of Utah State University, passed away on June 3, 1989.

Del was a member of the USU faculty for 43 years in teaching and research, retiring in 1967. He was a pioneer in wheat hybridization, weed science and biometry. In 1942, he was selected by the U.S. government to do rubber research on guayule in Salinas, California. In 1982, he was honored by the USU Alumni Association with a Distinguished Service Award for his many years of significant achievement and dedication. Del was a member of the Weed Science Society of America. He was selected by the Western Society of Weed Science as one of the original group of Honorary Members (now Fellows) of the society in recognition for his pioneering work in weed control.

Lloyd Stitt, retired University of Nevada pesticide specialist, died recently. He was 86 years old.

Lloyd was employed by USDA at the University of Nevada Reno for 25 years. He received a 20 Years of Service Award and was granted emeritus status in 1985. He was a member of American Men of Science, Entomological Society of America, American Registry of Entomology, and Alpha Zeta.

Alden S. Crafts, professor emeritus at the University of California, Davis, died February 9 1990 at the age of 92.

Born in Fort Collins, Colorado, on 25 June 1897, he earned his bachelor of science and doctoral degrees from UC Berkeley. He joined the faculty at UC Davis in 1931 and became a faculty research lecturer in 1954. He was the first person in the United States to have the title of weed scientist. Crafts retired in 1964 after 33 years of teaching and research. Crafts was a pioneer in the study of weed control and plant physiology. He led early investigations of chemical weed control. He helped develop the use of radioactive tracers to study the movement of herbicides in plants and the effect of herbicides and other compounds on vegetation. He also sounded early warning about effects of air pollution on plants. Crafts was elected an Honorary Member of the Weed Science Society of America in 1964, the first year such awards were granted. He was president of the WSSA during 1959 to 1960, and president of the American Society of Plant Physiologists during 1995 to 1956. He was a former chairman of the UC Davis botany department. He received the Charles Reid Barnes life membership award from the American Society of Plant Physiologists and was presented with honorary degrees from the University of California and Oxford University. He was an honorary member of the Zoological-Botanical Society of Vienna, Austria.

He was the author and coauthor of six books on weed control and the author of more than 150 scientific publications. Crafts' books include Weed Control (with W. W. Robbins and R. N. Raynor), first published by McGraw-Hill in 1942 and revised in 1952 and 1962; it was the first textbook on weed control. Crafts described this book as an early version of Modern Weed Control, published in 1975 by the University of California Press. He wrote Mode of Action of Herbicides with Floyd Ashton, first published in 1973 by John Wiley & Sons; a second edition was released in 1981. Crafts also wrote eight other books, some dealing exclusively with physiology. His paper "Recollections of a Weed Controller" is in the Archives of the Weed Science Society of America and in the University of California Library at Davis. A series of interviews with Crafts conducted in 1981 by A. I. Dickman and bound together as Chemical Weed Control Researcher: Alden S. Crafts is also deposited at the Davis campus.

1990 MEMBERSHIP LIST

Ed Adams
WSU Cooperative Ext.
N 222 Havana
Spokane, WA 99202
509/456-3651

Donald Addison
Dow Elanco
7521 W. California Ave.
Fresno, CA 93706
209/485-5550

Harry Agamalian
UC Cooperative Ext.
118 Wilgart Way
Salinas, CA 93901
408/758-4637

Mauricio Alcocer-Ruthling
University of Idaho
P.S.E.S. Department
Moscow, ID 83843

Jack Aldridge
Nor-Am
P. O. Box 728
Sonora, CA 95370
209/532-5832

Shaffeek Ali
Alberta Agriculture
7000 - 113 St., 2nd Floor
Edmonton, Alberta, CANADA
403/427-7098

David Anderson
Western Biochemical
14760 S.W. Forest Dr.
Beaverton, OR 97007
503/643-6286

J. LaMar Anderson
Plant, Soil & Biometerology
Utah State University
Logan, UT 84322-4820
801/750-2236

Monte Anderson
Hoechst-Roussel
South 11611 Keeney Rd.
Spokane, WA 99204
509/448-4419

Mike Ansolabehere
Valent
5910 N. Monroe
Fresno, CA 93722
209/276-5300

Arnold Appleby
Oregon State University
Crop Science Department
Corvallis, OR 97331
503/737-4715

Richard Arnold
NMSU Ag Science Center
P. O. Box 1018
Farmington, NM 87499
505/327-7757

Tony Arnold
American Cyanamid
P. O. Box 65248
W. Des Moines, IA 50265
515/223-4142

Jon Arvik
Monsanto
2130 Professional Dr. #200
Roseville, CA 95661
916/784-7887

David Austin
PBI/Gordon Corp.
P. O. Box 4090
Kansas City, MO 64101
816/421-4070

Al Baber
Dupont
673 Rosecrans
San Diego, CA 92106
619/222-8110

R. D. Baker
New Mexico State Univ/CES
Box 3AE
Las Cruces, NM 88003
505/985-2292

Dan Ball
UDSA-ARS
1701 Center Ave.
Ft. Collins, CO 80526
303/484-8777

Ben Barstow
University of ID/CES
Box 9
Nezperce, ID 83543
208/937-2311

David Barton
Plant, Soil & Ent Science
University of ID
Moscow, ID 83843
208/885-6236

Mike Barton
Dow Elanco
10890 Benson Dr.
Shawnee Mission, KS 66210
913/451-2000

James Bates
ICI Americas
P. O. Box 4023
Richmond, CA 94804-0023
415/231-1572

Brooks Bauer
Sandoz
20592 Ayers
Escalon, CA 95320
209/599-7806

George Bayer
Agrolinz
121 E. Buffalo St.
Ithaca, NY 14850
607/273-1323

George Beck
Colorado State University
115 Weed Research Lab
Ft. Collins, CO 80550
303/491-7568

Lance Beem
Rhone Poulenc
1449 Towse Dr.
Woodland, CA 95695
916/666-6377

Carl Bell
UC Cooperative Ext.
1050 E. Holton Rd.
Holtville, CA 92250
619/352-9474

Wayne Belles
Sandoz
1240 Joyce Rd.
Moscow, ID 83843
208/882-3040

Warren Bendixen
UC Cooperative Ext.
624 W. Foster Rd.
Santa Maria, CA 93455
805/934-6240

Barney Bernstein
American Cyanamid
P. O. Box 400
Princeton, NJ 08543-0400
609/799-0400

Prithvi Bhalla
American Cyanamid
P. O. Box 400
Princeton, NJ 08543-0400
609/799-0400

Sheldon Blank
Monsanto
3805 S. Dennis
Kennewick, WA 99337
509/586-4113

Chris Boerboom
Washington State Univ.
Dept of Agronomy & Soils
Pullman, WA 99164-6420
509/335-2961

Steven Bowe
Sandoz
1300 E. Touhy Ave.
Des Plains, IL 60018
708/390-3804

Robert Bowman
New Mexico Tech
Dept of Geoscience
Socorro, NM 87801
505/835-5992

Rick Boydston
USDA-ARS
Rt 2, Box 2953-A
Prosser, WA 99350
509/786-2226

Steve Bradburn
Lincoln Co. Weed Board
P. O. Box 241
Davenport, WA 99122
509/725-3646

Stan Brauen
Washington State University
Reserch & Extension Center
Puyallup, WA 98371

Ron Brenchley
Mobay
Rt 1, Box 31
Ashton, ID 83420
208/652-3911

Bill Brewster
Oregon State University
Dept of Crop Science
Corvallis, OR 97331
503/737-4715

Bart Brinkman
Sandoz
5130 2nd Ave. S.E.
Salem, OR 97306
503/363-1934

John Brock
Arizona State University
Agribusiness & Envion Res.
Tempe, AZ 85287-3306
602/965-7036

Jonathan Brown
Norpac
4755 Brooklake Rd.
Salem, OR 97305
503/393-4221

Jimmy Bryson
ICI Americas
13495 Prairie Lane
Red Bluff, CA 96080
916/527-0406

Carl Buchholz
Ciba-Geigy
12413 Wide Hollow Rd.
Yakima, WA 98908
509/966-5740

Henry Buckwalter
Uniroyal
4800 T Street
Sacramento, CA 95819
916/731-4925

Bruce Burdick
BASF
RR 2, Box 113
Plattsburg, MO 64477
816/539-2997

Stephen Burningham
Utah Dept of Agric
350 N Redwood Rd.
Salt Lake City, UT 84116
801/538-7183

Larry Burrill
Oregon State University
Crop Science Dept
Corvallis, OR 97331
503/737-2771

Mary Callan
Colorado State Univ.
Weed Science Dept.
Ft. Collisn, CO 80523
303/491-5667

Robert Callihan
University of Idaho
P.S.E.S. Dept.
Moscow, ID 83843
208/885-6617

David Cammack
Cenex/L.O.L. Research
Rt 1, Box 3879 Rd. 6 NW
Ephrata, WA 98823
509/787-2518

Mick Canevari
UC Cooperative Ext.
420 S. Wilson Way
Stockton, CA 95205
209/468-2085

Ted Carpenter
University of Idaho
P.S.E.S. Dept.
Moscow, ID 83843
208/885-6236

Mike Carrigan
American Cyanamid
P. O. Box 687
Roswell, NM 88201
505/624-0699

Vanelle Carrithers
Dow Elanco
28884 S. Marshall
Mulino, OR 97042
503/829-4933

Jose A. de Castro
American Cyanamid
P. O. Box 400
Princeton, NJ 08543-0400
609/799-0400

Rick Chamblee
American Cyanamid
P. O. Box 400
Princeton, NJ 08543
609/799-0400

Jon Chernicky
Maricopa Agric Center
37860 W. Smith-Enke Rd.
Maricopa, AZ 85239
602/568-2273

Dale Christensen
Ciba-Geigy
1951 Chateau Ct.
Walnut Creek, CA 94598
415/689-8991

Pedro Christoffoleti
Colorado State University
1500 W. Plum St., Apt-2G
Ft. Collins, CO 80521
303/491-5667

Dennis Cihacek
Rhone Poulenc
11900 W. 87th St. Pkwy.
Lenexa, KS 66215
913/894-1004

Don Colbert
American Cyanamid
2133 Jackson St.
Lodi, CA 95242
209/369-1102

Liz Cole
Oregon State University
College of Forestry
Corvallis, OR 97331
502/737-2244

Ron Collins
Collins Agric Consultants
Rt 2, Box 344
Hillsboro, OR 97123
503/628-2108

Richard Comes
Retired-WSU
946 Parkside Dr.
Prosser, WA 99350
509/786-2324

Jim Conley
ICI Americas
7345 Wilderness
Colorado Springs, CO 80908
719/495-3561

Gilbert Cook
Dupont
S. 303 Barker Rd.
Greenacres, WA 99016
509/922-1656

John Corkins
Research For Hire
1696 So. Leggett
Porterville, CA 93257
209/784-5787

Garvin Crabtree
Oregon State University
Dept. of Horticulture
Corvallis, OR 97331
503/737-3695

Keith Crabtree
Soil Conservation Serv WDA
24800 Oro Valley Rd.
Auburn, CA 95603
916/272-3417

Ron Crockett
Monsanto
17004 NE 37the Circle
Vancouver, WA 98682
206/892-9884

Dave Cudney
UC Cooperative Ext.
University of CA
Rivrside, CA 92521
714/787-5305

Kem Cunningham
ICI Americas
36642 View Ridge Dr.
Elizabeth, CO 80107
303/646-0206

Dan Curtis
Oregon State University
Horticulture Dept.
Corvallis, OR 97331-2911
503/737-3695

Alan Dalrymple
University of Wyoming
Box 3354
Laramie, Wyoming 82071
307/766-3949

Tim D'Amato
Colorado State Univ.
Plant Pathology/Weed Sci.
Ft. Collins, CO 80523
303/491-5667

Jim Daniel
ICI Americas
P. O. Box 149
Loveland, CO 80539

Lee Darlington
BASF
4609 Englewood Ave.
Yakima, WA 98908
509/966-6553

Ed Davis
Montana State University
Dept of Plant Science
Bozeman, MT 59717
406/994-6841

Brian Deeter
Rhone Poulenc
P. O. Box 2420
Wickenburg, AZ 85358
602/684-5544

Steve Dewey
Utah State University
Plant Science Dept.
Logan, UT 84322-4820
801/750-2256

Thomas DeWitt
Valent
5910 N. Monroe
Fresno, CA 93722
209/276-5308

Mike Dial
University of Idaho
PSES Dept.
Moscow, ID 83843
208/885-7730

Chuck Doty
ICI Americas
498 N. Mariposa
Visalia, CA 93277
209/747-0713

Keith Duncan
New Mexico State Univ.
67 E. Four Dinkus Rd.
Artesia, NM 88210
505/748-1228

Bob Dunlap
Rhone Poulenc
3239 E. Vartikian Ave.
Fresno, CA 93710
209/299-1829

Ken Dunster
Rhone Poulenc
P. O. Box 598
Byron, CA 94514
415/634-0996

Donal Dwyer
Nor-Am
266 S. Monroe
Fresno, CA 93726
209/225-1669

William Dyer
Plant & Soil Sci Dept.
Montana State University
Bozeman, MT 59717
406/994-5063

Charlotte Eberlein
University of ID
Aberdeen Res & Ext Ctr.
Aberdeen, ID 83210
208/397-4181

Clyde Elmore
University of CA
Botany Dept-106 Robbins
Davis, CA 95616
916/752-0612

Greg Elmore
UCD - Agronomy
196 Full Circle
Davis, CA 95616
916/758-1781

Carrol Engelbert
Valley Co Weed Supr.
P. O. Box 737
Cascade, ID 83611
208/382-4843

J. J. Enyard
Turf-Seed, Inc.
P. O. Box 250
Hubbard, OR 97032
503/981-9571

Steve Eskelsen
Oregon State University
Horticulture Dept.
Corvallis, OR 97331-2911
503/737-3695

John Evans
Utah State University
Plant, Soil & Biometerology
Logan, UT 84322-4820
801/750-2242

Pete Fay
Montana State University
705 Johnson Hall
Bozeman, MT 59717
406/994-5061

John Fenderson
Sandoz
902 Hardtner, Box 47
Kiowa, KS 67070
316/825-4315

Mark Ferrell
University of Wyo
Box 3354
Laramie, WY 82071
307/766-5381

Paul Figueroa
Weyerhaeuser Co.
505 N. Pearl St.
Centralia, WA 98531
206/736-8241

Vernon Fischer
Oregon State University
Rt 2, Box 344
Hillsboro, OR 97123
503/628-2108

Duane Flom
University of Nevada
441 Shipley Dr.
Yerington, NV 89447
702/463-5208

Kevin Forney
Research For Hire
1696 S. Leggett
Porterville, CA 93257
209/784-5787

Jim Fornstrom
University of Wyoming
Box 3295
Laramie, WY 82071
307/766-3328

Gus Foster
Sandoz
812 E. Elizabeth
Ft. Collins, CO 80524
303/484-8925

Michael Foster
TX Agric Expt Station
P. O. Box 9000
Ft. Stockton, TX 79735
915/336-7696

Jim Freeman
Cascade County
521 1st Ave. N.W.
Great Falls, MT 59404
406/727-2804

Mark Fricker
Turf Seed, Inc.
P. O. Box 250
Hubbard, OR 97032
503/981-9571

Pat Fuerst
Washington State Univ.
Agronomy Dept.
Pullman, WA 99164-6420
509/335-7484

Dean Gaiser
Dow Chemical
E. 15407 Mission Ave, #200
Veradale, WA 99037
509/924-4801

Sahag Garabedian
Unocal
3960 Industrial Blvd #600B
W. Sacramento, CA 95691
916/372-3743

David Gealy
WSU - USDA/ARS
215 Johnson Hall
Pullman, WA 99164
509/335-1551

Gale Gingrich
OSU Extension Service
3180 Center St. NE #160
Salem, OR 97301
503/588-5301

Harvey Glick
Monsanto
800 N. Lindbergh C3SH
St. Louis, MO 63161
314/694-3763

Gaylan Goddard
American Cyanamid
1100 Itasca
Plainview, TX 79072
806/296-5373

Mike Gorrell
American Cyanamid
P. O. Box 400
Princeton, NJ 08543-0400
609/799-0400

Wanda Graves
W S W S
P. O. Box 963
Newark, CA 94560
415/793/4169

Kell Gregg
K. A. Gregg Co.
P. O. Box 292
Upland, CA 91785
714/982-0034

E. J. Gregory
New Mexico State Univ.
Box 1018
Farmington, NM 87499
505/327-7757

Bob Gunnell
Agraserv, Inc.
P.O. Box 99
Arimo, ID 83214
208/254-3871

Lloyd Haderlie
Agraserv, Inc.
3243 W. JoAnna Ct.
American Falls, ID 83211
208/226-2602

Neal Hageman
Monsanto
3720 Ave A, Suite E
Kearney, NE 68847
308/237-3110

Mostapha Haidar
Colorado State Univ.
500 W. Prospect #2A
Ft. Collins, CO 80526
303/491-0717

Don Hall
Brea Ag Service
P. O. Box 201059
Stockton, CA 95201
209/466-5911

Eric Hall
Washington State Univ.
1468 Memorial Highway
Mt. Vernon, WA 98273-9788
206/424-6121

Eric Hanson
Colorado State Univ.
110 Weed Research Lab
Ft. Collins, CO 80523
303/491-5667

Ron Hanson
Rhone Poulenc
8172 Pollard Ave.
Fair Oaks, CA 95628
916/966-4646

Del Harper
Monsanto
800 N. Lindbergh Blvd.
St. Louis, MO 63167
314/694-3424

Gull Hassan
Oregon State Univ.
Crop Science Dept.
Corvallis, OR 97331
503/757-4502

Louis Hearn
ICI Americas
P. O. Box 3959
Visalia, CA 93278
209/798-2457

Stan Heathman
University of AZ
1662 N. Westridge
Tucson, AZ 85745
602/743-7058

Eugene Heikes
Retired
716 Garfield
Ft. Collins, CO 80524
303/482-9360

James Helmer
Dow Elanco
7521 W. California Ave.
Fresno, Ca 93706
209/485-5550

Randall Hemb
Minnesota Vly Testing Labs
326 Center St.
New Ulm, MN 56073
507/354-8517

Jerry Hensley
Ciba-Geigy
P. O. Box 158
Sanger, CA 93657
209/875-6075

Ann Henson
Dupont
926 Yucca Ct.
Longmont, CO 80501
303/651-0206

Robert Herrick
American Cyanamid
P. O. Box 400
Princeton, NJ 08543-0400
609/799-0400

Michael Hickman
USDA-ARS
2413 E. Highway 83
Weslaco, TX 78596
512/969-2511

Charles Hicks
Rhone Poulenc
1643 W. Swallow Rd.
Ft. Collins, CO 80526
303/223-6229

Jack Hills
University of CA
Agronomy Dept.
Davis, CA 95616
916/752-0702

George Hittle
Wyoming Dept of Ag
P. O. Box 4101
Cheyenne, WY 82003
307/777-6585

Jodie Holt
Dept of Botany & Plant Sci.
University of CA
Riverside, CA 92521
714/787-3801

Keith Holmes
Rhone Poulenc
1690 E. Fir #212
Fresno, CA 93710
209/299-2725

Stott Howard
Washington State Univ.
1468 Memorial Hwy
Mt. Vernon, WA 98273-9788
206/424-6121

James Hutchison
Dupont
Stine-Haskell Res Center
Newark, DE 19714
302/366-5554

Nick Hutchinson
Monsanto M2M
800 N. Lindbergh Blvd.
St. Louis, MO 63767
314/694-2467

Roger Hybner
University of Wyoming
663 Wyarno Rd.
Sheridan, WY 82801
307/737-2415

Myron Isherwood, Jr.
Hawaii Dept of Agric.
P. O. Box 22159
Honolulu, HI 96822
808/528-7122

Richard Iverson
American Cyanamid
P. O. Box 400
Princeton, NJ 08543-0400
609/799-0400

Nelroy Jackson
Monsanto
400 S. Ramona Blvd, #212
Corona, CA 91719
714/279-7787

Kurt Jacobsen
Plant Sciences, Inc.
514 Calabasas Rd.
Watsonville, CA 95076
408/728-7771

Larry Jeffery
Brigham Young Univ.
Dept. of Agronomy & Hort.
Provo, UT 84602
801/378-2760

Brian Jenks
Utah State University
Plant, Soil & Biomet.
Logan, UT 84322-4820
801/750-3513

James Jessen
ICI Americas
Box 889
Glendive, MT 59330
406/365-8129

Doug Johnson
Rhone Poulenc
1123 W. Tenaya Way
Fresno, CA 93711
209/431-2713

Glen Johnson
ICI Americas
2200 Douglas Blvd. B200
Roseville, CA 95661
917/783-7467

Richard Johnston
American Cyanamid
1411 South Slope Rd.
Emmett, ID 83617
208/365-2257

Lowell Jordan
Botany & Plant Sciences
University of CA
Riverside, CA 92521
714/787-4416

Donald Joy
Uniroyal
4205 Barge
Yakima, WA 98908
509/966-5472

Larry Justesen
Carbon County Weed & Pest
P. O. Box 1126
Rawlins, WY 82301
307/324-6584

George Kapusta
Southern Illinois Univ.
Dept of Plant & Soil Sci.
Carbondale, IL 62901
618/453-2496

Don Kelley
Rohm & Haas Co.
1520 E. Shaw Ave.
Fresno, CA 93710
209/224-0158

Bruce Kelpsas
Northwest Chemical Corp.
4560 Ridge Dr. NE
Salem, OR 97303
503/390-3030

Rod Kepner
American Cyanamid
7675 N. 1st St., #213
Fresno, CA 93710
209/435-1334

K. Khodayari
ICI Americas
498 N. Mariposa Ave.
Visalia, CA 93277
209/747-0713

Elmar Kibler
BASF
10181 Avenue 416
Dinuba, CA 93618
209/591-2548

Dan Kidder
Ciba-Geigy
2305 - 14th St., S.
Moorhead, MN 65660
218/236-7957

Roy Killins
Cyanamid Canada
6A Modesto Rd.
Lethbridge, Alb, CANADA
403/381-871

Steven Kimball
Monsanto
1060 W. Sierra, Ste 105
Fresno, CA 93711
209/431-1863

David King
Sandoz
975 California Ave.
Palo Alto, CA 94304
415/354-3439

Mike King
Dupont
5477 Gene Sarazen Dr.
Billings, MT 59106
406/652-8486

Bill Kirby
Valent
5910 N. Monroe Ave
Fresno, CA 93722
209/276-5300

Jim Klauzer
SIARCO
P. O. Box 329
Kuna, ID 83634
209/922-4322

Don Kloft
Oregon State Univ.
Dept of Crop Science
Corvallis, OR 97331
503/737-4715

David Kopec
University of AZ
Room 201, Bldg. 36
Tucson, AZ 85721
602/621-5323

William Koskinen
USDA-ARS/Soil Sci Dept.
University of Minnesota
St. Paul, MN 55108
612/625-427

Larry Knerr
U of Wis-Dept of Hort
1575 Linden Dr.
Madison, WI 53706
608/262-0364

Don Koehler
Calif Dept Food & Agric.
1220 N St., Room A-400
Sacramento, CA 95814
916/322-5031

Bill Krall
Dupont
1739 Julie Lane
Twin Falls, ID 83301
208/734-9726

Jim Krall
Univ of Wyoming
Rt 1, Box 374
Torrington, WY 82240
307/532-7126

L. Butch Kreps
Calif Dept Food & Agric.
3708 Charlanne Dr.
Redding, CA 96002
916/224-2425

Ron Kukas
FMC
1128 W. Evergreen
Visalia, CA 93277
209/627-4094

Celestine Lacey
Weed Mgmt. Cons. Serv.
P. O. Box 9055
Helena, MT 59604
406/443-1469

Byron Lake
ICI Americas
P. O. Box 4023
Richmond, CA 4023
415/231-1253

Carol Lambert
BASF
4337 Kiernan Ave.
Modesto, CA 95356
209/545-0401

Tom Lanini
UCD - Botany Dept.
106 Robbins Hall
Davis, CA 95616
916/752-0612

Larry Lass
University of Idaho
913 W. Palouse Dr. #35
Moscow, ID 83843
208/885-6236

Jerry Lavoy
Rhone Poulenc
1046 Senora Ave.
Billings, MT 59105
406/245-9298

Bryan Leavitt
BYU Agronomy Dept.
Univ Station Box 7151
Provo, UT 84602
801/278-7039

Richard Lee
New Mexico State Univ/CES
Box 3AE
Las Cruces, NM 88001
505/646-2888

Gary Leek
Dupont
Stine Lab-Bldg 200/138
Newark, DE 19713
302/366-5533

John Leffel
OSU Ext. Serv-Wash. County
1260 NE Oleander
Hillsboro, OR 97124
503/681-7013

Reed Lencse
Louisiana State Univ.
302 Life Sciences Bldg.
Baton Rouge, LA 30806
504/388-1767

Carl Libbey
Washington State Univ.
1468 Memorial Hwy
Mt. Vernon, WA 98273
206/424-6121

R. M. Lindemann
Valent
5910 N. Monroe
Fresno, CA 93722
209/276-5311

Joan Lish
University of ID
P.S.E.S. Dept.
Moscow, ID 83843
208/885-7730

Kelly Luff
Rhone Poulenc
3560 E. 4000 North
Kimberly, ID 83341
208/423-5947

Al Luke
Rhone Poulenc
P. O. Box 12014
Res. Triangle Pk, NC 27709
919/549-2409

Earl Lukkes
Big Horn Co Weed & Pest 355
E. 5th St.
Lovell, WY 82431
307/548-7261

Rod Lym
North Dakota State Univ.
Crop & Weed Sci. Dept.
Fargo, ND 58105
701/237-8996

Jim Magana
Dupont-Ag Products Dept.
Walker's Mill - 3-284
Wilmington, DEL 19898
302/992-6107

Ghersa Marco
OSU & Buenos Aires Univ.
Forest Science Dept.
Corvallis, OR 97331
503/758-1239

Phil Martinelli
Retired
11125 Vincent Ln.
Reno, NV 89511
702/853-5992

John May
Dupont
2136 W. San Ramon
Fresno, CA 93711
209/431-4353

Terry Mayberry
Nor-Am
Rt 1, Box 218
Pendleton, OR 97801
503/278-2219

Kirk McDaniel
New Mexico State Univ.
Box 3I
Las Cruces, NM 89001
505/646-1191

Bernalyn McGaughey
Compliance Serv Int'l
700 Seafirst Center
Tacoma, WA 98402
206/272-6345

James McKinley
Rhone Poulenc
424 Aero View
Yakima, WA 98908
509/965-6203

Mary McKone
Doe Elanco
1001 S. 24th St. W #115
Billings, MT 59102
406/652-4977

R. D. McLaughlin
Rhone Poulenc
P. O. Box 12014
Res. Triangle Pk., NC 27709
919/549-2505

Jerry McLean
Grant Co. Noxious Weed Bd.
P. O. Box 1115
Ephrata, WA 98823
206/754-2011

Robert Merz
Monsanto
800 N. Lindbergh Blvd.
St. Louis, MO 63167
314/694-5002

Tom Mester
Landis Int'l
415 Placerville Dr., Ste T
Placerville, CA 95667
916/626-8552

Reao Mickelson
Caribou Co Weed Control
P. O. Box 775
Soda Springs, ID 83276
208/547-4483

Steve Miller
University of Wyoming
Dept. Plant, Soil & Insect
Laramie, WY 82071
307/766-3112

Bill Miller
Dow Elanco
1970 SW Quinney Place
Pendleton, OR 97804
503/276-9020

Larry Mitich
University of Calif
Dept of Botany
Davis, CA 95616
916/752-0612

Allen Mooney
Campbell Co Weed & Pest
P. O. Box 191
Gillette, WY 82717
307/682-4369

Don Morishita
University of Idaho
1330 Filer Ave., East
Twin Falls, ID 83301
208/734-3600

Howard Morton
USDA-ARS
2000 E. Allen Rd.
Tucson, AZ 85719

Philip Motooka
University of Hawaii
P. O. Box 208
Kealakekua, HI 96750
808/322-2718

Barbra Mullin
Montana Dept of Ag
920 N. Benton
Helena, MT 59601
406/444-2944

Bob Mullen
UC Cooperative Ext.
420 So. Wilson Way
Stockton, CA 95205
209/468-2085

Brad Muller
Montana State University
Plant Science Dept.
Bozeman, MT 59717
406/994-6841

Wendell Mullison
Consultant
1412 N. Parkway
Midland, MI 48640
519/835-2091

Danit Mulugeta
Montana State Univ.
Dept of Plant & Soil Sci.
Bozeman, MT 59717
406/994-5070

Seth Neibaur
Power Co. Weed Control
543 Bonnock Ave, Box 531
American Falls, ID 83211
208/226-5226

Tom Neidlinger
Rohm & Haas
16580 SE Bel Air Dr.
Clackamas, OR 97015
503/658-8233

Marlyn Nelson
Bingham County
83 Frontage Rd.
Blackfoot, ID 83221
208/785-8066

Michael Newton
Oregon State Univ.
College of Forestry
Corvallis, OR 97331
503/737-2244

Scott Nield
Lincoln Co. Weed & Pest
P. O. Box 1117
Afton, WY 83110
307/886-3394

Bruce Nielsen
Bonneville Co Weed Control
605 No. Capital
Idaho Falls, ID 83402
208/529-1397

Phil Odom
Nor-Am
15409 S. 28th Street
Phoenix, AZ 85044

Alex Ogg, Jr.
USDA-ARS/WSU
215 Johnson Hall
Pullman, WA 99164
509/335-1551

Paul Ogg
American Cyanamid
3619 Mountain View Ave.
Longmont, CO 80503
302/772-0628

Chris Olsen
Rhone Poulenc
28908 NE 39th Street
Camas, WA 98607
206/834-1089

Steve Orloff
UC Cooperative Ext.
335 East Ave K-6
Lancaster, CA 93535
805/723-4477

Jack Orr
UC Cooperative Ext.
4145 Branch Center
Sacramento, CA 95827
916/366-2013

John Orr
ICI Americas
251 Longhorn Ave.
Eagle, ID 83616
208/286-9300

Charles Osgood
BASF
11134 Chickadee Dr.
Boise, ID 83709
208/322-5616

David Ouse
Dow Elanco
825 Oak Grove Rd #24
Concord, CA 94518
415/680-2652

Bill Parker
Monsanto
800 N. Linbergh Blvd.
St. Louis, MO 63167
314/694-3825

Bob Parker
Washington State Univ.
Rt 2, Box 2953A
Prosser, WA 99350
509/786-2226

James Parochetti
United States Dept of Ag
CSRS-USDA
Washington, DC 20250
202-447-4354

John Pearson
BASF
1384 Greenborough
Roseville, CA 95661
916/786-0443

Neil Phillips, Jr.
Unocal
100 N. 4th St.
Patterson, CA 95363
209/892-3760

Emmanuel Pomela
Utah State University
Plant, Soil & Biomet.
Logan, UT 84322-4820
801/750-3513

Malyn Poulson
Agraserv, Inc.
3243 W. Jo Anna Ct.
American Falls, ID 83211
208/226-2602

Warren Purdy, III
Brea Agric Svc.
P. O. Box 201059
Stockton, CA 95201
209/466-5911

Steve Radosevich
Oregon State Univ.
Forestry Dept.
Corvallis, OR 97330
503/737-2244

Michael Ralphs
USDA/ARS Poisonous Plants
1150 E. 1400 N.
Logan, UT 84321
801/752-2941

Martin Reid
Dupont-Railroad Veg
1624 Indian Wells Dr.
Boulder City, NV 89005
702/294-1825

Carolos Reyes
OSU - USDA/ARS
3450 SW Campus Way
Corvallis, OR 97321
503/757-4502

Wendell Rich
Agraserv, Inc.
1200 N. 3861 E.
Ashton, ID 83420
208/652-7860

Jesse Richardson
Dow Elanco
9330 10th Ave.
Hesperia, CA 92345
619/949-2565

Mark Risley
American Cyanamid
P. O. Box 400
Princeton, NJ 08543
609/799-0400

Roy Roggenbuck
Primus Labs
3130 Skyway Dr., Ste 308
Santa Maria, CA 93455
805/922-6055

Malone Rosemond
Monsanto
2130 Professional Dr. #200
Roseville, CA 95616
916/784-7884

Leah Rosenbeck
University of California
1855 E. 8th
Davis, CA 95616
916/753-0886

Claude Ross
FMC Corp.
4343 Redbird Ct.
Loveland, CO 80537
303/669-3622

Mel Rueppel
Monsanto
800 N. Lindbergh Blvd.
St. Louis, MO 63167
314/694-5095

Dale Rusit
Unocal
1916 Barry Rd.
Davis, CA 95616
916/372-6050

Lou Russo
Sandoz
9269F Mesa Ave.
Clovis, CA 93612
209/297-7542

Don Rydrych
OSU-Columbia Basin Ag Res
P. O. Box 370
Pendleton, OR 97801
503/276-5721

Doug Ryerson
Monsanto
1201 10th Ave. S.
Great Falls, MT 59404
406/727-7071

Erich Saches
Monsanto
7234 N. Teilman
Fresno, CA 93711
209/431-7459

Kip Sander
Ciba-Geigy
P. O. Box 158
Sanger, CA 93667
209/875-6075

James Saxton
Bear Lake County
P. O. Box 237
Paris, ID 83261
208/945-2262

William Schaiffers
University of Idaho
P. O. Box AA
Aberdeen, ID 83210
208/397-4181

Edgar Scheurer
Hoechst Canada, Inc.
295 Henderson Dr.
Regina, Sask. Canada S4N7K1
306/924-2300

Roland Schirman
WSU Cooperative Ext.
202 S. Second
Dayton, WA 99328
509/382-4741

Jack Schlesselman
Rohm & Haas
726 E. Kip Patrick
Reedley, CA 93654
209/638-7003

Jerry Schmierer
UC Cooperative Ext.
Memorial Bldg.
Susanville, CA 96130
916/257-6363

Bob Schnackenberg
Agri-Turf Supplies
2257 Las Positas Rd.
Santa Barbara, CA 93105
805/569-2257

Galen Schroeder
Sandoz
P. O. Box 2277
Fargo, ND 58108
701/235-0131

Jill Schroeder
New Mexico State Univ.
Box 30003, Dept 3BE
Las Cruces, NM 88003
505/646-2328

Rodney Schultz
Dow Elanco
7521 W. California Ave.
Fresno, CA 93706
209/485-5550

Tom Schwartz
Beet Sugar Dev. Foundation
90 Madison St. #208
Denver, CO 80206
303/321-1520

Jim Sebastian
Colorado State Univ.
2935 Windmill Dr. #G-7
Ft. Collins, CO 80523
303/491-5667

Bill Selelyo
Twin Falls Co. Weed Bureau
246 3rd Ave. East
Twin Falls, ID 83301
208/734-9000

David Shields
BASF
10181 Ave. 416
Dinuba, CA 93618
209/591-2548

Ed Sieckert
Monsanto
2415 Rockingham
Lodi, CA 95242
209/334-4234

Bill Smith
Dupont
Stine-Haskell Box 30
Newark, DEL 19714
302/366-5154

Brenda Smith
Cal Poly
Crop Science Dept.
San Luis Obispo, CA 93407
805/756-6139

Brian Smith
Target
17710 Studebaker Rd.
Cerritos, CA 90701
213/865-9541

Carol Smith
University of Idaho
Box 247
Troy, ID 83871
208/885-6236

John Smith
American Cyanamid
4870 Justice Way S.
Salem, OR 97302
503/362-7927

Ray Smith
Jefferson Co. Weed Cont.
Jefferson Cnty Crthouse #34
Rigby, ID 83442
208/745-6984

Les Sonder
Calif Dept of Food & Agric.
9026 La Valencia Ct.
Elk Grove, CA 95624
916/685-9346

David Spencer
USDA Aquatic Weed Lab
University of Calif
Davis, CA 95616
916/752-1096

Earl Spurrier
NACA
1155 15th St. NW #900
Washington, DC 20005
202/296-1585

Phil Stahlman
Ft. Hays Experiment Sta.
Rt 2
Hays, KS 67601
913/625-3425

Gil Stallknecht
Montana State University
So. Ag Research Center
Huntley, MT 59037
406/348-3400

Charles Stanger
OSU Malheur Exp. Station
595 Onion Ave.
Ontario, OR 97914
503/889-2174

Tracy Sterling
New Mexico State Univ.
Box 30003, Dept. 3BE
Las Cruces, NM 88001
505/646-6177

Jim Stewart
Nor-Am
68 N. Cindy
Clovis, CA 93612
209/299-4691

Vern Stewart
MSU NW Agric. Res. Center
4570 Montana 35
Kalispell, MT 59901
406/755-4303

Richard Stoltz
American Cyanamid
506 W. Tenaya Ave.
Clovis, CA 93612
209/298-7034

William Stump
Colorado State Univ.
Weed Research Lab
Ft. Collins, CO 80523
303/491-5667

Dean Swan
Washington State Univ.
S.W. 822 Crestview
Pullman, WA 99163
509/334-1836

Clair Stymiest
So Dakota State Univ.
801 San Francisco St.
Rapid City, SD 57701
605/394-2236

Mark Sybouts
BASF
42490 Alpha Place
Temecula, CA 92390
714/699-3509

Siyuan Tan
Oregon State University
Horticulture Dept.
Corvallis, OR 97331-2911
503/737-3695

Abbes Tanji
Colorado State Univ
500 W. Prospect 25J
Ft. Collins CO 80526
303/491-5667

Frank Tenne
American Cyanamid
P. O. Box 400
Princeton, NJ 08540
609/799-0400

Don Thill
P.S.E.S. Dept.
University of ID
Moscow, ID 83843
208/885-6214

Curtis Thompson
P.S.E.S. Dept.
University of ID
Moscow, ID 83843
208/885-6236

Robert Thullen
USDA-ARS
17053 Shafter Ave.
Shafter, CA 93263
805/746-3069

Jeff Tichota
Sandoz
4949 S. Syracuse Pkwy #3700
Denver, CO 80237
303/220-0834

Dennis Tonks
Brigham Young Univ.
737 South 850 West
Provo, UT 84601
801/374-1971

Harvey Tripple
Monsanto
Box 6544
Englewood, CO 80155-6544
303/792-1192

John Troth
Dow Elanco
5004 Cortland Ct.
Midland, MI 48640
517/636-5160

Stuart A. Turner
Stuart W. Turner & Co.
P.O. Box 10539
Bainbridge Island, WA 98110
206/842-3494

Stuart W. Turner
Stuart W. Turner & Co.
P.O. Box 10539
Bainbridge Island, WA 98110
206/842-3494

Vince Ulstad
BASF
1513 Sylvan Circle
Brandon, SD 57005
605/582-6999

Kai Umeda
American Cyanamid
4531 W. Gail
Chandler, AZ 85226
602/345-2517

Tim Vargas
Varco Ag Res & Cons.
180 W. 100th North
Jerome, ID 83338
208/324-4080

Ron Vargas
UC Cooperative Ext.
328 Madera Ave.
Madera, CA 93637
209/675-7879

Mark Veil
Solano Irrigation Dist.
508 Elmira Rd.
Vacaville, CA 95687
707/448-6847

Kurt Volker
ICI Americas
7610 Scenic
Yakima, WA 98908
509/965-2822

Paul Walgenbach
American Cyanamid
789 Lakecrest Dr.
El Dorado Hills, CA 95630
916/933-3180

Kandy Walker
Landis International
415 Placerville Dr., Ste T
Placerville, CA 95667
916/626-8552

Ted Warfield
FMC Corp
11128 John Galt Blvd.
Omaha, NE 68137
402/592-5090

Steven Watkins
ICI Americas
2210 Lorie Lane
Yuma, AZ 85365
602/726-1509

Jimmy Welch
Nor-Am Chemical
266 S. Monroe
Fresno, CA 93722
209/268-5088

Len Welch
Valent
5910 N. Monroe
Fresno, CA 93722
209/276-5309

Doug West
Rohm & Haas Co.
4000 Meder Rd.
Shingle Springs, CA 95682
916/677-6886

Philip Westra
Colorado State University
112 Weed Science Lab
Ft. Collins, CO 80523
303/491-5219

Ralph Whitesides
Utah State University
Dept of Plant, Soil & Biom.
Logan, UT 84322
801/750-2259

Russ Whitmore
American Cyanamid
801 Forest Ridge #102
Bedford, TX 76022
817/571-3535

Roy Whitson
Valent
5910 Monroe
Fresno, CA 93722
209/276-5306

Tom Whitson
Univ of Wyoming
Box 3354, Ag Bldg.
Laramie, WY 82071
307/766-3113

David Wichman
MSU Central Ag Res Center
HC90 - Box 20
Moccasin, MT 59462
406/423-5421

Dee Wilde
Lincoln Co Weed & Pest
Star Route
Cokeville, WY 83114
307/849-0513

Duke Wiley
BASF
P. O. Box 2198
Paradise, CA 95967
916/872-8006

Roger Willemsen
Rhone Poulenc
2491 W. Shaw #123
Fresno, CA 93711
209/224-8484

Ray William
Oregon State University
Horticulture Dept.
Corvallis, OR 97331
503/737-3464

Linda Willits
ICI Americas
104 Prospector Ct.
Folsom, CA 95630
916/989-3567

Barry Wingfield
United Agri Products
P. O. Box E
Greeley, CO 80632
303/352-4750

Sandra Wingfield
Agrisan Pest Mgmt.
P. O. Box 323
Eaton, CO 80615
303/834-2607

Winn Winkyaw
Salt River Project
P. O. Box 52025
Phoenix, AZ 85072
602/236-5227

Neal Winslow
Sandoz
975 California Ave.
Palo Alto, CA 94304-1104
415/354-3439

Carl Winter
University of CA
Dept of Entomology
Riverside, CA 92521
714/787-5994

Steve Wright
UC Cooperative Ext
County Civic Ctr, Ag Bldg.
Visalia, CA 93291
209/733-6363

Wayne Wright
Dow Elanco
3905 Vincennes Rd.
Indianapolis, IN 46268
317/871-4626

Nancy Yates-Parker
Monsanto
800 N. Lindbergh Blvd/C2SF
St. Louis, MO 63011
314/694-3095

Ken Yelle
Ag Chem Search
P. O. Box 667
Elk Grove, CA 95759
916/689-6400

Frank Young
Wash State Univ/USDA-ARS
Johnson Hall, Rm 215
Pullman, WA 99164
509/335-1551

David Zamora
American Cyanamid
4525 Cochees Way
Boise, ID 83709
209/362-4695

AUTHOR INDEX

CROP INDEX

Common and Botanical Name	Page

Common and Botanical Name	Page

WEED INDEX

HERBICIDE INDEX

Common name or Code designation,
Trade name and Chemical name **Page**